(ee) For hydraulically designed systems, the information on the hydraulic data nameplate.

(ff) A graphic representation of the scale used on all plans.

(gg) Name and address of contractor.

(hh) Hydraulic reference points shown on the plan shall correspond with comparable reference points on the hydraulic calculation sheets.

(ii) The minimum rate of water application (density), the design area of water application, in-rack sprinkler demand, and the water required for hose streams both inside and outside.

(jj) The total quantity of water and the pressure required noted at a common reference point for each system.

(kk) Relative elevations of sprinklers, junction points, and supply or reference points.

(ll) If room design method is used, all unprotected wall openings throughout the floor protected.

(mm) Calculation of loads for sizing, and details of, sway bracing.

(nn) The setting for pressure-reducing valves.

(oo) Information about backflow preventers (manufacturer, size, type).

(pp) Information about antifreeze solution used (type and amount).

6-1.1.2 The working plan submittal shall include manufacturer's installation instructions for any specially listed equipment, including descriptions, applications, and limitations for any sprinklers, devices, piping, or fittings.

6-1.1.3* Working plans for automatic sprinkler systems with nonfire protection connections. Special symbols shall be used and explained for auxiliary piping, pumps, heat exchangers, valves, strainers, and the like, clearly distinguishing these devices and piping runs from those of the sprinkler system. Model number, type, and manufacturer's name shall be identified for each piece of auxiliary equipment.

6-2 Hydraulic Calculation Forms.

6-2.1 General. Hydraulic calculations shall be prepared on form sheets that include a summary sheet, detailed work sheets, and a graph sheet. [*See copies of typical forms, Figures A-6-2.2(a), A-6-2.3, and A-6-2.4.*]

6-2.2* Summary Sheet. The summary sheet shall contain the following information, where applicable:

(a) Date.
(b) Location.
(c) Name of owner and occupant.
(d) Building number or other identification.
(e) Description of hazard.
(f) Name and address of contractor or designer.
(g) Name of approving agency.
(h) System design requirements.
1. Design area of water application, sq ft (m^2).
2. Minimum rate of water application (density), gpm per sq ft (L/min/m^2).
3. Area per sprinkler, sq ft (m^2).

(i) Total water requirements as calculated including allowance for inside hose, outside hydrants, and water curtain and exposure sprinklers.

(j) Allowance for in-rack sprinklers, gpm (L/min).

(k) Limitations (dimension, flow, and pressure) on extended coverage or other listed special sprinklers.

6-2.3* Detailed Work Sheets. Detailed work sheets or computer printout sheets shall contain the following information:

(a) Sheet number.
(b) Sprinkler description and discharge constant (K).
(c) Hydraulic reference points.
(d) Flow in gpm (L/min).
(e) Pipe size.
(f) Pipe lengths, center-to-center of fittings.
(g) Equivalent pipe lengths for fittings and devices.
(h) Friction loss in psi per ft (bars/m) of pipe.
(i) Total friction loss between reference points.
(j) In-rack sprinkler demand balanced to ceiling demand.
(k) Elevation head in psi (bars) between reference points.
(l) Required pressure in psi (bars) at each reference point.
(m) Velocity pressure and normal pressure if included in calculations.
(n) Notes to indicate starting points, reference to other sheets, or to clarify data shown.
(o)* Diagram to accompany gridded system calculations to indicate flow quantities and directions for lines with sprinklers operating in the remote area.
(p) Combined K-factor calculations for sprinklers on drops, armovers, or sprigs where calculations do not begin at sprinkler.

6-2.4* Graph Sheet. A graphic representation of the complete hydraulic calculation shall be plotted on semi-exponential graph paper ($Q^{1.85}$) and shall include the following:

(a) Water supply curve.
(b) Sprinkler system demand.
(c) Hose demand (where applicable).
(d) In-rack sprinkler demand (where applicable).

6-3 Water Supply Information. The following information shall be included:

(a) Location and elevation of static and residual test gauge with relation to the riser reference point.
(b) Flow location.
(c) Static pressure, psi (bars).
(d) Residual pressure, psi (bars).
(e) Flow, gpm (L/min).
(f) Date.
(g) Time.
(h) Test conducted by or information supplied by.
(i) Other sources of water supply, with pressure or elevation.

6-4 Hydraulic Calculation Procedures.

6-4.1* General. A calculated system for a building, or a calculated addition to a system in an existing sprinklered

Table 6-4.3.1 Equivalent Schedule 40 Steel Pipe Length Chart

Fittings and Valves	Fittings and Valves Expressed in Equivalent Feet of Pipe													
	½ in.	¾ in.	1 in.	1¼ in.	1½ in.	2 in.	2½ in.	3 in.	3½ in.	4 in.	5 in.	6 in.	8 in.	10 in.	12 in.
45° Elbow		1	1	1	2	2	3	3	3	4	5	7	9	11	13
90° Standard elbow	1	2	2	3	4	5	6	7	8	10	12	14	18	22	27
90° Long turn elbow	0.5	1	2	2	2	3	4	5	5	6	8	9	13	16	18
Tee or cross (flow turned 90°)	3	4	5	6	8	10	12	15	17	20	25	30	35	50	60
Butterfly valve		-	-	-	-	6	7	10	-	12	9	10	12	19	21
Gate valve		-	-	-	-	1	1	1	1	2	2	3	4	5	6
Swing check*		-	5	7	9	11	14	16	19	22	27	32	45	55	65

For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.

*Due to the variations in design of swing check valves, the pipe equivalents indicated in the above chart are considered average.

NOTE 1: This table applies to all types of pipe listed in Table 6-4.4.5.

NOTE 2: Information on ½-in. pipe is included in this table only because it is allowed under 4-13.18.2 and 4-13.18.3.

building, supersedes the rules in this standard governing pipe schedules, except that all systems continue to be limited by area, and pipe sizes shall be no less than 1 in. (25.4 mm) nominal for ferrous piping and ¾ in. (19 mm) nominal for copper tubing or nonmetallic piping listed for fire sprinkler service. The size of pipe, number of sprinklers per branch line, and number of branch lines per cross main are otherwise limited only by the available water supply. However, sprinkler spacing and all other rules covered in this and other applicable standards shall be observed.

6-4.2 Formulas.

6-4.2.1 Friction Loss Formula. Pipe friction losses shall be determined on the basis of the Hazen-Williams formula.

$$p = \frac{4.52\,Q^{1.85}}{C^{1.85}\,d^{4.87}}$$

where:

p = frictional resistance in pounds pressure per square inch per foot of pipe
Q = flow in gpm
d = actual internal diameter of pipe in inches
C = friction loss coefficient.

$$\text{For SI Units: } p_m = 6.05 \times \frac{Q_m^{1.85}}{C^{1.85}\,d_m^{4.87}} \times 10^5$$

where:

p_m = frictional resistance in bars per meter of pipe
Q_m = flow in L/min
d_m = actual internal diameter in mm
C = friction loss coefficient.

6-4.2.2 Velocity Pressure Formula. Velocity pressure shall be determined on the basis of the formula

$$P_v = \frac{0.001123Q^2}{D^4}$$

where:

P_v = velocity pressure in psi
Q = flow in gpm
D = inside diameter in inches

For SI Units: 1 in. = 25.4 mm; 1 gal = 3.785 L; 1 psi = 0.0689 bar.

6-4.2.3 Normal Pressure Formula. Normal pressure (P_n) shall be determined on the basis of the formula

$$P_n = P_t - P_v$$

where:

P_n = normal pressure
P_t = total pressure in psi (bars)
P_v = velocity pressure in psi (bars).

6-4.2.4 Hydraulic Junction Points. Pressures at hydraulic junction points shall balance within 0.5 psi (0.03 bar). The highest pressure at the junction point, and the total flows as adjusted, shall be carried into the calculations.

6-4.3 Equivalent Pipe Lengths of Valves and Fittings.

6-4.3.1 Table 6-4.3.1 shall be used to determine the equivalent length of pipe for fittings and devices unless manufacturer's test data indicate that other factors are appropriate. For saddle-type fittings having friction loss greater than that shown in Table 6-4.3.1, the increased friction loss shall be included in hydraulic calculations. For internal pipe diameters different from Schedule 40 steel pipe, the equivalent feet shown in Table 6-4.3.1 shall be multiplied by a factor derived from the following formula:

$$\left[\frac{\text{Actual inside diameter}}{\text{Schedule 40 steel pipe inside diameter}}\right]^{4.87} = \text{Factor}$$

The factor thus obtained shall be further modified as required by Table 6-4.3.2.

This table shall apply to other types of pipe listed in Table 6-4.4.5 only where modified by factors from 6-4.3.1 and 6-4.3.2.

6-4.3.2 Table 6-4.3.1 shall be used with Hazen-Williams C = 120 only. For other values of C, the values in Table 6-4.3.1 shall be multiplied by the factors indicated in Table 6-4.3.2.

Table 6-4.3.2 C Value Multiplier

Value of C	100	130	140	150
Multiplying Factor	0.713	1.16	1.33	1.51

NOTE: This is based upon the friction loss through the fitting being independent of the C factor available to the piping.

6-4.3.3 Specific friction loss values or equivalent pipe lengths for alarm valves, dry pipe valves, deluge valves,

strainers, and other devices shall be made available to the authority having jurisdiction.

6-4.3.4 Specific friction loss values or equivalent pipe lengths for listed fittings not in Table 2-4.1 (*see 2-4.2*) shall be used in hydraulic calculations where these losses or equivalent pipe lengths are different from those shown in Table 6-4.3.1.

6-4.4* Calculation Procedure.

6-4.4.1* For all systems the design area shall be the hydraulically most demanding based on the criteria of 5-2.3.

Exception: Special design approaches in accordance with 5-3.3.

(a) Where the design is based on area/density method, the design area shall be a rectangular area having a dimension parallel to the branch lines at least 1.2 times the square root of the area of sprinkler operation (A) used. This shall permit the inclusion of sprinklers on both sides of the cross main. Any fractional sprinkler shall be carried to the next higher whole sprinkler.

Exception: In systems having branch lines with an insufficient number of sprinklers to fulfill the 1.2 $\sqrt{A}$ requirement, the design area shall be extended to include sprinklers on adjacent branch lines supplied by the same cross main.

(b) Where the design is based on the room design method, see 5-2.3.3. The calculation shall be based on the room and communicating space, if any, that is the hydraulically most demanding.

6-4.4.2* For gridded systems, the designer shall verify that the hydraulically most demanding area is being used. A minimum of two additional sets of calculations shall be submitted to demonstrate peaking of demand area friction loss when compared to areas immediately adjacent on either side along the same branch lines.

Exception: Computer programs that show the peaking of the demand area friction loss shall be acceptable based on a single set of calculations.

6-4.4.3 System piping shall be hydraulically designed using design densities and areas of operation in accordance with Figure 5-2.3 as required for the occupancies involved.

(a)* The density shall be calculated on the basis of floor area of sprinkler operation. The area covered by any sprinkler used in hydraulic design and calculations shall be the horizontal distances measured between the sprinklers on the branch line and between the branch lines in accordance with 4-2.2.1.

(b)* Where sprinklers are installed above and below a ceiling or in a case where more than two areas are supplied from a common set of branch lines, the branch lines and supplies shall be calculated to supply the largest water demand.

6-4.4.4* Each sprinkler in the design area and the remainder of the hydraulically designed system shall discharge at a flow rate at least equal to the stipulated minimum water application rate (density) multiplied by the area of sprinkler operation. Calculations shall begin at the hydraulically most remote sprinkler. Discharge at each sprinkler shall be based on the calculated pressure at that sprinkler.

Exception No. 1: Where the area of application is equal to or greater than the minimum allowable area of Figure 5-2.3 for the appropriate hazard classification (including a 30 percent increase for dry pipe systems), sprinkler discharge in closets, washrooms, and similar small compartments requiring only one sprinkler shall be permitted to be omitted from hydraulic calculations within the area of application. Sprinklers in these small compartments shall, however, be capable of discharging minimum densities in accordance with Figure 5-2.3.

Exception No. 2: Where sprinklers are provided above and below obstructions such as wide ducts or tables, the water supply for one of the levels of sprinklers shall be permitted to be omitted from the hydraulic ceiling design calculations within the area of application. In any case, the most hydraulically demanding arrangement shall be calculated.

6-4.4.5 Pipe friction loss shall be calculated in accordance with the Hazen-Williams formula with C values from Table 6-4.4.5.

(a) Include pipe, fittings, and devices such as valves, meters, and strainers, and calculate elevation changes that affect the sprinkler discharge.

Exception: Tie-in drain piping shall not be included in the hydraulic calculations.

(b) Calculate the loss for a tee or a cross where flow direction change occurs based on the equivalent pipe length of the piping segment in which the fitting is included. The tee at the top of a riser nipple shall be included in the branch line; the tee at the base of a riser nipple shall be included in the riser nipple; and the tee or cross at a cross main-feed main junction shall be included in the cross main. Do not include fitting loss for straight-through flow in a tee or cross.

(c) Calculate the loss of reducing elbows based on the equivalent feet value of the smallest outlet. Use the equivalent feet value for the standard elbow on any abrupt 90-degree turn, such as the screw-type pattern. Use the equivalent feet value for the long-turn elbow on any sweeping 90-degree turn, such as a flanged, welded, or mechanical joint-elbow type. (*See Table 6-4.3.1.*)

(d) Friction loss shall be excluded for the fitting directly connected to a sprinkler.

(e) Losses through a pressure-reducing valve shall be included based on the normal inlet pressure condition. Pressure loss data from the manufacturer's literature shall be used.

* **Table 6-4.4.5 Hazen-Williams C Values**

Pipe or Tube	C Value*
Unlined cast or ductile iron	100
Black steel (dry systems including preaction)	100
Black steel (wet systems including deluge)	120
Galvanized (all)	120
Plastic (listed)—all	150
Cement lined cast or ductile iron	140
Copper tube or stainless steel	150

*The authority having jurisdiction is permitted to consider other C values.

6-4.4.6* Orifice plates or sprinklers of different orifice sizes shall not be used for balancing the system.

Exception No. 1: Sprinklers with different orifice sizes shall be acceptable for special use such as exposure protection, small rooms or enclosures, or directional discharge. (See 1-4.2 for definition of small rooms.)

Exception No. 2: Extended-coverage sprinklers with a different orifice size shall be acceptable for part of the protection area where installed in accordance with their listing.

6-4.4.7* When calculating flow from an orifice, the total pressure (P_t) shall be used.

Exception: Use of the normal pressure (P_n) calculated by subtracting the velocity pressure from the total pressure shall be permitted. Where the normal pressure is used, it shall be used on all branch lines and cross mains where applicable.

6-4.4.8 Minimum operating pressure of any sprinkler shall be 7 psi (0.5 bar).

Exception: Where higher minimum operating pressure for the desired application is specified in the listing of the sprinkler.

6-5 Pipe Schedules. Pipe schedules shall not be used, except in existing systems and in new systems or extensions to existing systems described in Chapter 5. Water supplies shall conform to 5-2.2.

6-5.1* General. The pipe schedule sizing provisions shall not apply to hydraulically calculated systems. Sprinkler systems having sprinklers with orifices other than ½ in. (13 mm) nominal, listed piping material other than that covered in Table 2-3.1, Extra Hazard Groups 1 and 2 systems, and exposure protection systems shall be hydraulically calculated.

6-5.1.1 The number of automatic sprinklers on a given pipe size on one floor shall not exceed the number given in 6-5.2, 6-5.3, or 6-5.4 for a given occupancy.

6-5.1.2* Size of Risers. Each system riser shall be sized to supply all sprinklers on the riser on any one floor as determined by the standard schedules of pipe sizes in 6-5.2, 6-5.3, or 6-5.4.

6-5.1.3 Slatted Floors, Large Floor Openings, Mezzanines, and Large Platforms. Buildings having slatted floors, or large unprotected floor openings without approved stops, shall be treated as one area with reference to pipe sizes, and the feed mains or risers shall be of the size required for the total number of sprinklers.

6-5.1.4 Stair Towers. Stairs, towers, or other construction with incomplete floors, if piped on independent risers, shall be treated as one area with reference to pipe sizes.

6-5.2 Schedule for Light Hazard Occupancies.

6-5.2.1 Branch lines shall not exceed 8 sprinklers on either side of a cross main.

Exception: Where more than 8 sprinklers on a branch line are necessary, lines may be increased to 9 sprinklers by making the 2 end lengths 1 in. (25.4 mm) and 1¼ in. (33 mm), respectively, and the sizes thereafter standard. Ten sprinklers may be placed on a branch line making the 2 end lengths 1 in. (25.4 mm) and 1¼ in. (33 mm), respectively, and feeding the tenth sprinkler by a 2½-in. (64-mm) pipe.

6-5.2.2 Pipe sizes shall be in accordance with Table 6-5.2.2.

Exception: Each area requiring more sprinklers than the number specified for 3 ½-in. (89-mm) pipe in Table 6-5.2.2 and without subdividing partitions (not necessarily fire walls) shall be supplied by mains or risers sized for Ordinary Hazard Occupancies.

6-5.2.3 Where sprinklers are installed above and below ceilings [*see Figures 6-5.2.3(a), (b), and (c)*] and such sprinklers are supplied from a common set of branch lines or separate branch lines from a common cross main, such branch lines shall not exceed 8 sprinklers above and 8 sprinklers below any ceiling on either side of the cross main. Pipe sizing up to and including 2 ½ in. (64 mm) shall be as shown in Table 6-5.2.3 utilizing the greatest number of sprinklers to be found on any two adjacent levels.

Exception: Branch lines and cross mains supplying sprinklers installed entirely above, or entirely below, ceilings shall be sized in accordance with Table 6-5.2.2.

Table 6-5.2.2 Light Hazard Pipe Schedules

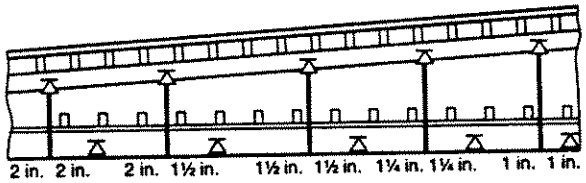
Steel		Copper	
1 in.	2 sprinklers	1 in.	2 sprinklers
1¼ in.	3 sprinklers	1¼ in.	3 sprinklers
1½ in.	5 sprinklers	1½ in.	5 sprinklers
2 in.	10 sprinklers	2 in.	12 sprinklers
2½ in.	30 sprinklers	2½ in.	40 sprinklers
3 in.	60 sprinklers	3 in.	65 sprinklers
3½ in.	100 sprinklers	3½ in.	115 sprinklers
4 in.	See 4-2.1	4 in.	See 4-2.1

For SI Units: 1 in. = 25.4 mm.

Table 6-5.2.3 Number of Sprinklers above and below a Ceiling

Steel		Copper	
1 in.	2 sprinklers	1 in.	2 sprinklers
1¼ in.	4 sprinklers	1¼ in.	4 sprinklers
1½ in.	7 sprinklers	1½ in.	7 sprinklers
2 in.	15 sprinklers	2 in.	18 sprinklers
2½ in.	50 sprinklers	2½ in.	65 sprinklers

For SI Units: 1 in. = 25.4 mm.



For SI units: 1 in. = 25.4 mm.

Figure 6-5.2.3(a) Arrangement of branch lines supplying sprinklers above and below a ceiling.

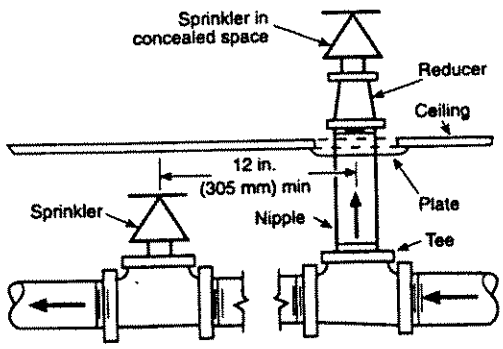


Figure 6-5.2.3(b) Sprinkler on riser nipple from branch line in lower fire area.

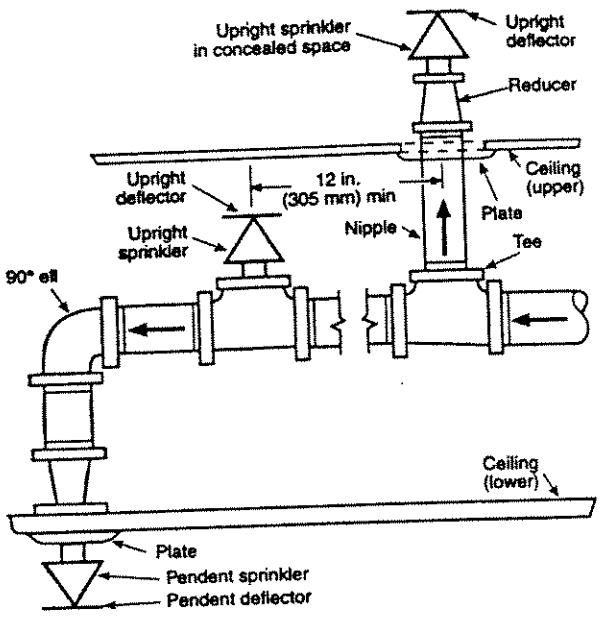


Figure 6-5.2.3(c) Arrangement of branch lines supplying sprinklers above and below ceilings.

6-5.2.3.1* Where the total number of sprinklers above and below a ceiling exceeds the number specified in Table 6-5.2.3 for 2½-in. (64-mm) pipe, the pipe supplying such sprinklers shall be increased to 3 in. (76 mm) and sized thereafter according to the schedule shown in Table 6-5.2.2 for the number of sprinklers above or below a ceiling, whichever is larger.

6-5.3 Schedule for Ordinary Hazard Occupancies.

6-5.3.1 Branch lines shall not exceed 8 sprinklers on either side of a cross main.

Exception: Where more than 8 sprinklers on a branch line are necessary, lines may be increased to 9 sprinklers by making the 2 end lengths 1 in. (25.4 mm) and 1¼ in. (33 mm), respectively, and the sizes thereafter standard. Ten sprinklers are permitted to be placed on a branch line making the 2 end lengths 1 in. (25.4 mm) and 1¼ in. (33 mm), respectively, and feeding the tenth sprinkler by a 2½-in. (64-mm) pipe.

6-5.3.2 Pipe sizes shall be in accordance with Table 6-5.3.2(a).

Table 6-5.3.2(a) Ordinary Hazard Pipe Schedule

Steel		Copper	
1 in.	2 sprinklers	1 in.	2 sprinklers
1¼ in.	3 sprinklers	1¼ in.	3 sprinklers
1½ in.	5 sprinklers	1½ in.	5 sprinklers
2 in.	10 sprinklers	2 in.	12 sprinklers
2½ in.	20 sprinklers	2½ in.	25 sprinklers
3 in.	40 sprinklers	3 in.	45 sprinklers
3½ in.	65 sprinklers	3½ in.	75 sprinklers
4 in.	100 sprinklers	4 in.	115 sprinklers
5 in.	160 sprinklers	5 in.	180 sprinklers
6 in.	275 sprinklers	6 in.	300 sprinklers
8 in.	See 4-2.1	8 in.	See 4-2.1

For SI Units: 1 in. = 25.4 mm.

Exception: Where the distance between sprinklers on the branch line exceeds 12 ft (3.7 m), or the distance between the branch lines exceeds 12 ft (3.7 m), the number of sprinklers for a given pipe size shall be in accordance with Table 6-5.3.2(b).

Table 6-5.3.2(b) Number of Sprinklers—Greater than 12 ft Separations

Steel		Copper	
2½ in.	15 sprinklers	2½ in.	20 sprinklers
3 in.	30 sprinklers	3 in.	35 sprinklers
3½ in.	60 sprinklers	3½ in.	65 sprinklers

For other pipe and tube sizes, see Table 6-5.3.2(a).

For SI Units: 1 in. = 25.4 mm.

6-5.3.3 Where sprinklers are installed above and below ceilings and such sprinklers are supplied from a common set of branch lines or separate branch lines supplied by a common cross main, such branch lines shall not exceed 8 sprinklers above and 8 sprinklers below any ceiling on either side of the cross main. Pipe sizing up to and including 3 in. (76 mm) shall be as shown in Table 6-5.3.3 [*see Figures 6-5.2.3(a), (b), and (c)*] utilizing the greatest number of sprinklers to be found on any two adjacent levels.

Exception: Branch lines and cross mains supplying sprinklers installed entirely above, or entirely below, ceilings shall be sized in accordance with Tables 6-5.3.2(a) or (b).

Table 6-5.3.3 Number of Sprinklers above and below a Ceiling

Steel		Copper	
1 in.	2 sprinklers	1 in.	2 sprinklers
1¼ in.	4 sprinklers	1¼ in.	4 sprinklers
1½ in.	7 sprinklers	1½ in.	7 sprinklers
2 in.	15 sprinklers	2 in.	18 sprinklers
2½ in.	30 sprinklers	2½ in.	40 sprinklers
3 in.	60 sprinklers	3 in.	65 sprinklers

For SI Units: 1 in. = 25.4 mm.

6-5.3.3.1* Where the total number of sprinklers above and below a ceiling exceeds the number specified in Table 6-5.3.3 for 3-in. (76-mm) pipe, the pipe supplying such sprinklers shall be increased to 3 ½ in. (89 mm) and sized thereafter according to the schedule shown in Table 6-5.2.2 or Table 6-5.3.2(a) for the number of sprinklers above or below a ceiling, whichever is larger.

Exception: Where the distance between the sprinklers protecting the occupied area exceeds 12 ft (3.7 m) or the distance between the branch lines exceeds 12 ft (3.7 m), the branch lines shall be sized in accordance with either Table 6-5.3.2(b), taking into consideration the sprinklers protecting the occupied area only, or paragraph 6-5.3.3, whichever requires the greater size of pipe.

6-5.4* Extra Hazard Occupancies shall be hydraulically calculated.

Exception: For existing systems, see A-6-5.4.

6-5.5 Deluge Systems. Open sprinkler and deluge systems shall be hydraulically calculated according to applicable standards.

6-5.6* Exposure Systems. Exposure sprinklers shall be hydraulically calculated using Table 6-5.6 and a relative classification of exposures guide number.

Table 6-5.6 Exposure Protection

Section A—Window Sprinklers

Guide Number	Level of Window Sprinkler	Window Sprinkler Orifice Size	Discharge Coefficient (K Factor)	Flow Rate (Q)	Application Rate over 25 ft² of Window Area
1.50 or less	Top 2 levels	3/8 in. (9.5 mm)	2.8	7.4 gpm	0.30 gpm/ft²
	Next lower 2 levels	5/16 in. (7.9 mm)	1.9	5.0 gpm	0.20 gpm/ft²
	Next lower 2 levels	1/4 in. (6.4 mm)	1.4	3.7 gpm	0.15 gpm/ft²
1.51 to 2.20	Top 2 levels	1/2 in. (12.7 mm)	5.6	14.8 gpm	0.59 gpm/ft²
	Next lower 2 levels	7/16 in. (11.1 mm)	4.2	11.1 gpm	0.44 gpm/ft²
	Next lower 2 levels	3/8 in. (9.5 mm)	2.8	7.4 gpm	0.30 gpm/ft²
2.21 to 13.15	Top 2 levels	5/8 in. (15.9 mm)	11.2	29.6 gpm	1.18 gpm/ft²
	Next lower 2 levels	17/32 in. (13.5 mm)	8.0	21.2 gpm	0.85 gpm/ft²
	Next lower 2 levels	1/2 in. (12.7 mm)	5.6	14.8 gpm	0.59 gpm/ft²

Section B—Cornice Sprinklers

Guide Number	Cornice Sprinkler Orifice Size	Application Rate per Lineal Foot
1.50 or less	3/8 in. (9.5 mm)	0.75 gpm
1.51 to 2.20	1/2 in. (12.7 mm)	1.50 gpm
2.21 to 13.15	5/8 in. (15.9 mm)	3.00 gpm

For SI Units: 1 gpm = 3.785 L/min; 1 gpm/ft² = 40.76 (L/min)/m².

6-6 In-Rack Sprinklers.

6-6.1 Pipes to in-rack sprinklers shall be sized by hydraulic calculations.

6-6.2 Water demand of sprinklers installed in racks shall be added to ceiling sprinkler water demand over the same protected area at the point of connection. The demand shall be balanced to the higher pressure.

Chapter 7 Water Supplies

7-1 General. Every automatic sprinkler system shall have at least one automatic water supply.

7-1.1 Capacity. Water supplies shall be reliable and be capable of providing the required flow and pressure for the required duration as specified in Chapter 5 ("Design Approaches").

7-1.2 Arrangement.

7-1.2.1 Underground Supply Pipe. For pipe schedule systems, the underground supply pipe shall be at least as large as the system riser.

7-1.2.2 Connection between Underground and Aboveground Piping. The connection between the system piping and underground piping shall be made with a suitable transition piece and shall be properly strapped or fastened by approved devices. The transition piece shall be protected against possible damage from corrosive agents, solvent attack, or mechanical damage.

7-1.2.3* Connection Passing through or under Foundation Walls. When system piping pierces a foundation wall below grade or is located under the foundation wall, clearance shall be provided to prevent breakage of the piping due to building settlement.

7-1.3 Meters. Where meters are required by other authorities, they shall be listed.

7-2 Types.

7-2.1* Connections to Water Works Systems. A connection to a reliable water works system shall be an acceptable water supply source. The volume and pressure of a public water supply shall be determined from waterflow test data. (*See NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.*) The authority having jurisdiction shall be permitted to require an adjustment to the waterflow test data to account for daily and seasonal fluctuations, possible interruption by flood or ice conditions, large simultaneous industrial use, future demand on the water supply system, or any other condition that could affect the water supply.

7-2.2 Pumps.

7-2.2.1* Acceptability. A single automatically controlled fire pump installed in accordance with NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*, shall be an acceptable water supply source.

7-2.3 Pressure Tanks.

7-2.3.1 Acceptability.

7-2.3.1.1 A pressure tank installed in accordance with NFPA 22, *Standard for Water Tanks for Private Fire Protection*, shall be an acceptable water supply source.

7-2.3.1.2 Pressure tanks shall be provided with an approved means for automatically maintaining the required air pressure. Where a pressure tank is the sole water supply, there shall also be provided an approved trouble alarm to indicate low air pressure and low water level with the alarm supplied from an electrical branch circuit independent of the air compressor.

7-2.3.1.3 Pressure tanks shall not be used to supply other than sprinklers and hand hose attached to sprinkler piping.

7-2.3.2 Capacity. In addition to the requirements of 7-1.1, the water capacity of a pressure tank shall include the extra capacity needed to fill dry pipe or preaction systems where installed. The total volume shall be based on the water capacity, plus the air capacity required by 7-2.3.3.

7-2.3.3* Water Level and Air Pressure. Pressure tanks shall be kept two-thirds full of water, and an air pressure of at least 75 psi (5.2 bars) by the gauge shall be maintained. Where the bottom of the tank is located below the highest sprinklers served, the air pressure by the gauge shall be at least 75 psi (5.2 bars) plus three times the pressure caused by the column of water in the sprinkler system above the tank bottom.

7-2.4 Gravity Tanks. An elevated tank installed in accordance with NFPA 22, *Standard for Water Tanks for Private Fire Protection*, shall be an acceptable water supply source.

Chapter 8 System Acceptance

8-1 Approval of Sprinkler Systems. The installing contractor shall:

(a) Notify the authority having jurisdiction and owner's representative of the time and date testing will be performed.

(b) Perform all required acceptance tests. (*See Section 8-2.*)

(c) Complete and sign the appropriate Contractor's Material and Test Certificate(s) [*see Figures 8-1(a) and 8-1(b)*].

8-2 Acceptance Requirements.

8-2.1* Flushing of Piping. Underground mains and lead-in connections to system risers shall be completely flushed before connection is made to sprinkler piping. The flushing operation shall be continued for a sufficient time to ensure thorough cleaning. The minimum rate of flow shall be not less than:

(a) The hydraulically calculated water demand rate of the system including any hose requirements, or

(b) That flow necessary to provide a velocity of 10 ft per sec (3 m/s), [*see Table 8-2.1(b)*] or

(c) The maximum flow rate available to the system under fire conditions.

Table 8-2.1(b) Flow Required to Produce a Velocity of 10 ft per sec (3 m/s) in Pipes

Pipe Size (in.)	Pipe Size (mm)	Flow Rate (gpm)	Flow Rate (L/min)
4	102	390	1476
6	152	880	3331
8	203	1560	5905
10	254	2440	9235
12	305	3520	13323

8-2.2 Hydrostatic Tests.

8-2.2.1* All interior piping and attached appurtenances subjected to system working pressure shall be hydrostatically tested at 200 psi (13.8 bars) and shall maintain that pressure without loss for 2 hours. Loss shall be determined by a drop in gauge pressure or visual leakage.

Exception No. 1: Portions of systems normally subjected to working pressures in excess of 150 psi (10.4 bars) shall be tested as described above at a pressure of 50 psi (3.5 bars) in excess of normal working pressure.

Exception No. 2: Where cold weather will not permit testing with water, an interim air test may be conducted as described in 8-2.3.

Exception No. 3: When an addition or modification is made to an existing system, the new installation shall be isolated and tested at not less than 50 psi (3.4 bars) in excess of normal static pressure for 2 hr.

Exception No. 4: Modifications that cannot be isolated, such as relocated drops, shall not require testing in excess of normal static pressure.

The test pressure shall be read from a gauge located at the low elevation point of the system or portion being tested.

8-2.2.2 Additives. Additives, corrosive chemicals such as sodium silicate or derivatives of sodium silicate, brine, or other chemicals shall not be used while hydrostatically testing systems or for stopping leaks.

8-2.2.3 Piping between the exterior fire department connection and the check valve in the fire department inlet pipe shall be hydrostatically tested in the same manner as the balance of the system.

8-2.2.4 When deluge systems are being hydrostatically tested, plugs shall be installed in fittings and replaced with open sprinklers after the test is completed, or the operating elements of automatic sprinklers shall be removed after the test is completed.

8-2.2.5 All underground piping shall be hydrostatically tested in accordance with NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*. The allowable leakage shall be within the limits prescribed by NFPA 24 and shall be recorded on the test certificate.

8-2.2.6 Provision shall be made for the proper disposal of water used for flushing or testing.

8-2.2.7* Test blanks shall have painted lugs protruding in such a way as to clearly indicate their presence. The test blanks shall be numbered, and the installing contractor shall have a record-keeping method ensuring their removal after work is completed.

8-2.2.8 Differential-Type Valves. When subject to hydrostatic test pressures, the clapper of a differential-type valve shall be held off its seat to prevent damaging the valve.

8-2.3 Dry and Double Interlocked System(s) Air Test. In addition to the standard hydrostatic test, an air pressure leakage test at 40 psi (2.8 bars) shall be conducted for 24 hr. Any leakage that results in a loss of pressure in excess of 1 ½ psi (0.1 bar) for the 24 hr shall be corrected.

8-2.3.1 Where systems are installed in spaces that are capable of being operated at temperatures below 32°F (0°C), air pressure leakage tests required in 8-2.3 shall be conducted at the lowest nominal temperature of the space.

8-2.4 System Operational Tests.

8-2.4.1 Waterflow detecting devices including the associated alarm circuits shall be flow tested through the inspec-

Contractor's Material and Test Certificate for Aboveground Piping

PROCEDURE
Upon completion of work, inspection and tests shall be made by the contractor's representative and witnessed by an owner's representative. All defects shall be corrected and system left in service before contractor's personnel finally leave the job.

A certificate shall be filled out and signed by both representatives. Copies shall be prepared for approving authorities, owners, and contractor. It is understood the owner's representative's signature in no way prejudices any claim against contractor for faulty material, poor workmanship, or failure to comply with approving authority's requirements or local ordinances.

PROPERTY NAME	DATE
PROPERTY ADDRESS	

PLANS	ACCEPTED BY APPROVING AUTHORITIES (NAMES)		
	ADDRESS		
	INSTALLATION CONFORMS TO ACCEPTED PLANS	☐ YES	☐ NO
	EQUIPMENT USED IS APPROVED	☐ YES	☐ NO
	IF NO, EXPLAIN DEVIATIONS		
INSTRUCTIONS	HAS PERSON IN CHARGE OF FIRE EQUIPMENT BEEN INSTRUCTED AS TO LOCATION OF CONTROL VALVES AND CARE AND MAINTENANCE OF THIS NEW EQUIPMENT? IF NO, EXPLAIN	☐ YES	☐ NO
	HAVE COPIES OF THE FOLLOWING BEEN LEFT ON THE PREMISES?		
	1. SYSTEM COMPONENTS INSTRUCTIONS	☐ YES	☐ NO
	2. CARE AND MAINTENANCE INSTRUCTIONS	☐ YES	☐ NO
	3. NFPA 25	☐ YES	☐ NO
LOCATION OF SYSTEM	SUPPLIES BUILDINGS		

SPRINKLERS	MAKE	MODEL	YEAR OF MANUFACTURE	ORIFICE SIZE	QUANTITY	TEMPERATURE RATING

PIPE AND FITTINGS
Type of Pipe _____
Type of Fittings _____

ALARM VALVE OR FLOW INDICATOR	ALARM DEVICE			MAXIMUM TIME TO OPERATE THROUGH TEST CONNECTION	
	TYPE	MAKE	MODEL	MIN	SEC

DRY PIPE OPERATING TEST	DRY VALVE			Q. O. D.		
	MAKE	MODEL	SERIAL NO.	MAKE	MODEL	SERIAL NO.

	TIME TO TRIP THROUGH TEST CONNECTION[1]		WATER PRESSURE	AIR PRESSURE	TRIP POINT AIR PRESSURE	TIME WATER REACHED TEST OUTLET[1]		ALARM OPERATED PROPERLY	
	MIN	SEC	PSI	PSI	PSI	MIN	SEC	YES	NO
Without Q.O.D.									
With Q.O.D.									

IF NO, EXPLAIN

[1]MEASURED FROM TIME INSPECTOR'S TEST CONNECTION IS OPENED.

Figure 8-1(a) Part 1.

DELUGE AND PREACTION VALVES

OPERATION ☐ PNEUMATIC ☐ ELECTRIC ☐ HYDRAULIC

PIPING SUPERVISED ☐ YES ☐ NO | DETECTING MEDIA SUPERVISED ☐ YES ☐ NO

DOES VALVE OPERATE FROM THE MANUAL TRIP, REMOTE, OR BOTH CONTROL STATIONS ☐ YES ☐ NO

IS THERE AN ACCESSIBLE FACILITY IN EACH CIRCUIT FOR TESTING ☐ YES ☐ NO | IF NO, EXPLAIN

MAKE	MODEL	DOES EACH CIRCUIT OPERATE SUPERVISION LOSS ALARM? YES	NO	DOES EACH CIRCUIT OPERATE VALVE RELEASE? YES	NO	MAXIMUM TIME TO OPERATE RELEASE MIN	SEC

PRESSURE REDUCING VALVE TEST

LOCATION & FLOOR	MAKE & MODEL	SETTING	STATIC PRESSURE INLET (PSI)	STATIC PRESSURE OUTLET (PSI)	RESIDUAL PRESSURE (FLOWING) INLET (PSI)	RESIDUAL PRESSURE (FLOWING) OUTLET (PSI)	FLOW RATE FLOW (GPM)

TEST DESCRIPTION

HYDROSTATIC: Hydrostatic tests shall be made at not less than 200 psi (13.6 bars) for 2 hours or 50 psi (3.4 bars) above static pressure in excess of 150 psi (10.2 bars) for 2 hours. Differential dry-pipe valve clappers shall be left open during the test to prevent damage. All aboveground piping leakage shall be stopped.

PNEUMATIC: Establish 40 psi (2.7 bars) air pressure and measure drop, which shall not exceed 1½ psi (0.1 bars) in 24 hours. Test pressure tanks at normal water level and air pressure and measure air pressure drop, which shall not exceed 1½ psi (0.1 bars) in 24 hours.

TESTS

ALL PIPING HYDROSTATICALLY TESTED AT ___ PSI (__ BARS) FOR ___ HRS | IF NO, STATE REASON

DRY PIPING PNEUMATICALLY TESTED ☐ YES ☐ NO

EQUIPMENT OPERATES PROPERLY ☐ YES ☐ NO

DO YOU CERTIFY AS THE SPRINKLER CONTRACTOR THAT ADDITIVES AND CORROSIVE CHEMICALS, SODIUM SILICATE OR DERIVATIVES OF SODIUM SILICATE, BRINE, OR OTHER CORROSIVE CHEMICALS WERE NOT USED FOR TESTING SYSTEMS OR STOPPING LEAKS?

☐ YES ☐ NO

DRAIN TEST | READING OF GAUGE LOCATED NEAR WATER SUPPLY TEST CONNECTION: _____ PSI (__ BARS) | RESIDUAL PRESSURE WITH VALVE IN TEST CONNECTION OPEN WIDE: _____ PSI (__ BARS)

UNDERGROUND MAINS AND LEAD IN CONNECTIONS TO SYSTEM RISERS FLUSHED BEFORE CONNECTION MADE TO SPRINKLER PIPING

VERIFIED BY COPY OF THE U FORM NO. 85B ☐ YES ☐ NO | OTHER EXPLAIN

FLUSHED BY INSTALLER OF UNDERGROUND SPRINKLER PIPING ☐ YES ☐ NO

IF POWDER-DRIVEN FASTENERS ARE USED IN CONCRETE, HAS REPRESENTATIVE SAMPLE TESTING BEEN SATISFACTORILY COMPLETED? ☐ YES ☐ NO | IF NO, EXPLAIN

BLANK TESTING GASKETS

NUMBER USED	LOCATIONS	NUMBER REMOVED

WELDING

WELDED PIPING ☐ YES ☐ NO

IF YES. . .

DO YOU CERTIFY AS THE SPRINKLER CONTRACTOR THAT WELDING PROCEDURES COMPLY WITH THE REQUIREMENTS OF AT LEAST AWS D10.9, LEVEL AR-3? ☐ YES ☐ NO

DO YOU CERTIFY THAT THE WELDING WAS PERFORMED BY WELDERS QUALIFIED IN COMPLIANCE WITH THE REQUIREMENTS OF AT LEAST AWS D10.9, LEVEL AR-3? ☐ YES ☐ NO

DO YOU CERTIFY THAT WELDING WAS CARRIED OUT IN COMPLIANCE WITH A DOCUMENTED QUALITY CONTROL PROCEDURE TO ENSURE THAT ALL DISCS ARE RETRIEVED, THAT OPENINGS IN PIPING ARE SMOOTH, THAT SLAG AND OTHER WELDING RESIDUE ARE REMOVED, AND THAT THE INTERNAL DIAMETERS OF PIPING ARE NOT PENETRATED? ☐ YES ☐ NO

CUTOUTS (DISCS)

DO YOU CERTIFY THAT YOU HAVE A CONTROL FEATURE TO ENSURE THAT ALL CUTOUTS (DISCS) ARE RETRIEVED? ☐ YES ☐ NO

Figure 8-1(a) Part 2.

HYDRAULIC DATA NAMEPLATE	NAMEPLATE PROVIDED ☐ YES ☐ NO	IF NO, EXPLAIN	
REMARKS	DATE LEFT IN SERVICE WITH ALL CONTROL VALVES OPEN		
SIGNATURES	NAME OF SPRINKLER CONTRACTOR		
	TESTS WITNESSED BY		
	FOR PROPERTY OWNER (SIGNED)	TITLE	DATE
	FOR SPRINKLER CONTRACTOR (SIGNED)	TITLE	DATE
ADDITIONAL EXPLANATION AND NOTES			

Figure 8-1(a) Part 3.

tor's test connection and shall result in an audible alarm on the premises within 5 min after such flow begins and until such flow stops.

8-2.4.2 A working test of the dry pipe valve alone, and with a quick-opening device, if installed, shall be made by opening the inspector's test connection. The test shall measure the time to trip the valve and the time for water to be discharged from the inspector's test connection. All times shall be measured from the time the inspector's test connection is completely opened. The results shall be recorded using the Contractor's Material and Test Certificate for Aboveground Piping.

8-2.4.3 The automatic operation of a deluge or preaction valve shall be tested in accordance with the manufacturer's instructions. The manual and remote control operation, where present, shall also be tested.

8-2.4.4 The main drain valve shall be opened and remain open until the system pressure stabilizes. The static and residual pressures shall be recorded on the contractor's test certificate.

8-2.5 Each pressure-reducing valve shall be tested upon completion of installation to ensure proper operation under flow and no-flow conditions. Testing shall verify that the device properly regulates outlet pressure at both maximum and normal inlet pressure conditions. The results of the flow test of each pressure-reducing valve shall be recorded on the contractor's test certificate. The results shall include the static and residual inlet pressures, static and residual outlet pressures, and the flow rate.

8-2.6 The backflow prevention assembly shall be forward flow tested to ensure proper operation. The minimum flow rate shall be the system demand, including hose stream demand where applicable.

8-2.7 Operating tests shall be made of exposure protection systems upon completion of the installation, where such tests do not risk water damage to the building on which they are installed or to adjacent buildings.

8-3 Circulating Closed Loop Systems. For sprinkler systems with nonfire protection connections, additional information shall be appended to the Contractor's Material and Test Certificate shown in Figure 8-1(a) as follows:

(a) Certification that all auxiliary devices, such as heat pumps, circulating pumps, heat exchangers, radiators, and luminaries, if a part of the system, have a pressure rating of at least 175 psi or 300 psi (12.1 or 20.7 bars) if exposed to pressures greater than 175 psi (12.1 bars).

(b) All components of sprinkler system and auxiliary system have been pressure tested as a composite system in accordance with 8-2.2.

(c) Waterflow tests have been conducted and waterflow alarms have operated while auxiliary equipment is in each of the possible modes of operation.

(d) With auxiliary equipment tested in each possible mode of operation and with no flow from sprinklers or test connection, waterflow alarm signals did not operate.

(e) Excess temperature controls for shutting down the auxiliary system have been properly field tested.

8-4 Instructions.

8-4.1 The installing contractor shall provide the owner with:

(a) All literature and instructions provided by the manufacturer describing proper operation and maintenance of any equipment and devices installed.

(b) Publication titled NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.*

Contractor's Material and Test Certificate for Underground Piping

PROCEDURE

Upon completion of work, inspection and tests shall be made by the contractor's representative and witnessed by an owner's representative. All defects shall be corrected and system left in service before contractor's personnel finally leave the job.

A certificate shall be filled out and signed by both representatives. Copies shall be prepared for approving authorities, owners, and contractor. It is understood the owner's representative's signature in no way prejudices any claim against contractor for faulty material, poor workmanship, or failure to comply with approving authority's requirements or local ordinances.

PROPERTY NAME		DATE
PROPERTY ADDRESS		
PLANS	ACCEPTED BY APPROVING AUTHORITIES (NAMES)	
	ADDRESS	
	INSTALLATION CONFORMS TO ACCEPTED PLANS	☐ YES ☐ NO
	EQUIPMENT USED IS APPROVED IF NO, STATE DEVIATIONS	☐ YES ☐ NO
INSTRUCTIONS	HAS PERSON IN CHARGE OF FIRE EQUIPMENT BEEN INSTRUCTED AS TO LOCATION OF CONTROL VALVES AND CARE AND MAINTENANCE OF THIS NEW EQUIPMENT? IF NO, EXPLAIN	☐ YES ☐ NO
	HAVE COPIES OF APPROPRIATE INSTRUCTIONS AND CARE AND MAINTENANCE CHARTS BEEN LEFT ON PREMISES? IF NO, EXPLAIN	☐ YES ☐ NO
LOCATION	SUPPLIES BUILDINGS	
UNDERGROUND PIPES AND JOINTS	PIPE TYPES AND CLASS	TYPE JOINT
	PIPE CONFORMS TO _____ STANDARD FITTINGS CONFORM TO _____ STANDARD IF NO, EXPLAIN	☐ YES ☐ NO ☐ YES ☐ NO
	JOINTS NEEDING ANCHORAGE CLAMPED, STRAPPED, OR BLOCKED IN ACCORDANCE WITH _____ STANDARD IF NO, EXPLAIN	☐ YES ☐ NO
TEST DESCRIPTION	FLUSHING: Flow the required rate until water is clear as indicated by no collection of foreign material in burlap bags at outlets such as hydrants and blow-offs. Flush at flows not less than 390 GPM (1476 L/min) for 4-inch pipe, 880 GPM (3331 L/min) for 6-inch pipe, 1560 GPM (5905 L/min) for 8-inch pipe, 2440 GPM (9235 L/min) for 10-inch pipe, and 3520 GPM (13323 L/min) for 12-inch pipe. When supply cannot produce stipulated flow rates, obtain maximum available. HYDROSTATIC: Hydrostatic tests shall be made at not less than 200 psi (13.8 bars) for two hours or 50 psi (3.4 bars) above static pressure in excess of 150 psi (10.3 bars) for two hours. LEAKAGE: New pipe laid with rubber gasketed joints shall, if the workmanship is satisfactory, have little or no leakage at the joints. The amount of leakage at the joints shall not exceed 2 qts. per hr. (1.89 L/h) per 100 joints irrespective of pipe diameter. The leakage shall be distributed over all joints. If such leakage occurs at a few joints the installation shall be considered unsatisfactory and necessary repairs made. The amount of allowable leakage specified above may be increased by 1 fl oz per in. valve diameter per hr. (30 mL/25 mm/h) for each metal seated valve isolating the test section. If dry barrel hydrants are tested with the main valve open, so the hydrants are under pressure, an additional 5 oz per minute (150 mL/min) leakage is permitted for each hydrant.	
FLUSHING TESTS	NEW UNDERGROUND PIPING FLUSHED ACCORDING TO _____ STANDARD BY (COMPANY) IF NO, EXPLAIN	☐ YES ☐ NO
	HOW FLUSHING FLOW WAS OBTAINED ☐ PUBLIC WATER ☐ TANK OR RESERVOIR ☐ FIRE PUMP	THROUGH WHAT TYPE OPENING ☐ HYDRANT BUTT ☐ OPEN PIPE
	LEAD-INS FLUSHED ACCORDING TO _____ STANDARD BY (COMPANY) IF NO, EXPLAIN	☐ YES ☐ NO
	HOW FLUSHING FLOW WAS OBTAINED ☐ PUBLIC WATER ☐ TANK OR RESERVOIR ☐ FIRE PUMP	THROUGH WHAT TYPE OPENING ☐ Y CONN. TO FLANGE & SPIGOT ☐ OPEN PIPE

Figure 8-1(b) Part 1.

HYDROSTATIC TEST	ALL NEW UNDERGROUND PIPING HYDROSTATICALLY TESTED AT _____ PSI FOR _____ HOURS	JOINTS COVERED ☐ YES ☐ NO
LEAKAGE TEST	TOTAL AMOUNT OF LEAKAGE MEASURED _____ GALS. _____ HOURS	
	ALLOWABLE LEAKAGE _____ GALS. _____ HOURS	
HYDRANTS	NUMBER INSTALLED / TYPE AND MAKE	ALL OPERATE SATISFACTORILY ☐ YES ☐ NO
CONTROL VALVES	WATER CONTROL VALVES LEFT WIDE OPEN ☐ YES ☐ NO IF NO, STATE REASON	
	HOSE THREADS OF FIRE DEPARTMENT CONNECTIONS AND HYDRANTS INTERCHANGEABLE WITH THOSE OF FIRE DEPARTMENT ANSWERING ALARM ☐ YES ☐ NO	
REMARKS	DATE LEFT IN SERVICE	
SIGNATURES	NAME OF INSTALLING CONTRACTOR	
	TESTS WITNESSED BY	
	FOR PROPERTY OWNER (SIGNED) / TITLE / DATE	
	FOR INSTALLING CONTRACTOR (SIGNED) / TITLE / DATE	
ADDITIONAL EXPLANATION AND NOTES		

Figure 8-1(b) Part 2.

8-5* Hydraulic Design Information Sign. The installing contractor shall identify a hydraulically designed sprinkler system with a permanently marked weatherproof metal or rigid plastic sign secured with corrosion-resistant wire, chain, or other approved means. Such signs shall be placed at the alarm valve, dry pipe valve, preaction valve, or deluge valve supplying the corresponding hydraulically designed area. The sign shall include the following information:

(a) Location of the design area or areas.

(b) Discharge densities over the design area or areas.

(c) Required flow and residual pressure demand at the base of riser.

(d) Occupancy classification or commodity classification and maximum permitted storage height and configuration.

(e) Hose stream demand included in addition to the sprinkler demand.

8-6 Circulating Closed Loop Systems. Discharge tests of sprinkler systems with nonfire protection connections shall be conducted using system test connections described in 2-7.2. Pressure gauges shall be installed at critical points and readings taken under various modes of auxiliary equipment operation. Waterflow alarm signals shall be responsive to discharge of water through system test pipes while auxiliary equipment is in each of the possible modes of operation.

Chapter 9 Marine Systems

9-1 General. This chapter outlines the deletions, modifications, and additions that are necessary for marine application. All other requirements of this standard shall apply to merchant vessel systems except as modified by this chapter.

9-1.1 The following definitions shall be applicable to this chapter.

A-Class Boundary. A boundary designed to resist the passage of smoke and flame for 1 hr when tested in accordance with ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials*.

B-Class Boundary. A boundary designed to resist the passage of flame for ½ hr when tested in accordance with ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials*.

Central Safety Station. A continuously manned control station from which all of the fire control equipment is monitored. If this station is not the bridge, direct communication with the bridge shall be provided by means other than the ship's service telephone.

Heat-Sensitive Material.* A material whose melting point is below 1700°F (926.7°C).

Heel. The inclination of a ship to one side.

Heel Angle. The angle defined by the intersection of a vertical line through the center of a vessel and a line perpendicular to the surface of the water.

International Shore Connection.* A universal connection complying with ASTM F1121, to which shoreside firefighting hoses are to be connected.

Marine Thermal Barrier.* An assembly that is constructed of noncombustible materials and made intact with the main structure of the vessel, such as shell, structural bulkheads, and decks. A marine thermal barrier shall meet the requirements of a B-Class boundary. In addition, a marine thermal barrier shall be insulated such that, if tested in accordance with ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, for 15 min, the average temperature of the unexposed side does not rise more than 250°F (193°C) above the original temperature, nor does the temperature at any one point, including any joint, rise more than 405°F (225°C) above the original temperature.

Supervision. A visual and audible alarm signal given at the central safety station to indicate when the system is in operation or when a condition that would impair the satisfactory operation of the system exists. Supervisory alarms shall give a distinct indication for each individual system component that is monitored.

Survival Angle. The maximum angle to which a vessel is permitted to heel after the assumed damage required by stability regulations is imposed.

Type 1 Stair. A fully enclosed stair that serves all levels of a vessel in which persons may be employed.

Water Supply. The supply portion of the sprinkler system from the water pressure tank or the sea suction of the designated sprinkler system pump up to and including the valve that isolates the sprinkler system from these two water sources.

9-1.2* Occupancy Classifications. Marine environment classifications shall be in accordance with 1-4.7.

9-1.3* Partial installation of automatic sprinklers shall not be permitted.

Exception No. 1: Spaces shall be permitted to be protected with an alternative, approved fire suppression system where such areas are separated from the sprinklered areas with a 1-hr-rated assembly.

Exception No. 2: Where specific sections of this standard permit the omission of sprinklers.

9-2 System Components, Hardware, and Use.

9-2.1* A sprinkler orifice shall not be less than a nominal ⅜ in. (9.5 mm) in size. Sprinklers shall have a discharge coefficient greater than 2.9. The minimum operating pressure of any sprinkler shall be 10 psi (68.9 kPa).

9-2.2* Sprinkler piping penetrations shall be designed to preserve the fire integrity of the ceiling or bulkhead penetrated.

9-2.3 Spare Sprinklers.

9-2.3.1 The required stock of spare sprinklers shall be carried for each type of sprinkler installed onboard the vessel. Where fewer than six sprinklers of a particular type are installed, 100 percent spares shall be kept in stock. Where applicable, at least one elastometric gasket shall be kept in the cabinet for each fire department connection that is installed onboard the vessel.

9-2.3.2 The cabinet containing spare sprinklers, special wrenches, and elastometric gaskets shall be located in the same central safety station that contains the alarm annunciator panel(s) and supervisory indicators.

9-2.4 System Pipe and Fittings.

9-2.4.1 All the materials listed in Tables 2-3.1 and 2-4.1 shall be acceptable for use except Brazing Filler Metal (AWS A5.8). Where ferrous materials are subjected to salt water, the materials shall be protected against corrosion by hotdip galvanizing or by the use of extra heavy schedule material.

9-2.4.2 Maximum design pressure for copper and brass pipe shall not exceed 250 psi (1722 kPa).

9-2.4.3 Materials other than those meeting the requirements of Table 2-3.1 or Table 2-4.1 shall be permitted to be installed in wet automatic sprinkler systems in accordance with their listing, subject to the following restrictions:

(a) Portions of a system that are constructed from heat-sensitive materials shall be installed behind a marine thermal barrier.

(b)* Piping materials shall be listed for the intended service and installed according to the listing requirements.

9-2.5 Pipe Support.

9-2.5.1* Pipe supports shall comply with the following:

(a) Pipe supports shall be designed to provide adequate lateral, longitudinal, and vertical sway bracing. The design shall account for the degree of bracing, which varies with the route and operation of the vessel. Bracing shall be designed to ensure that:

1. Slamming, heaving, and rolling will not shift sprinkler piping, potentially moving sprinklers above ceilings, bulkheads, or other obstructions.

2. Piping and sprinklers will remain in place at a steady heel angle at least equal to the maximum required damaged survival angle.

(b) Pipe supports shall be welded to the structure. Hangers that can loosen during ship motion or vibration, such as screw-down-type hangers, shall not be permitted.

Exception to (b): Hangers that are listed for seismic use shall be permitted to be used in accordance with their listing.

9-2.5.2 Sprinkler piping shall be supported by the primary structural members of the vessel such as beams, girders, and stiffeners.

9-2.5.3* The components of hanger assemblies that are welded directly to the ship structure are not required to be listed.

9-2.5.4* U-hook sizes shall be no less than that specified in Table 2-6.4.1.

9-2.6 Valves.

9-2.6.1* All indicating, supply, and zone control valves shall be supervised open from a central safety station.

9-2.6.2 Drain and test valves shall meet the applicable requirements of 46 CFR 56.20 and 56.60.

9-2.6.3 Valve markings shall include the information required by 46 CFR 56.20-5(a).

9-2.7 Fire Department Connections and International Shore Connections.

9-2.7.1* A fire department connection and an International Shore Connection shall be installed.

Exception: Fire department connections shall not be required on vessels that operate primarily on international voyages.

9-2.7.2 Connections shall be located near the gangway or other shore access point so that they are readily accessible to the landbased fire department. Fire department and international shore connections shall be colored and marked so that the connections are easily located from the shore access point (i.e., gangway location) and will not be confused with a firemain connection. An 18 × 18 in. (0.46 × 0.46 m) sign displaying standard symbol 4-2.1 of NFPA 170, *Standard for Fire Safety Symbols*, shall be placed at the connection so that it is in plain sight from the shore access point. Connections on both sides of the vessel shall be provided where shore access arrangements make it necessary.

9-2.7.3* Fire department connection thread type shall be compatible with fire department equipment.

9-3 System Requirements.

9-3.1* Relief Valves. Relief valves shall be provided on all wet pipe systems.

9-3.2 Spare Detection Devices. The number of spare detection devices or fusible elements used for protection systems that shall be carried per temperature rating is as follows:

(a) Vessels shall have 2 spare detection devices or fusible elements when operating voyages are normally less than 24 hr.

(b) Vessels shall have 4 spare detection devices or fusible elements when operating voyages are normally more than 24 hr.

9-3.3 System Piping Supervision. All preaction sprinkler systems shall be supervised regardless of the number of sprinklers supplied.

9-3.4 Circulating Closed Loop Systems. Circulating closed loop systems shall not be permitted.

9-4 Installation Requirements.

9-4.1 Temperature Zones. Intermediate-temperature-rated sprinklers shall be installed under a noninsulated steel deck that is exposed to sunlight.

9-4.2* Residential Sprinklers. Residential sprinklers shall be permitted for use only in sleeping accommodation areas.

9-4.3 Window Protection. Where required, windows shall be protected as outlined below:

(a) Sprinklers shall be installed at a distance not exceeding 1 ft (0.3 m) from the glazing at a spacing not exceeding 6 ft (1.8 m) such that the entire glazing surface is wetted at a linear density not less than 6 gpm/ft (75 Lpm/m).

Exception: Window sprinkler protection systems installed in accordance with their installation and testing criteria.

9-4.4* Concealed Spaces. Concealed spaces that are constructed of combustible materials, or materials with combustible finishes or that contain combustible materials, shall be sprinklered.

Exception: Spaces that contain only nonmetallic piping that is continuously filled with water are not required to be sprinklered.

9-4.5 Vertical Shafts.

9-4.5.1 Sprinklers are not required in vertical shafts used as duct, electrical, or pipe shafts that are nonaccessible, noncombustible, and enclosed in an A-Class-rated assembly.

9-4.5.2 Stairway enclosures shall be fully sprinklered.

9-4.6 Bath Modules. Sprinklers shall be installed in bath modules (full room modules) constructed with combustible materials, regardless of room fire load.

9-4.7 Ceiling Types. Drop-out ceilings shall not be used in conjunction with sprinklers.

9-4.8 Return Bends. To prevent sediment buildup, return bends shall be installed in all shipboard sprinkler systems where pendent-type or dry pendent-type sprinklers are used in wet systems. (*See Figure 4-13.17.*) Consideration shall be given concerning the intrusion of saltwater into the system. Specifically, sprinklers shall not be rendered ineffective by corrosion related to saltwater entrapment within the return bend.

9-4.9 Hose Connections. Sprinkler system piping shall not be used to supply hose connections or hose connections for fire department use.

9-4.10* Heat-Sensitive Piping Materials.

9-4.10.1 Portions of the piping system constructed with a heat-sensitive material permitted by 9-2.4.3 shall be subject to the following restrictions:

(a) Piping shall be of non-heat-sensitive type from the sea suction up through the penetration of the last A-Class barrier enclosing the space(s) in which the heat-sensitive piping is installed.

(b) B-Class draft stops shall be fitted not more than 45 ft (13.7 m) apart between the marine thermal barrier (*see definitions*) and the deck or shell.

9-4.10.2 Each zone in which heat-sensitive piping is used (under the provisions of 9-2.4.3) shall be fitted with a valve capable of segregating that zone from the remainder of the system. The valve shall be supervised and shall be located within a constantly attended control station or Type 1 stair.

9-4.11 Discharge of Drain Lines.

9-4.11.1 Drain lines shall not be connected to housekeeping, sewage, or deck drains. Drains shall be permitted to be discharged to bilges. Overboard discharges shall meet the requirements of 46 CFR 56.50-95 and shall be corrosion resistant in accordance with 46 CFR 56.60. Systems that contain water additives that are not permitted to be discharged into the environment shall be specially designed to prevent such discharge.

9-4.11.2 Discharges shall be provided with a down-turned elbow.

9-4.12 Alarm Signals and Devices.

9-4.12.1* A visual and audible alarm signal shall be given at the central safety station to indicate when the system is in operation or when a condition that would impair the satisfactory operation of the system exists. Alarm signals shall be provided for, but not limited to, each of the following: monitoring position of control valves, fire pump power supplies and operating condition, water tank levels and temperatures, zone water flow alarms, pressure of tanks, and air pressure on dry-pipe valves. Alarms shall give a distinct indication for each individual system component that is monitored. An audible alarm shall be given at the central safety station within 30 sec of water flow.

9-4.12.2 Waterflow alarms shall be installed for every zone of the sprinkler system. Sprinkler zones shall not encompass more than two adjacent decks or encompass more than one main vertical zone.

9-4.12.3 Electrically operated alarm attachments shall comply with, meet, and be installed in accordance with the requirements of 46 CFR, Subchapter J (Electrical Engineering). All wiring shall be chosen and installed in accordance with IEEE 45, *Marine Supplement*.

9-4.13 Test Connections. Where test connections are below the bulkhead deck, they shall comply with the overboard discharge arrangements of 46 CFR 56.50-95.

9-5 Design Approaches.

9-5.1 Design Options. Marine sprinkler systems shall be designed using the hydraulic calculation procedure of Chapter 5. The pipe schedule method shall not be used to determine the water demand requirements.

9-5.2* Window Protection. Minimum water demand requirements shall include sprinklers that are installed for the protection of windows as described in 9-4.3.

9-5.3* Hose Stream Allowance. No allowance for hose stream use is required.

9-6 Water Supplies.

9-6.1 General. The water supply requirements for marine applications shall be in accordance with Section 9-6.

9-6.2 Pressure Tank.

9-6.2.1 A pressure tank shall be provided. The pressure tank shall be sized and constructed so that:

(a) The tank shall contain a standing charge of fresh water equal to that specified by Table 9-6.2.1.

(b) The pressure tank shall be sized in accordance with 7-2.3.2.

(c) A glass gauge shall be provided to indicate the correct level of water within the pressure tank.

(d) Arrangements shall be provided for maintaining an air pressure in the tank such that, while the standing charge of water is being expended, the pressure will not be less than that necessary to provide the design pressure and flow of the hydraulically most remote design area.

(e) Suitable means of replenishing the air under pressure and the fresh water standing charge in the tank shall be provided.

(f) Tank construction shall be in accordance with the applicable requirements of 46 CFR, Subchapter F (Marine Engineering).

Exception: In lieu of a pressure tank, a dedicated pump connected to a fresh water tank shall be permitted to be used provided:

(a) The pump is listed for marine use and is sized to meet the required system demand;

(b) The suction for the fire pump is located below the suction for the fresh water system so that there shall be a minimum water supply of at least 1 min for the required system demand;

(c) Pressure switches are provided in the system and the controller for the pump that automatically start the pump within 10 sec after detection of a pressure drop of more than 5 percent;

(d) There shall be a reduced pressure zone backflow preventer to prevent contamination of the potable water system by salt water; and

(e) There are at least two sources of power for this pump. Where the sources of power are electrical, these shall be a main generator and an emergency source of power. One supply shall be taken from the main switchboard, by separate feeder reserved solely for that purpose. This feeder shall be run to an automatic change-over switch situated near the sprinkler unit and the switch shall normally be kept closed to the feeder from the emergency switchboard. The changeover switch shall be clearly labeled and no other switch shall be permitted in these feeders.

Table 9-6.2.1 Required Water Supply

System type	Additional Water Volume
Wet pipe system	Flow requirement of the hydraulically most remote system demand for one minute.
Dry pipe system	Flow requirement of the hydraulically most remote system demand for one minute of system demand plus the volume needed to fill all dry piping.
Preaction system Deluge system	

9-6.2.2 Relief valves shall be installed on the tank to avoid overpressurization and false actuation of any dry pipe valve. Relief valves shall comply with 46 CFR 54.15-10.

9-6.2.3 There shall be not less than two sources of power for the compressors that supply air to the pressure tank. Where the sources of power are electrical, these shall be a main generator and an emergency source of power. One supply shall be taken from the main switchboard, by separate feeders reserved solely for that purpose. Such feeders shall be run to a changeover switch situated near the air compressor, and the switch normally shall be kept closed to the feeder from the emergency switchboard. The changeover switch shall be clearly labeled, and no other switch shall be permitted in these feeders.

9-6.2.4 More than one pressure tank can be installed provided that each is treated as a single water source when determining valve arrangements. Check valves shall be installed to prohibit flow from tank to tank or from pump to tank.

Exception: Arrangements where a tank is designed to hold only pressurized air.

9-6.2.5 In systems subject to use with saltwater, valves shall be so arranged as to prohibit contamination of the pressure tank with saltwater.

9-6.2.6* Where applicable, a means shall be provided to restrict the amount of air that can enter the pressure tank from the air supply system. A means shall also be provided to prevent water from backflowing into the air supply system.

9-6.3 Fire Pump.

9-6.3.1 A dedicated, automatically controlled pump that is listed for marine service, which takes suction from the sea, shall be provided to supply the sprinkler system. Where two pumps are required to ensure the reliability of the water supply, the pump that supplies the fire main shall be allowed to serve as the second fire pump.

9-6.3.2 The pump shall be sized to meet the water demand of the hydraulically most demanding area. Pumps shall be designed to not exceed 120 percent of the rated capacity of the pump.

9-6.3.3 The system shall be designed so that, before the supply falls below the design criteria, the fire pump shall be automatically started and shall supply water to the system until manually shut off.

Exception: Where pump and fresh water tank arrangement is used in lieu of the pressure tank, there must be a pressure switch that senses a system pressure drop of 25 percent, and the controller must automatically start the fire pump(s) if pressure is not restored within 20 sec.

9-6.3.4 There shall be not less than two sources of power supply for the fire pumps. Where the sources of power are electrical, these shall be a main generator and an emergency source of power. One supply shall be taken from the main switchboard, by separate feeders reserved solely for that purpose. Such feeders shall be run to a changeover switch situated near to the sprinkler unit and the switch normally shall be kept closed to the feeder from the emergency switchboard. The changeover switch shall be clearly labeled and no other switch shall be permitted in these feeders.

9-6.3.5 A test valve(s) shall be installed on the discharge side of the pump with a short open-ended discharge pipe. The area of the pipe shall be adequate to permit the release of the required water output to supply the demand of the hydraulically most remote area.

9-6.3.6 Where two fire pumps are required to ensure the reliability of the water supply, each fire pump shall meet the requirements of 9-7.1.1.7, exception items (a) through (d), above. In addition, a system that is required to have more than one pump shall be designed to accommodate the following features:

(a)* Pump controls and system sensors shall be arranged such that the secondary pump will automatically operate if the primary pump fails to operate or deliver the required water pressure and flow. (*Figure A-9-7.1.2.6(a) is an example of an acceptable dual pump arrangement.*)

(b) Both pumps shall be served from normal and emergency power sources. However, where approved by the authority having jurisdiction, the secondary pump shall be permitted to be non-electrically driven.

(c) Pump failure or operation shall be indicated at the central safety station.

9-6.3.7 If not specifically prohibited, the fire pump that supplies the fire main is permitted to be used as the second pump provided that: (*See Figure A-9-6.3.7*).

(a) The pump is adequately sized to meet the required fire hose and sprinkler system pressure and flow demands simultaneously;

(b) The fire main system is segregated from the sprinkler system by a normally closed valve that is designed to automatically open upon failure of the designated fire pump; and

(c) The fire pump that supplies the fire main is automatically started in the event of dedicated fire pump failure or loss of pressure in the sprinkler main.

9-6.4 Water Supply Configurations.

9-6.4.1 The pressure tank and fire pump shall be located in a position reasonably remote from any machinery space of Category A.

9-6.4.2 All valves within the water supply piping system shall be supervised.

9-6.4.3 The sprinkler system shall be cross-connected with the ship's fire main system and fitted with a lockable screw-down nonreturn valve such that backflow from the sprinkler system to the fire main is prevented.

9-6.4.4 The piping, tanks, and pumps that make up the water supply shall be installed in accordance with the applicable requirements of 46 CFR, Subchapter F (Marine Engineering).

9-6.4.5* When a shore water supply is to be used during extended dockside periods, the water supply shall be qualified in the manner described in 7-2.1. Tests shall be conducted in accordance with the requirements of the local shore-based authority having jurisdiction. The water supply information listed in Section 6-3 shall then be provided to the authority having jurisdiction.

9-7 Plans and Calculations.

9-7.1 Additional Information. The pressure tank size, high pressure relief setting, high and low water alarm settings, low pressure alarm setting, and pump start pressure shall be provided.

9-7.2 Sprinklers specifically installed for the protection of windows under 9-4.3 are permitted to be of a different size from those protecting the remainder of the occupancy classification. All of the window sprinklers, however, shall be of the same size.

9-8 System Acceptance.

9-8.1 Hydrostatic Tests. In addition to the interior piping, the test required by 8-2.2.3 shall also be conducted on all external water supply connections including international shore and fireboat connections.

9-8.2 Alarm Test. A waterflow test shall result in an alarm at the central safety station within 30 sec after flow through the test connection begins.

9-8.3 Operational Tests. Pressure tank and pump operation, valve actuation, and water flow shall also be tested. Pump operation and performance shall be tested in accordance with Chapter 11 of NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*.

9-9 System Maintenance.

9-9.1 Periodic Inspection, Test, and Maintenance.

9-9.1.1 Sprinkler systems shall be inspected, tested, and maintained in accordance with Chapter 2 of NFPA 25, *Stan-*

dard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.

9-9.1.2 Sprinkler pumps and any fire pumps that are cross-connected to the sprinkler system shall be inspected, tested, and maintained in accordance with Chapter 5 of NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.*

9-9.1.3 The pressure tank shall be inspected, tested, and maintained in accordance with 46 CFR, Subchapter F, Marine Engineering and Chapter 6 of NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.*

9-9.1.4 System valves, international shore connections, and fire department connections shall be inspected, tested, and maintained in accordance with Chapter 9 of NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.*

9-9.1.5 Instructions for operation, inspection, maintenance, and testing shall be kept in the cabinet containing the spare sprinklers.

9-9.1.6 Impairments to the system shall be handled in accordance with Chapter 11 of NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, except that inspections, maintenance, and testing shall not be conducted when the vessel is at sea. Extended periods of impairment shall not be scheduled for periods when passengers or cargo are onboard the vessel. Log entries shall be made whenever a system impairment occurs or is removed. In addition, shipboard fire-fighting personnel shall be onboard the vessel and notified whenever portions of the system are impaired.

9-9.1.7 A separate card or booklet with tabulated spaces for the date and signature of the licensed officer of the vessel who shall witness or conduct inspections, maintenance, and tests shall also be kept in the cabinet containing the spare sprinklers.

9-9.1.8 Fresh water wet pipe systems that have had sea water introduced into the pipe network shall be flushed with fresh water within 45 days.

Exception: Flushing the pipe network at the vessel's next port of call shall be permitted when the vessel's voyage is longer than 45 days.

Chapter 10 System Maintenance

10-1 General.

10-1.1* A sprinkler system installed in accordance with this standard shall be properly inspected, tested, and maintained in accordance with NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, to provide at least the same level of performance and protection as designed. The owner shall be responsible for maintaining the system and keeping the system in good operating condition.

Chapter 11 Referenced Publications

11-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

11-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, 1996 edition.

NFPA13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height*, 1996 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 1996 edition.

NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*, 1996 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 1996 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 1995 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 1995 edition.

NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes*, 1994 edition.

NFPA 70, *National Electrical Code*, 1996 edition.

NFPA 72, *National Fire Alarm Code*, 1996 edition.

NFPA 170, *Standard for Fire Safety Symbols*, 1996 edition.

NFPA 231, *Standard for General Storage*, 1995 edition.

NFPA 231C, *Standard for Rack Storage of Materials*, 1995 edition.

NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*, 1995 edition.

11-1.2 The following NFPA codes, standards, and recommended practices contain specific sprinkler design criteria.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, 1996 edition.

NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height*, 1996 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 1996 edition.

NFPA 16, *Standard on Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*, 1995 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 1996 edition.

NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products*, 1994 edition.

NFPA 33, *Standard for Spray Application Using Flammable and Combustible Materials*, 1995 edition.

NFPA 34, *Standard for Dipping and Coating Processes Using Flammable or Combustible Liquids*, 1995 edition.

NFPA 35, *Standard for the Manufacture of Organic Coatings*, 1995 edition.

NFPA 40, *Standard for the Storage and Handling of Cellulose Nitrate Motion Picture Film*, 1994 edition.

NFPA 40E, *Code for the Storage of Pyroxylin Plastic*, 1993 edition.

NFPA 43B, *Code for the Storage of Organic Peroxide Formulations*, 1993 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 1996 edition.

NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*, 1992 edition.

NFPA 51A, *Standard for Acetylene Cylinder Charging Plants*, 1996 edition.

NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*, 1995 edition.

NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Products Facilities*, 1995 edition.

NFPA 75, *Standard for the Protection of Electronic Computer/Data Processing Equipment*, 1995 edition.

NFPA 82, *Standard on Incinerators and Waste and Linen Handling Systems and Equipment*, 1994 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 1995 edition.

NFPA 86C, *Standard for Industrial Furnaces Using a Special Processing Atmosphere*, 1995 edition.

NFPA 88B, *Standard for Repair Garages*, 1991 edition.

NFPA 99, *Standard for Health Care Facilities*, 1996 edition.

NFPA 99B, *Standard for Hypobaric Facilities*, 1996 edition.

NFPA *101®*, *Life Safety Code®*, 1994 edition.

NFPA 120, *Standard for Coal Preparation Plants*, 1994 edition.

NFPA 122, *Standard for Fire Prevention and Control in Underground Metal and Nonmetal Mine*, 1995 edition.

NFPA 123, *Standard for Fire Prevention and Control in Underground Bituminous Coal Mines*, 1995 edition.

NFPA 130, *Standard for Fixed Guideway Transit Systems*, 1995 edition.

NFPA 150, *Standard on Fire Safety in Racetrack Stables*, 1995 edition.

NFPA 214, *Standard on Water-Cooling Towers*, 1996 edition.

NFPA 231, *Standard for General Storage*, 1995 edition.

NFPA 231C, *Standard for Rack Storage of Materials*, 1995 edition.

NFPA 231D, *Standard for Storage of Rubber Tires*, 1994 edition.

NFPA 231E, *Recommended Practice for the Storage of Baled Cotton*, 1996 edition.

NFPA 231F, *Standard for Storage of Roll Paper*, 1996 edition.

NFPA 232, *Standard for the Protection of Records*, 1995 edition.

NFPA 307, *Standard for the Construction and Fire Protection of Marine Terminals, Piers, and Wharves*, 1995 edition.

NFPA 318, *Standard for the Protection of Cleanrooms*, 1995 edition.

NFPA 409, *Standard on Aircraft Hangars*, 1995 edition.

NFPA 423, *Standard for Construction and Protection of Aircraft Engine Test Facilities*, 1994 edition.

NFPA 430, *Code for the Storage of Liquid and Solid Oxidizers*, 1995 edition.

NFPA 850, *Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations*, 1996 edition.

NFPA 851, *Recommended Practice for Fire Protection for Hydroelectric Generating Plants*, 1996 edition.

NFPA 1231, *Standard on Water Supplies for Suburban and Rural Fire Fighting*, 1993 edition.

11-1.3 Other Publications.

11-1.3.1 ANSI Publications. American National Standards Institute, Inc., 1450 Broadway, New York, NY 10018.

ANSI B1.20.1-1983, *Pipe Threads, General Purpose (Inch)*.

ANSI B16.1-1989, *Cast Iron Pipe Flanges and Flanged Fittings*.

ANSI B16.3-1992, *Malleable Iron Threaded Fittings*.

ANSI B16.4-1992, *Cast Iron Threaded Fittings*.

ANSI B16.5-1988, *Pipe Flanges and Flanged Fittings*.

ANSI B16.9-1993, *Factory-Made Wrought Steel Buttwelding Fittings*.

ANSI B16.11-1991, *Forged Steel Fittings, Socket-Welding and Threaded*.

ANSI B16.18-1984, *Cast Copper Alloy Solder Joint Pressure Fittings*.

ANSI B16.22-1995, *Wrought Copper and Copper Alloy Solder Joint Pressure Fittings*.

ANSI B16.25-1992, *Buttwelding Ends*.

ANSI B36.10M-1995, *Welded and Seamless Wrought Steel Pipe*.

11-1.3.2 ASME Publication. American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

ASME A17.1-1993, *Safety Code for Elevators and Escalators*.

11-1.3.3 ASTM Publications. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19105.

ASTM A 53-Rev. A-95, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*.

ASTM A 135-1993, *Standard Specification for Electric-Resistance-Welded Steel Pipe*.

ASTM A 234/A234M-Rev. B-95, *Standard Specification for Piping Fittings of Wrought-Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures*.

ASTM A 795-1995, *Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use*.

ASTM B 32-Rev. B-95, *Standard Specification for Solder Metal*.

ASTM B 75-Rev. A-95, *Standard Specification for Seamless Copper Tube*.

ASTM B 88-Rev. A-95, *Standard Specification for Seamless Copper Water Tube*.

ASTM B 251-1993, *Standard Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube.*

ASTM B 813-1993, *Standard Specification for Liquid and Paste Fluxes for Soldering Applications of Copper and Copper-Alloy Tube.*

ASTM D 3309-1995, *Standard Specification for Polybutylene (PB) Plastic Hot- and Cold-Water Distribution Systems.*

ASTM E 119-Rev. A-95, *Standard Test Methods for Fire Tests of Building Construction and Materials.*

ASTM E 136-1995, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C.*

ASTM F 437-1995, *Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.*

ASTM F 438-1993, *Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.*

ASTM F 439-Rev. A-93, *Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.*

ASTM F 442-1994, *Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR).*

ASTM F 1121-1987, *Standard Specification for International Shore Connections for Marine Fire Applications.*

11-1.3.4 AWS Publications. American Welding Society, 550 N.W. LeJeune, Miami, FL 33135.

AWS A5.8-1992, *Specification for Filler Metals for Brazing and Braze Welding.*

AWS D10.9-1980, *Specification for Qualification of Welding Procedures and Welders for Piping and Tubing.*

11-1.3.5 IEEE Publication. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.

UL 300-1996, *Standard for Safety Fire Testing of Fire Extinguishing Systems for Protection of Restaurant Cooking Areas.*

11-1.3.6 UL Publication. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.

UL 300-1996, *Standard for Safety Fire Testing of Fire Extinguishing Systems for Protection of Restaurant Cooking Areas.*

11-1.3.7 U.S. Government Publications. Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Title 46, *Code of Federal Regulations*, Subchapter F, (Marine Engineering).

Title 46, *Code of Federal Regulations*, Subchapter H, Subpart 76.25 (Automatic Sprinkling System, Details).

11-1.3.8 Additional References.

International Convention for the Safety of Life at Sea, International Maritime Organization, London, UK.

SNAME Technical and Research Bulletin No. 2-21, *Aluminum Fire Protection Guidelines*, July 1974, Society of Naval Architects and Marine Engineers, 601 Pavonia Ave, Jersey City, NJ 07306.

Appendix A Explanatory Material

This Appendix is not a part of the requirements of this NFPA document, but is included for informational purposes only.

A-1-1 Exception No. 2. The limitations on the type and size of storage are intended to identify the situations where tire storage is present in limited quantities and incidental to the main use of the building. Occupancies such as aircraft hangars, automobile dealers, repair garages, retail stores, automotive and truck assembly plants, mobile home assembly plants, etc., are types of facilities where miscellaneous storage could be present. The fire protection sprinkler design densities specified by NFPA 13 are adequate to provide protection to the storage heights and areas indicated. Storage beyond these heights and areas present hazards that are properly addressed by NFPA 231D and are outside the scope of NFPA 13.

A-1-4.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations that is in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-4.1 Authority Having Jurisdiction. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations that is in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-4.1 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed.

A-1-4.2 Miscellaneous Storage. The sprinkler system design criteria for miscellaneous storage at heights below 12 ft (3.7 m) is covered by this standard in Chapters 4 and 5. Paragraph 5-2.3.1.1 describes design criteria and 4-2.2 (Table 4-2.2) describes installation requirements (area limits). These apply to all storage of 12 ft (3.7 m) or less in height.

A-1-4.2 Sprinkler System. A sprinkler system is considered to have a single system riser control valve.

A-1-4.3 Gridded System. See Figure A-1-4.3(a).

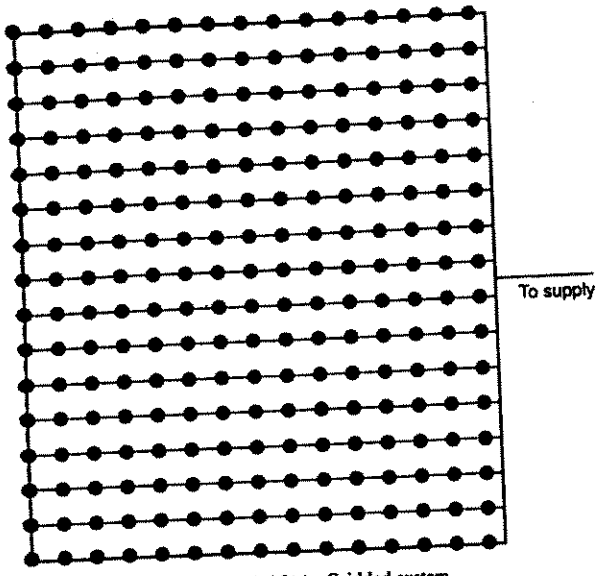


Figure A-1-4.3(a) Gridded system.

A-1-4.3 Looped System. See Figure A-1-4.3(b).

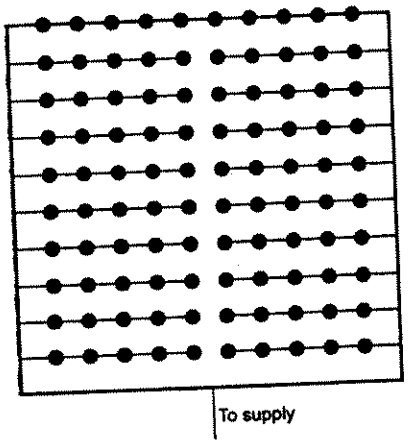


Figure A-1-4.3(b) Looped system.

A-1-4.4 See Figure A-1-4.4.

A-1-4.5.1 The Response Time Index is a measure of the sensitivity of the sprinkler's thermal element as installed in a specific sprinkler. It is usually determined by plunging a sprinkler into a heated laminar airflow within a test oven. The plunge test is not currently applicable to certain sprinklers. These sprinklers must have their thermal sensitivity determined by other standardized test methods.

The RTI is calculated using:

1. The operating time of the sprinkler,
2. The operating temperature of the sprinkler's heat-responsive element (as determined in a bath test),
3. The air temperature of the test oven,
4. The air velocity of the test oven, and
5. The sprinkler's conductivity (c) factor, which is the measure of conductance between the sprinkler's heat-responsive element and the sprinkler oven mount.

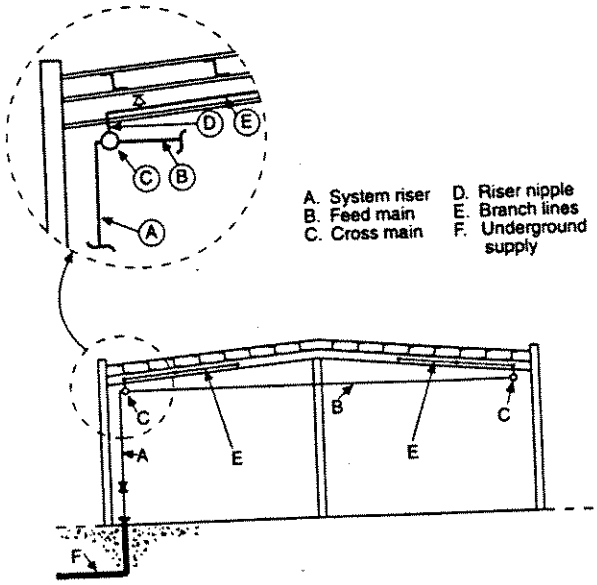


Figure A-1-4.4 Building elevation showing parts of sprinkler piping system.

Other factors affecting response include temperature rating, sprinkler position, fire exposure, and radiation.

ISO standard 6182-1 currently recognizes the RTI range of greater than 50 meter-seconds$^{1/2}$ and less than 80 meter-seconds$^{1/2}$ as special response. Such sprinklers can be recognized as special sprinklers under 4-4.9.1.

A-1-4.5.2 ESFR Sprinkler. It is important to realize that the effectiveness of these highly tested and engineered sprinklers depends on the combination of fast response and the quality and uniformity of the sprinkler discharge. It should also be realized that ESFR sprinklers cannot be relied upon to provide fire control, let alone suppression, if they are used outside the guidelines specified in 5-3.5.

A-1-4.5.2 QRES Sprinkler. Research into the development of QRES sprinklers is continuing under the auspices of the National Fire Protection Research Foundation. It is expected that the proposed design criteria will be added to the standard when a thorough analysis of the test data is completed.

A-1-4.5.4 Dry Sprinkler. Under certain ambient conditions, wet pipe systems having dry-pendent (or upright) sprinklers may freeze due to heat loss by conduction. Therefore, due consideration should be given to the amount of heat maintained in the heated space, the length of the nipple in the heated space, and other relevant factors.

A-1-4.6 Obstructed Construction. The following are examples of obstructed construction. The definitions are provided as guidance to assist the user in determining the type of construction feature:

(i) *Beam and Girder Construction.* The term "beam and girder construction" as used in this standard includes noncombustible and combustible roof or floor decks supported by wood beams of 4 in. (102 mm) or greater nominal thickness or concrete or steel beams spaced 3 to 7½ ft (0.9 to 2.3 m) on center and either supported on or framed into girders. [Where supporting a wood plank deck, this includes

semi-mill and panel construction, and where supporting (with steel framing) gypsum plank, steel deck, concrete, tile, or similar material, this includes much of the so-called noncombustible construction.]

(ii) *Composite Wood Joist Construction*. The term "composite wood joist construction" refers to wood beams of I cross section constructed of wood flanges and solid wood web, supporting a floor or roof deck. Composite wood joists may vary in depth up to 48 in. (1.2 m), may be spaced up to 48 in. (1.2 m) on centers, and may span up to 60 ft (18 m) between supports. Joist channels should be firestopped to the full depth of the joists with material equivalent to the web construction so that individual channel areas do not exceed 300 sq ft (27.9 m^2). See Figure A-1-4.6(a)(ii) for examples of composite wood joist construction.

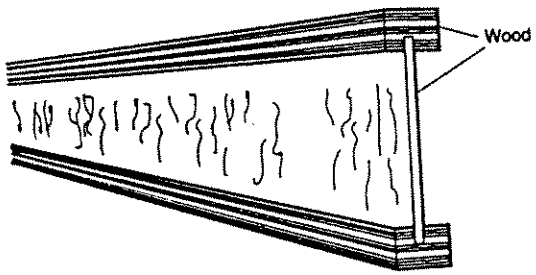


Figure A-1-4.6(a)(ii) Typical composite wood joist construction.

(iii) *Panel Construction*. The term "panel construction" as used in this standard includes ceiling panels formed by members capable of trapping heat to aid the operation of sprinklers and limited to a maximum of 300 sq ft (27.9 m^2) in area. Beams spaced more than 7½ ft (2.3 m) apart and framed into girders qualify for panel construction provided the 300-sq ft (27.9-m^2) area limitation is met.

(iv) *Semi-Mill Construction*. The term "semi-mill construction" as used in this standard refers to a modified standard mill construction, where greater column spacing is used and beams rest on girders.

(v) *Wood Joist Construction*. The term "wood joist construction" refers to solid wood members of rectangular cross section, which may vary from 2 to 4 in. (51 to 102 mm) nominal width and up to 14 in. (356 mm) nominal depth spaced up to 3 ft (0.9 m) on centers, and spanning up to 40 ft (12 m) between supports, supporting a floor or roof deck. Solid wood members less than 4 in. (102 mm) nominal width and up to 14 in. (356 mm) nominal depth, spaced more than 3 ft (0.9 m) on centers, are also considered as wood joist construction.

A-1-4.6 Unobstructed Construction. The following are examples of unobstructed construction. The definitions are provided as guidance to assist the user in determining the type of construction feature:

(i) *Bar Joist Construction*. The term "bar joist construction" refers to construction employing joists consisting of steel truss-shaped members. Wood truss-shaped members, which consist of wood top and bottom chord members not exceeding 4 in. (102 mm) in depth with steel tube or bar webs, are also defined as bar joists. Bar joist includes noncombustible or combustible roof or floor decks on bar joist construction. See Figures A-1-4.6(b)(i)1 and A-1-4.6(b)(i)2 for examples of bar joist construction.

(ii) *Open-Grid Ceilings*. Open-grid ceilings are ceilings in which the openings are ¼ in. (6.4 mm) or larger in the least dimension, the thickness of the ceiling material does not exceed the least dimension of the openings, and such openings constitute at least 70 percent of the ceiling area.

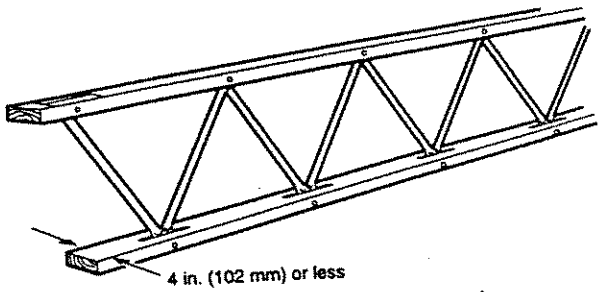


Figure A-1-4.6(b)(i)1 Wood bar joist construction.

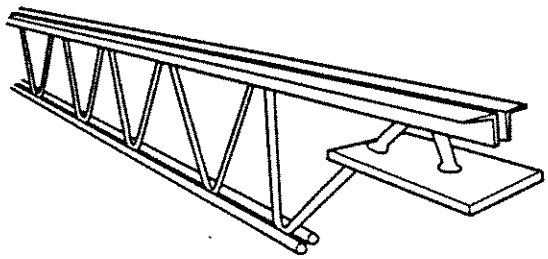


Figure A-1-4.6(b)(i)2 Open-web bar joist construction.

(iii) *Smooth Ceiling Construction*. The term "smooth ceiling construction" as used in this standard includes:

a. Flat slab, pan-type reinforced concrete.

b. Continuous smooth bays formed by wood, concrete, or steel beams spaced more than 7½ ft (2.3 m) on centers — beams supported by columns, girders, or trusses.

c. Smooth roof or floor decks supported directly on girders or trusses spaced more than 7½ ft (2.3 m) on center.

d. Smooth monolithic ceilings of at least ¾ in. (19 mm) of plaster on metal lath or a combination of materials of equivalent fire-resistive rating attached to the underside of wood joists, wood trusses, and bar joists.

e. Open web-type steel beams, regardless of spacing.

f. Smooth shell-type roofs, such as folded plates, hyperbolic paraboloids, saddles, domes, and long barrel shells.

NOTE: In b. through f. above, combustible or noncombustible floor decks are permitted. Item b. would include standard mill construction.

g. Suspended ceilings of combustible or noncombustible construction.

h. Smooth monolithic ceilings with fire resistance less than that specified under item d. attached to the underside of wood joists, wood trusses, and bar joists.

(iv) *Standard Mill Construction*. The term "standard mill construction" as used in this standard refers to heavy timber construction as defined in NFPA 220, *Standard on Types of Building Construction*.

(v) *Wood Truss Construction*. The term "wood truss construction" refers to parallel or pitched wood chord members connected by open wood members (webbing) supporting a roof or floor deck. Trusses with steel webbing, similar to bar

joist construction, having top and bottom wood chords exceeding 4 in. (102 mm) in depth, should also be considered wood truss construction. [*See Figure A-1-4.6(b)(v).*]

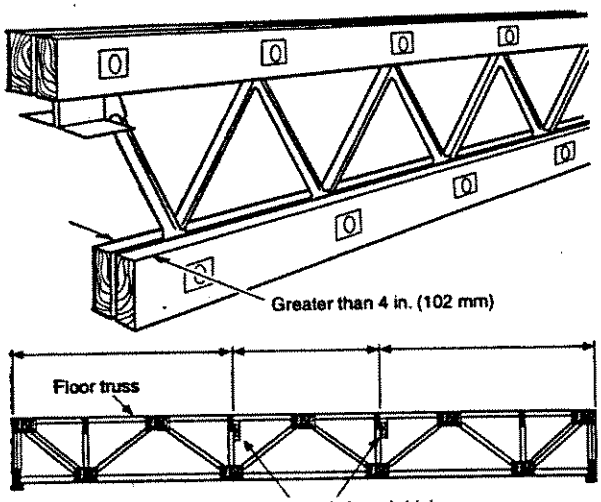


Figure A-1-4.6(b)(v) Examples of wood truss construction.

A-1-4.7 Occupancy examples in the listings as shown in the various hazard classifications are intended to represent the norm for those occupancy types. Unusual or abnormal fuel loadings or combustible characteristics and susceptibility for changes in these characteristics, for a particular occupancy, are considerations that should be weighed in the selection and classification.

The Light Hazard classification is intended to encompass residential occupancies; however, this is not intended to preclude the use of listed residential sprinklers in residential occupancies or residential portions of other occupancies.

A-1-4.7.1 Light Hazard Occupancies include occupancies having conditions similar to:

Churches
Clubs
Eaves and overhangs, if combustible construction with no combustibles beneath
Educational
Hospitals
Institutional
Libraries, except large stack rooms
Museums
Nursing or convalescent homes
Office, including data processing
Residential
Restaurant seating areas
Theaters and Auditoriums excluding stages and prosceniums
Unused attics.

A-1-4.7.2.1 Ordinary Hazard Occupancies (Group 1) include occupancies having conditions similar to:

Automobile parking and showrooms
Bakeries
Beverage manufacturing
Canneries
Dairy products manufacturing and processing
Electronic plants
Glass and glass products manufacturing
Laundries
Restaurant service areas.

A-1-4.7.2.2 Ordinary Hazard Occupancies (Group 2) include occupancies having conditions similar to:

Cereal mills
Chemical plants — ordinary
Confectionery products
Distilleries
Dry cleaners
Feed mills
Horse stables
Leather goods manufacturing
Libraries — large stack room areas
Machine shops
Metal working
Mercantile
Paper and pulp mills
Paper process plants
Piers and wharves
Post offices
Printing and publishing
Repair garages
Stages
Textile manufacturing
Tire manufacturing
Tobacco products manufacturing
Wood machining
Wood product assembly.

A-1-4.7.3.1 Extra Hazard Occupancies (Group 1) include occupancies having conditions similar to:

Aircraft hangars (except as governed by NFPA 409)
Combustible hydraulic fluid use areas
Die casting
Metal extruding
Plywood and particle board manufacturing
Printing [using inks having flash points below 100°F (37.9°C)]
Rubber reclaiming, compounding, drying, milling, vulcanizing
Saw mills
Textile picking, opening, blending, garnetting, carding, combining of cotton, synthetics, wool shoddy, or burlap
Upholstering with plastic foams.

Extra Hazard Occupancies (Group 2) include occupancies having conditions similar to:

Asphalt saturating
Flammable liquids spraying
Flow coating
Manufactured home or modular building assemblies (where finished enclosure is present and has combustible interiors)
Open oil quenching
Plastics processing
Solvent cleaning
Varnish and paint dipping.

A-1-4.7.4.1 Other NFPA standards contain design criteria for fire control or fire suppression (*see 1-4.7.4 and Chapter 11*). While these may form the basis of design criteria, this standard describes the methods of design, installation, fabrication, calculation, and evaluation of water supplies that should be used for the specific design of the system.

A-2-1.1 Included among items requiring listing are sprinklers, some pipe and some fittings, hangers, alarm devices, valves controlling flow of water to sprinklers, valve tamper switches, and gauges.

A-2-2.4 Information regarding the highest temperature that may be encountered in any location in a particular installation may be obtained by use of a thermometer that will register the highest temperature encountered; it should be hung for several days in the location in question, with the plant in operation.

A-2-2.5.1 Examples of such locations are paper mills, packing houses, tanneries, alkali plants, organic fertilizer plants, foundries, forge shops, fumigation, pickle and vinegar works, stables, storage battery rooms, electroplating rooms, galvanizing rooms, steam rooms of all descriptions including moist vapor dry kilns, salt storage rooms, locomotive sheds or houses, driveways, areas exposed to outside weather such as piers and wharves exposed to salt air, areas under sidewalks, around bleaching equipment in flour mills, all portions of cold storage buildings where a direct ammonia expansion system is used, and portions of any plant where corrosive vapors prevail.

A-2-2.5.2 Care should be taken in the handling and installation of wax-coated or similar sprinklers to avoid damaging the coating.

A-2-2.5.3 Painting of sprinklers may retard the thermal response of the heat-responsive element, may interfere with the free movement of parts, and may render the sprinkler inoperative. Moreover, painting may invite the application of subsequent coatings, thus increasing the possibility of a malfunction of the sprinkler.

A-2-2.6.2 The use of the wrong type of escutcheon with recessed or flush type sprinklers can result in severe disruption of the spray pattern, which can destroy the effectiveness of the sprinkler.

A-2-2.7 Sprinklers under open gratings should be provided with shields. Shields over automatic sprinklers should not be less, in least dimension, than four times the distance between the shield and fusible element, except special sprinklers incorporating a built-in shield need not comply with this recommendation if listed for the particular application.

A-2-3.2 See Table A-2-3.2.

A-2-3.4 See Table A-2-3.4.

A-2-3.5 Other types of pipe and tube that have been investigated and listed for sprinkler applications include lightweight steel pipe and thermoplastic pipe and fittings. While these products may offer advantages, such as ease of handling and installation, cost effectiveness, reduction of friction losses, and improved corrosion resistance, it is important to recognize that they also have limitations that are to be considered by those contemplating their use or acceptance.

With respect to lightweight steel pipe, corrosion studies have shown that, in comparison to Schedule 40 pipe, its effective life may be reduced, the level of reduction being related to its wall thickness. Further information with respect to corrosion resistance is contained in the individual listings of such products.

With respect to thermoplastic pipe and fittings, exposure of such piping to elevated temperatures in excess of that for which it has been listed may result in distortion or failure. Accordingly, care must be exercised when locating such systems to ensure that the ambient temperature, including seasonal variations, does not exceed the rated value.

The upper service temperature limit of currently listed CPVC sprinkler pipe is 150°F (65.5°C) at 175 psi (1206 kPa). The upper service temperature limit of currently listed polybutylene sprinkler pipe is 120°F (49°C) at 175 psi (1206 kPa).

Not all pipe or tube made to ASTM F 442 and D 3309 as described in 2-3.5 is listed for fire sprinkler service. Listed pipe is identified by the logo of the listing agency.

Not all fittings made to ASTM F 437, F 438, and F 439 as described in 2-4.2 are listed for fire sprinkler service. Listed fittings are identified by the logo of the listing agency.

Consideration must also be given to the possibility of exposure of the piping to elevated temperatures during a fire. The survival of thermoplastic piping under fire conditions derives primarily from the cooling effect of the discharge from the sprinklers it serves. As this discharge may not occur simultaneously with the rise in ambient temperature and, under some circumstances, may be delayed for periods beyond the tolerance of the piping, protection in the form of a fire-resistant membrane is generally required. (Some listings do provide for the use of exposed piping in conjunction with residential or quick-response sprinklers, but only under specific, limited installation criteria.) Where protection is required, it is described in the listing information for each individual product, and the requirements given must be followed. Equally important, such protection must be maintained. Removal of, for example, one or more panels in a lay-in ceiling can expose piping in the concealed space to the possibility of failure in the event of a fire. Similarly, the relocation of openings through protective ceilings that expose the pipe to heat, inconsistent with the listing, would place the system in jeopardy. The potential for loss of the protective membrane under earthquake conditions should also be considered.

While the listings of thermoplastic piping do not prohibit its installation in combustible concealed spaces where the provision of sprinkler protection is not required, and while the statistical record of fire originating in such spaces is low, it should be recognized that the occurrence of a fire in such a space could result in failure of the piping system.

The investigation of pipe and tube other than described in Table 2-3.1 should involve consideration of many factors, including:

(a) Pressure rating.

(b) Beam strength (hangers).

(c) Unsupported vertical stability.

(d) Movement during sprinkler operation (affecting water distribution).

(e) Corrosion (internal and external), chemical and electrolytic.

(f) Resistance to failure when exposed to elevated temperatures.

(g) Methods of joining (strength, permanence, fire hazard).

(h) Physical characteristics related to integrity during earthquakes.

Table A-2-3.2 Steel Pipe Dimensions

Nominal Pipe Size in.	Outside Diameter in.	(mm)	Schedule 10[1] Inside Diameter in.	(mm)	Schedule 10[1] Wall Thickness in.	(mm)	Schedule 30 Inside Diameter in.	(mm)	Schedule 30 Wall Thickness in.	(mm)	Schedule 40 Inside Diameter in.	(mm)	Schedule 40 Wall Thickness in.	(mm)
½	.840	(21.3)	.674	(17)	.083	(2.1)					.622	(15.8)	.109	(2.8)
¾	1.050	(26.7)	.884	(22.4)	.083	(2.1)					.824	(21)	.113	(2.9)
1	1.315	(33.4)	1.097	(27.9)	0.109	(2.8)	—	—	—	—	1.049	(26.6)	0.133	(3.4)
1¼	1.660	(42.2)	1.442	(36.6)	0.109	(2.8)	—	—	—	—	1.380	(35.1)	0.140	(3.6)
1½	1.900	(48.3)	1.682	(42.7)	0.109	(2.8)	—	—	—	—	1.610	(40.9)	0.145	(3.7)
2	2.375	(60.3)	2.157	(54.8)	0.109	(2.8)	—	—	—	—	2.067	(52.5)	0.154	(3.9)
2½	2.875	(73.0)	2.635	(66.9)	0.120	(3.0)	—	—	—	—	2.469	(62.7)	0.203	(5.2)
3	3.500	(88.9)	3.260	(82.8)	0.120	(3.0)	—	—	—	—	3.068	(77.9)	0.216	(5.5)
3½	4.000	(101.6)	3.760	(95.5)	0.120	(3.0)	—	—	—	—	3.548	(90.1)	0.226	(5.7)
4	4.500	(114.3)	4.260	(108.2)	0.120	(3.0)	—	—	—	—	4.026	(102.3)	0.237	(6.0)
5	5.563	(141.3)	5.295	(134.5)	0.134	(3.4)	—	—	—	—	5.047	(128.2)	0.258	(6.6)
6	6.625	(168.3)	6.357	(161.5)	0.134[2]	(3.4)	—	—	—	—	6.065	(154.1)	0.280	(7.1)
8	8.625	(219.1)	8.249	(209.5)	0.188[2]	(4.8)	8.071	(205.0)	0.277	(7.0)	—	—	—	—
10	10.75	(273.1)	10.37	(263.4)	0.188[2]	(4.8)	10.14	(257.6)	0.307	(7.8)	—	—	—	—

For SI Units: 1 in. = 25.4 mm.

NOTES:
1. Schedule 10 defined to 5 in. (127 mm) nominal pipe size by ASTM A 135.
2. Wall thickness specified in 2-3.2.
3. These values applicable when used in conjunction with 4-5.18.2 and 4-5.18.3.

Table A-2-3.4 Copper Tube Dimensions

Nominal Tube Size in.	Outside Diameter in.	(mm)	Type K Inside Diameter in.	(mm)	Type K Wall Thickness in.	(mm)	Type L Inside Diameter in.	(mm)	Type L Wall Thickness in.	(mm)	Type M Inside Diameter in.	(mm)	Type M Wall Thickness in.	(mm)
¾	0.875	(22.2)	0.745	(18.9)	0.065	(1.7)	0.785	(19.9)	0.045	(1.1)	0.811	(20.6)	0.032	(0.8)
1	1.125	(28.6)	0.995	(25.3)	0.065	(1.7)	1.025	(26.0)	0.050	(1.3)	1.055	(26.8)	0.035	(0.9)
1¼	1.375	(34.9)	1.245	(31.6)	0.065	(1.7)	1.265	(32.1)	0.055	(1.4)	1.291	(32.8)	0.042	(1.1)
1½	1.625	(41.3)	1.481	(37.6)	0.072	(1.8)	1.505	(38.2)	0.060	(1.5)	1.527	(38.8)	0.049	(1.2)
2	2.125	(54.0)	1.959	(49.8)	0.083	(2.1)	1.985	(50.4)	0.070	(1.8)	2.009	(51.0)	0.058	(1.5)
2½	2.625	(66.7)	2.435	(61.8)	0.095	(2.4)	2.465	(62.6)	0.080	(2.0)	2.495	(63.4)	0.065	(1.7)
3	3.125	(79.4)	2.907	(73.8)	0.109	(2.8)	2.945	(74.8)	0.090	(2.3)	2.981	(75.7)	0.072	(1.8)
3½	3.625	(92.1)	3.385	(86.0)	0.120	(3.0)	3.425	(87.0)	0.100	(2.5)	3.459	(87.9)	0.083	(2.1)
4	4.125	(104.8)	3.857	(98.0)	0.134	(3.4)	3.905	(99.2)	0.110	(2.8)	3.935	(99.9)	0.095	(2.4)
5	5.125	(130.2)	4.805	(122.0)	0.160	(4.1)	4.875	(123.8)	0.125	(3.2)	4.907	(124.6)	0.109	(2.8)
6	6.125	(155.6)	5.741	(145.8)	0.192	(4.9)	5.845	(148.5)	0.140	(3.6)	5.881	(149.4)	0.122	(3.1)
8	8.125	(206.4)	7.583	(192.6)	0.271	(6.9)	7.725	(196.2)	0.200	(5.1)	7.785	(197.7)	0.170	(4.3)
10	10.13	(257.3)	9.449	(240.0)	0.338	(8.6)	9.625	(244.5)	0.250	(6.4)	9.701	(246.4)	0.212	(5.4)

For SI Units: 1 in. = 25.4 mm.

A-2-4.2 Rubber-gasketed pipe fittings and couplings should not be installed where ambient temperatures can be expected to exceed 150°F (66°C) unless listed for this service. If the manufacturer further limits a given gasket compound, those recommendations should be followed.

A-2-4.4 Listed flexible connections are permissible and encouraged for sprinkler installations in racks to reduce the possibility of physical damage. Where flexible tubing is used, it should be located so that it will be protected against mechanical injury.

A-2-5.1.2 Some steel piping material having lesser wall thickness than specified in 2-5.1.2 has been listed for use in sprinkler systems where joined with threaded connections. The service life of such products may be significantly less than that of Schedule 40 steel pipe, and it should be determined if this service life will be sufficient for the application intended.

All such threads should be checked by the installer using working ring gauges conforming to the Basic Dimensions of Ring Gauges for USA (American) Standard Taper Pipe Threads, NPT, as per ANSI/ASME B1.20.1, Table 8.

A-2-5.2 See Figure A-2-5.2(a) and Figure A-2-5.2(b).

A-2-5.2.2 Cutting and welding operations account for 4 percent of fires each year in nonresidential properties and 8 percent in industrial and manufacturing properties. In-place welding of sprinkler piping introduces a significant hazard that can normally be avoided by shop-welding the piping and installing the welded sections with mechanical fittings. As a result, the standard requires that all piping be shop-welded. When such situations cannot be avoided, the exceptions outline procedures and practices that minimize the increase in hazard.

A-2-5.2.5(a) Listed, shaped, contoured nipples meet the definition of fabricated fittings.

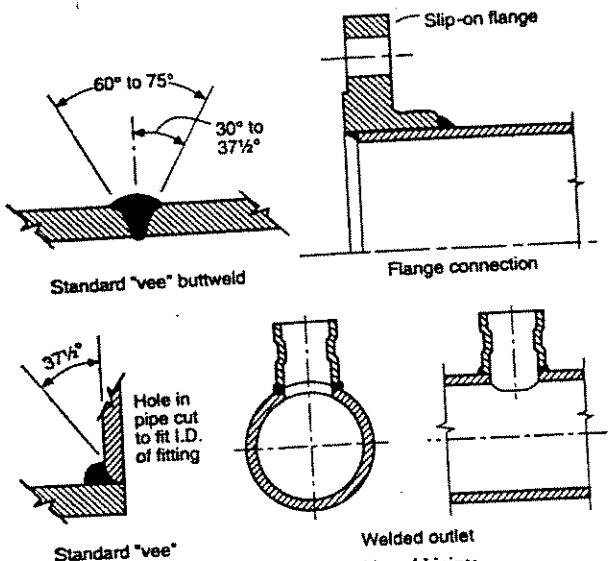


Figure A-2-5.2(a) Acceptable weld joints.

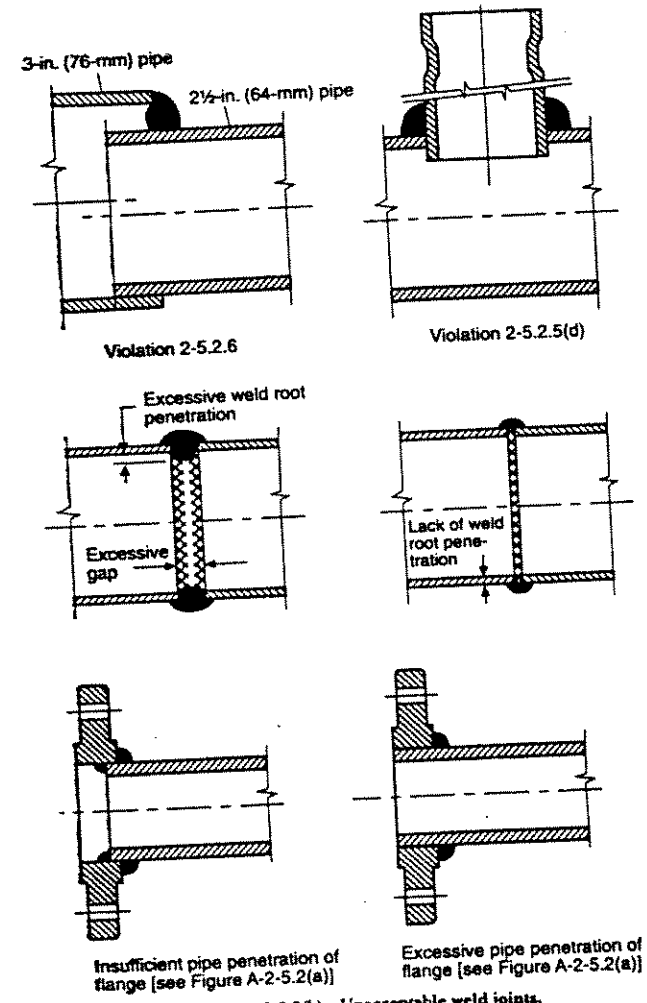


Figure A-2-5.2(b) Unacceptable weld joints.

A-2-5.4 The fire hazard of the brazing and soldering processes should be suitably safeguarded.

A-2-5.4.1 Soldering fluxes manufactured to the specifications required by Table 2-3.1 are unlikely to cause damage to the seats of sprinklers. When brazing flux is used, it must be of a type not likely to damage the seats of sprinklers.

A-2-6.1 See Figure A-2-6.1.

A-2-6.1.5 Table 2-6.1.5(a) assumes that the load from 15 ft (5 m) of water-filled pipe, plus 250 lb (114 kg), is located at the midpoint of the span of the trapeze member, with a maximum allowable bending stress of 15 KSI (111 kg). If the load is applied at other than the midpoint, for the purpose of sizing the trapeze member, an equivalent length of trapeze may be used, derived from the formula

$$L = \frac{4ab}{a + b}$$

where:

L = equivalent length
a = distance from one support to the load
b = distance from the other support to the load.

Where multiple mains are to be supported or multiple trapeze hangers are provided in parallel, the required or available section modulus may be added.

A-2-6.1.7 The rules covering the hanging of sprinkler piping take into consideration the weight of water-filled pipe plus a safety factor. No allowance has been made for the hanging of nonsystem components from sprinkler piping.

A-2-6.3.1 Powder-driven studs should not be used in steel of less than $\frac{3}{16}$ in. (4.8 mm) total thickness.

A-2-6.3.3 The ability of concrete to hold the studs varies widely according to type of aggregate, quality of concrete, and proper installation.

A-2-7.3 The intent of this section is to provide assistance in determining the area of a building served by a particular control valve.

A-2-9.2.4 The surge of water when the valve trips may seriously damage the device.

A-2-9.3.1 Audible alarms are normally located on the outside of the building. Listed electric gongs, bells, horns, or sirens inside the building or a combination inside and outside are sometimes advisable.

A-2-9.3.2 All alarm apparatus should be so located and installed that all parts are accessible for inspection, removal, and repair and should be substantially supported.

The water motor gong bell mechanism should be protected from weather-related elements such as rain, snow, or ice. To the extent practicable, they should also be protected from other influencing factors such as birds or other small animals that might attempt to nest in such devices.

A-2-9.5 Switches that will silence electric alarm-sounding devices by interruption of electrical current are not desirable; however, if such means are provided, then the electrical alarm-sounding device circuit should be arranged so that, when the sounding device is electrically silenced, that fact should be indicated by means of a conspicuous light located in the vicinity of the riser or alarm control panel. This light should remain in operation during the entire period of the electrical circuit interruption.

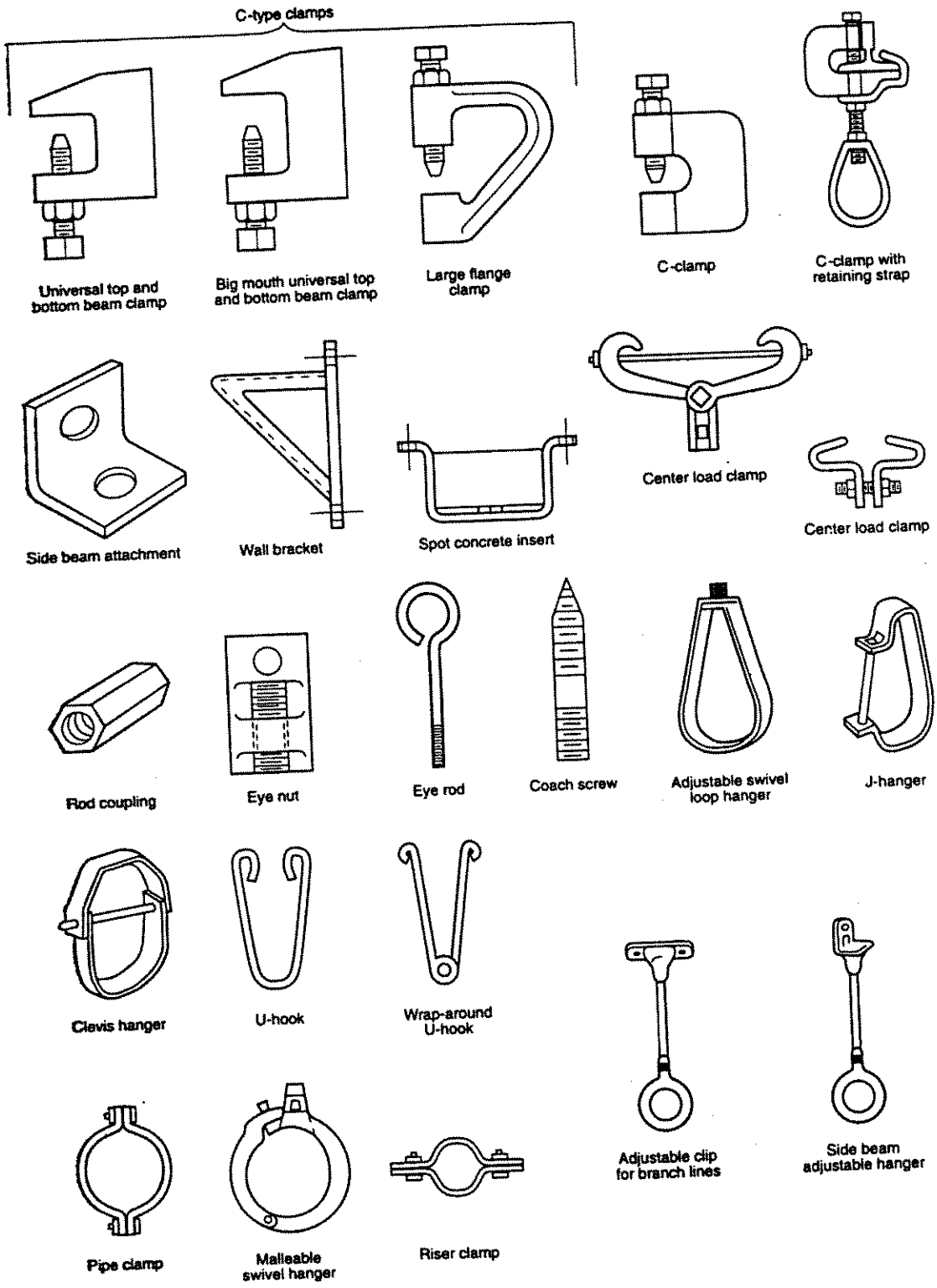


Figure A-2-6.1 Common types of acceptable hangers.

A-3-2 A dry pipe system should be installed only where heat is not adequate to prevent freezing of water in all or sections of the system. Dry pipe systems should be converted to wet pipe systems when they become unnecessary because adequate heat is provided. Sprinklers should not be shut off in cold weather.

Where two or more dry pipe valves are used, systems preferably should be divided horizontally to prevent simultaneous operation of more than one system and the resultant increased time delay in filling systems and discharging water, plus receipt of more than one waterflow alarm signal.

Where adequate heat is present in sections of the dry pipe system, consideration should be given to dividing the system into a separate wet pipe system and dry pipe system. Minimized use of dry pipe systems is desirable where speed of operation is of particular concern.

A-3-2.2 Exception No. 1. Installation limitations of listed dry pendent sprinklers can vary with different products. Limitations should be included in product installation instructions to warn against the potential accumulation of water, scale, and sediment from collecting at the sprinkler.

A-3-2.3 The capacities of the various sizes of pipe given in Table A-3-2.3 are for convenience in calculating the capacity of a system.

Table A-3-2.3 Capacity of One Foot of Pipe (Based on Actual Internal Pipe Diameter)

Nominal Diameter	Gal Sch 40	Gal Sch 10	Nominal Diameter	Gal Sch 40	Gal Sch 10
¾ in.	0.028	—	3 in.	0.383	0.433
1 in.	0.045	0.049	3½ in.	0.513	0.576
1¼ in.	0.078	0.085	4 in.	0.660	0.740
1½ in.	0.106	0.115	5 in.	1.040	1.144
2 in.	0.174	0.190	6 in.	1.501	1.649[1]
2½ in.	0.248	0.283	8 in.	2.66[3]	2.776[2]

For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m; 1 gal = 3.785 L.

[1] 0.134 Wall Pipe.
[2] 0.188 Wall Pipe.
[3] Schedule 30.

A-3-2.3.1 The 60-sec limit does not apply to dry systems with capacities of 500 gal (1893 L) or less, nor to dry systems with capacities of 750 gal (2839 L) or less if equipped with a quick-opening device.

A-3-2.5 The dry pipe valve should be located in an accessible place near the sprinkler system it controls. Where exposed to cold, the dry pipe valve should be located in a valve room or enclosure of adequate size to properly service equipment.

A-3-2.6.2 The compressor should draw its air supply from a place where the air is dry and not too warm. Moisture from condensation can cause trouble in the system.

A-3-3.1 Conditions of occupancy or special hazards might require quick application of large quantities of water, and in such cases deluge systems might be needed.

Fire detection devices should be selected to assure operation, yet guard against premature operation of sprinklers, based on normal room temperatures and draft conditions.

In locations where ambient temperature at the ceiling is high from heat sources other than fire conditions, heat-responsive devices that operate at higher than ordinary temperature and are capable of withstanding the normal high temperature for long periods of time should be selected.

Where corrosive conditions exist, materials or protective coatings that resist corrosion should be used.

To help avoid ice formation in piping due to accidental tripping of dry pipe valves in cold storage rooms, a deluge automatic water control valve can be used on the supply side of the dry pipe valve. Where this combination is employed:

(a) Dry systems can be manifolded to a deluge valve, the protected area not exceeding 40,000 sq ft (3716 m²). The distance between valves should be as short as possible to minimize water hammer.

(b) The dry pipe valves should be pressurized to 50 psi (3.4 bars) to reduce the possibility of dry pipe valve operation from water hammer.

A-3-3.2.4 Exception No. 1. See A-3-2.2 Exception No. 1.

A-3-3.3 Where 8-in. (203-mm) piping is employed to reduce friction losses in a system operated by fire detection devices, a 6-in. (152-mm) preaction or deluge valve and 6-in. (152-mm) gate valve between tapered reducers should be permitted.

A-3-4.1 Systems described by Section 3-4 are special types of non-interlocking preaction systems intended for use in, but not limited to, structures where a number of dry pipe valves would be required if a dry pipe system were installed. These systems are primarily used in piers and wharves.

A-3-4.1.1 See Figure A-3-4.1.1.

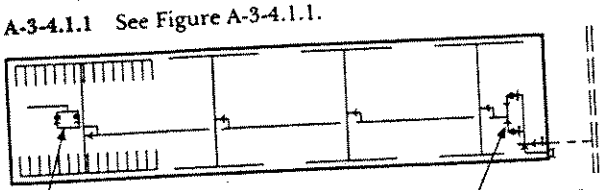


Figure A-3-4.1.1 Typical piping layout for combined dry pipe and preaction sprinkler system.

A-3-4.1.4 Exception No. 1. See A-3-2.2 Exception No. 1.

A-3-4.3 See Figure A-3-4.3.

A-3-5.1 Antifreeze solutions may be used for maintaining automatic sprinkler protection in small unheated areas. Antifreeze solutions are recommended only for systems not exceeding 40 gal (151 L).

Because of the cost of refilling the system or replenishing small leaks, it is advisable to use small dry valves where more than 40 gal (151 L) are to be supplied.

A-3-5.2 Listed CPVC sprinkler pipe and fittings should be protected from freezing with glycerine only. The use of diethylene, ethylene, or propylene glycols are specifically prohibited. Laboratory testing shows that glycol-based antifreeze solutions present a chemical environment detrimental to CPVC.

A-3-5.2.3 Beyond certain limits, increased proportion of antifreeze does not lower the freezing point of solution. (*See Figure A-3-5.2.3.*)

Glycerine, diethylene glycol, ethylene glycol, and propylene glycol should never be used without mixing with water

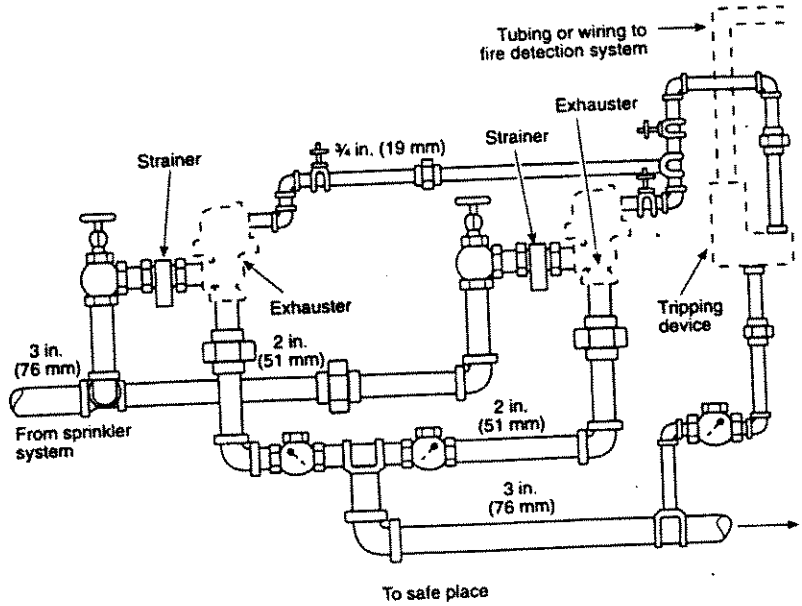


Figure A-3-4.3 Arrangement of air exhaust valves for combined dry pipe and preaction sprinkler system.

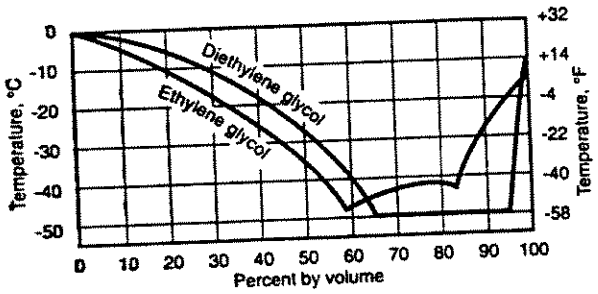


Figure A-3-5.2.3 Freezing points of water solutions of ethylene glycol and diethylene glycol.

in proper proportions, because these materials tend to thicken near 32°F (0°C).

A-3-5.3.1 All permitted antifreeze solutions are heavier than water. At the point of contact (interface), the heavier liquid will be below the lighter liquid, preventing diffusion of water into the unheated areas.

A-3-6.1.2 Outlets should be provided at critical points on sprinkler system piping to accommodate attachment of pressure gauges for test purposes.

A-3-7.2.1 The water supply should be capable of furnishing the total demand for all exposure sprinklers operating simultaneously for protection against the exposure fire under consideration for a duration of not less than 60 min.

A-3-8 Careful installation and maintenance, and some special arrangements of piping and devices as outlined in this section, are needed to avoid the formation of ice and frost inside piping in cold storage rooms that will be maintained at or below 32°F (0°C). Conditions are particularly favorable to condensation where pipes enter cold rooms from rooms having temperatures above freezing.

Whenever the opportunity offers, fittings such as those specified in 3-8.1 and illustrated in Figures A-3-8(a) and (b), as well as flushing connections, should be provided in existing systems.

Where possible, risers should be located in stair towers or other locations outside of refrigerated areas. This would reduce the probabilities of ice or frost formation within the riser (supply) pipe.

Cross mains should be connected to risers or feed mains with flanges. In general, flanged fittings should be installed at points that would allow easy dismantling of the system. Split ring or other easily removable types of hangers will facilitate the dismantling.

Because it is not practical to allow water to flow into sprinkler piping in spaces that might be constantly subject to freezing, or where temperatures must be maintained at or below 40°F (4.4°C), it is important that means be provided at the time of system installation to conduct trip tests on dry pipe valves that service such systems. NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, contains requirements in this matter.[101]

A-3-8.2 The requirements in this section are intended to minimize the chances of ice plug formation inside sprinkler system piping protecting freezers.

A-3-8.2.4 A higher degree of preventing ice blocks can be achieved by lowering moisture of the air supply entering the refrigerated space to a pressure dew point no greater than 20°F (−6.6°C) below the lowest nominal temperature of the refrigerated space. The pressure dew point of the air supply can cause moisture to condense and freeze in sprinkler pipe even when the air supply is from the freezer. One method of reducing moisture content of the air by use of air drying systems is illustrated in Figure A-3-8.2.4.

When compressors and dryers are used for an air supply, consideration should be given to pressure requirements of

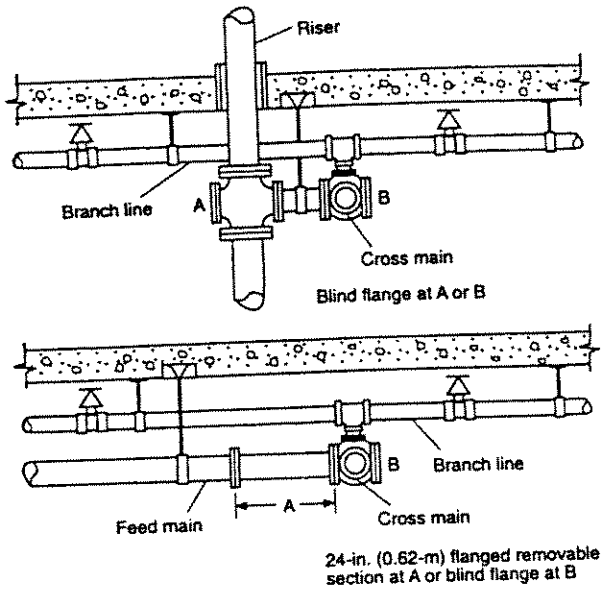


Figure A-3-8(a) Fittings to facilitate examination of feed mains, risers, and cross mains in freezing areas. Top: elevation at riser and cross main. Bottom: elevation at feed main and cross main.

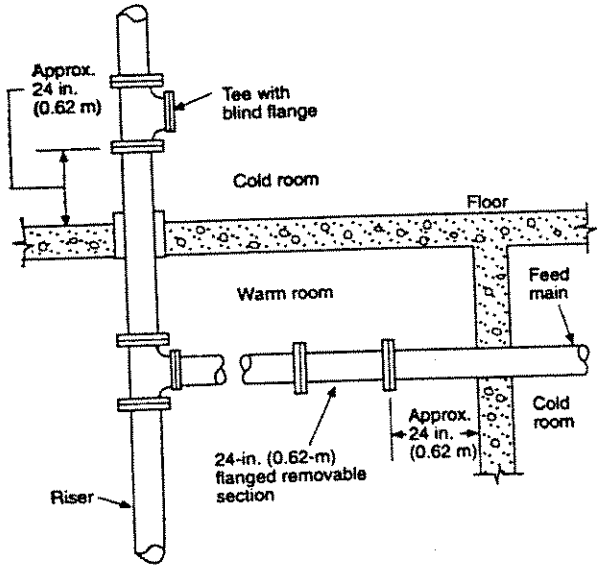
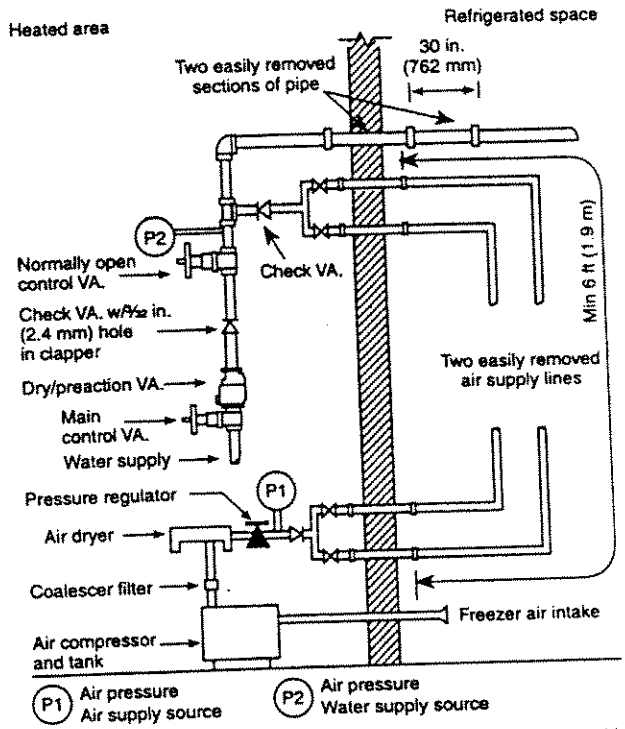


Figure A-3-8(b) Fittings in feed main or riser passing through wall or floor from warm room to cold room.

the regenerative dryers, compressor size, air pressure regulator capacity, and air fill rate. Application of these factors could necessitate use of increased air pressures and larger air compressor.

The compressed air supply should be properly prepared prior to entering a regenerative-type air dryer, such as minimum air pressure, maximum inlet air temperature, and proper filtration of compressed air.

A-3-8.2.5 A major contributing factor of introducing moisture in the system piping comes from excessive air compressor operation caused by system leakage. Where excessive compressor operation is noted or ice is accumulated in the air supply piping, the system should be checked for leakage and appropriate corrective action should be taken.



1. If pressure gauge P1 and P2 do not indicate equal pressures, it could mean the air line is blocked or the air supply is malfunctioning.
2. Air dryer and coalescer filter not required when system piping capacity is less than 250 gal.

Figure A-3-8.2.4 Refrigerator area sprinkler systems to minimize the chances of developing ice plugs.

A-3-8.2.7 The dual lines feeding the system air entering the cold area is intended to facilitate continued service of the system when one line is removed for inspection. It should be noted that, when using a system as described in Figure A-3-8.2.4, differences in the pressures at gauge P1 and gauge P2 indicate blockage in the air supply line or other malfunctions.

A-3-9.2 See Figure A-3-9.2.

A-4-1 The installation requirements are specific for the normal arrangement of structural members. There will be arrangements of structural members not specifically detailed by the requirements. By applying the basic principles, layouts for such construction can vary from specific illustrations, provided the maximum specified for the spacing and location of sprinklers (Section 4-4) are not exceeded.

Where buildings or portions of buildings are of combustible construction or contain combustible material, standard fire barriers should be provided to separate the areas that are sprinkler protected from adjoining unsprinklered areas. All openings should be protected in accordance with applicable standards, and no sprinkler piping should be placed in an unsprinklered area unless the area is permitted to be unsprinklered by this standard.

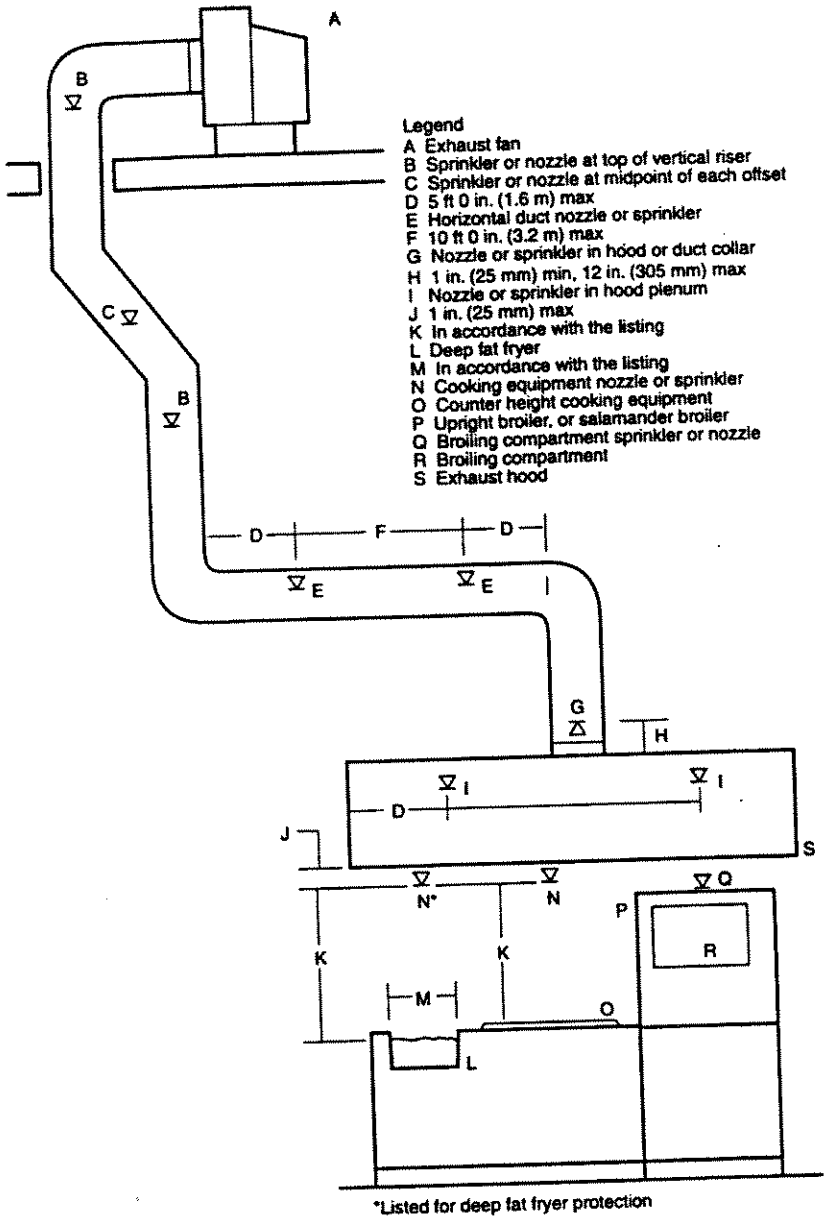


Figure A-3-9.2 Typical installation showing automatic sprinklers or automatic nozzles being used for the protection of commercial cooking equipment and ventilation systems.

Water supplies for partial systems should be designed with consideration to the fact that in a partial system more sprinklers might be opened in a fire that originates in an unprotected area and spreads to the sprinklered area than would be the case in a completely protected building. Fire originating in a nonsprinklered area might overpower the partial sprinkler system.

Where sprinklers are installed in corridors only, sprinklers should be spaced up to the maximum of 15 ft (4.5 m) along the corridor, with one sprinkler opposite the center of any door or pair of adjacent doors opening onto the corridor, and with an additional sprinkler installed inside each adjacent room above the door opening. Where the sprinkler in the adjacent room provides full protection for that space, an additional sprinkler is not required in the corridor adjacent to the door.

A-4-1.1 This standard contemplates full sprinkler protection for all areas. Other NFPA standards that mandate sprinkler installation might not require sprinklers in certain areas. The requirements of this standard should be used

insofar as they are applicable. The authority having jurisdiction should be consulted in each case.

A-4-1.2 The components need not be open or exposed. Doors, removable panels, or valve pits can satisfy this need. Such equipment should not be obstructed by such permanent features as walls, ducts, columns, or direct burial.

A-4-3.1.1 The evaluation for usage should be based upon a review of available technical data.

A-4-3.1.2 This requirement is to minimize the obstruction of the discharge pattern.

A-4-4 The selection of a sprinkler type will vary by occupancy. Where more than one type of sprinkler is used within a compartment, sprinklers with similar response characteristics should be used (i.e., standard or quick response). However, some hazards might benefit from designs that include the use of both standard and quick-response sprinklers. Examples include rack storage protected by standard-response ceiling sprinklers and quick-response in-rack sprinklers. Another case might include opening protection using closely spaced quick-response sprinklers with standard-response sprinklers in the adjoining areas. Other designs can be compromised when sprinklers of differing sensitivity are mixed. An example is a system utilizing ESFR sprinklers adjacent to a system using high temperature standard-response sprinklers as might be found in a warehouse. In this case a fire occurring near the boundary might open ESFR sprinklers, which would not be contemplated in the standard-response system design.

A-4-4.5.1 The response and water distribution pattern of listed residential sprinklers have been shown by extensive fire testing to provide better control than spray sprinklers in residential occupancies. These sprinklers are intended to prevent flashover in the room of fire origin, thus improving the chance for occupants to escape or be evacuated.

The protection area for residential sprinklers is defined in the listing of the sprinkler as a maximum square or rectangular area. Listing information is presented in even 2-ft (.65-m) increments from 12 ft to 20 ft (3.9 m to 6.5 m). When a sprinkler is selected for an application, its area of coverage must be equal to or greater than both the length and width of the hazard area. For example, if the hazard to be protected is a room 13 ft 6 in. (4.4 m) wide and 17 ft 6 in. (5.6 m) long, a sprinkler that is listed to protect a rectangular area of 14 ft × 18 ft (4.5 m × 5.8 m) or a square area of 18 ft × 18 ft (5.8 m × 5.8 m) must be selected. The flow used in the calculations is then selected as the flow required by the listing for the selected coverage.

A-4-4.7.2 This requirement is to avoid scale accumulation.

A-4-4.9.1 Tests of standard sprinklers by approved laboratories have traditionally encompassed a fire test using a 330-lb (160-kg) wood crib and water distribution tests in which water is collected in pans from several arrangements of sprinklers to evaluate distribution under nonfire conditions.

Tests of special sprinklers are customized to evaluate responsiveness, distribution, and other unique characteristics of the sprinkler to control or extinguish. These include variables such as:

(a) The location of the fire relative to the sprinklers, i.e., below 1 sprinkler or between 2, 4, or 6 sprinklers,

(b) Fire conditions that encompass a variety of fire growth rates representative of anticipated conditions of use,

(c) Tests of room areas where sprinklers are expected to function in multiple arrays,

(d) Adverse conditions of use, i.e., pipe shadows or other obstructions to discharge,

(e) Effect of a fire plume on water distribution and discharge under a variety of heat release rates.

A-4-5.5.2 Where of a depth that will obstruct the spray discharge pattern, girders, beams, or trusses forming narrow pockets of combustible construction along walls may require additional sprinklers.

A-4-5.5.3 Frequently, additional sprinkler equipment can be avoided by reducing the width of decks or galleries and providing proper clearances. Slatting of decks or walkways or the use of open grating as a substitute for automatic sprinklers thereunder is not acceptable. The use of cloth or paper dust tops for rooms forms obstruction to water distribution. If dust tops are used, the area below should be sprinklered.

A-4-6.3.2 See Figure A-4-6.3.2.

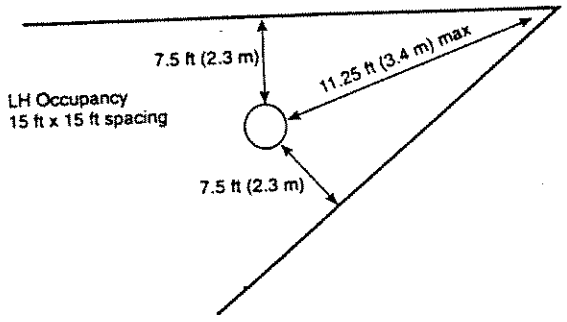


Figure A-4-6.3.2 Maximum distance from walls.

A-4-6.3.2.1 Exception. An example of sprinklers in small rooms for hydraulically designed and pipe schedule systems is shown in Figure A-4-6.3.2 Exception (a), and examples for hydraulically designed systems only are shown in Figures A-4-6.3.2 Exception (b), (c), and (d).

A-4-6.4.1.2 Exception No. 4. For concrete joists spaced less than 3 ft (.91 m) on center, the rules for obstructed construction shown in 4-6.4.1.2 apply. (*See Figure A-4-6.4.1.2 Exception No. 4.*)

A-4-6.4.1.3 Saw-toothed roofs have regularly spaced monitors of saw tooth shape, with the nearly vertical side glazed and usually arranged for venting. Sprinkler placement is limited to a maximum of 3 ft (0.91 m) down the slope from the peak because of the effect of venting on sprinkler sensitivity.

A-4-6.4.2 On sprinkler lines larger than 2 in. (51 mm), consideration should be given to the distribution interference caused by the pipe, which can be minimized by installing sprinklers on riser nipples or installing sprinklers in the pendent position.

A-4-6.5.3 See A-4-5.5.3.

A-4-6.5.4 The distances given in Table 4-6.5.4 were determined through tests in which privacy curtains with either a solid fabric or close mesh [¼ in. (6.4 mm)] top panel were

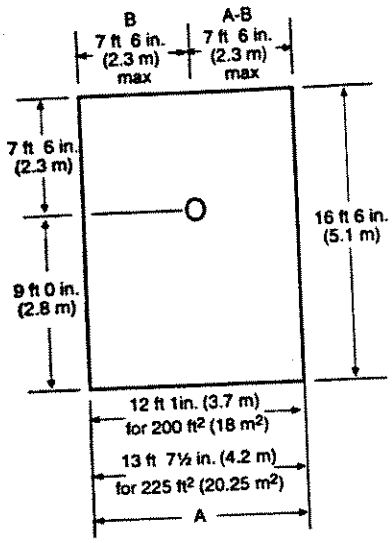


Figure A-4-6.3.2 Exception (a) Small room provision.

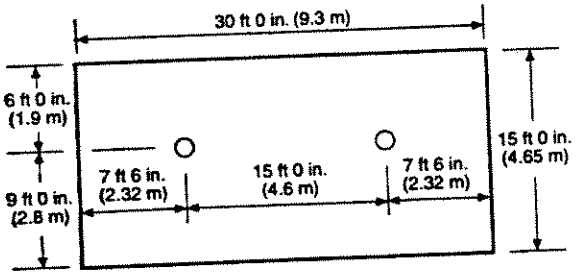


Figure A-4-6.3.2 Exception (b) Small room provision.

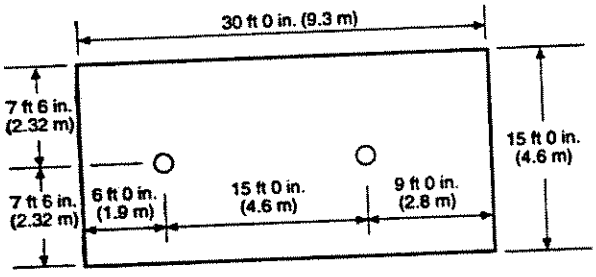


Figure A-4-6.3.2 Exception (c) Small room provision.

installed. For broader-mesh top panels, e.g., ½ in. (13 mm), the obstruction of the sprinkler spray is not likely to be severe and the authority having jurisdiction may not need to apply the requirements in 4-6.5.4.

A-4-6.6 The 18-in. (457-mm) dimension is not intended to limit the height of shelving on a wall or shelving against a wall in accordance with 4-4.1.6. Where shelving is installed on a wall and is not directly below sprinklers, the shelves, including storage thereon, may extend above the level of a plane located 18 in. (457 mm) below ceiling sprinkler deflectors. Shelving, and any storage thereon, directly below the sprinklers may not extend above a plane located 18 in. (457 mm) below the ceiling sprinkler deflectors.

A-4-7.5.3 See A-4-5.5.3.

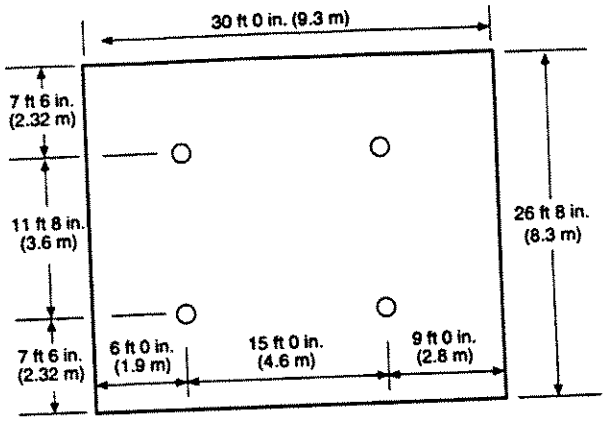


Figure A-4-6.3.2 Exception (d) Small room provision.

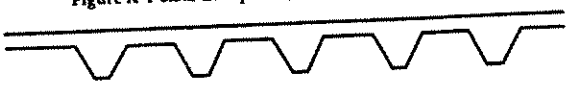


Figure A-4-6.4.1.2 Exception No. 4 Typical concrete joist construction.

A-4-8.2.1 The protection area for extended coverage upright and pendent sprinklers is defined in the listing of the sprinkler as a maximum square area. Listing information is presented in even 2-ft (0.65-m) increments up to 20 ft (6.5 m). When a sprinkler is selected for an application, its area of coverage must be equal to or greater than both the length and width of the hazard area. For example, if the hazard to be protected is a room 13 ft 6 in. (4.4 m) wide and 17 ft 6 in. (5.6 m) long, a sprinkler that is listed to protect an area of 18 ft × 18 ft (5.8 m × 5.8 m) must be selected. The flow used in the calculations is then selected as the flow required by the listing for the selected coverage.

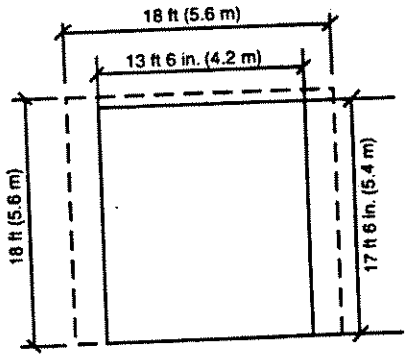


Figure A-4-8.2.1 Determination of protection area of coverage for EC upright and pendent sprinklers.

A-4-8.4.1.3 Saw-toothed roofs have regularly spaced monitors of saw tooth shape, with the nearly vertical side glazed and usually arranged for venting. Sprinkler placement is limited to a maximum of 3 ft (0.91 m) down the slope from the peak because of the effect of venting on sprinkler sensitivity.

A-4-8.5.3 See A-4-5.5.3.

A-4-9.2.1 The protection area for extended coverage sidewall spray sprinklers is defined in the listing of the sprinkler

as a maximum square or rectangular area. Listing information is presented in even 2-ft (0.65-m) increments up to 28 ft (9 m) for extended coverage sidewall spray sprinklers. When a sprinkler is selected for an application, its area of coverage must be equal to or greater than both the length and width of the hazard area. For example, if the hazard to be protected is a room 14 ft 6 in. (4.7 m) wide and 20 ft 8 in. (6.7 m) long, a sprinkler that is listed to protect an area of 16 ft × 22 ft (5.2 m × 7.1 m) must be selected. The flow used in the calculations is then selected as the flow required by the listing for the selected coverage.

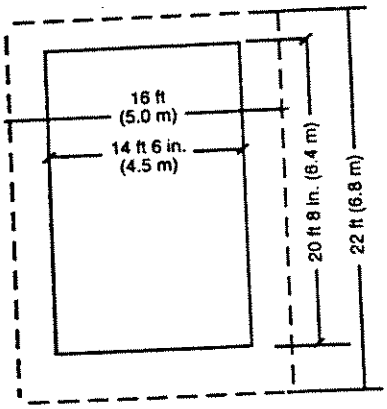


Figure A-4-9.2.1 Determination of protection area of coverage for EC sidewall sprinklers.

A-4-9.5.3 See A-4-5.5.3.

A-4-10.2 Tests involving areas of coverage over 100 ft² (9.3 m²) for large-drop sprinklers are limited in number, and use of areas of coverage over 100 ft² (9.3 m²) should be carefully considered.

A-4-10.3.1 It is important that sprinklers in the immediate vicinity of the fire center not skip, and this requirement imposes certain restrictions on the spacing.

A-4-10.4.1 If all other factors are held constant, the operating time of the first sprinkler will vary exponentially with the distance between the ceiling and deflector. At distances greater than 7 in. (178 mm), for other than open wood joist construction, the delayed operating time will permit the fire to gain headway, with the result that substantially more sprinklers operate. At distances less than 7 in. (178 mm), other effects occur. Changes in distribution, penetration, and cooling nullify the advantage gained by faster operation. The net result again is increased fire damage accompanied by an increase in the number of sprinklers operated. The optimum clearance between deflectors and ceiling is, therefore, 7 in. (178 mm). For open wood joist construction, the optimum clearance between deflectors and the bottom of joists is 3½ in. (89 mm).

A-4-10.5 To a great extent, large-drop sprinklers rely on direct attack to gain rapid control of both the burning fuel and ceiling temperatures. Therefore, interference with the discharge pattern and obstructions to the distribution should be avoided.

A-4-10.5.3 See A-4-5.5.3.

A-4-11.5.3 See A-4-5.5.3.

A-4-13.1.1 Exceptions Nos. 1, 2, and 3 do not require sprinkler protection because it is not physically practical to install sprinklers in these spaces. To reduce the possibility of uncontrolled fire spread, consideration should be given in these unsprinklered concealed space situations to using Exceptions Nos. 5, 8, and 10.

A-4-13.2.2 Where practicable, sprinklers should be staggered at the alternate floor levels, particularly where only one sprinkler is installed at each floor level.

A-4-13.3.3 See Figures A-4-13.3.3(a) and (b). Sprinklers would be required in the case shown in Figure (a) but not in the case shown in Figure (b).

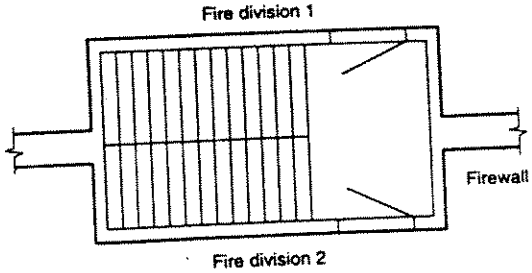


Figure A-4-13.3.3(a) Noncombustible stair shaft serving two fire sections.

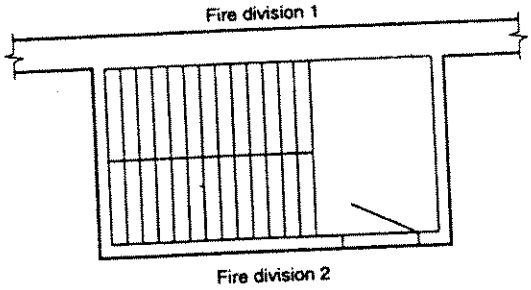


Figure A-4-13.3.3(b) Noncombustible stair shaft serving one fire section.

A-4-13.3.4 Where sprinklers in the normal ceiling pattern are closer than 6 ft (1.8 m) from the water curtain, it might be preferable to locate the water curtain sprinklers in recessed baffle pockets. (*See Figure A-4-13.3.4.*)

A-4-13.4 The installation of sprinklers at floor levels should be arranged so as to protect the sprinklers from mechanical injury and from falling materials and not cause obstruction within the chute. This usually can be accomplished by recessing the sprinkler in the wall of the chute or by providing a protective deflector canopy over the sprinkler. Sprinklers should be placed so that there will be minimum interference of the discharge therefrom. Sprinklers with special directional discharge characteristics might be advantageous. (*See Figure A-4-13.4.*)

A-4-13.5.1 The sprinklers in the pit are intended to protect against fires cause by debris, which can accumulate over time. Ideally, the sprinklers should be located near the side of the pit below the elevator doors, where most debris accumulates. However, care should be taken that the sprinkler location does not interfere with the elevator toe guard, which extends below the face of the door opening.

A-4-13.5.2 The ASME A17.1 code requires the shutdown of power to the elevator upon or prior to the application of

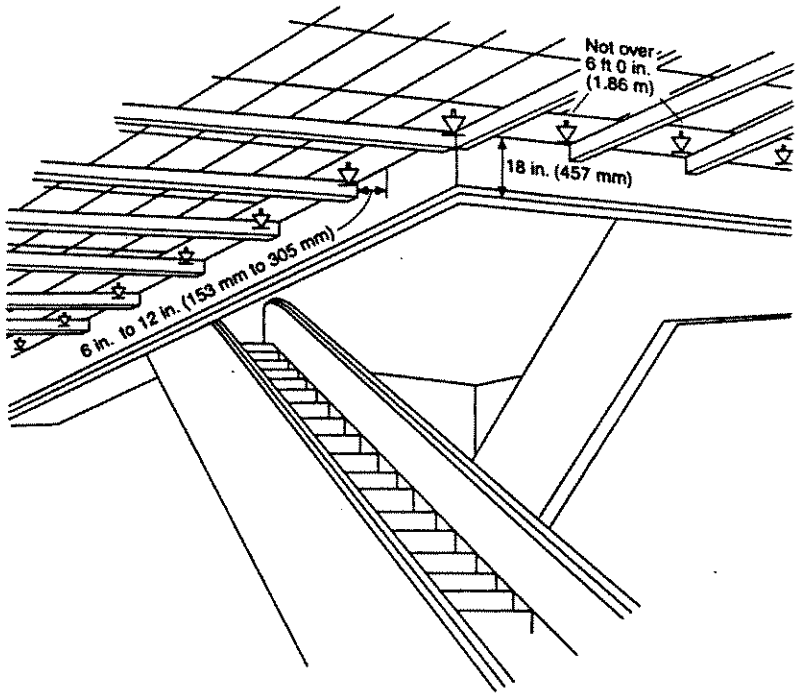


Figure A-4-13.3.4 Sprinklers around escalators.

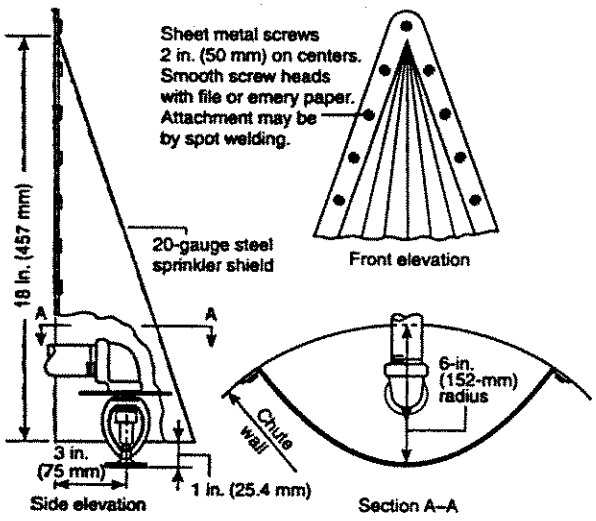


Figure A-4-13.4 Canopy for protecting sprinklers in building service chutes.

water in elevator machine rooms or hoistways. This can be accomplished by a detection system with sufficient sensitivity to operate prior to the activation of the sprinklers (*see also NFPA 72*). As an alternative, the system can be arranged using devices or sprinklers capable of effecting power shutdown immediately upon sprinkler activation, such as a waterflow switch without a time delay. This is intended to interrupt power before significant sprinkler discharge.

A-4-13.5.3 Passenger elevator cars that have been constructed in accordance with A17.1 Rule 204.2a (under A17.1a-1985 and later editions of the code) have limited combustibility. Materials exposed to the interior of the car and the hoistway, in their end-use composition, are limited to a flame spread rating of 0 to 75, and a smoke development rating of 0 to 450.

A-4-13.7 Small loading docks, covered platforms, ducts, or similar small unheated areas can be protected by dry-pendent sprinklers extending through the wall from wet sprinkler piping in an adjacent heated area. Where protecting covered platforms, loading docks, and similar areas, a dry-pendent sprinkler should extend down at a 45-degree angle. The width of the area to be protected should not exceed 7½ ft (2.3 m). Sprinklers should be spaced not over 12 ft (3.7 m) apart. (*See Figure A-4-13.7.*)

A-4-13.8.2 Portable wardrobe units, such as those typically used in nursing homes and mounted to the wall, do not require sprinklers to be installed in them. Although the units are attached to the finished structure, the standard views those units as pieces of furniture rather than a part of the structure; thus, sprinklers are not required.

A-4-13.11 The installation of open-grid egg crate, louver, or honeycomb ceilings beneath sprinklers restricts the sideways travel of the sprinkler discharge and can change the character of discharge.

A-4-13.12.3 Drop-out ceilings do not provide the required protection for soft-soldered copper joints or other piping that requires protection.

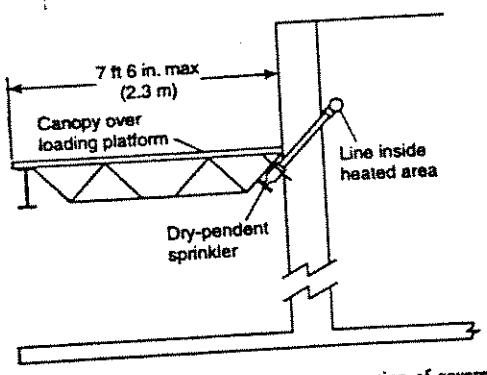


Figure A-4-13.7 Dry-pendent sprinklers for protection of covered platforms, loading docks, and similar areas.

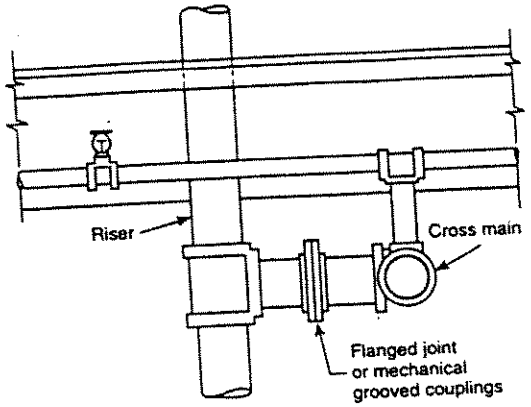


Figure A-4-13.22 One arrangement of flanged joint at sprinkler riser.

A-4-13.12.4 The ceiling tiles might drop before sprinkler operation. Delayed operation might occur because heat must then bank down from the deck above before sprinklers will operate.

A-4-13.13 Exception No. 1. For tests of sprinkler performance in fur vaults see "Fact Finding Report on Automatic Sprinkler Protection for Fur Storage Vaults" of Underwriters Laboratories Inc., dated November 25, 1947.

Sprinklers should be listed old-style having orifice sizes selected to provide as closely as possible but not less than 20 gal per min (76 L/min) per sprinkler, for four sprinklers, based on the water pressure available.

Sprinklers in fur storage vaults should be located centrally over the aisles between racks and shall be spaced not over 5 ft (1.5 m) apart along the aisles.

Where sprinklers are spaced 5 ft (1.5 m) apart along the sprinkler branch lines, pipe sizes should be in accordance with the following schedule:

1 in. (25.4 mm)	4 sprinklers	2 in. (50.8 mm)	20 sprinklers
1¼ in. (31.7 mm)	6 sprinklers	2 ½ in. (63.5 mm)	40 sprinklers
1½ in. (38.1 mm)	10 sprinklers	3 in. (76.2 mm)	80 sprinklers

A-4-13.20 One-and-one-half (1½) in. hose connections for use in storage occupancies and other locations where standpipe systems are not required are covered by this standard. Where Class II standpipe systems are required, see the appropriate provisions of NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, with respect to hose stations and water supply for hose connections from sprinkler systems.

A-4-13.21 Combined automatic sprinkler and standpipe risers should not be interconnected by sprinkler system piping.

A-4-13.22 See Figure A-4-13.22.

A-4-14.1.1 See Figure A-4-14.1.1.

A-4-14.1.1.1 A water supply connection should not extend into a building or through a building wall unless such connection is under the control of an outside listed indicating valve or an inside listed indicating valve located near the outside wall of the building.

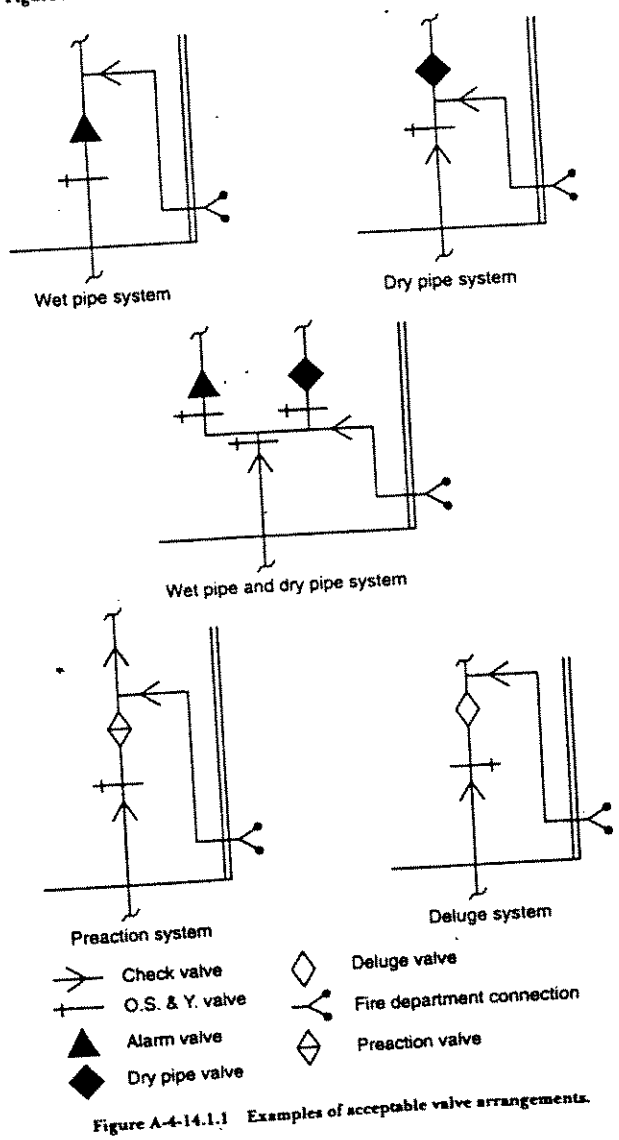


Figure A-4-14.1.1 Examples of acceptable valve arrangements.

All valves controlling water supplies for sprinkler systems or portions thereof, including floor control valves, should be accessible to authorized persons during emergencies. Permanent ladders, clamped treads on risers, chain-operated hand wheels, or other accepted means should be provided where necessary.

Outside control valves are suggested in the following order of preference:

(a) Listed indicating valves at each connection into the building at least 40 ft (12.2 m) from buildings if space permits.

(b) Control valves installed in a cutoff stair tower or valve room accessible from outside.

(c) Valves located in risers with indicating posts arranged for outside operation.

(d) Key-operated valves in each connection into the building.

A-4-14.1.1.7 Where a system having only one dry pipe valve is supplied with city water and fire department connection, it will be satisfactory to install the main check valve in the water supply connection immediately inside of the building. In instances where there is no outside control valve, the system indicating valve should be placed at the service flange, on the supply side of all fittings.

A-4-14.1.1.8 See Figure A-4-14.1.1.8.

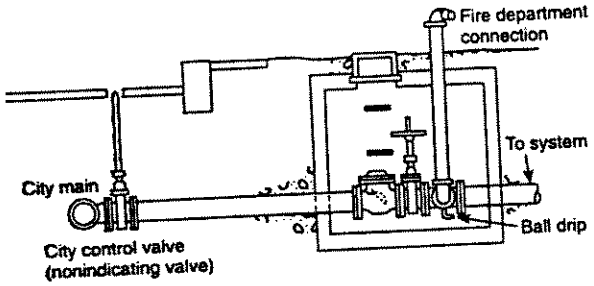


Figure A-4-14.1.1.8 Pit for gate valve, check valve, and fire department connection.

A-4-14.1.2.3 Where the relief valve operation would result in water being discharged onto interior walking or working surfaces, consideration should be given to piping the discharge from the valve to a drain connection or other safe location.

A-4-14.2.2.1 Where copper tube is to be installed in moist areas or other environments conducive to galvanic corrosion, copper hangers or ferrous hangers with an insulating material should be used.

A-4-14.2.3.1 Exception No. 1. See Figure A-4-14.2.3.1 Exception No. 1.

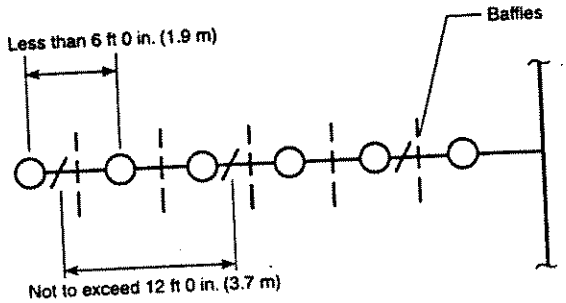


Figure A-4-14.2.3.1 Exception No. 1 Distance between hangers.

A-4-14.2.3.3 Sprinkler piping should be adequately secured to restrict the movement of piping upon sprinkler operation. The reaction forces caused by the flow of water through the sprinkler could result in displacement of the sprinkler, thereby adversely affecting sprinkler discharge. Listed CPVC pipe and listed polybutylene pipe have specific requirements for piping support to include additional pipe bracing of sprinklers. (*See Figure A-4-14.2.3.3.*)

A-4-14.2.3.3 Exception No. 1. See Figure A-4-14.2.3.3 Exception No. 1.

A-4-14.2.3.3 Exception No. 2. See Figure A-4-14.2.3.3 Exception No. 2.

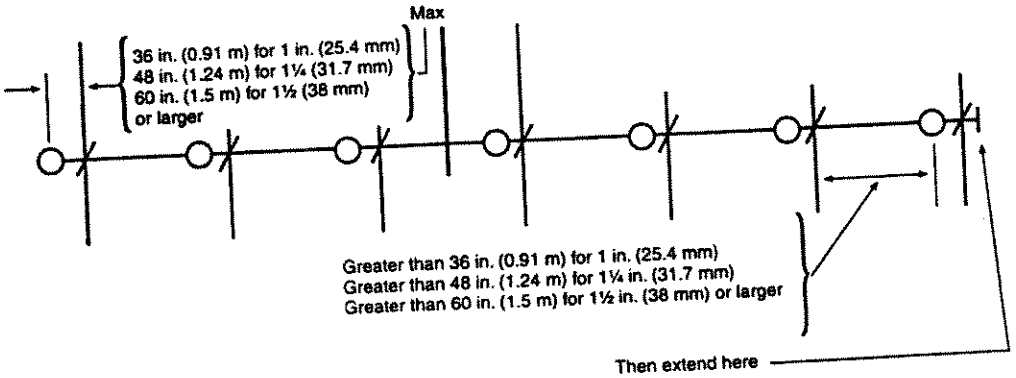


Figure A-4-14.2.3.3 Distance from sprinkler to hanger.

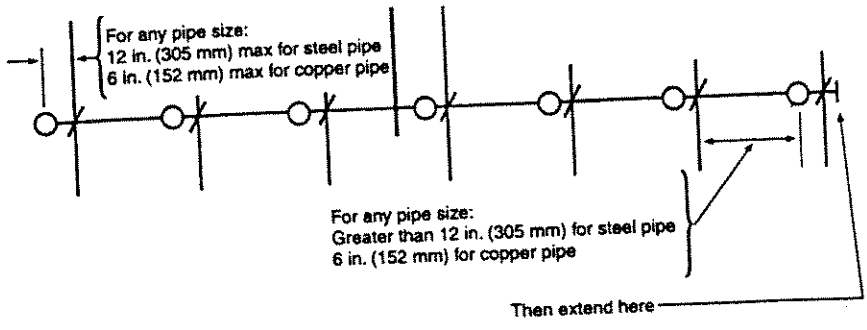
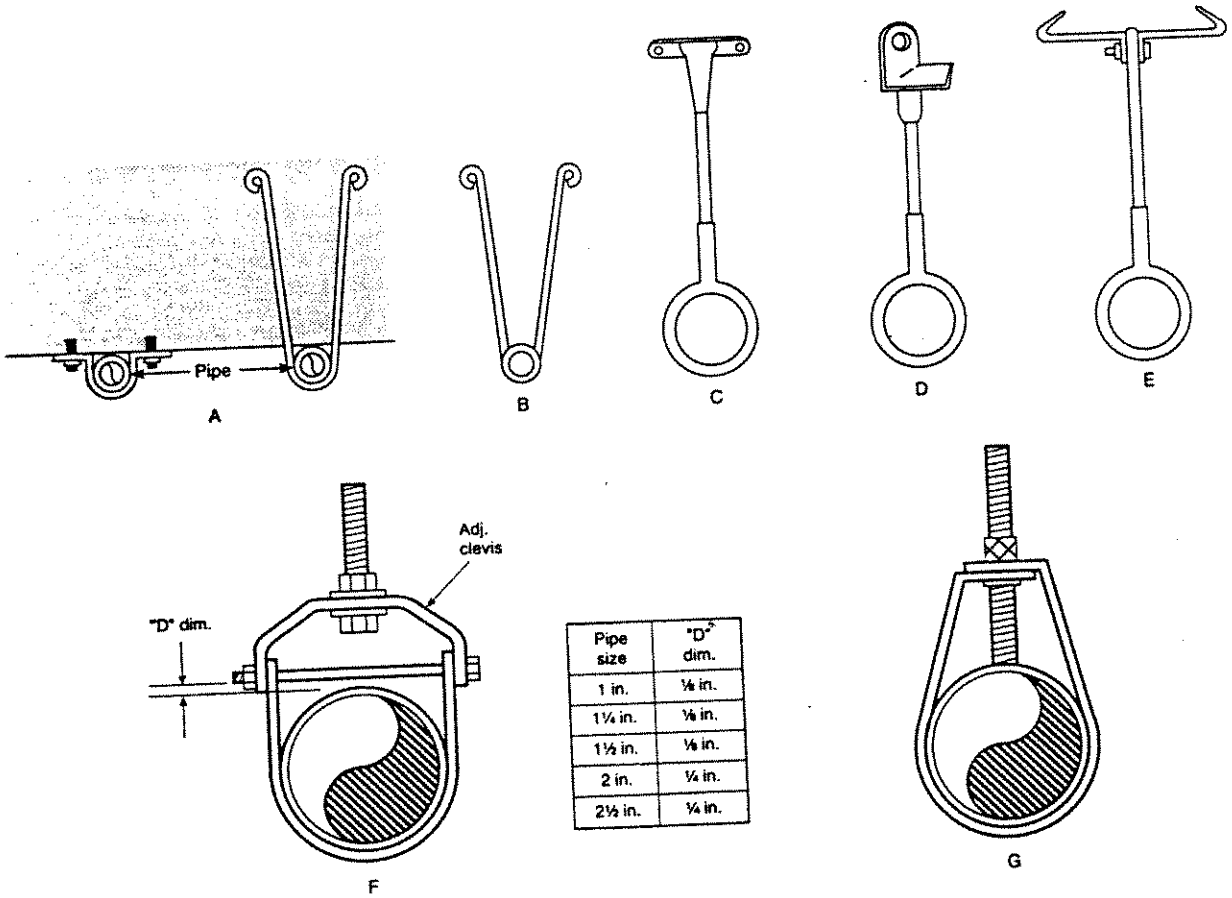


Figure A-4-14.2.3.3 Exception No. 1 Distance from sprinkler to hanger where maximum pressure exceeds 100 psi (6.9 bars) and a branch line above a ceiling supplies pendent sprinklers below the ceiling.



Pipe size	"D" dim.
1 in.	⅛ in.
1¼ in.	⅛ in.
1½ in.	⅛ in.
2 in.	¼ in.
2½ in.	¼ in.

A. U-type hangers for branch lines
B. Wrap-around U-hook
C. Adjustable clip for branch lines
D. Side beam adjustable hanger
E. Adjustable coach screw clip for branch lines
F. Clevis hanger
G. Adjustable swivel loop hanger

Figure A-4-14.2.3.3 Exception No. 2 Examples of acceptable hangers for end of line (or armover) pendent sprinklers.

A-4-14.2.3.4 See Figure A-4-14.2.3.4.

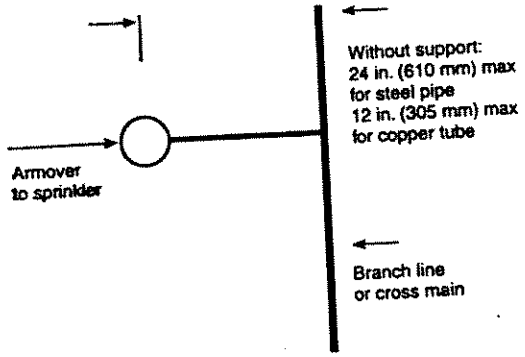
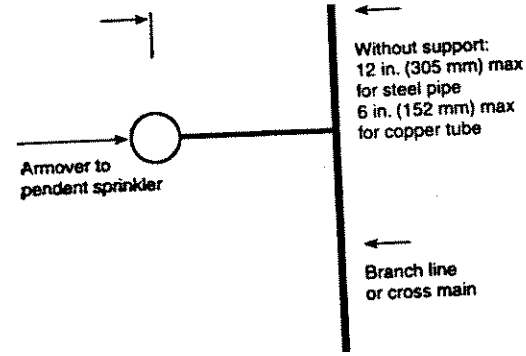


Figure A-4-14.2.3.4 Maximum length for unsupported armover.

A-4-14.2.3.4 Exception See Figure A-4-6.2.3.4 Exception.



Note: The pendent sprinkler may be installed either directly in the fitting at the end of the armover or in a fitting at the bottom of a drop nipple.

Figure A-4-14.2.3.4 Exception Maximum length of unsupported armover where the maximum pressure exceeds 100 psi (6.9 bars) and a branch line above a ceiling supplies pendent sprinklers below the ceiling.

A-4-14.3.1 All piping should be arranged where practicable to drain to the main drain valve.

A-4-14.3.5.2.3 An example of an accessible location would be a valve located approximately 7 ft (2 m) above the floor level to which a hose could be connected to discharge the water in an acceptable manner.

A-4-14.3.6.1 Where possible, the main sprinkler riser drain should discharge outside the building at a point free from the possibility of causing water damage. Where it is not possible to discharge outside the building wall, the drain should be piped to a sump, which in turn should discharge by gravity or be pumped to a waste water drain or sewer. The main sprinkler riser drain connection should be of a size sufficient to carry off water from the fully open drain valve while it is discharging under normal water system pressures. Where this is not possible, a supplementary drain of equal size should be provided for test purposes with free discharge, located at or above grade.

A-4-14.4.2.1 Types of locations where corrosive conditions can exist include bleacheries, dye houses, metal plating processes, animal pens, and certain chemical plants.

If corrosive conditions are not of great intensity and humidity is not abnormally high, good results can be obtained by a protective coating of red lead and varnish or by a good grade of commercial acid-resisting paint. The paint manufacturer's instructions should be followed in the preparation of the surface and in the method of application.

Where moisture conditions are severe but corrosive conditions are not of great intensity, copper tube or galvanized steel pipe, fittings, and hangers might be suitable. The exposed threads of steel pipe should be painted.

In instances where the piping is not readily accessible and where the exposure to corrosive fumes is severe, either a protective coating of high quality can be employed or some form of corrosion-resistant material used.

A-4-14.4.3.1 Sprinkler systems are protected against earthquake damage by means of the following:

(a) Stresses that would develop in the piping due to differential building movement are minimized through the use of flexible joints or clearances.

(b) Bracing is used to keep the piping fairly rigid when supported from a building component expected to move as a unit, such as a ceiling.

Areas known to have a potential for earthquakes have been identified in building code and insurance maps. Examples of two such maps are shown in Figures A-4-14.4.3.1(a) and A-4-14.4.3.1(b).

A-4-14.4.3.2 Strains on sprinkler piping can be greatly lessened and, in many cases, damage prevented by increasing the flexibility between major parts of the sprinkler system. One part of the piping should never be held rigidly and another part allowed to move freely without provision for relieving the strain. Flexibility can be provided by using listed flexible couplings, by joining grooved end pipe at critical points, and by allowing clearances at walls and floors.

Tank or pump risers should be treated the same as sprinkler risers for their portion within a building. The discharge pipe of tanks on buildings should have a control valve above the roof line so any pipe break within the building can be controlled.

Piping 2 in. (50 mm) or smaller in size is pliable enough so that flexible couplings are not usually necessary. "Rigid-type" couplings that permit less than 1 degree of angular movement at the grooved connections are not considered to be flexible couplings. [*See Figures A-4-14.4.3.2(a) and (b).*]

A-4-14.4.3.2(d) A building expansion joint is usually a bituminous fiber strip used to separate blocks or units of concrete to prevent cracking due to expansion as a result of temperature changes. In this case, the flexible coupling required on one side by 4-14.4.3.2(d) will suffice.

For seismic separation joints, considerably more flexibility is needed, particularly for piping above the first floor. Figure A-4-14.4.3.3 shows a method of providing additional flexibility through the use of swing joints.

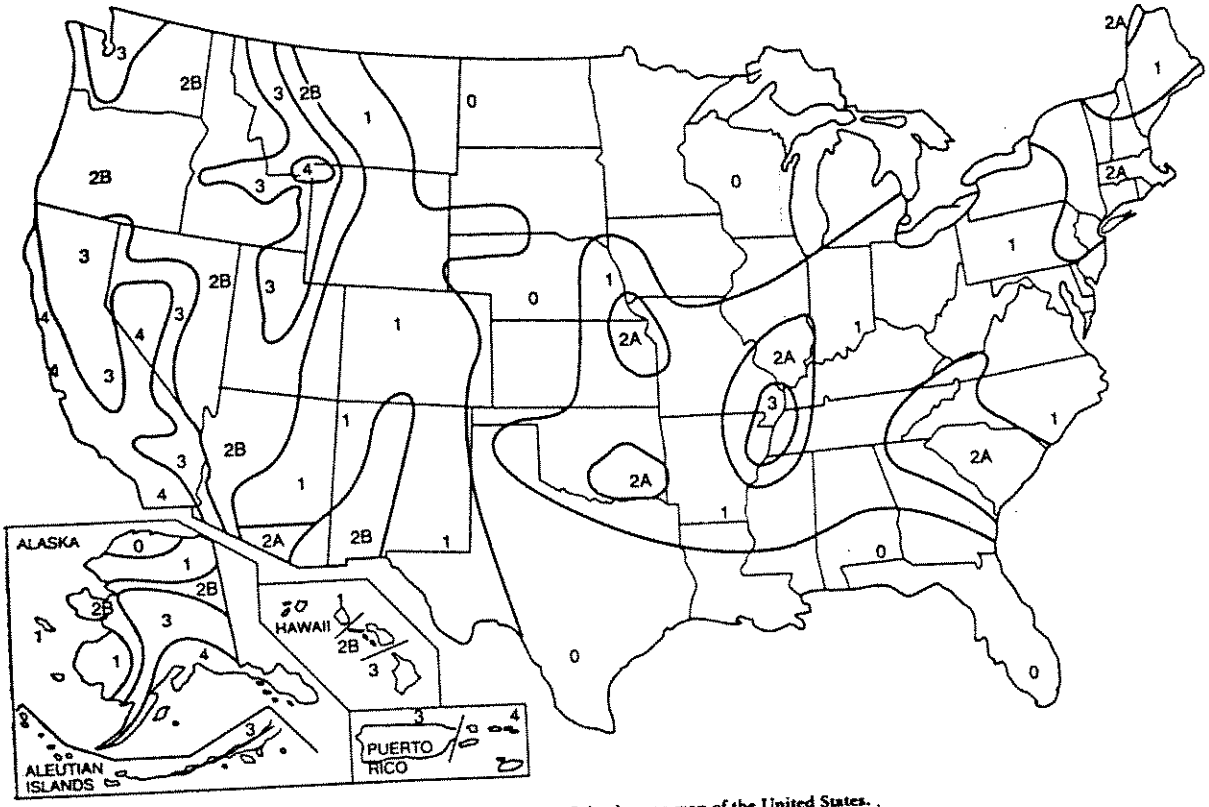


Figure A-4-14.4.3.1(a) Seismic zone map of the United States.

A-4-14.4.3.3 Plan and elevation views of a seismic separation assembly assembled with flexible elbows are shown in Figure A-4-14.4.3.3.

A seismic separation assembly is considered to be an assembly of fittings, pipe, and couplings or an assembly of pipe and couplings that permits movement in all directions. The extent of permitted movement should be sufficient to accommodate calculated differential motions during earthquakes. In lieu of calculations, permitted movement can be made at least twice the actual separations, at right angles to the separation as well as parallel to it.

A-4-14.4.3.4 While clearances are necessary around the sprinkler piping to prevent breakage due to building movement, suitable provision should also be made to prevent passage of water, smoke, or fire.

Drains, fire department connections, and other auxiliary piping connected to risers should not be cemented into walls or floors; similarly, pipes that pass horizontally through walls or foundations should not be cemented solidly or strains will accumulate at such points.

Where risers or lengths of pipe extend through suspended ceilings, they should not be fastened to the ceiling framing members.

A-4-14.4.3.5.2 Exception. The investigation of tension only bracing using materials, connection methods, or both, other than those described in Table 4-14.4.3.5.5 should involve consideration of:

(a) Corrosion resistance.

(b) Prestretching to eliminate permanent construction stretch and to obtain a verifiable modulus of elasticity.

(c) Color coding of each different size cable for field verification.

(d) The capacity of all components of the brace assemblies, including the field connections, to maintain the manufacturer's minimum certified break strength.

(e) Manufacturer's published design data sheets/manual showing product design guidelines, including connection details, load calculation procedures for sizing of braces, and the maximum recommended horizontal load-carrying capacity of the brace assemblies including the associated fasteners as described in Table 4-14.4.3.5.6. The maximum allowable horizontal loads shall not exceed the manufacturer's minimum certified break strength of the brace assemblies, excluding fasteners, after taking a safety factor of 1.5 and then adjusting for the brace angle.

(f) Brace product shipments accompanied by the manufacturer's certification of the minimum break strength, and prestretching and installation instructions.

(g) The manufacturer's literature, including any special tools or precautions required to ensure proper installation.

(h) The installation should include a means to prevent vertical motion due to seismic forces.

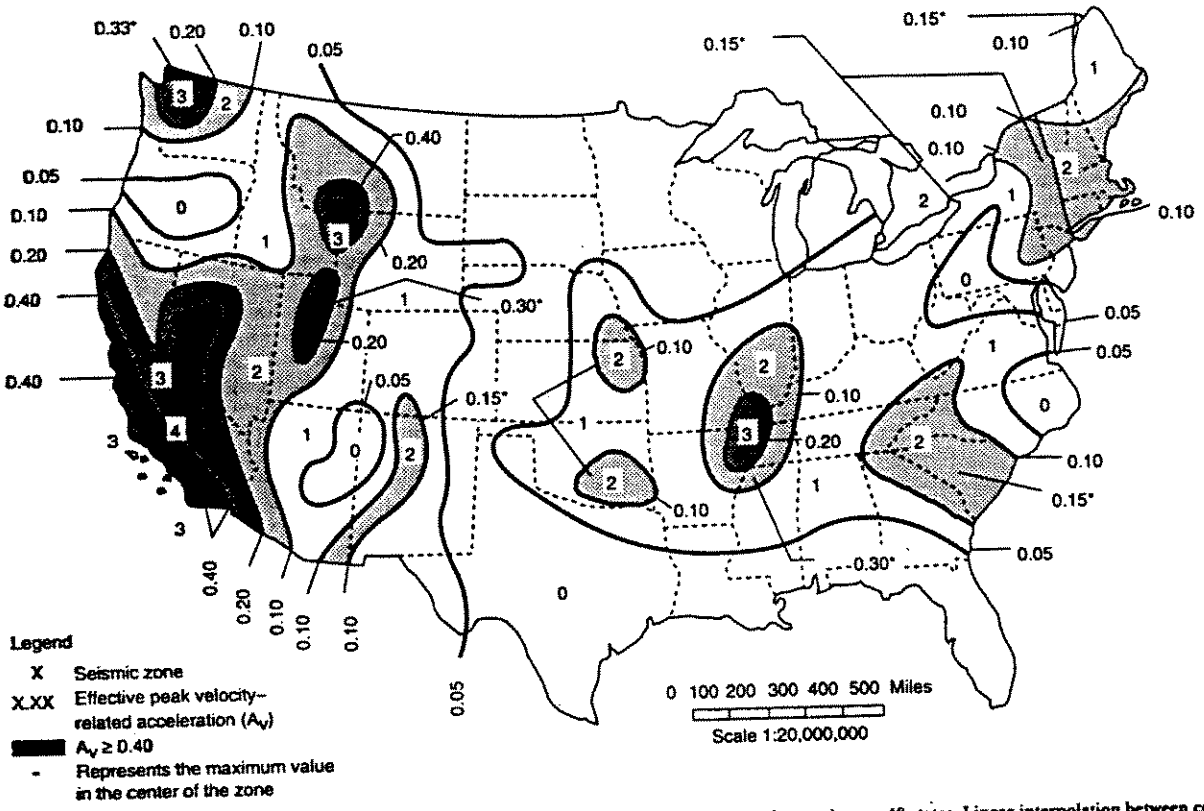
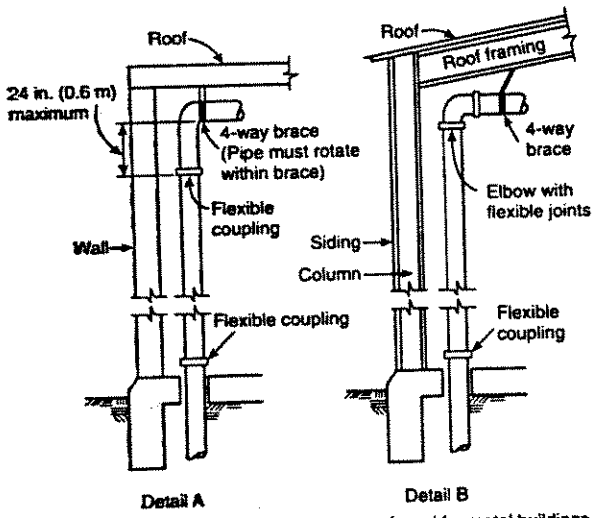


Figure A-4-14.4.3.1(b) Map of seismic zones and effective peak velocity-related acceleration (A_V) for contiguous 48 states. Linear interpolation between contours is acceptable.



Note to Detail A: The four-way brace should be attached above the upper flexible coupling required for the riser and preferably to the roof structure if suitable. The brace should not be attached directly to a plywood or metal deck.

Figure A-4-14.4.3.2(a) Riser details.

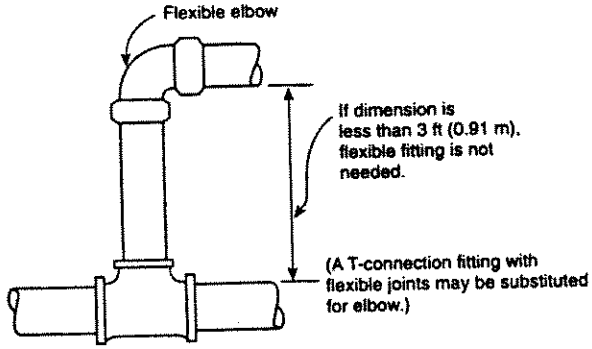


Figure A-4-14.4.3.2(b) Detail at short riser.

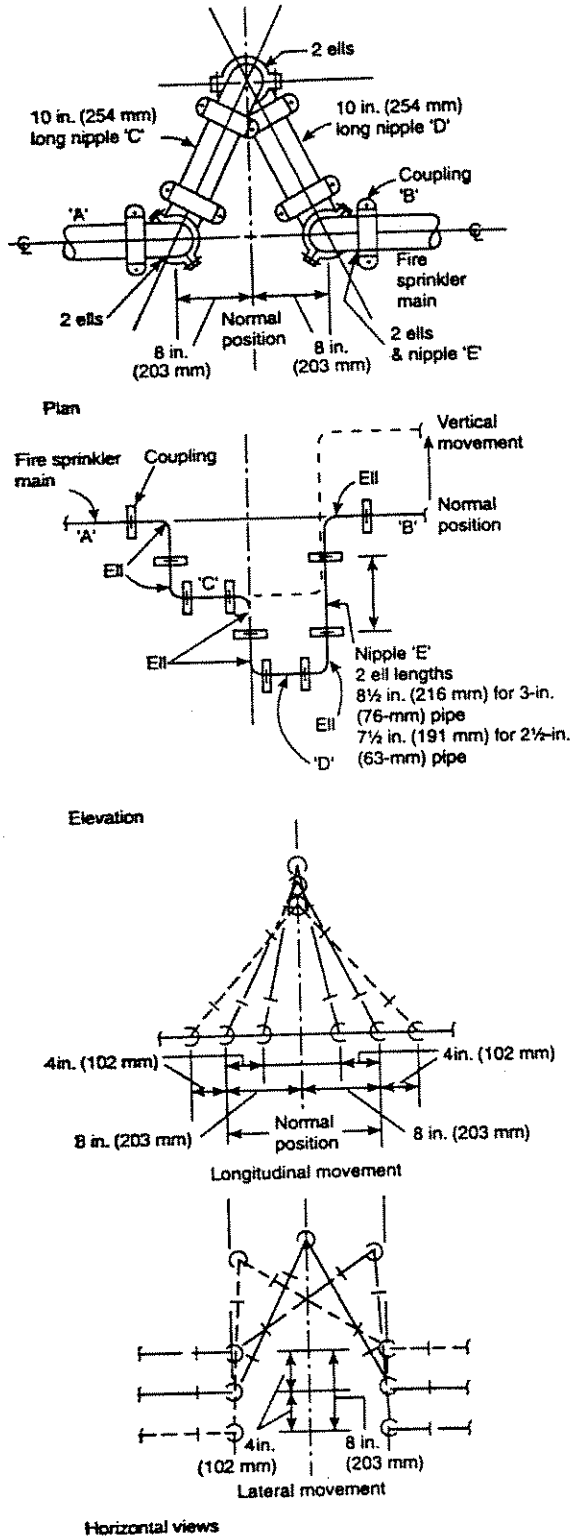


Figure A-4-14.4.3.3 Seismic separation assembly. Illustrates an 8-in. (203-mm) separation crossed by pipes up to 4 in. (102 mm) in nominal diameter. For other separation distances and pipe sizes, lengths and distances should be modified proportionally.

Table A-4-14.4.3.5.2 Exception Specially Listed Tension Only Seismic Bracing

Materials and Dimensions	Standard
Manual for Structural Application of Steel Cables	AISI
Wire Rope Users Manual of the Wire Rope Technical Board	AISI
Mechanical Strength Requirements	ASTM A 603
Breaking Strength Failure Testing	ASTM E 8

A-4-14.4.3.5.3 Location of Sway Bracing. Two-way braces are either longitudinal or lateral depending on their orientation with the axis of the piping. [*See Figures A-4-14.4.3.5.3(a), (b), (c), and (d).*] The simplest form of two-way brace is a piece of steel pipe or angle. Because the brace must act in both compression and tension, it is necessary to size the brace to prevent buckling.

An important aspect of sway bracing is its location. In Building 1 of Figure A-4-14.4.3.5.3(a), the relatively heavy main will pull on the branch lines when shaking occurs. If the branch lines are held rigidly to the roof or floor above, the fittings can fracture due to the induced stresses.

Bracing should be on the main as indicated at Location B. With shaking in the direction of the arrows, the light branch lines will be held at the fittings. Where necessary, a lateral brace or other restraint should be installed to prevent a branch line from striking against building components or equipment.

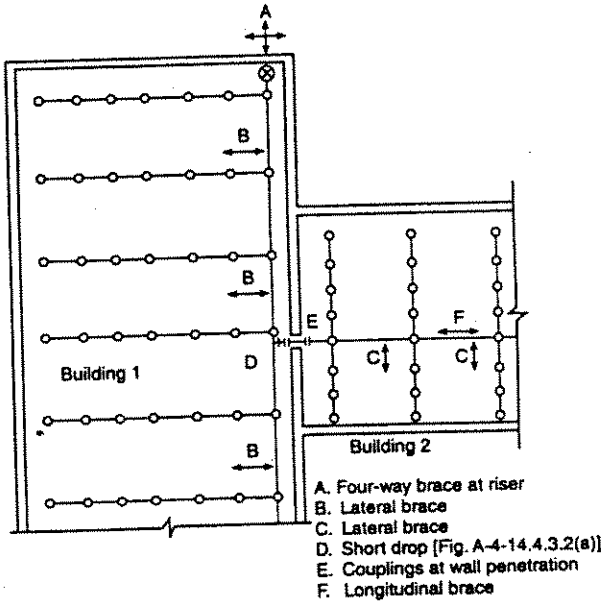


Figure A-4-14.4.3.5.3(a) Earthquake protection for sprinkler piping.

A four-way brace is indicated at Location A. This keeps the riser and main lined up and also prevents the main from shifting.

In Building 1, the branch lines are flexible in a direction parallel to the main, regardless of building movement. The heavy main cannot shift under the roof or floor, and it also steadies the branch lines. While the main is braced, the flexible couplings on the riser allow the sprinkler system to move with the floor or roof above, relative to the floor below.

Figures A-4-14.4.3.5.3(b), (c), and (d) show typical locations of sway bracing.

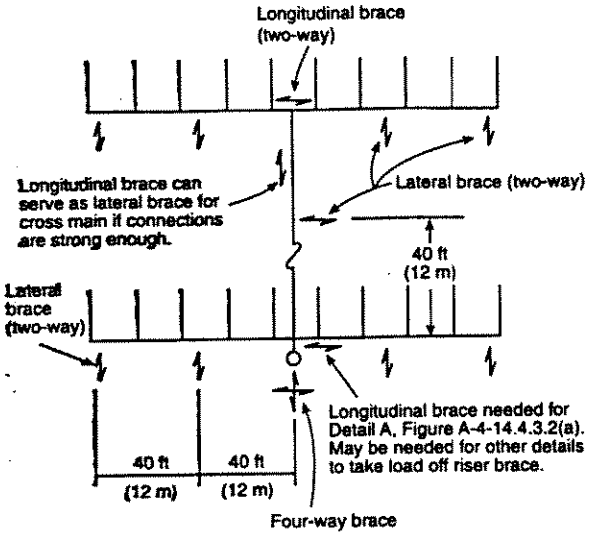


Figure A-4-14.4.3.5.3(b) Typical location of bracing on a tree system.

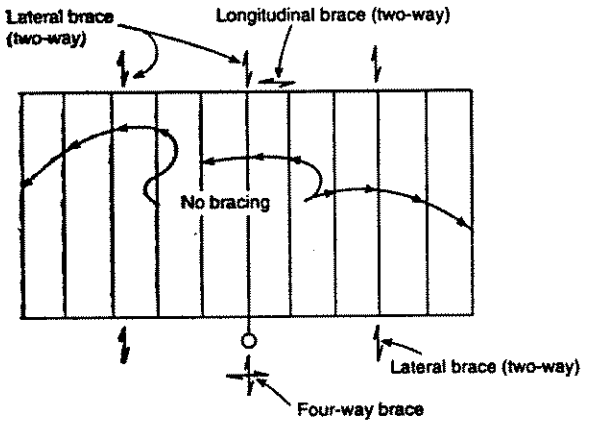


Figure A-4-14.4.3.5.3(c) Typical location of bracing on a gridded system.

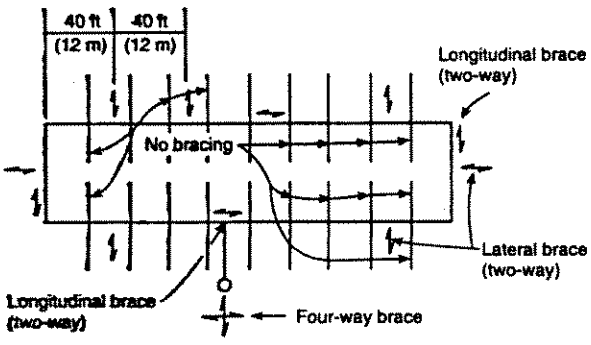


Figure A-4-14.4.3.5.3(d) Typical location of bracing on a looped system.

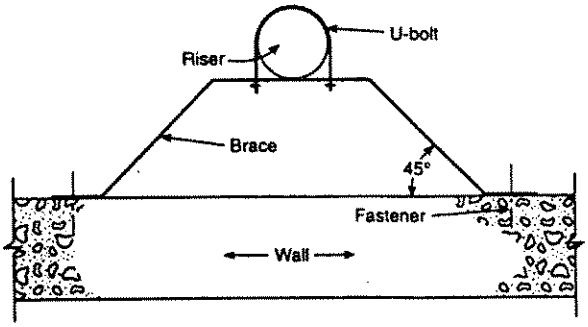


Figure A-4-14.4.3.5.3(e) Detail of four-way brace at riser.

Listed devices permitting connection of braces to both the pipe and the building structure are available and are recommended. However, alternate means of attachment capable of handling the expected loads are acceptable.

Connection of the brace to the pipe can be made with a pipe clamp or U-bolt. One bolt of the pipe clamp can pass through a flattened end of pipe or one leg of an angle. (The other leg and filet of the angle can be cut away.) Pipe rings should be avoided because they result in a loose fit. Once the pipe is able to vibrate within a loose fitting, the bolts in the ring assembly can be fractured.

The brace can be attached to the structural system directly through a leg of an angle or a flattened portion of pipe. Figures A-4-14.4.3.5.3(e) and (f) show acceptable connections. Where dimensions are tight or some play must be allowed, a special fitting can be used. [*See Figure A-4-14.4.3.5.3(g).*] This threads on an end of pipe. Rotation of the flat around the bolt allows play in the angle of the brace without sacrificing snugness.

Some adjustment can be provided in a pipe brace by use of a left-hand/right-hand coupling. For all threaded connections, sight holes or other means should be provided to permit indication that sufficient thread is engaged.

To properly size and space braces, it is necessary to employ the following steps:

(a) Based on the distance of mains from the structural members that will support the braces, choose brace shapes and sizes from Table 4-14.4.3.5.5 such that the maximum slenderness ratios l/r do not exceed 300. The angle of the braces from the vertical should be at least 30 degrees and preferably 45 degrees or more.

(b) Tentatively space lateral braces at 40-ft (12-m) maximum distances along mains and tentatively space longitudinal braces at 80-ft (24-m) maximum distances along mains. Lateral braces should meet the piping at right angles, and longitudinal braces should be aligned with the piping.

(c) Determine the total load tentatively applied to each brace in accordance with the examples shown in Figure A-4-14.4.3.5.3(h) and the following:

1. For the loads on lateral braces on cross mains, add one-half the weight of the branch to one-half the weight of the portion of the cross main within the zone of influence of the brace. [*See examples 1, 3, 6, and 7 in Figure A-4-14.4.3.5.3(h).*]

2. For the loads on longitudinal braces on cross mains, consider only one-half the weight of the cross mains and feed mains within the zone of influence. Branch lines need not be included. (*See examples 2, 4, 5, 7, and 8.*)

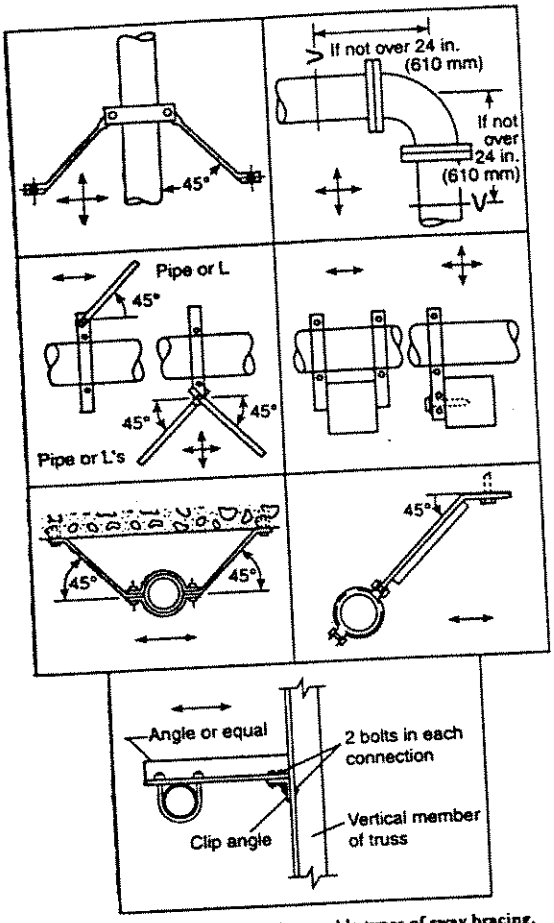


Figure A-4-14.4.3.5.3(f) Acceptable types of sway bracing.

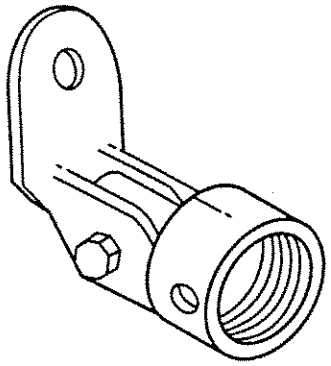


Figure A-4-14.4.3.5.3(g) Special fitting.

3. For the four-way brace at the riser, add the longitudinal and lateral loads within the zone of influence of the brace. [*See examples 2, 3, and 5 in Figure A-4-14.4.3.5.3(h).*]

Use the information on weights of water-filled piping contained within Table A-4-14.4.3.5.3.

(d) If the total expected loads are less than the maximums permitted in Table 4-14.4.3.5.5 for the particular brace and orientation, go on to step (e). If not, add additional braces to reduce the zones of influence of overloaded braces.

(e) Check that fasteners connecting the braces to structural supporting members are adequate to support the expected loads on the braces in accordance with Table 4-14.4.3.5.6. If not, again add additional braces or additional means of support.

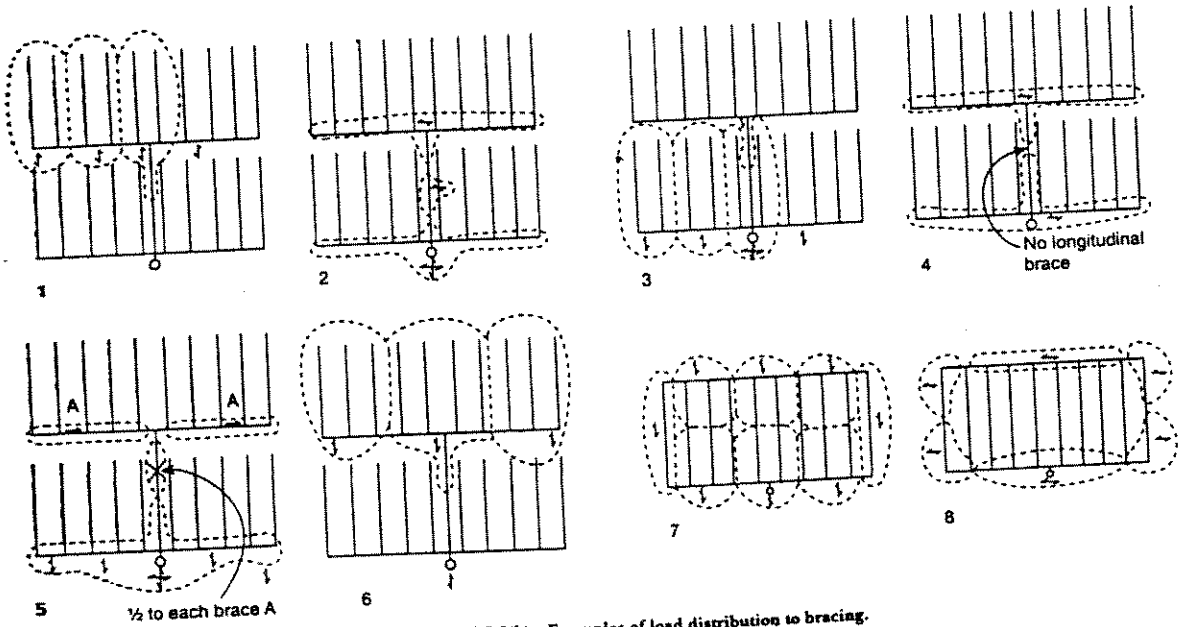


Figure A-4-14.4.3.5.3(h) Examples of load distribution to bracing.

Table A-4-14.4.3.5.3 Piping Weights for Determining Horizontal Load

Schedule 40 Pipe (in.)	Weight of Water-Filled Pipe (lb per ft)	½ Weight of Water-Filled Pipe (lb per ft)
1	2.05	1.03
1¼	2.93	1.47
1½	3.61	1.81
2	5.13	2.57
2½	7.89	3.95
3	10.82	5.41
3½	13.48	6.74
4	16.40	8.20
5	23.47	11.74
6	31.69	15.85
8*	47.70	23.85
Schedule 10 Pipe (in.)		
1	1.81	0.91
1¼	2.52	1.26
1½	3.04	1.52
2	4.22	2.11
2½	5.89	2.95
3	7.94	3.97
3½	9.78	4.89
4	11.78	5.89
5	17.30	8.65
6	23.03	11.52
8	40.08	20.04

For SI Units: 1 in. = 25.4 mm; 1 lb = 0.45 Kg; 1 ft = 0.3048 m.
* Schedule 30.

A-4-14.4.3.5.5 Sway brace members should be continuous. Where necessary, splices in sway bracing members should be designed and constructed to insure that brace integrity is maintained.

A-4-14.4.3.5.6 The criteria in Table 4-14.4.3.5.6 are based upon the use of a shield-type expansion anchor. Use of other anchors in concrete should be in accordance with the listing provisions of the anchor.

Current fasteners for anchoring to concrete are referred to as expansion anchors. Expansion anchors come in two types. Deformation-controlled anchors are set by driving a plug into the expansion port in the anchor or driving the anchor over a plug that expands the end of the anchor into the concrete. Torque-controlled expansion anchors are set by applying a torque to the anchor, usually to a nut, which causes the expansion sleeves to be pressed against the wall of the drilled hole.

Consideration should be given with respect to the position near the edge of the concrete and to the type of bolts used in conjunction with the anchors.

A-4-14.4.3.5.9 The four-way brace provided at the riser may also provide longitudinal and lateral bracing for adjacent mains.

A-4-14.4.3.5.13 Wires used for piping restraints should be attached to the branch line with two tight turns around the pipe, and fastened with four tight turns within 1½ in. (37.5 mm), and should be attached to the structure in accordance with the details shown in Figures A-4-14.4.3.5.13(a) through (d) or other approved method.

A-4-14.4.3.5.13 Exception No. 2. The splayed seismic wire should be provided as close as possible to the hanger.

A-4-14.4.3.5.15 Such restraint can be provided by using the splayed seismic brace wire discussed in A-4-14.4.3.5.13 Exception No. 2.

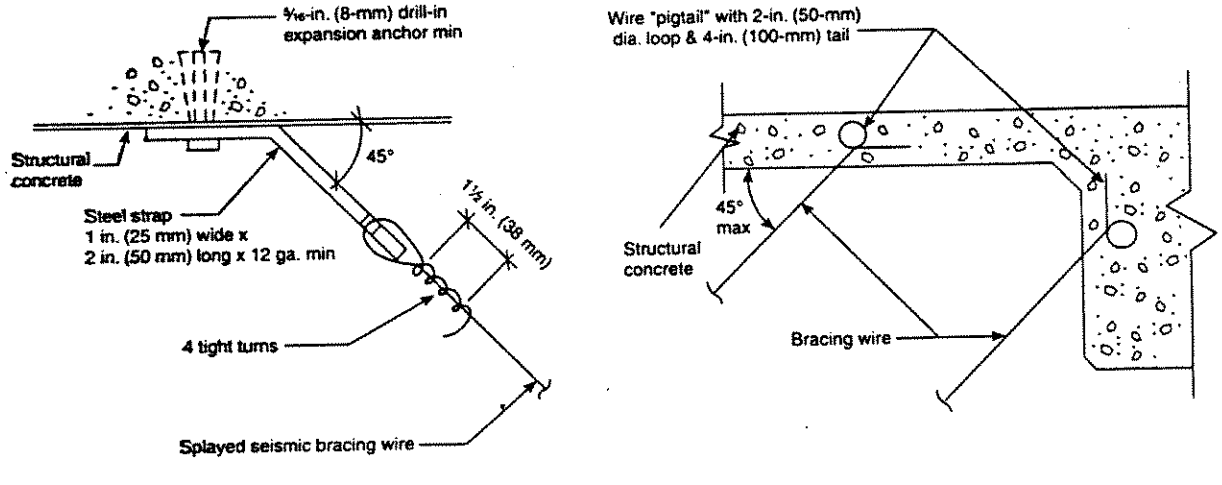
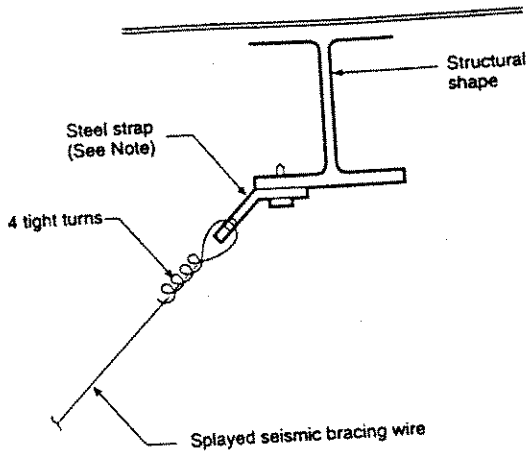
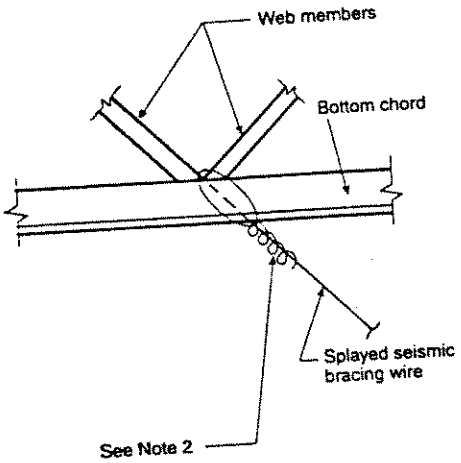


Figure A-4-14.4.3.5.13(a) Wire attachment to cast-in-place concrete.



Note: See Figure A-4-14.4.3.5.13(a), Detail (B).

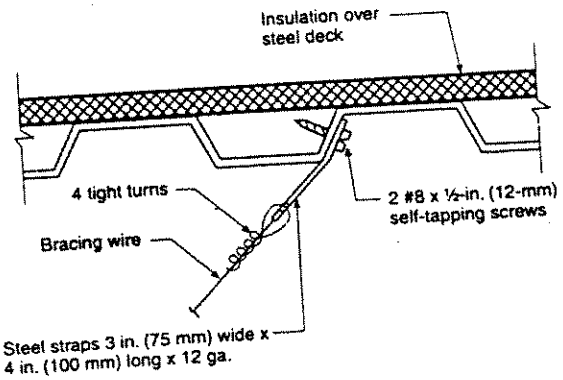
Detail (A) At steel beams



Note 1: Splay wires parallel to joist. Splay wires cannot be perpendicular to joist.

Note 2: See Figure A-4-14.4.3.5.13(a), Details (A) and (B).

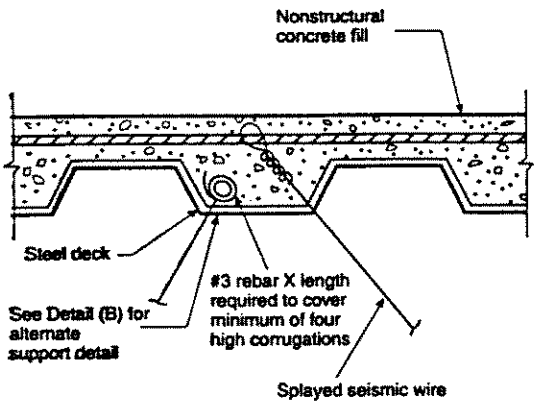
Detail (B) At open web steel joist



Note: If self-tapping screws are used with concrete fill, set screws before placing concrete.

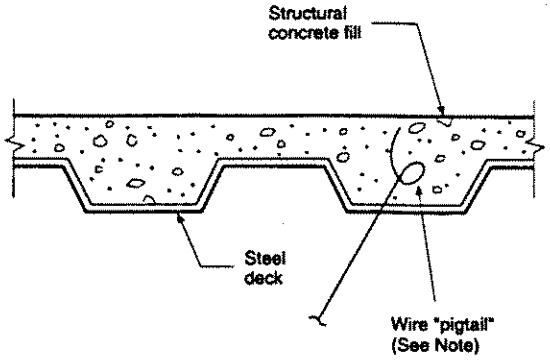
Detail (C) At steel roof deck

Figure A-4-14.4.3.5.13(b) Acceptable details—wire connections to steel framing.



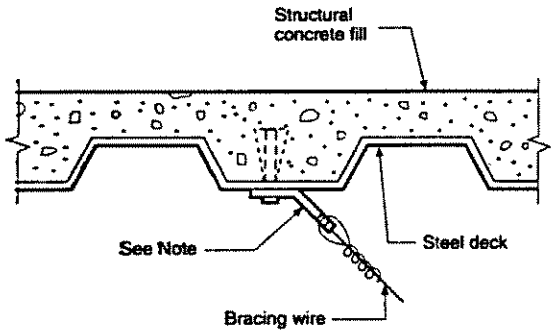
Note: Bracing wire detail similar.

Detail (A) At steel deck with insulating fill



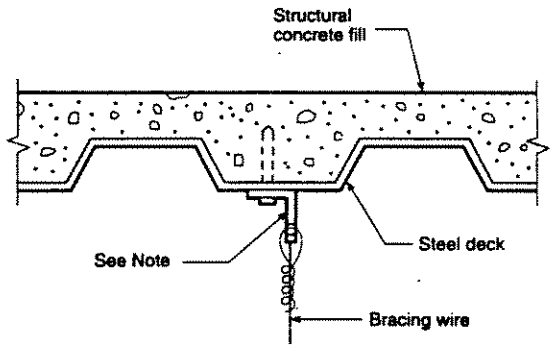
Note: See Figure A-4-14.4.3.5.13(a), Detail (B).

Detail (B) At steel deck with concrete fill



Note: See Figure A-4-14.4.3.5.13(a), Detail (B).

Detail (C) At steel deck with concrete fill

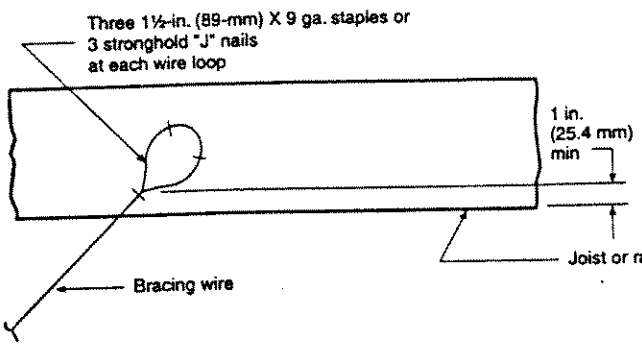


Note: See Figure A-4-14.4.3.5.13(a), Detail (A).

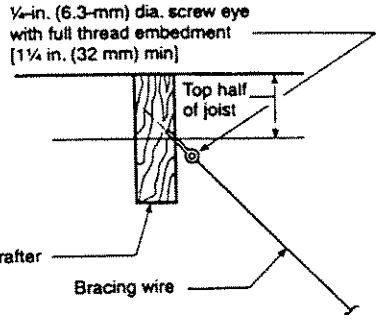
Detail (D) At steel deck with concrete fill

For SI units: 1 in. = 25.4 mm.
Note: If self-tapping screws are used with concrete fill, set screws before placing concrete.

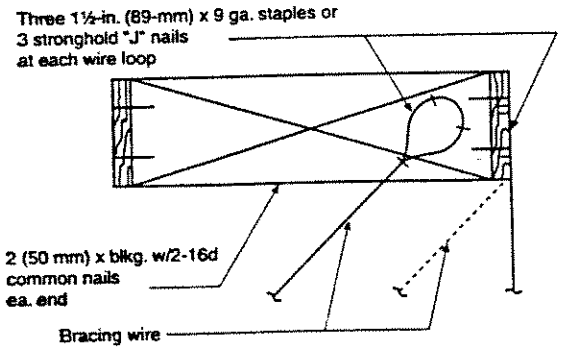
Figure A-4-14.4.3.5.13(c) Acceptable details — wire connections to steel framing.



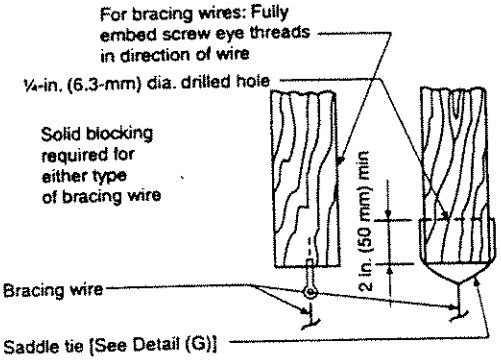
Detail (A) Wood joist or rafter



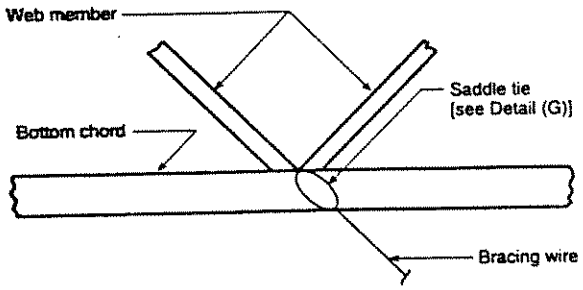
Detail (B) At wood joist or rafter



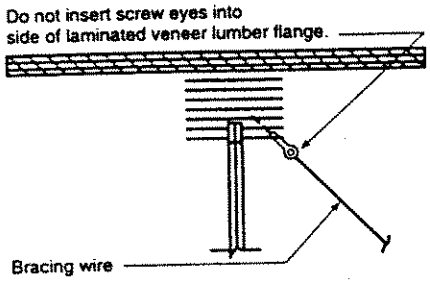
Detail (C) At wood joist or block



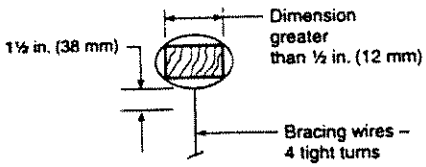
Detail (D) To bottom of joist



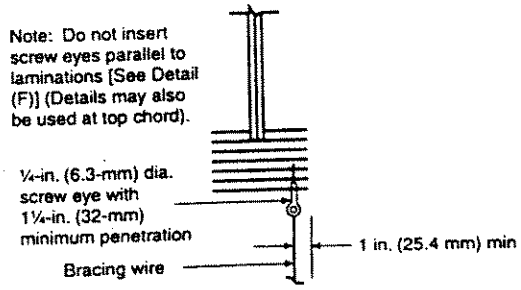
Detail (E) Bracing wire parallel to wood truss



Detail (F) Laminated veneer lumber upper flange



Detail (G) Typ. saddle tie



(H) Laminated veneer lumber lower flange

Figure A-4-14.4.3.5.13(d) Acceptable details — wire connections to wood framing.

A-4-15.1.1 Central station, auxiliary, remote station, or proprietary protective signaling systems are a highly desirable supplement to local alarms, especially from a safety to life standpoint. (*See 4-15.1.1.6.*)

Identification Signs. Approved identification signs, as shown in Figure A-4-15.1.1, should be provided for outside alarm devices. The sign should be located near the device in a conspicuous position and should be worded as follows:

"SPRINKLER FIRE ALARM — WHEN BELL RINGS CALL FIRE DEPARTMENT OR POLICE."

Figure A-4-15.1.1 Identification sign.

A-4-15.1.1.5 Water-motor-operated devices should be located as near as practicable to the alarm valve, dry pipe valve, or other waterflow detecting device. The total length of the pipe to these devices should not exceed 75 ft (22.9 m), nor should the water-motor-operated device be located over 20 ft (6.1 m) above the alarm device or dry pipe valve.

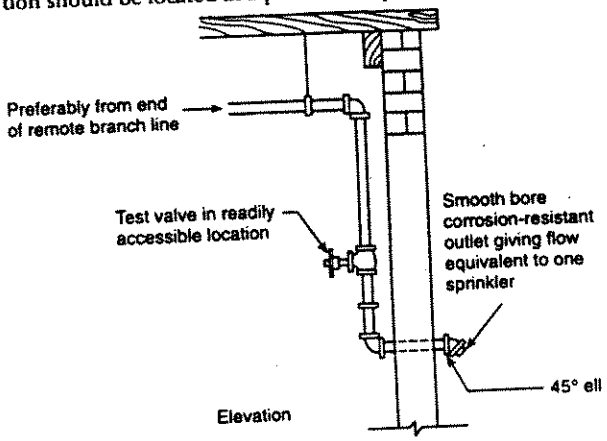
A-4-15.1.1.6 Monitoring should include but not be limited to control valves, building temperatures, fire pump power supplies and running conditions, and water tank levels and temperatures. Pressure supervision should also be provided on pressure tanks.

A-4-15.2 The fire department connection should be located not less than 18 in. (457 mm) and not more than 4 ft (1.22 m) above the level of the adjacent grade or access level.

A-4-15.2.1 Fire department connections should be located and arranged so that hose lines can be readily and conveniently attached without interference from nearby objects including buildings, fences, posts, or other fire department connections. Where a hydrant is not available, other water supply sources such as a natural body of water, a tank, or reservoir should be utilized. The water authority should be consulted when a nonpotable water supply is proposed as a suction source for the fire department.

A-4-15.2.3 The check valve should be located to maximize accessibility and minimize freezing potential.

A-4-15.4.2 This test connection should be in the upper story, and the connection preferably should be piped from the end of the most remote branch line. The discharge should be at a point where it can be readily observed. In locations where it is not practical to terminate the test connection outside the building, the test connection is permitted to terminate into a drain capable of accepting full flow under system pressure. In this event, the test connection should be made using an approved sight test connection containing a smooth bore corrosion-resistant orifice giving a flow equivalent to one sprinkler simulating the least flow from an individual sprinkler in the system. [*See Figures A-4-15.4.2(a) and A-4-15.4.2(b).*] The test valve should be located at an accessible point and preferably not over 7 ft (2.1 m) above the floor. The control valve on the test connection should be located at a point not exposed to freezing.



Note: Not less than 4 ft (1.2 m) of exposed test pipe in warm room beyond valve where pipe extends through wall to outside.

Figure A-4-15.4.2(a) System test connection on wet pipe system.

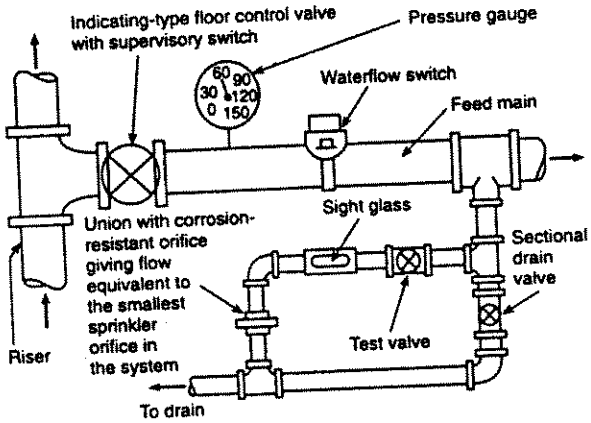
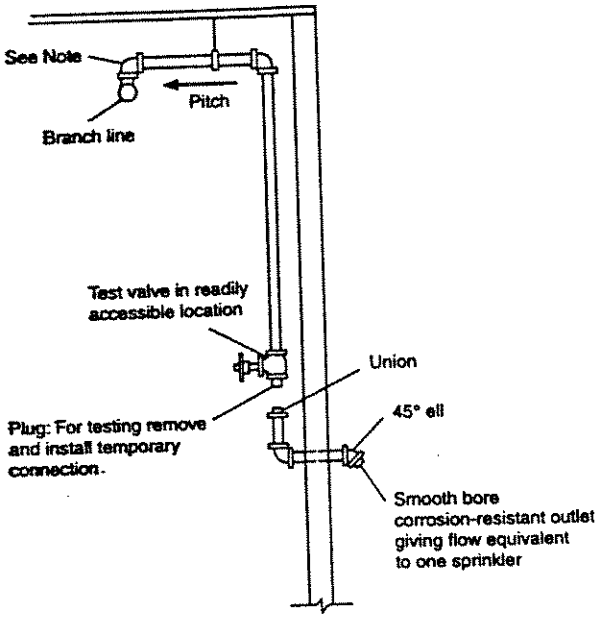


Figure A-4-15.4.2(b) Floor control valve.

A-4-15.4.3 See Figure A-4-15.4.3.

A-4-15.4.6.2 The full flow test of the backflow prevention valve can be performed with a test header or other connection downstream of the valve. A bypass around the check valve in the fire department connector line with a control valve in the normally closed position can be an acceptable arrangement. When flow to a visible drain cannot be accomplished, closed loop flow can be acceptable if a flow meter or site glass is incorporated into the system to ensure flow.

A-5-2.1.3 When renovations occur in an existing building and no changes are made in the existing sprinkler system, it is not intended to require the replacement of existing standard sprinklers with quick-response sprinklers.



Note: To minimize condensation of water in the drop to the test connection, provide a nipple-up off of the branch line.

Figure A-4-15.4.3 System test connection on dry pipe system.

A-5-2.2.3 The additional pressure that is needed at the level of the water supply to account for sprinkler elevation is 0.433 psi per ft (9.8 kPa/m) of elevation above the water supply. When backflow prevention valves are installed on pipe schedule systems, the friction losses of the device must be accounted for when determining acceptable residual pressure at the top level of sprinklers. The friction loss (in psi) should be added to the elevation loss and the residual pressure at the top row of sprinklers to determine the total pressure needed at the water supply.

A-5-2.3.1.1 Appropriate area/density, other design criteria, and water supply requirements should be based on scientifically based engineering analyses that may include submitted fire testing, calculations, or results from appropriate computational models.

A-5-2.3.1.3(b) This section is included to compensate for possible delay in operation of sprinklers from fires in combustible concealed spaces found in wood frame, brick veneer, and ordinary construction.

A-5-2.3.1.3(b) Exception No. 2. Composite wood joists are not considered solid wood joists for the purposes of this section. Their web members are too thin and easily penetrated to adequately compartment a fire in an unsprinklered space.

A-5-2.3.1.3(b) Exception No. 3. This exception is intended to apply only when the exposed materials in the space are limited combustible materials or fire retardant treated wood as defined in NFPA 703, *Standard for Fire Retardant Impregnated Wood and Fire Retardant Coatings for Building Materials*.

A-5-2.3.2.3 Exception No. 1. It is not the intent of this exception to restrict the use of quick-response sprinklers in Extra Hazard Occupancies, but rather to indicate that the areas and densities shown in Figure 5-2.3 might not be appropriate for use with quick-response sprinklers in those environments due to a concern with water supplies.

A-5-2.3.3.1 This section allows for calculation of the sprinklers in the largest room, so long as the calculation produces the greatest hydraulic demand among selection of rooms and communicating spaces. For example, in a case where the largest room has 4 sprinklers and a smaller room has 2 sprinklers but communicates through unprotected openings with 3 other rooms, each having 2 sprinklers, the smaller room and group of communicating spaces should also be calculated.

Corridors are rooms and should be considered as such.

Walls can terminate at a substantial suspended ceiling and need not be extended to a rated floor slab above for this section to be applied.

A-5-3.2.1 The protection area for residential sprinklers with extended coverage areas is defined in the listing of the sprinkler as a maximum square or rectangular area. Listing information is presented in even 2-ft (.61-m) increments from 12 ft to 20 ft (3.6 m to 6.1 m) for residential sprinklers. When a sprinkler is selected for an application, its area of coverage must be equal to or greater than both the length and width of the hazard area. For example, if the hazard to be protected is a room 14 ft 6 in. (4.3 m) wide and 20 ft 8 in. (6.2 m) long, a sprinkler that is listed to protect an area of 16 ft × 22 ft (4.9 m x 6.8 m) must be selected. The flow used in the calculations is then selected as the flow required by the listing for the selected coverage. (*See Figure A-5-3.2.1.*)

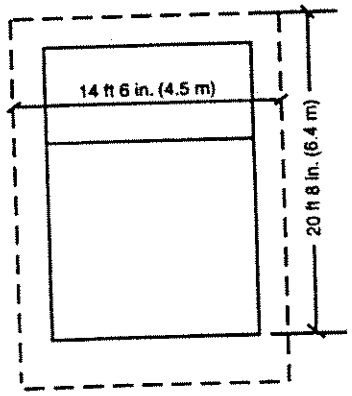


Figure A-5-3.2.1 Determination of protection area of coverage for residential sprinklers.

A-5-3.2.2 See Figure A-5-3.2.2.

A-5-3.4 See Table A-5-3.4.

A-5-3.5 See Table A-5-3.5.

A-5-3.5.1.1 While these sprinklers are intended primarily for use in high-pile storage situations, this section permits their use and extension into adjacent portions of an occupancy that might have a lesser classification.

A-5-3.6.1 If the system is a deluge type, then all the sprinklers need to be calculated even if they are located on different building faces.

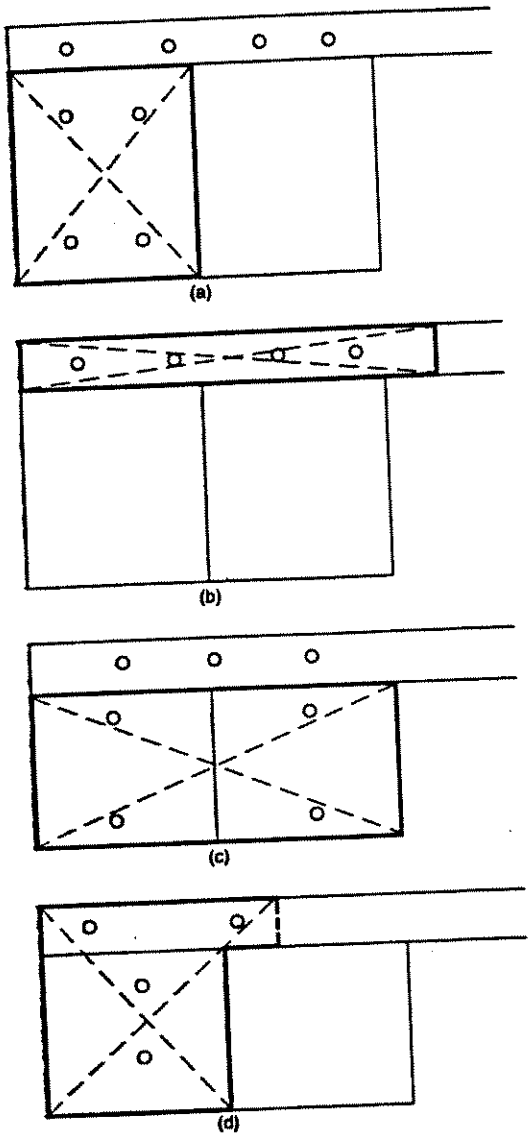


Figure A-5-3.2.2 Examples of design area for dwelling units. Calculate area indicated by heavy outline and X. Circle indicates sprinklers.

A-6-1 Preliminary layouts should be submitted for review to the authority having jurisdiction before any equipment is installed or remodeled in order to avoid error or subsequent misunderstanding. (*See Figure A-6-1.*) Any material deviation from approved plans will require permission of the authority having jurisdiction.

Preliminary layouts should show as much of the following information as is required to provide a clear representation of the system, hazard, and occupancy:

(a) Name of owner and occupant.

(b) Location, including street address.

(c) Point of compass.

(d) Construction and occupancy of each building.

NOTE: Data on special hazards should be submitted as they may require special rulings.

(e) Building height in feet.

(f) If it is proposed to use a city main as a supply, whether the main is dead-end or circulating, size of main and pressure in psi, and, if dead-end, direction and distance to nearest circulating main.

(g) Distance from nearest pumping station or reservoir.

(h) In cases where reliable, up-to-date information is not available, a waterflow test of the city main should be conducted in accordance with A-7-2.1. The preliminary plans should specify the person who conducted the test, date and time, the location of the hydrants where flow was taken, and where static and residual pressure readings were recorded; the size of main supplying these hydrants, and the results of the test, giving size and number of open hydrant butts flowed; also, data covering minimum pressure in the connection with the city main should be included.

(i) Data covering waterworks systems in small towns in order to expedite the review of plans.

(j) Fire walls, fire doors, unprotected window openings, large unprotected floor openings, and blind spaces.

(k) Distance to and construction and occupancy of exposing buildings—e.g., lumber yards, brick mercantiles, fire-resistive office buildings, etc.

(l) Spacing of sprinklers, number of sprinklers in each story or fire area and total number of sprinklers, number of sprinklers on each riser and on each system by floors, total area protected by each system on each floor, total number of sprinklers on each dry pipe system or preaction or deluge system and if extension to present equipment, sprinklers already installed.

(m) Capacities of dry pipe systems with bulk pipe included, see Table A-3-2.3; and, if an extension is made to an existing dry pipe system, the total capacity of the existing and also the extended portion of the system.

(n) Weight or class, size, and material of any proposed underground pipe.

(o) Whether property is located in a flood or earthquake area requiring consideration in the design of sprinkler system.

(p) Name and address of party submitting the layout.

A-6-1.1 See Figure A-6-1.1.

A-6-1.1.3 See Figures A-6-1.1.3(a) and (b).

A-6-2.2 See Figures A-6-2.2(a) through (d).

A-6-2.3 See Figure A-6-2.3.

A-6-2.3(o) See Figure A-6-2.3(o).

A-6-2.4 See Figure A-6-2.4.

A-6-4.1 When additional sprinkler piping is added to an existing system, the existing piping does not have to be increased in size to compensate for the additional sprinklers, provided the new work is calculated and the calculations include that portion of the existing system as may be required to carry water to the new work.

A-6-4.4 See Figure A-6-4.4.

A-6-4.4.1 See Figures A-6-4.4.1(a) and (b).

A-6-4.4.2 See Figure A-6-4.4.2.

A-6-4.4.3(a) See Figure A-6-4.4.3(a).

Table A-5-3.4 Large-Drop Sprinkler Data

Pressure and Number of Design Sprinklers Required for Various Hazards for Large-Drop Sprinklers

Hazard	Type of System	Minimum Operating Pressure,[1] psi (bar) 25 (1.7)	50 (3.4)	75 (5.2)	Hose Stream Demand gal/min (dm³/min)	Water Supply Duration, hr
		Number Design Sprinklers				
Palletized[2] Storage						
Class I, II, and III commodities up to 25 ft (7.6 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	15	Note 4	Note 4	500 (1900)	2
	Dry	25	Note 4	Note 4		
Class IV commodities up to 20 ft (6.1 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	20	15	Note 4	500 (1900)	2
	Dry	Does not apply	Does not apply	Does not apply		
Unexpanded plastics up to 20 ft (6.1 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	25	15	Note 4	500 (1900)	2
	Dry	Does not apply	Does not apply	Does not apply		
Expanded plastics commodities up to 18 ft (5.5 m) with maximum 8 ft (2.4 m) clearance to ceiling	Wet	Does not apply	15	Note 4	500 (1900)	2
	Dry	Does not apply	Does not apply	Does not apply		
Idle wood pallets up to 20 ft (6.1 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	15	Note 4	Note 4	500 (1900)	1½
	Dry	25	Note 4	Note 4		
Solid Piled[2] Storage						
Class I, II, and III commodities up to 20 ft (6.1 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	15	Note 4	Note 4	500 (1900)	1½
	Dry	25	Note 4	Note 4		
Class IV commodities and unexpanded plastics up to 20 ft (6.1 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	Does not apply	15	Note 4	500 (1900)	1½
	Dry	Does not apply	Does not apply	Does not apply		
Double-Row Rack Storage[3] with Minimum 5.5 ft (1.7 m) Aisle Width and Multiple-Row Rack Storage with Minimum 8.0 ft (2.5 m) Aisle Width						
Class I and II commodities up to 25 ft (7.6 m) with maximum 5 ft (1.5 m) clearance to ceiling	Wet	20	Note 4	Note 4	500 (1900)	1½
	Dry	30	Note 4	Note 4		
Class I and II commodities up to 30 ft (9.2 m) with maximum 5 ft (1.5 m) clearance to ceiling	Wet	20 plus one level of in-rack sprinklers[5]	Note 4	Note 4	500 (1900)	1½
	Dry	30 plus one level of in-rack sprinklers[5]	Note 4	Note 4		
Class I, II, and III commodities up to 20 ft (6.1 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	15	Note 4	Note 4	500 (1900)	1½
	Dry	25	Note 4	Note 4		
Class I, II, and III commodities up to 25 ft (7.6 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	15 plus one level of in-rack sprinklers[5]	Note 4	Note 4	500 (1900)	1½
	Dry	25 plus one level of in-rack sprinklers[5]	Note 4	Note 4		
Class IV commodities up to 20 ft (6.1 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	Does not apply	20	15	500 (1900)	2
	Dry	Does not apply	Does not apply	Does not apply		
Class IV commodities up to 25 ft (7.6 m) with maximum 10 ft clearance to ceiling	Wet	Does not apply	20 plus one level of in-rack sprinklers[5]	15 plus one level of in-rack sprinklers[5]	500 (1900)	2
	Dry	Does not apply	Does not apply	Does not apply		

Table A-5-3.4 (cont.)

Hazard	Type of System	Minimum Operating Pressure,[1] psi (bar) 25 (1.7)	50 (3.4)	75 (5.2)	Hose Stream Demand gal/min (dm³/min)	Water Supply Duration, hr
Unexpanded plastics up to 20 ft (6.1 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	Does not apply	30	20	500 (1900)	2
	Dry	Does not apply	Does not apply	Does not apply		
Unexpanded plastics up to 25 ft (7.6 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	Does not apply	30 plus one level of in-rack sprinklers[4]	20 plus one level of in-rack sprinklers[4]	500 (1900)	2
	Dry	Does not apply	Does not apply	Does not apply		
Class IV commodities and unexpanded plastics up to 20 ft (6.1 m) with maximum 5 ft (1.5 m) clearance to ceiling	Wet	Does not apply	15	Note 4	500 (1900)	2
	Dry	Does not apply	Does not apply	Does not apply		
Class IV commodities and unexpanded plastics up to 25 ft (7.6 m) with maximum 5 ft (1.5 m) clearance to ceiling	Wet	Does not apply	15 plus one level of in-rack sprinklers[4]	Note 4	500 (1900)	2
	Dry	Does not apply	Does not apply	Does not apply		
On-end Storage of Roll Paper[2]						
Heavyweight paper in closed array, banded in open array, or banded or unbanded in a standard array, up to 26 ft (7.9 m) with maximum 34 ft (10.4 m) clearance to ceiling	Wet	Does not apply	15	Note 4	0 (Note 6)	4 (Note 6)
	Dry	Does not apply	Does not apply	Does not apply		
Any grade of paper, except lightweight paper with stacks in closed array, or banded or unbanded in a standard array, up to 20 ft (6.1 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	Does not apply	15	Note 4	0 (Note 6)	4 (Note 6)
	Dry	Does not apply	25	Note 4	Note 6	Note 6
Medium weight paper completely wrapped (sides and ends) in one or more layers of heavyweight paper, or lightweight paper in two or more layers of heavyweight paper, with closed array, banded in open array, or unbanded in a standard array, up to 26 ft (7.9 m) with maximum 34 ft (10.4 m) clearance to ceiling	Wet	Does not apply	Does not apply	Does not apply	Does not apply	Does not apply
	Dry	15	Note 4	Note 4	500 (1900)	1½
Record Storage						
Paper records and/or computer tapes in multitier steel shelving up to 5 ft (1.5 m) in width and with aisles 30 in. (76 cm) or wider, without catwalks in the aisles, up to 15 ft (4.6 m) with maximum 5 ft (1.5 m) clearance to ceiling	Dry	25	Note 4	Note 4	500 (1900)	1½
	Wet	Does not apply	15	Note 4		
Same as above, but with catwalks of expanded metal or metal grid with minimum 50 percent open area in the aisles	Dry	Does not apply	15	Note 4		

For SI Units: 1 ft = 0.3048 m; 1 psi = 0.0689 bar.

NOTES:

1. Open wood joist construction. Fully firestop each joist channel to its full depth at intervals not exceeding 20 ft (6.2 m). In unfirestopped open wood joist construction, or if firestops are installed at intervals exceeding 20 ft (6.1 m), increase the minimum operating pressures of Table A-5-3.4 by 40 percent.
2. See NFPA 231, *Standard for General Storage*.
3. With rack storage, use conventional wood pallets only; no slave pallets.
4. The high pressure may be used, but the required number of design sprinklers may not be reduced from that required for the lower pressure.
5. Install in-rack sprinklers in accordance with NFPA 231C, *Standard for Rack Storage*.
6. Hose stream demands and water supply durations may vary for roll paper storage depending on local conditions. See NFPA 231F, *Standard for the Storage of Roll Paper*.

Table A-5-3.5 ESFR Sprinkler Data

Type of Storage	Commodity	Maximum Ht. of Storage in ft	Maximum Ht. of Building in ft (Note 1)	Nominal K Factor	Sprinkler Design Pressure in psi	Commodity Limitation
Palletized and solid pile storage and single, double, and multiple row rack storage (no open top containers or solid shelves)	Cartoned unexpanded plastic; cartoned, expanded plastic; uncartoned, unexpanded plastic; and Class I, II, III, or IV commodities encapsulated or unencapsulated	25 (7.6 m)	30 (9.1 m)	13.5–14.5	50 (3.4 bars)	
	Cartoned, unexpanded plastic; and Class I, II, III, or IV commodities, encapsulated or unencapsulated	35 (10.7 m)	40 (12.2 m)	13.5–14.5	75 (5.2 bars)	Note 2
		20 (6.1 m)	25 (7.6 m)	11.0–11.5	50 (3.4 bars)	
Roll paper on end, open/standard or closed array, banded or unbanded	Heavy weight or medium weight	20 (6.1 m)	30 (9.1 m)	13.5–14.5	50 (3.4 bars)	
Aerosol storage	See NFPA 30B					

For SI Units: 1 ft = 0.3048 m.

NOTE 1: Maximum building height is to be measured to the underside of the roof deck or ceiling.
NOTE 2: Only ESFR sprinklers specifically listed for 40-ft (12.2-m) high buildings should be used in buildings higher than 30 ft (9.1 m) up to 40 ft (12.2 m).

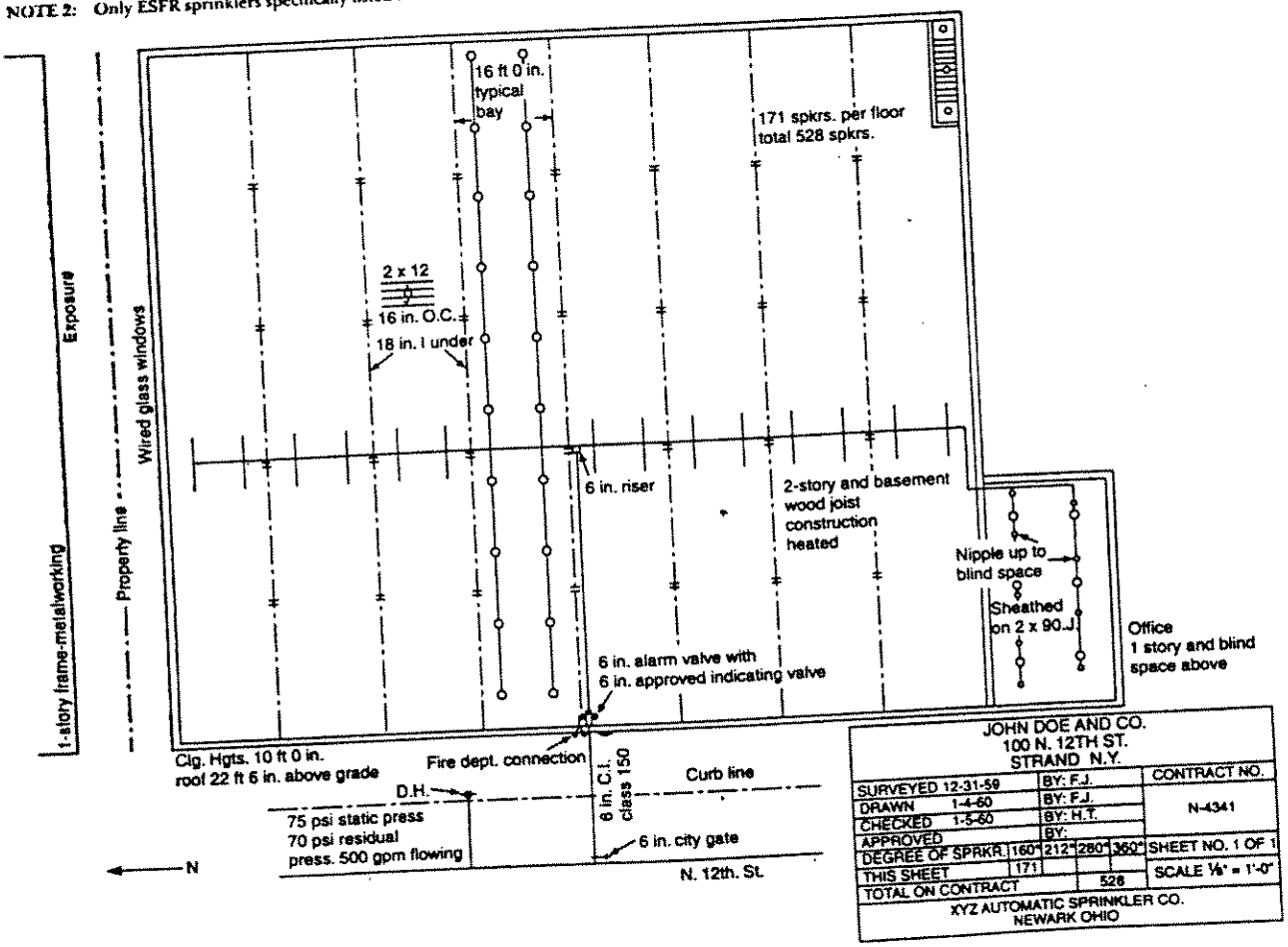


Figure A-6-1 Typical preliminary plan.

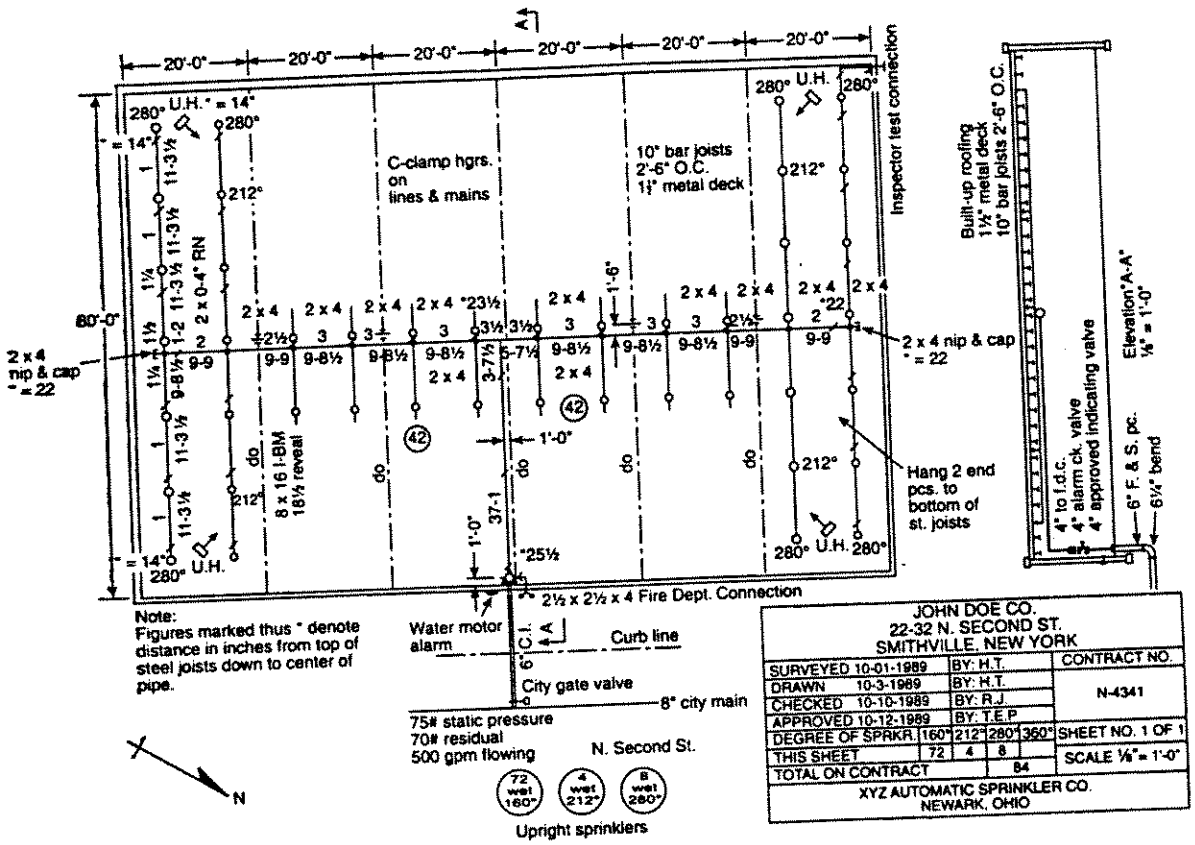


Figure A-6-1.1 Typical working plans.

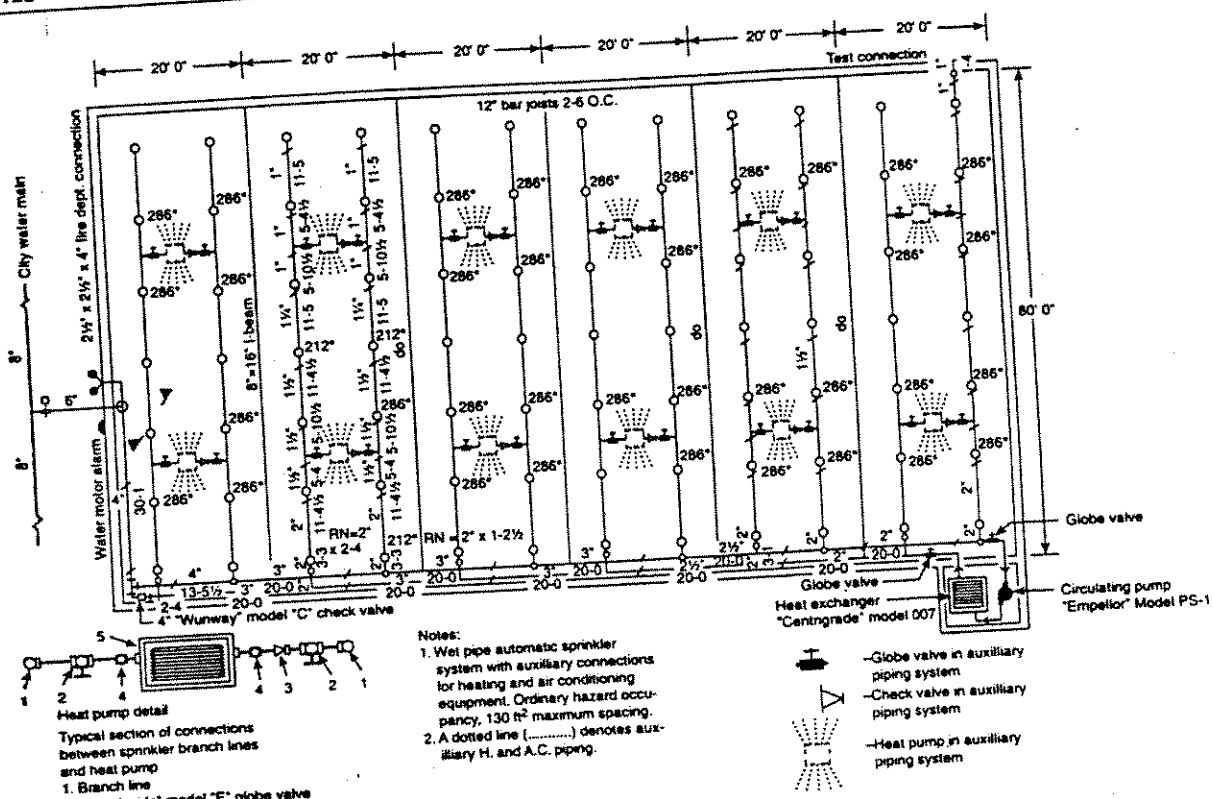
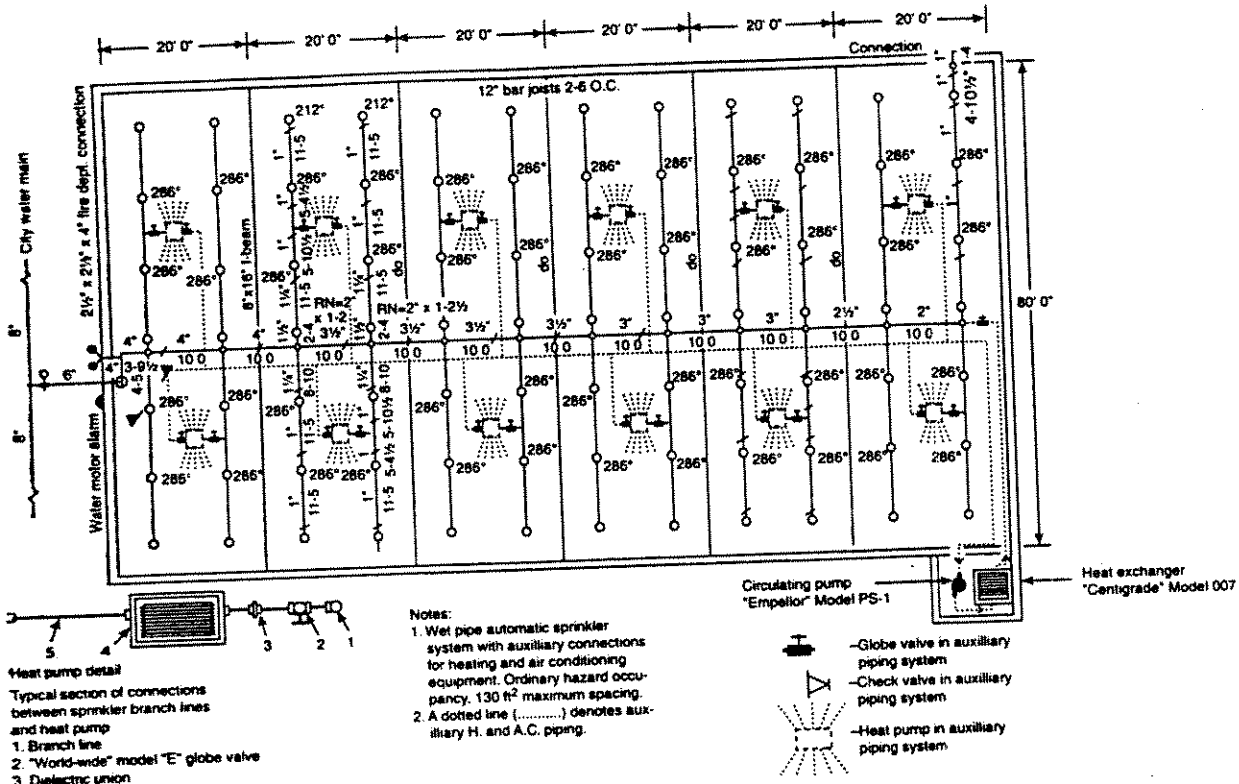


Figure A-6-1.1.3(a) Working plans for circulating closed-loop systems.



Heat pump detail

Typical section of connections between sprinkler branch lines and heat pump

1. Branch line
2. "World-wide" model "E" globe valve
3. Dielectric union
4. "Farenheit" model #72 heat pump
5. Water return line

Notes:

1. Wet pipe automatic sprinkler system with auxiliary connections for heating and air conditioning equipment. Ordinary hazard occupancy, 130 ft^2 maximum spacing.
2. A dotted line (.....) denotes auxiliary H. and A.C. piping.

Figure A-6-1.1.3(b) Working plans for circulating closed-loop systems.

Hydraulic Calculations

for

ABC Company, Employee Garage

7499 Franklin Road

Charleston, SC

Contract No. 4001

Date 1-7-91

Design data:

Occupancy Classification ORD. GR. 1

Density 0.15 GPM/ft²

Area of Application 1500 ft²

Coverage per Sprinkler 130 ft²

Special Sprinklers —

No. of Sprinklers Calculated 12

In-rack Demand —

Hose streams 250 GPM

Total Water Required 510.4 GPM
Including hose streams

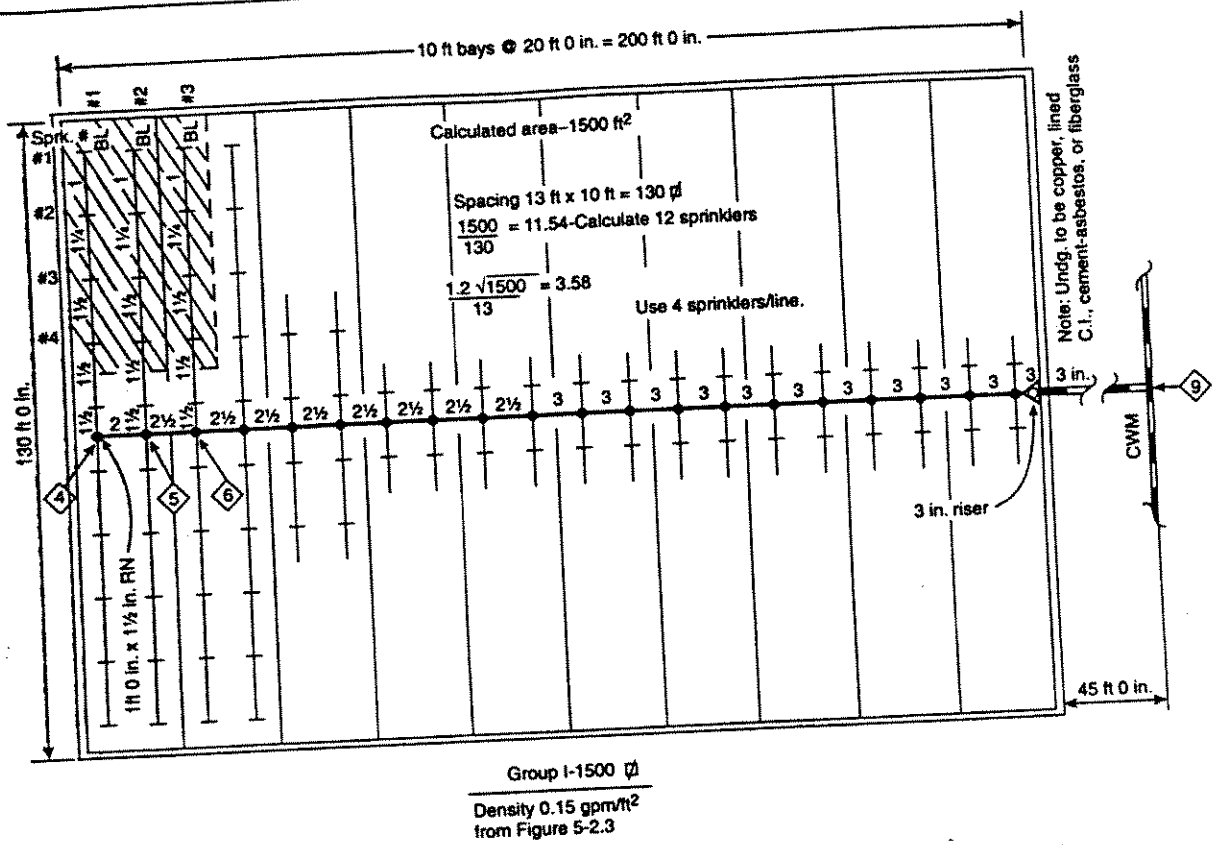
Name of Contractor

Name of Designer

Address

Authority Having Jurisdiction

Figure A-6-2.2(a) Summary sheet.



Group I-1500 ft²

Density 0.15 gpm/ft² from Figure 5-2.3

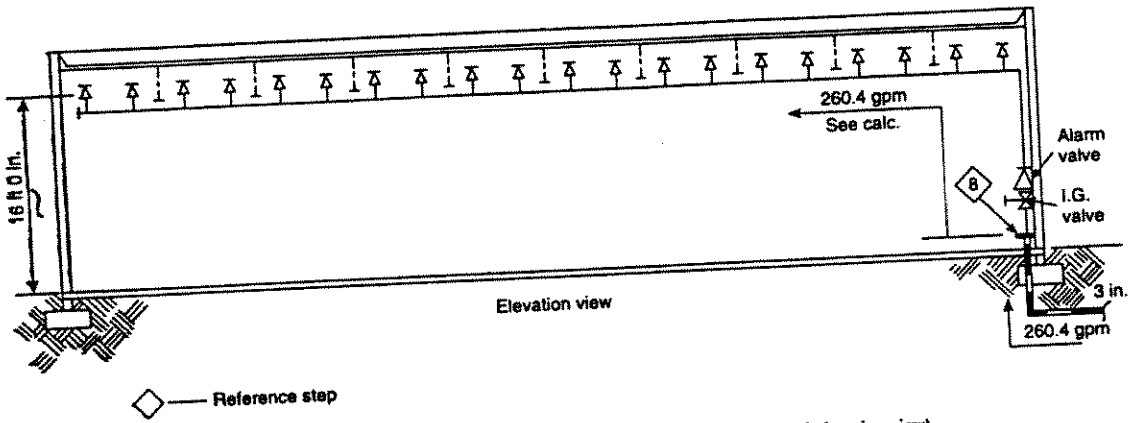


Figure A-6-2.2(b) Hydraulic calculation example (plan view and elevation view).

Contract Name GROUP 1 1500 ⌀ Sheet 2 Of 3

Step No.	Nozzle Ident. and Location		Flow in gpm	Pipe Size	Pipe Fittings and Devices	Equiv. Pipe Length	Friction Loss psi Foot	Pressure Summary	Normal Pressure	D=0.15 GPM/⌀ Notes K=5.65	Ref. Step
1	1	BL-1	q	1		L 13.0	C=120	Pt 11.9	Pt	q=130x.15=19.5	
						F		Pe	Pv		
			Q 19.5			T 13.0	0.124	Pf 1.6	Pn		
2	2		q 20.7	1¼		L 13.0		Pt 13.5	Pt	$q=5.65\sqrt{13.5}$	
						F		Pe	Pv		
			Q 40.2			T 13.0	0.125	Pf 1.6	Pn		
3	3		q 22	1½		L 13.0		Pt 15.1	Pt	$q=5.65\sqrt{15.1}$	4
						F		Pe	Pv		
			Q 62.2			T 13.0	0.132	Pf 1.7	Pn		
4	4	DN RN	q 23.2	1½	2T-16	L 20.5		Pt 16.8	Pt	$q=5.65\sqrt{16.8}$	5
						F 16.0		Pe	Pv		
			Q 85.4			T 36.5	0.237	Pf 8.6	Pn		
5		CM TO BL-2	q	2		L 10.0		Pt 25.4	Pt	$K=\frac{85.4}{\sqrt{25.4}}$ K=16.95	
						F		Pe	Pv		
			Q 85.4			T 10.0	0.07	Pf .7	Pn		
6		BL-2 CM TO BL-3	q 86.6	2½		L 10.0		Pt 26.1	Pt	$q=16.95\sqrt{26.1}$	6
						F		Pe	Pv		
			Q 172.0			T 10.0	0.109	Pf 1.1	Pn		
7		BL-3 CM	q 88.4	2½		L 70.0		Pt 27.2	Pt	$q=16.95\sqrt{27.2}$	
						F		Pe	Pv		
			Q 260.4			T 70.0	0.233	Pf 16.3	Pn		
8		CM TO FIS	q	3	E5	L 119.0		Pt 43.5	Pt	$P_E = 15 \times .433$	8
					AY15	F		Pe 6.5	Pv		
			Q 260.4		GV1	T 140.0	.081	Pf 11.3	Pn		
9		THROUGH UNDER-GROUND TO CITY MAIN	q	3	E5	L 50.0	C=150	Pt 61.3	Pt	COPPER 21 x 1.51=32	9
					GV1	F 32.0	TYPE'M'	Pe	Pv		
			Q 260.4		T15	T 82.2	0.061	Pf 5.0	Pn		
			q			L		Pt 66.3	Pt		
						F		Pe	Pv		
			Q			T		Pf	Pn		
			q			L		Pt	Pt		
						F		Pe	Pv		
			Q			T		Pf	Pn		
								Pt			

Figure A-6-2.2(c) Hydraulic calculations.

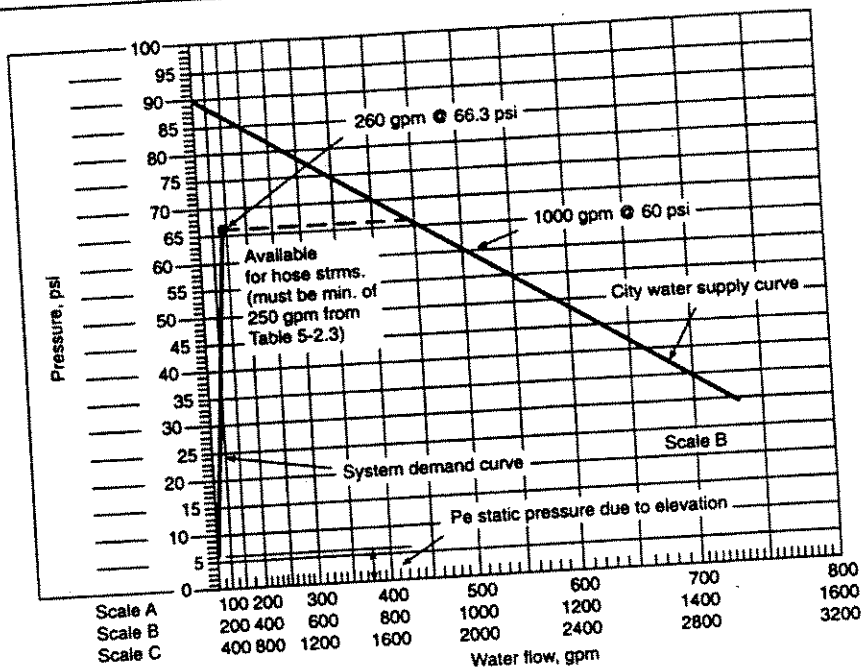


Figure A-6-2.2(d) Hydraulic graph.

Sheet no. ________ of ________

Contract no. ____________________

Name & location ____

Reference	Nozzle type & location	Flow in gpm (L/min)	Pipe size in.	Fitting & Devices	Pipe equiv. length	Friction loss psi/ft (bar/m)	Req. psi (bar)	Normal Pressure	Notes
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	
					lgth.		Pt	Pt	
		q			ftg.		Pf	Pv	
		Q			tot.		Pe	Pn	

Figure A-6-2.3 Sample work sheet.

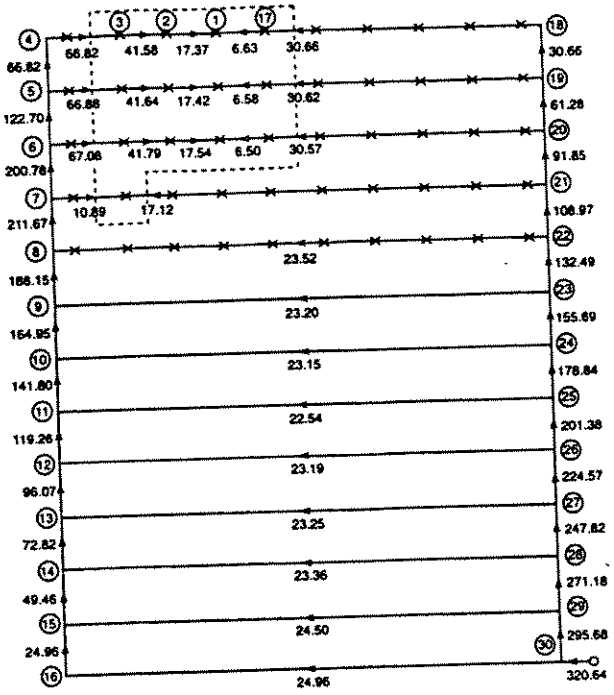


Figure A-6-2.3(o) Example of hydraulically remote area — grid system.

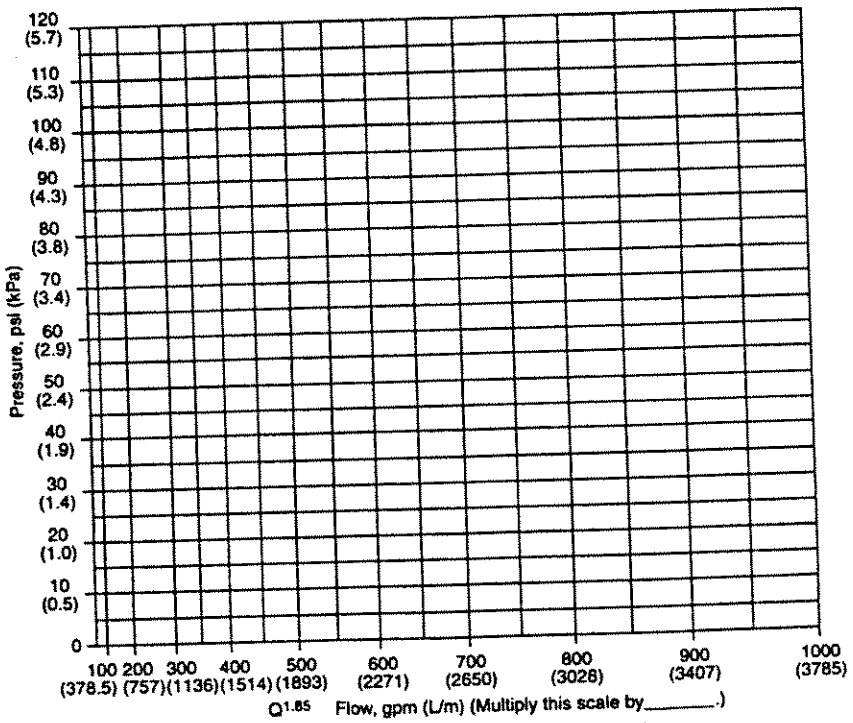
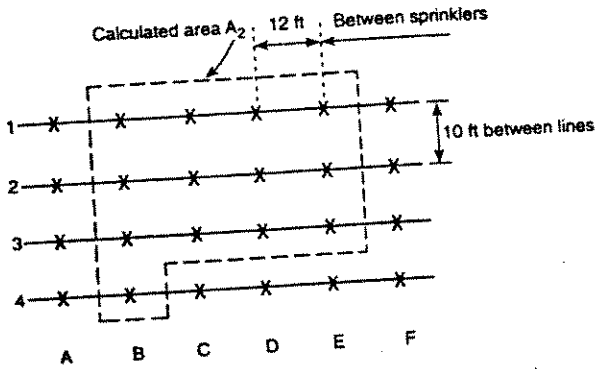


Figure A-6-2.4 Sample graph sheet.



NOTE 1: For gridded systems, the extra sprinkler (or sprinklers) on branch line 4 may be placed in any adjacent location from B to E at the designer's option.
NOTE 2: For tree and looped systems, the extra sprinkler on line 4 should be placed closest to the cross main.

Assume a remote area of 1500 ft^2 with sprinkler coverage of 120 ft^2

$$\text{Total sprinklers to calculate} = \frac{\text{Design area}}{\text{Area per sprinkler}}$$

$$= \frac{1500}{120} = 12.5, \text{ calculate } 13$$

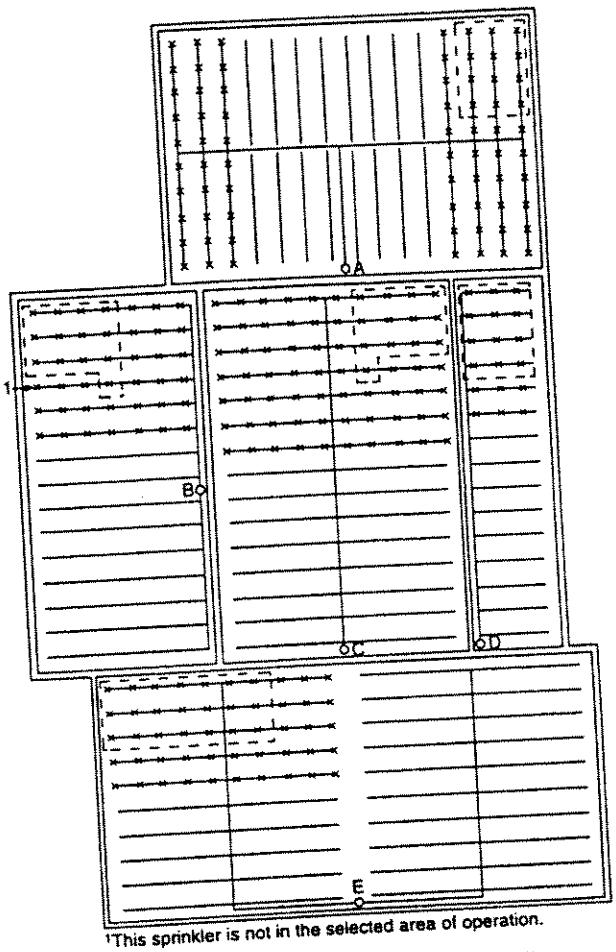
$$\text{Number of sprinklers on branch line} = \frac{1.2\sqrt{A}}{S}$$

Where A = Design area
S = Distance between sprinklers on branch line

$$\text{Number of sprinklers on branch line} = \frac{1.2\sqrt{1500}}{12} = 3.87.$$

For SI units: 1 ft = 0.3048 m; 1 ft^2 = 0.0929 m^2.

Figure A-6-4.4 Example of determining the number of sprinklers to be calculated.



[1]This sprinkler is not in the selected area of operation.

Figure A-6-4.4.1(a) Example of hydraulically most demanding area.

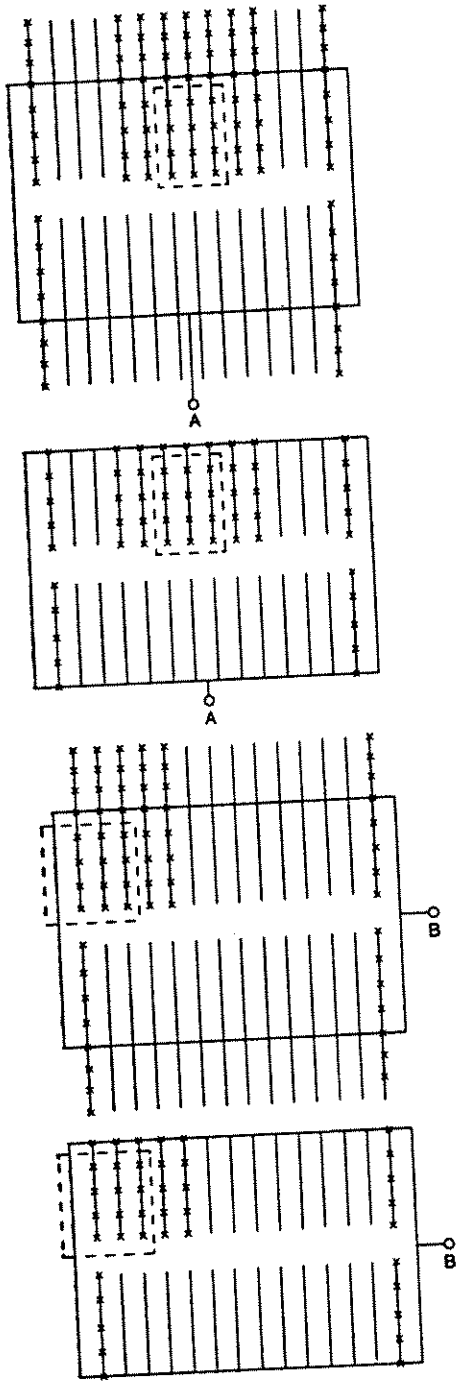


Figure A-6-4.4.1(b) Example of hydraulically most demanding area.

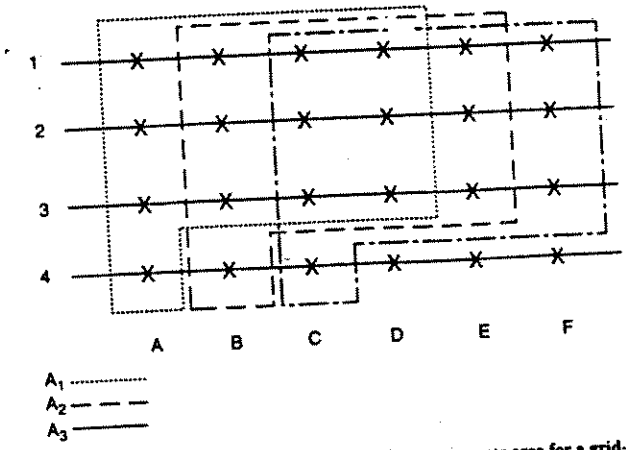


Figure A-6-4.4.2 Example of determining the most remote area for a gridded system.

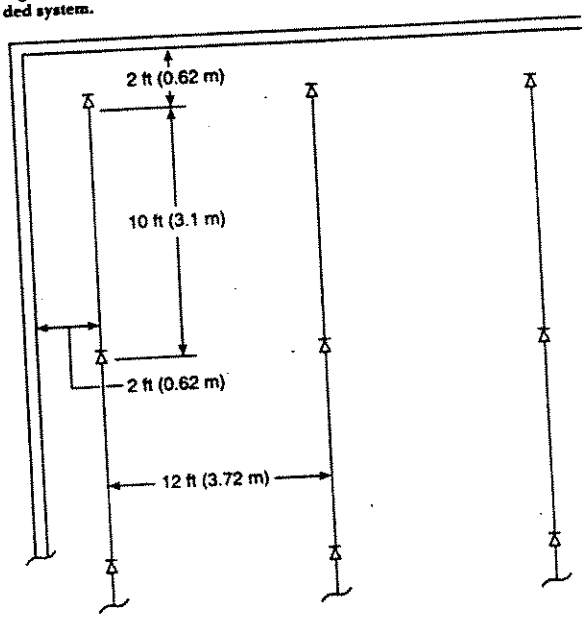


Figure A-6-4.4.3(a) Sprinkler design area.

A-6-4.4.3(b) This subsection assumes a ceiling constructed so as to reasonably assure that a fire on one side of the ceiling will operate sprinklers on one side only. Where a ceiling is sufficiently open, or of such construction that operation of sprinklers above and below the ceiling may be anticipated, the operation of such additional sprinklers should be considered in the calculations.

A-6-4.4.4 When it is not obvious by comparison that the design selected is the hydraulically most remote, additional calculations should be submitted. The most distant area is not necessarily the hydraulically most remote.

A-6-4.4.6 The use of sprinklers with differing orifice sizes in situations where different protection areas are needed is not considered balancing. An example would be a room that could be protected with sprinklers having different orifice size in closet, foyer, and room areas. However, this procedure introduces difficulties when restoring a system to service after operation since it is not always clear which sprinklers go where.

A-6-4.4.7 Where the normal pressure (P_n) is used to calculate the flow from an orifice, the following assumptions should be used.

(a) At any flowing outlet along a pipe, except the end outlet, only the normal pressure (P_n) can act on the outlet. At the end outlet the total pressure (P_t) can act. The following should be considered end outlets:

1. The last flowing sprinkler on a dead-end branch line
2. The last flowing branch line on a dead-end cross main
3. Any sprinkler where a flow split occurs on a gridded branch line
4. Any branch line where a flow split occurs on a looped system.

(b) At any flowing outlet along a pipe, except the end outlet, the pressure acting to cause flow from the outlet is equal to the total pressure (P_t) minus the velocity pressure (P_v) on the upstream (supply) side.

(c) To find the normal pressure (P_n) at any flowing outlet, except the end outlet, assume a flow from the outlet in question and determine the velocity pressure (P_v) for the total flow on the upstream side. Because normal pressure (P_n) equals total pressure (P_t) minus velocity pressure (P_v), the value of the normal pressure (P_n) so found should result in an outlet flow approximately equal to the assumed flow; if not, a new value should be assumed, and the calculations repeated.

A-6-5.1 The demonstrated effectiveness of pipe schedule systems is limited to their use with ½-in. (13-mm) orifice sprinklers. The use of other size orifices may require hydraulic calculations to prove their ability to deliver the required amount of water within the available water supply.

A-6-5.1.2 Long Runs of Pipe. Where the construction or conditions introduce unusually long runs of pipe or many angles in risers or feed or cross mains, an increase in pipe size over that called for in the schedules may be required to compensate for increased friction losses.

A-6-5.2.3.1 For example, a 2½-in. (64-mm) steel pipe, which is permitted to supply 30 sprinklers, may supply a total of 50 sprinklers where not more than 30 sprinklers are above, or below, a ceiling.

A-6-5.3.3.1 For example, a 3-in. (76-mm) steel pipe, which is permitted to supply 40 sprinklers in an Ordinary Hazard area, may supply a total of 60 sprinklers where not more than 40 sprinklers protect the occupied space below the ceiling.

A-6-5.4 Schedule for Extra Hazard Occupancies. The piping schedule shown in Table A-6-5.4 is reprinted only as a guide for existing systems. New systems for Extra Hazard Occupancies should be hydraulically calculated as required in 6-5.4.

Table A-6-5.4 Extra Hazard Pipe Schedule

Steel		Copper	
1 in.	1 sprinkler	1 in.	1 sprinkler
1¼ in.	2 sprinklers	1¼ in.	2 sprinklers
1½ in.	5 sprinklers	1½ in.	5 sprinklers
2 in.	8 sprinklers	2 in.	8 sprinklers
2½ in.	15 sprinklers	2½ in.	20 sprinklers
3 in.	27 sprinklers	3 in.	30 sprinklers
3½ in.	40 sprinklers	3½ in.	45 sprinklers
4 in.	55 sprinklers	4 in.	65 sprinklers
5 in.	90 sprinklers	5 in.	100 sprinklers
6 in.	150 sprinklers	6 in.	170 sprinklers

For SI Units: 1 in. = 25.4 mm.

A-6-5.6 In the design of an exposure protection system, the flow rate from window and cornice sprinklers is shown in Table 6-5.6. The flow rates are based on the guide numbers selected from Table 2-3 of NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*.

Section A of the table is for window sprinklers. The orifice size is selected according to the level on which the sprinkler is located.

Section B of the table is for cornice sprinklers.

A-7-1.2.3 Where the system riser is close to an outside wall, underground fittings of proper length should be used in order to avoid pipe joints located in or under the wall. Where the connection passes through the foundation wall below grade, a 1- to 3-in. (25- to 76-mm) clearance should be provided around the pipe and the clear space filled with asphalt mastic or similar flexible waterproofing material.

A-7-2.1 Water Supplies. Care should be taken in making water tests to be used in designing or evaluating the capability of sprinkler systems. The water supply tested should be representative of the supply that may be available at the time of a fire. For example, testing of public water supplies should be done at times of normal demand on the system. Public water supplies are likely to fluctuate widely from season to season and even within a 24-hour period. Allowance should be made for seasonal or daily fluctuations, for drought conditions, for possibility of interruption by flood, or for ice conditions in winter. Testing of water supplies also normally used for industrial use should be done while water is being drawn for industrial use. The range of industrial-use demand should be taken into account. In special situations where the domestic water demand could significantly reduce the sprinkler water supply, an increase in the size of the pipe supplying both the domestic and sprinkler water may be justified.

Future changes in water supplies should be considered. For example a large, established, urban supply is not likely to change greatly within a few years. However, the supply in a growing suburban industrial park might deteriorate quite rapidly as greater numbers of plants draw more water.

Testing of Water Supply. To determine the value of public water as a supply for automatic sprinkler systems, it is generally necessary to make a flow test to determine how much water can be discharged at a residual pressure at a rate sufficient to give the required residual pressure under the roof (with the volume flow hydraulically translated to the base of the riser), i.e., a pressure head represented by the height of the building plus the required residual pressure.

The proper method of conducting this test is to use two hydrants in the vicinity of the property. The static pressure should be measured on the hydrant in front of or nearest to the property and the water allowed to flow from the hydrant next nearest the property, preferably the one farthest from the source of supply if the main is fed only one way. The residual pressure will be that indicated at the hydrant where water is not flowing.

Referring to Figure A-7-2.1, the method of conducting the flow tests is as follows:

1. Attach gauge to hydrant (A) and obtain static pressure.
2. Either attach second gauge to hydrant (B) or use Pitot tube at outlet. Have hydrant (B) opened wide and read pressure at both hydrants.
3. Use the pressure at (B) to compute the gal flowing and read the gauge on (A) to determine the residual pressure or that which will be available on the top line of sprinklers in the property.

Water pressure in psi for a given height in ft equals height multiplied by 0.434.

In making flow tests, whether from hydrants or from nozzles attached to hose, always measure the size of the orifice. While hydrant outlets are usually 2½ in. (64 mm), they are sometimes smaller and occasionally larger. The UL play pipe is 1⅛ in. (29 mm) and 1¾ in. (44 mm) with tip removed, but occasionally nozzles will be 1 in. (25.4 mm) or 1¼ in. (33 mm), and with the tip removed the opening may be only 1½ in. (38 mm).

The Pitot tube should be held approximately one-half the diameter of the hydrant or nozzle opening away from the opening. It should be held in the center of the stream, except that in using hydrant outlets the stream should be explored to ascertain the average pressure.

For further information on water supply testing, see NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants*.

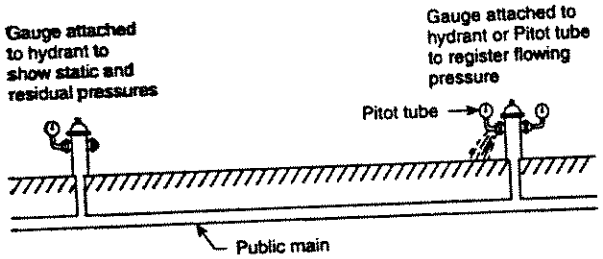


Figure A-7-2.1 Method of conducting flow tests.

A-7-2.2.1 An automatically controlled vertical turbine pump taking suction from a reservoir, pond, lake, river, or well complies with 7-2.2.1.

A-7-2.3.3 For pipe schedule systems, the air pressure to be carried and the proper proportion of air in the tank may be determined from the following formulas, in which

P = air pressure carried in pressure tank
A = proportion of air in tank
H = height of highest sprinkler above tank bottom.

When tank is placed above highest sprinkler

$$P = \frac{30}{A} - 15.$$

If A = ⅓ then P = 90 − 15 = 75 lb psi.
If A = ½ then P = 60 − 15 = 45 lb psi.
If A = ⅔ then P = 45 − 15 = 30 lb psi.

When tank is below level of the highest sprinkler

$$P = \frac{30}{A} - 15 + \frac{0.434H}{A}.$$

If A = ⅓ then P = 75 + 1.30H.
If A = ½ then P = 45 + 0.87H.
If A = ⅔ then P = 30 + 0.65H.

The respective air pressures above are calculated to ensure that the last water will leave the tank at a pressure of 15 psi (1.03 bars) when the base of the tank is on a level with the highest sprinkler, or at such additional pressure as is equivalent to a head corresponding to the distance between the base of the tank and the highest sprinkler when the latter is above the tank.

For hydraulically calculated systems, the following formula should be used to determine the tank pressure and ratio of air to water.

$$P_i = \frac{P_f + 15}{A} - 15$$

where:

P_i = tank pressure
P_f = pressure required from hydraulic calculations
A = proportion of air.

Example: Hydraulic calculations indicate 75 psi is required to supply the system. What tank pressure will be required?

$$P_i = \frac{75 + 15}{0.5} - 15$$

$$P_i = 180 - 15 = 165 \text{ psi}$$

For SI Units: 1 ft = 0.3048 m; 1 psi = 0.0689 bar.

In this case the tank would be filled with 50 percent air and 50 percent water and the tank pressure would be 165 psi (11.4 bars). If the pressure is too high, the amount of air carried in the tank will have to be increased.

Location of Pressure Tanks. Pressure tanks should be located above the top level of sprinklers, but may be located in the basement or elsewhere.

A-8-2.1 Underground mains and lead-in connections to system risers should be flushed through hydrants at dead ends of the system or through accessible aboveground flushing outlets allowing the water to run until clear. Figure A-8-2.1 shows acceptable examples of flushing the system. If water is supplied from more than one source or from a looped system, divisional valves should be closed to produce a high-velocity flow through each single line. The flows specified in Table 8-2.1 will produce a velocity of at least 10 ft/sec (3 m/s), which is necessary for cleaning the pipe and for lifting foreign material to an aboveground flushing outlet.

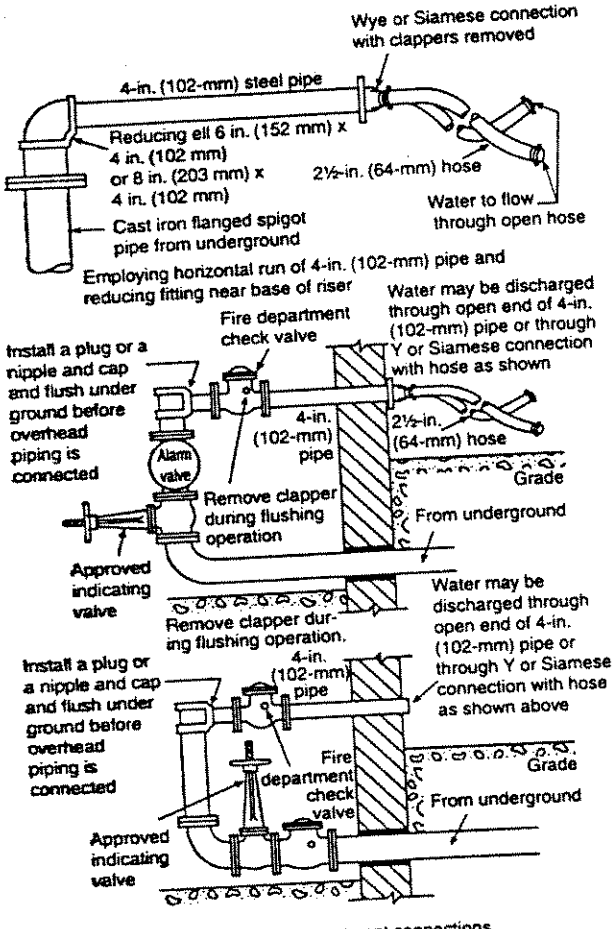


Figure A-8-2.1 Methods of flushing water supply connections.

A-8-2.2.1 A sprinkler system has for its water supply a connection to a public water service main. A 100-psi (6.9-bar) rated pump is installed in the connection. With a maximum normal public water supply of 70 psi (4.8 bars) at the low elevation point of the individual system or portion of the system being tested and a 120-psi (8.3-bar) pump (churn) pressure, the hydrostatic test pressure is 70 + 120 + 50 or 240 psi (16.5 bars).

To reduce the possibility of serious water damage in case of a break, pressure may be maintained by a small pump, the main controlling gate meanwhile being kept shut during the test.

Polybutylene pipe will undergo expansion during initial pressurization. In this case, a reduction in gauge pressure may not necessarily indicate a leak. The pressure reduction should not exceed the manufacturer's specifications and listing criteria.

When systems having rigid thermoplastic piping such as CPVC are pressure tested, the sprinkler system should be filled with water. The air should be bled from the highest and farthest sprinklers. Compressed air or compressed gas should never be used to test systems with rigid thermoplastic pipe.

A-8-2.2.7 Valves isolating the section to be tested may not be "drop-tight." When such leakage is suspected, test blanks of the type required in 8-2.2.7 should be used in a manner that includes the valve in the section being tested.

A-8-5 See Figure A-8-5.

This system as shown on ..... company

print no ..... dated .....

for .....

at ..... contract no .....

is designed to discharge at a rate of ..... gpm/ft^2

(L/min/m^2) of floor area over a maximum area of .....

..... ft^2 (m^2) when supplied

with water at a rate of ..... gpm (L/min)

at ..... psi (bars) at the base of the riser.

Hose stream allowance of ..... gpm (L/min)

is included in the above.

Occupancy classification .....

Commodity classification .....

Maximum storage height .....

Figure A-8-5 Sample nameplate.

A-9-1.1 Heat-Sensitive Material. The backbone of the fire protection philosophy for U.S. flagged vessels and passenger vessels that trade internationally is limiting a fire to the compartment of origin by passive means. Materials that do not withstand a 1-hr fire exposure when tested in accordance with ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, are considered "heat sensitive."

A-9-1.1 Marine Thermal Barrier. A marine thermal barrier is typically referred to as a B-15 boundary.

A-9-1.2 In addition to the examples provided in Appendix A-1-4.7 of the standard, Table A-9-1.2 provides additional examples of occupancy definitions of typical shipboard spaces.

The classifications in Table A-9-1.2 are not meant to be applied without giving consideration to the definition of each occupancy hazard given in the standard. Table A-9-1.2

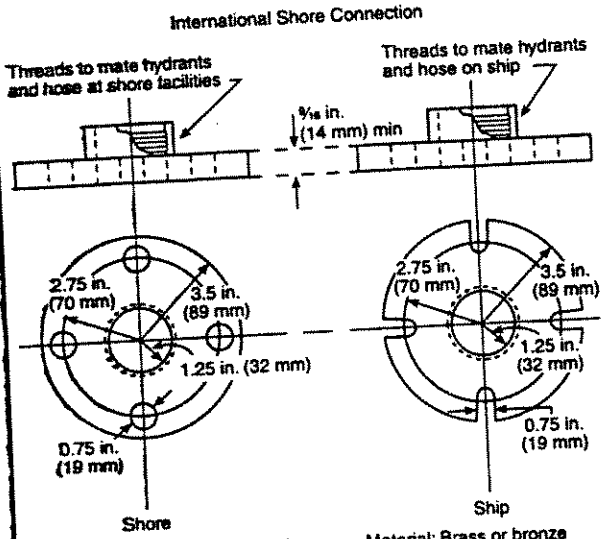


Figure A-9-1.1 International shore fire connection.

is general guidance for classification of typical spaces. Where a space is outfitted such that the occupancy definitions indicate that another classification would be more appropriate, the most representative and most demanding occupancy classification should be used. For example, it would certainly be possible to outfit a stateroom to require upgrading the occupancy to Ordinary Hazard Group 1.

When a vessel undergoes modifications, alterations, or service changes that significantly affect the fire risk of the occupancy of one or more compartments, the occupancy classification should be reevaluated to determine if it has changed.

A-9-1.3 Experience has shown that structures that are partially sprinklered can be overrun by well-developed fires originating in unsprinklered areas. Therefore, the entire vessel should be sprinklered whenever sprinkler systems are considered.

A-9-2.1 Sprinklers with a nominal orifice size 3/8 in. (9.5 mm) or less coupled with a system strainer minimize the potential for clogging. Attention is called to the minimum 10-psi (68.9-kPa) design and operating pressure requirement, which exceeds the typical 7 psi (48.3 kPa) required for land-based systems.

A-9-2.2 Where a marine thermal barrier is penetrated, limiting the opening around the sprinkler pipe to 1/16 in. (1.6 mm) is considered as meeting this requirement.

A-9-2.4.3(b) Materials that are not listed are permitted provided that they are shown to meet the performance requirements of International Maritime Organization Maritime Safety Committee Circular 580, *Guidelines for the Application of Plastic Pipes on Ships.*

A-9-2.5.1 When designing supports, the selection and spacing of pipe supports should take into account the pipe dimensions, mechanical and physical properties of piping materials and supports, operating temperature, thermal expansion effects, external loads, thrust forces, vibration, maximum accelerations, and differential motions to which the system might be subjected, and the type of support.

The route of the vessel is intended to be descriptive of its usual operating area. For example, expected motion of the system on an ocean vessel is expected to be considerably greater than the motion of a vessel that operates on a river. A vessel that operates within the confines of any of the Great Lakes is expected to subject the system pipe to greater motion than would a vessel that operates on a lake such as Lake Tahoe.

Table A-9-1.2 Examples of Shipboard Space Occupancy Classification

Occupancy Type	Space Types Included		Examples
	CFR[1]	SOLAS[2]	
Light Hazard	1[3], 2, 3, 4, 5, 8, 13	1[3], 2, 3, 4, 5, 9, 10	Public spaces Control stations
Ordinary Hazard (Group 1)	1[3], 6, 7, 8, 9	1[3], 3, 5, 9	Galleys Storage areas Laundries Pantries with high heat source equipment
Ordinary Hazard (Group 2)	9[4], 11[4]	5[4], 8[4], 9, 11	Sales shops Stages (with sets) Machine shops
Extra Hazard (Group 1)	1, 9[4], 10, 11[4]	1, 5[4], 7, 8[4]	Auxiliary machinery – limited combustible liquids Steering rooms – combustible hydraulic fluid in use
Extra Hazard (Group 2)	1, 9[4], 10, 11[4]	1, 5[4], 6, 7, 8[4]	Auxiliary machinery – with combustible liquids Machinery spaces

[1]Space type definitions are given in 46 CFR 72.05-5.
[2]Space type definitions are given in the *International Convention for the Safety of Life at Sea*, 1974 (SOLAS 74), as amended, regulations II-2/3 and II-2/26.
[3]Primarily for accommodation type control stations. This would not include generator or other similar type spaces.
[4]Depends on storage type, quantity and height and distance below sprinkler deflectors [must maintain 0.46 m (18 in.) clearance].

It is recommended that the designer review the requirements for automatic sprinkler systems that are subject to earthquakes. While it is obvious that shipboard motions and accelerations differ from those that occur during an earthquake, the general principle of protecting the piping system against damage applies. Individual hanger design, however, will be very similar. (*See 4-14.4.3.*)

Earthquake protection does not apply to ships; however, motions are similar to those that a ship will experience in a seaway. The design principles discussed in this section should be used as a guide for shipboard system design. See 2-6.1.

A-9-2.5.3 Use of heat sensitive materials for pipe hangers and supports might be desirable in some cases. Where heat-sensitive materials are used, the hangers and supports should be adequately protected by either the direct application of insulation or installation behind a marine thermal barrier. Insulation materials applied directly to hangers should be insulated in accordance with the method provided in Society of Naval Architects and Marine Engineers Technical Research Bulletin 2-21, "Aluminum Fire Protection Guidelines."

A-9-2.5.4 Consideration should be given to increasing the size of rods and U-hooks as necessary, to account for service and operational loading, including ship motion and vibrations.

A-9-2.6.1 Shipboard installations will normally require more than one valve per water supply. Locking valves in the open position is not an acceptable substitute for the requirement of 9-2.6.1 but can be done in addition to the supervision requirement.

A-9-2.7.1 International shore connections are portable universal couplings that permit connections of shipboard sprinkler or firemain systems between one ship and another or between a shore facility and a ship. Both the ship and the shore facility are expected to have an international shore connection fitting such that in an emergency they can be attached to their respective fire hoses and bolted together to permit charging the ship's system. It must be portable to accommodate hose-to-hose connection and allow assistance from any position.

Installation of an additional fire boat connection might be required on-board vessels whose route is such that regular access to fire boats is possible. An additional fire boat connection might not be necessary where fire boats are equipped to connect to the regular fire department connection. (*See A-9-2.7.3*).

A-9-2.7.3 Selection of the pipe thread for the fire department connection should be done very carefully. It is recommended that a 2½-in. Siamese connection with National Standard Hose Thread be used since a majority of fire department hose lines will be compatible with this thread. However, it must be noted that some fire jurisdictions might not be compatible with a connection of this type. Serious consideration should be given to the vessel's typical operating area. Precautions and planning should avert the possibility of the vessel being forced ashore by fire at a location where the fire department equipment is not compatible with this connection. Carriage of extra fittings and pre-voyage arrangements with all applicable jurisdictions should be considered. The international shore connection is required to ensure that all vessels fitted with sprinkler systems have at least one type of common connection.

A-9-3.1 Special consideration should be given to the installation of relief valves in all wet pipe systems. Ambient ship temperatures can vary greatly depending on operating environment, duration of voyage, and failure of climate control systems.

A-9-4.2 Areas fitted primarily with multiple staterooms and corridors should be considered sleeping accommodation areas.

A-9-4.4 If combustibles are present such that they constitute a threat, the space should be sprinklered. One example would be the presence of large bundles of unsheathed computer or electrical cable. Typical amounts of lighting or control cabling should not be considered to constitute a fire threat.

A-9-4.10 The objective of these requirements is to protect risers and cross mains, and to ensure that fire damage within one space or group of spaces will not inhibit the performance of the remainder of the sprinkler system. Heat-sensitive piping, as restricted by this section, should not be led between two spaces that are required to be separated by 60-min-rated divisions.

A-9-4.12.1 While not required, a dual annunciator alarm panel system is recommended. One panel should show the piping system layout and indicate status of zone valves, tank pressures, water supply valves, pump operation, etc. The second panel should show the vessel's general arrangement and indicate status of water flow (i.e., fire location) alarms.

A-9-5.2 For example, a design area of 1500 ft² (139.3 m²) is used to design a sprinkler system for an unobstructed Light Hazard occupancy. In this case, the system must supply at least 7 sprinklers that are installed within that area. If 8 sprinklers are installed to protect windows within this design area, the water demand of these sprinklers is added to the total water demand. Thus, 15 sprinklers must be supplied by this system.

A-9-5.3 Hose stream flow need not be added to the water demand. The water supply for fire streams is supplied by separate fire pump(s) that supply the vessel's fire main.

A-9-6.2.6 The purpose of this is to ensure that the pressure tank air supply will not keep the tank "fully" pressurized while water is expelled, thus preventing pump actuation.

A-9-6.3.6(a) Pumps should not be located within the same compartment. However, where this is not reasonable or practical, special attention should be given to protecting pumps such that a single failure will not render the sprinkler system inoperative.

A-9-6.4.5 This procedure should be used to qualify each water supply to which the vessel is to be attached. For example, this might require testing of multiple hydrants or connections in the same mooring area. The pressure loss effect of the hose or piping leading from the water supply to the ship should also be considered when qualifying each hydrant.

A-10-1.1 Impairments. Before shutting off a section of the fire service system to make sprinkler system connections, notify the authority having jurisdiction, plan the work carefully, and assemble all materials to enable completion in the shortest possible time. Work started on connections should be completed without interruption and protection restored as promptly as possible. During the impairment, provide emergency hose lines and extinguishers and maintain extra watch service in the areas affected.

When changes involve shutting off water from any considerable number of sprinklers for more than a few hours, temporary water supply connections should be made to sprinkler systems so that reasonable protection can be maintained. In adding to old systems or revamping them, protection should be restored each night so far as possible. The members of the private fire brigade as well as public fire departments should be notified as to conditions.

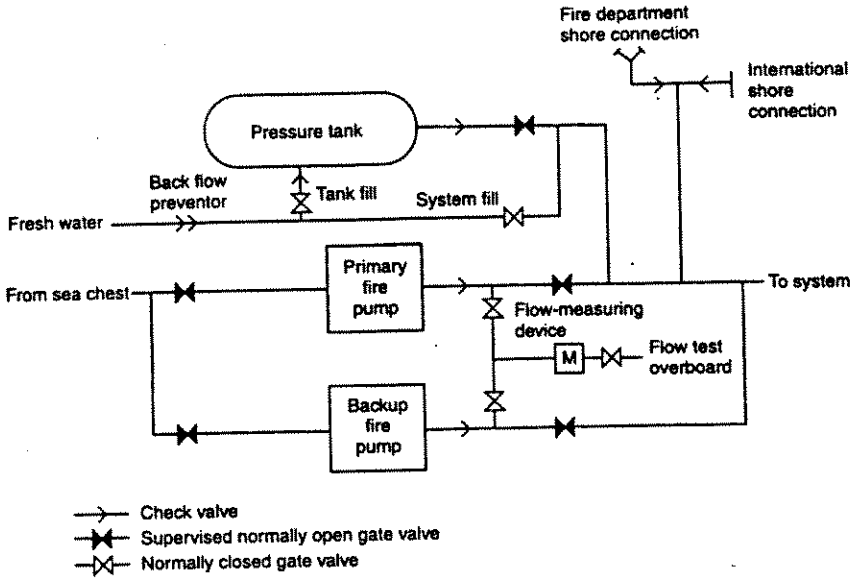


Figure A-9-6.3.6(a) Abbreviated example of a dual fire pump water supply.

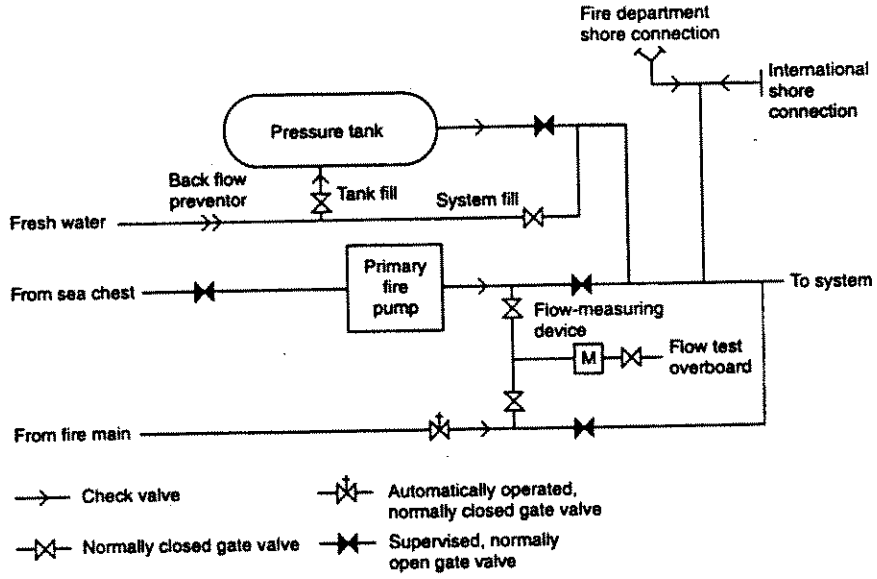


Figure A-9-6.3.7 Abbreviated example of a water supply with fire pump backup.