NATIONAL FIRE CODES®

A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1

This standard provides a range of sprinkler system approaches, design development alternatives, and component options that are all acceptable. Building owners and their designated representatives are advised to carefully evaluate proposed selections for appropriateness and preference.

A.1.1.2

Various codes and standards allow exceptions and reductions in building fire protection and other construction features where fire sprinkler systems are installed in accordance with NFPA standards. Only after appropriate analysis and evaluation of a tested mist system has been performed for the intended installation, and taking into consideration criteria other than solely firefighting performance (visibility, pressure ratings of backup systems, etc.) should exceptions and reductions in building fire protection and other construction features be allowed by the authority having jurisdiction. These systems are adequately described in NFPA 750.

A.1.1.3

This standard also provides guidance for the installation of systems for exterior protection and specific hazards. Where these systems are installed, they are also designed for protection of a fire from a single ignition source.

A.1.2

Since its inception, this document has been developed on the basis of standardized materials, devices, and design practices. However, Sections 1.2 and 15.2 allow the use of materials and devices not specifically designated by this standard, provided such use is within parameters established by a listing organization. In using such materials or devices, it is important that all conditions, requirements, and limitations of the listing be fully understood and accepted and that the installation be in complete accord with such listing requirements.

A.1.5

Subsequent editions of NFPA standards are not always adopted as soon as they are published and could lag several code cycles before the new edition is referenced. Where a newer edition of this standard is published, that standard should be permitted to be used in its entirety.

A.1.6.1.1

Two units (liter and bar), outside of but recognized by SI, are commonly used in international fire protection.

A.1.6.1.3

Where both units of measure are presented (SI and Imperial), users of this standard should apply one set of units consistently and should not alternate between units.

A.1.6.3

Some dimensions used in this standard require a tight precision and others do not. For example, when performing hydraulic calculations more precision is required than when specifying a nominal dimension. An example is pipe sizes, where we typically refer to a nominal diameter rather than the exact diameter. The metric equivalents also have a set of generally accepted nominal measurements, and they are not a precise conversion from the “English Unit” nominal dimension. Throughout the standard the generally accepted nominal pipe sizes have been used. For example, 1 in. pipe = 25 mm, $1\frac{1}{4}$ in. pipe = 32 mm, $1\frac{1}{2}$ in. pipe = 40 mm, and so forth. In other cases, rounding is used and the number of significant digits taken into account. For example, a 30 ft ceiling would be 9.144 m. This implies a level of precision that is higher than used for the original dimension, and a conversion to 9.1 m or even 9 m is more appropriate. Another example is that in the standard, 1 in. has been converted to 25 mm and not 25.4 mm, 2 in. to 50 mm, 6 in. to 150 mm, and so forth. Finally, locally available material can have different characteristics in countries that use metric units than are typically found in the United States. Examples are things like standard door or window sizes, rack dimensions, and so forth. In these cases an approximate conversion can also be used. Where approximate conversions have been used, it is acceptable for a designer or installer to use an exact conversion rather than the approximate conversion used in the standard.

A.3.2.1 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 or 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 that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ).

The phrase “authority having jurisdiction,” or its acronym AHJ, is used in NFPA standards in a broad manner because jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

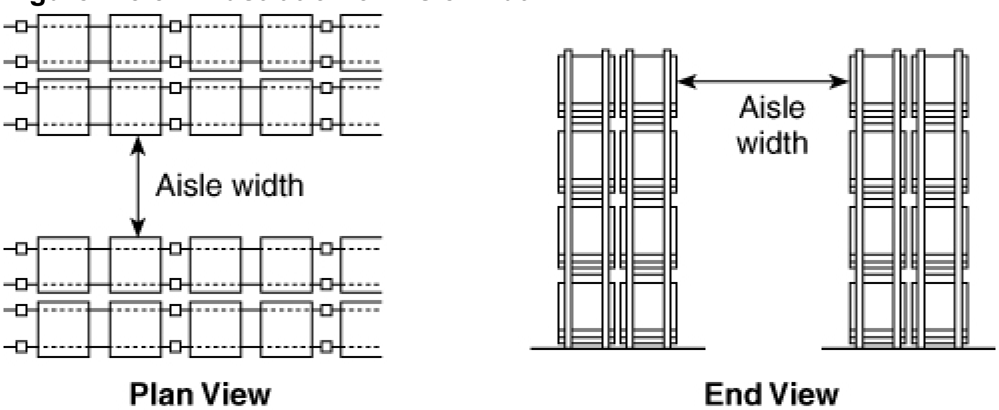
A.3.2.3 Listed.

The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations 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 product.

A.3.3.4 Aisle Width.

See Figure A.3.3.4. (AUT-SSD)

Figure A.3.3.4 Illustration of Aisle Width.



A.3.3.5 Alcove.

While most alcoves requiring sprinkler protection are enclosed on three sides, some alcoves are designed as an architectural feature with curved walls or other configurations. The area is incidental to the space it is adjacent to, is typically enclosed on three sides, and might contain a lower ceiling and/or an elevated floor. (AUT-SSI)

A.3.3.10.3 Open Array (Palletized, Solid-Piled, Bin Box, and Shelf Storage).

Fire tests conducted to represent a closed array utilized 6 in. (150 mm) longitudinal flues and no transverse flues. Fire tests conducted to represent an open array utilized 12 in. (300 mm) longitudinal flues. (AUT-SSD)

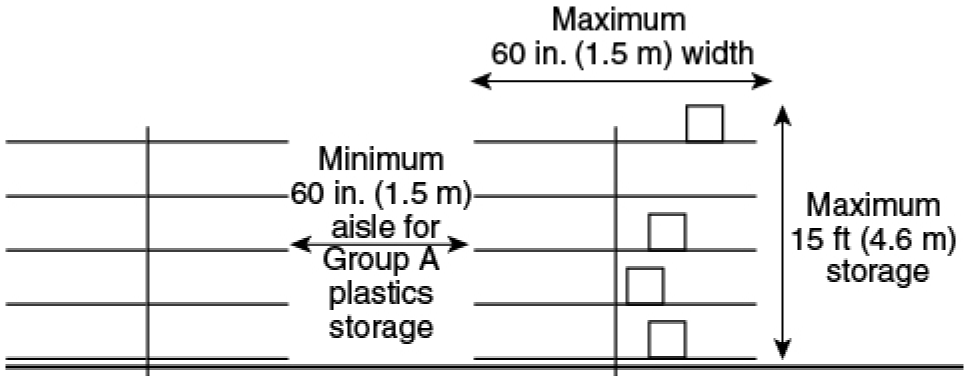
A.3.3.10.5 Standard Array (Rolled Paper).

The occasional presence of partially used rolls on top of columns of otherwise uniform diameter rolls does not appreciably affect the burning characteristics. (AUT-SSD)

A.3.3.15 Back-to-Back Shelf Storage.

The requirement for the lack of a longitudinal flue space does not prohibit a small gap between the units or a small gap between the shelves and the vertical barrier. See Figure A.3.3.15. (AUT-SSD)

Figure A.3.3.15 Back-to-Back Shelf Storage.



A.3.3.16 Baled Cotton.

Linter is another name for lint removed from cotton seed; *mote* is another name for residual materials from the ginning process.

See Table A.3.3.16. (AUT-SSD)

Table A.3.3.16 Typical Cotton Bale Types and Approximate Sizes

	Dimensions		Average Weight		Volume		Density	
Bale Type	in.	mm	lb	kg	ft^3	m^3	lb/ft^3	kg/m^3
Compressed, standard	57 × 29 × 23	1425 × 725 × 575	500	225	22.0	0.62	22.7	365
Gin, standard	55 × 31 × 21	1325 × 775 × 525	500	225	20.7	0.59	24.2	390
Compressed, universal	58 × 25 × 21	1450 × 625 × 525	500	225	17.6	0.50	28.4	455
Gin, universal	55 × 26 × 21	1375 × 650 × 525	500	225	17.4	0.49	28.7	460
Compressed, high density	58 × 22 × 21	1450 × 550 × 525	500	225	15.5	0.44	32.2	515
Densely packed baled cotton	55 × 21 × 27.6 to 35.4	1375 × 525 × 690 to 885	500	225	21.1	0.60	22.0	350

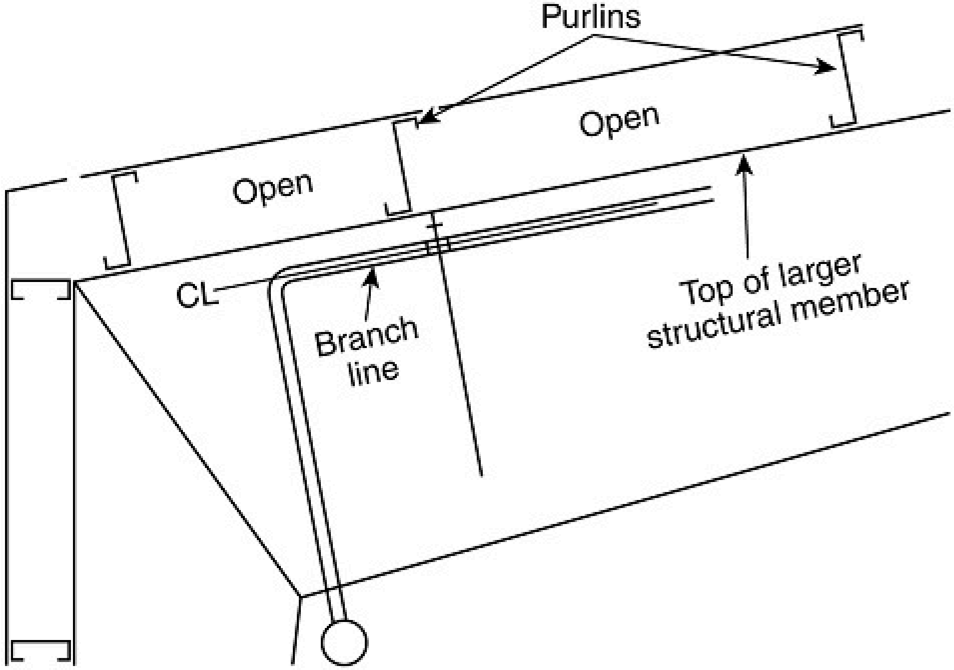
A.3.3.19 Bathroom.

A room is still considered a bathroom if it contains just a toilet. Additionally, two bathrooms can be adjacent to each other and are considered separate rooms, provided they are enclosed with the required level of construction. A compartment containing only a toilet, regardless of its intended use, is considered a bathroom. (AUT-SSI)

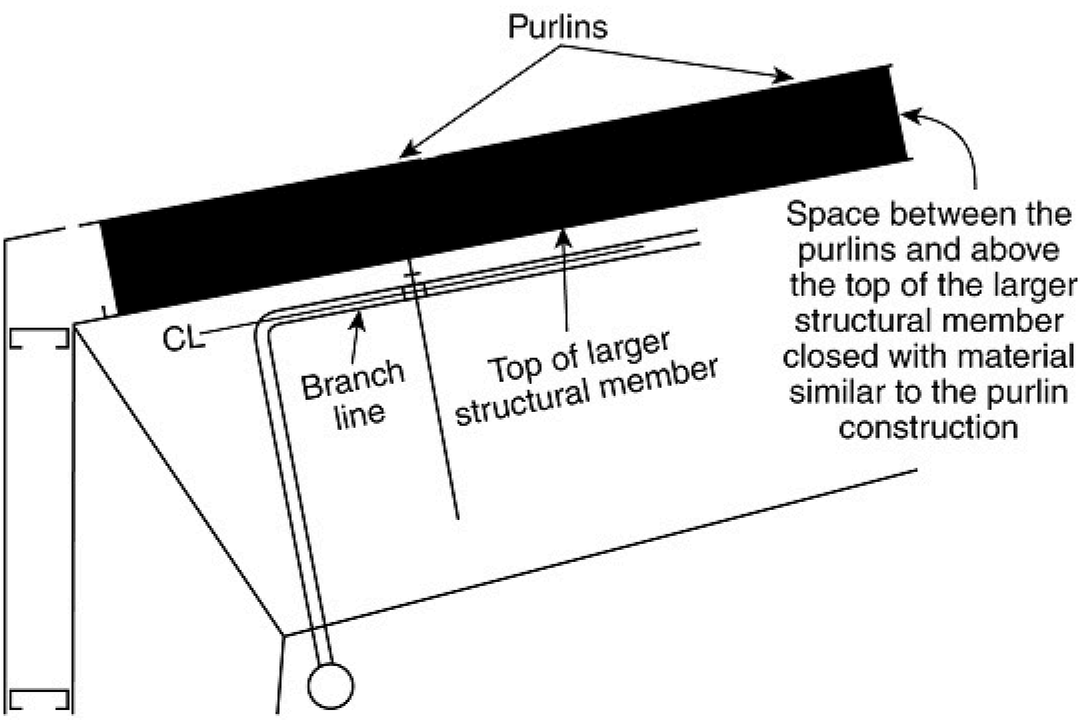
A.3.3.22 Blocking.

Blocking is required in several instances within this standard to restrict the horizontal flow of heat within channels created by obstructed construction, which is referred to as *channeling*. The blocking helps reduce the channeling effect created by obstructed construction so that the heat from a fire can fill a specified channel volume before eventually flowing horizontally under the structural members and activating ceiling sprinklers in a timely fashion. See Figure A.3.3.22 for an example of blocking a purlin at the intersection of a girder. The material utilized for blocking does not have to have a fire resistive rating, rather it only requires noncombustible materials for the blocking when the structural elements are noncombustible. While it is ideal to have blocking that is tight to the ceiling, the intent of this section is to not require the small gaps created by a corrugated roof decking to be filled. (AUT-SSD)

Figure A.3.3.22 Example of Blocking at Intersection of Purlins and Girders.



Openings Above Top of Girder



Top of Girder Provided with Blocking to Depth of Purlins

A.3.3.26 Carton Records Storage.

Carton records storage is a Class III commodity when it is within the definition of 20.4.3 and is permitted to contain a limited amount (5 percent by weight or volume or less) of Group A or Group B plastics. Materials stored include Class I and II commodities, paper business records, books, magazines, stationery, newspapers, cardboard dividers, and cartons. See Table A.20.4.3. (AUT-SSD)

A.3.3.30 Ceiling Pocket.

It is not the intent of this definition to be applied to structural and/or framing members otherwise used to define obstructed or unobstructed construction. Ceiling pockets can be protected or unprotected. A ceiling pocket where the upper ceiling is within the allowable vertical distance from the sprinkler deflector should be considered a protected ceiling pocket. Buildings with protected ceiling pockets are permitted to use the quick-response reduction of 19.2.3.2.3. Buildings with unprotected ceiling pockets greater than 32 ft^2 (3.0 m^2) are not allowed to use the quick-response reduction of 19.2.3.2.3.

Where a sprinkler(s) in the upper ceiling level is obstructed or where placing sprinklers in the lower ceiling (only) would violate the allowable deflector distance from the upper level ceiling, additional sprinklers would be necessary. (AUT-SSI)

A.3.3.44 Compartmented.

Cartons used in most of the FM Global–sponsored plastic tests involved an ordinary 200 lb (91 kg) test of outside corrugated cartons with five layers of vertical pieces of corrugated carton used as dividers on the inside. There were also single horizontal pieces of corrugated carton between each layer.

Other tests sponsored by the Society of Plastics Industry, Industrial Risk Insurers, FM Global, and Kemper used two vertical pieces of carton (not corrugated) to form an “X” in the carton for separation of product. This arrangement was not considered compartmented, as the pieces of carton used for separations were flexible (not rigid), and only two pieces were used in each carton. (AUT-SSD)

A.3.3.46.1 Obstructed Construction.

The following examples of obstructed construction are provided to assist the user in determining the type of construction feature:

(1) *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. (100 mm) or greater nominal thickness or concrete or steel beams spaced 3 ft to 7½ ft (900 mm 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.]

(2) *Concrete Tee Construction*. The term *concrete tee construction* as it is used in this standard refers to solid concrete members with stems (legs) having a nominal thickness less than the nominal height. *[See Figure A.3.3.46.1(a) for examples of concrete tee construction.]*

(3) *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 can vary in depth up to 48 in. (1.2 m), can be spaced up to 48 in. (1.2 m) on centers, and can span up to 60 ft (18 m) between supports. Joist channels should be constructed with blocking so that individual channel areas do not exceed 300 ft^2 (28 m^2). *[See Figure A.3.3.46.1(b) for an example of composite wood joist construction.]*

(4) *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 ft^2 (28 m^2) in area. There should be no unfilled penetrations in the cross-sectional area of the bounding structural members including the interface at the roof. Beams spaced more than 7½ ft (2.3 m) apart and framed into girders qualify as panel construction, provided the 300 ft^2 (28 m^2) area limitation is met.

(5) *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.

(6) *Wood Joist Construction*. The term *wood joist construction* refers to solid wood members of rectangular cross section, which can vary from 2 in. to 4 in. (50 mm to 100 mm) nominal width and can be up to 14 in. (350 mm) nominal depth, spaced up to 3 ft (900 mm) on centers, and can span up to 40 ft (12 m) between supports, supporting a floor or roof deck. Solid wood members less than 4 in. (100 mm) nominal width and up to 14 in. (350 mm) nominal depth, spaced more than 3 ft (900 mm) on centers, are also considered as wood joist construction. Wood joists can exceed 14 in. (350 mm) in nominal depth.

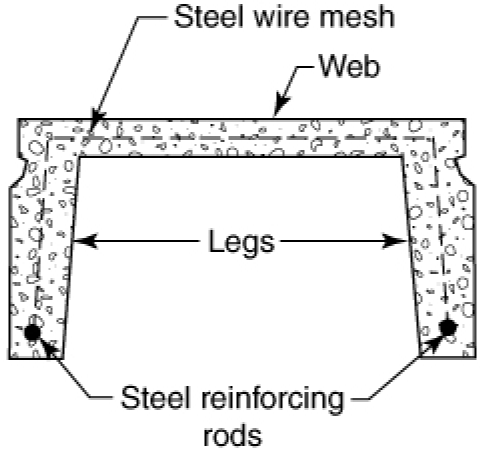
(7) *Bar Joist Construction with Fireproofing*. In order to meet building codes, bar joists are often covered with fireproofing materials. In such an event, if greater than 30 percent of the area of the joist is obstructed, it should be considered obstructed construction.

(8) *Steel Purlin Construction*. This term refers to clear span or multiple span buildings with straight or tapered columns and frames supporting C- or Z-type purlins greater than 4 in. (100 mm) in depth spaced up to 7½ ft (2.3 m) on center.

(9) *Truss Construction (Wood or Steel).* The term *truss construction* refers to parallel or pitched chord members connected by open web members supporting a roof or floor deck with top and bottom members greater than 4 in. (100 mm) in depth. *[See Figure A.3.3.46.1(c).]*

(10) *Bar Joist Construction (Wood or Steel).* 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 with steel tube or bar webs, are also defined as bar joists. Bar joists include noncombustible or combustible roof or floor decks on bar joist construction with top and bottom chord members greater than 4 in. (100 mm) in depth. *[See Figure A.3.3.46.2(a) and Figure A.3.3.46.2(b) for examples of bar joist construction.]* (AUT-SSI)

Figure A.3.3.46.1(a) Typical Concrete Tee Construction.



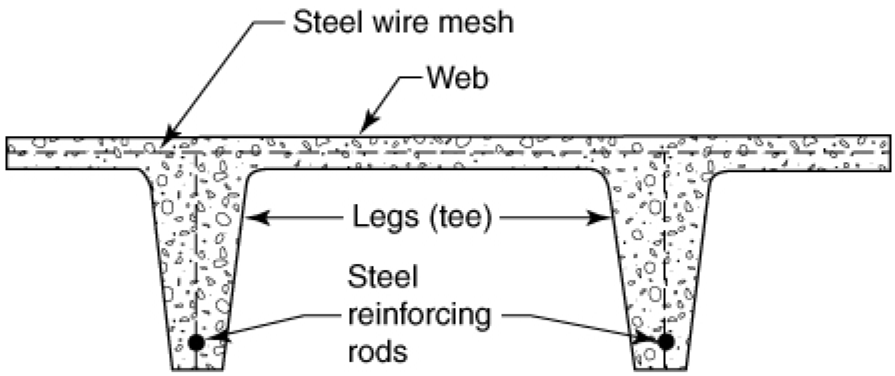


Figure A.3.3.46.1(b) Typical Composite Wood Joist Construction.

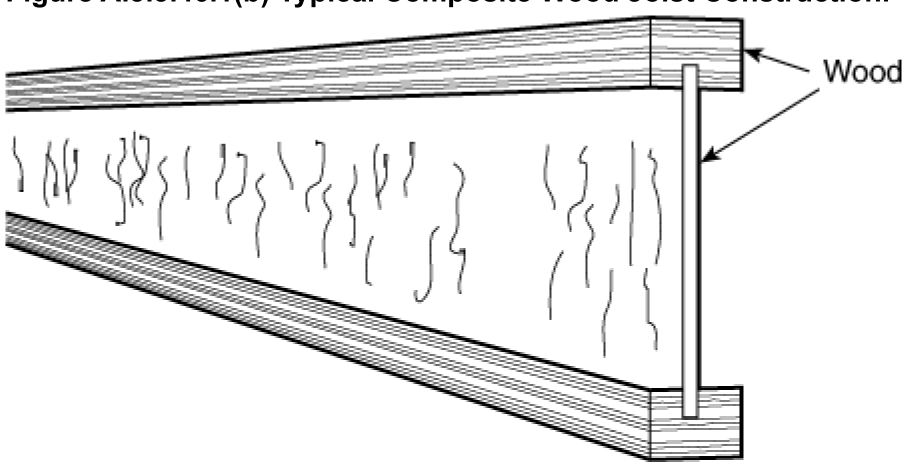
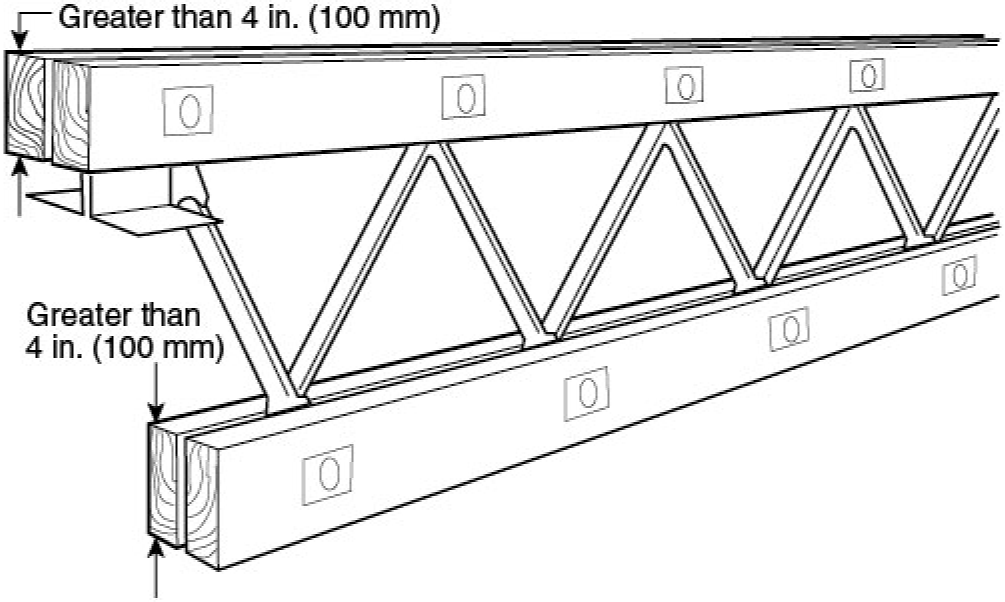
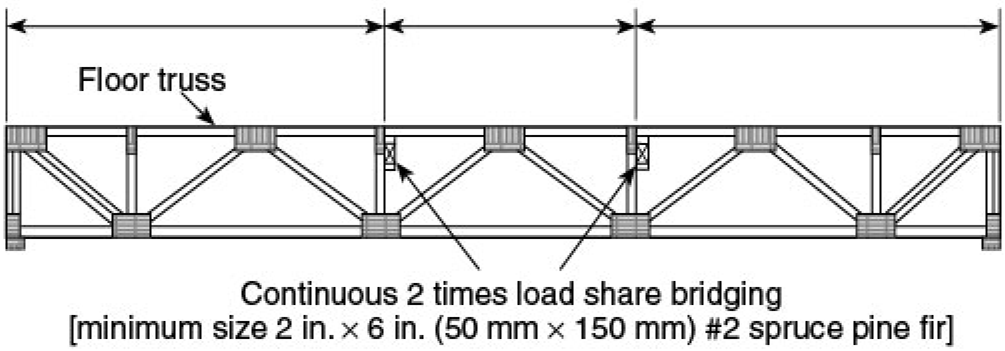


Figure A.3.3.46.1(c) Wood Truss Construction.





A.3.3.46.2 Unobstructed Construction.

The following examples of unobstructed construction are provided to assist the user in determining the type of construction feature:

(1) *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 with steel tube or bar webs, are also defined as bar joists. Bar joists include noncombustible or combustible roof or floor decks on bar joist construction with top and bottom chord members not exceeding 4 in. (100 mm) in depth. *[See Figure A.3.3.46.2(a) and Figure A.3.3.46.2(b) for examples of bar joist construction.]*

(2) *Open-Grid Ceilings*. The term *open-grid ceilings* as used in this standard refers to ceilings in which the openings are $\frac{1}{4}$ in. (6 mm) or larger in the least dimension, the thickness of the ceiling material does not exceed the least dimension of the openings, and the openings constitute at least 70 percent of the ceiling area.

(3) *Smooth Ceiling Construction*. The term *smooth ceiling construction* as used in this standard includes the following:

  (a) Flat slab, pan-type reinforced concrete

  (b) Continuous smooth bays formed by wood, concrete, or steel beams spaced more than 7$\frac{1}{2}$ 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 7$\frac{1}{2}$ ft (2.3 m) on center

  (d) Smooth monolithic ceilings of at least $\frac{3}{4}$ 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

  (g) Suspended ceilings of combustible or noncombustible construction

  (h) Smooth monolithic ceilings with fire resistance less than that specified under item A.3.3.46.2(3)(d) and attached to the underside of wood joists, wood trusses, and bar joists

  Combustible or noncombustible floor decks are permitted in the construction specified in A.3.3.46.2(3)(b) through A.3.3.46.2(3)(f). A.3.3.46.2(3)(b) would include standard mill construction.

(4) *Standard Mill Construction*. The term *standard mill construction* as used in this standard refers to heavy timber construction as defined in NFPA 220.

(5) *Truss Construction (Wood or Steel).* The term *truss construction* refers to parallel or pitched chord members connected by open web members supporting a roof or floor deck with top and bottom members not exceeding 4 in. (100 mm) in depth. *[See Figure A.3.3.46.2(c).]* (AUT-SSI)

Figure A.3.3.46.2(a) Wood Bar Joist Construction.

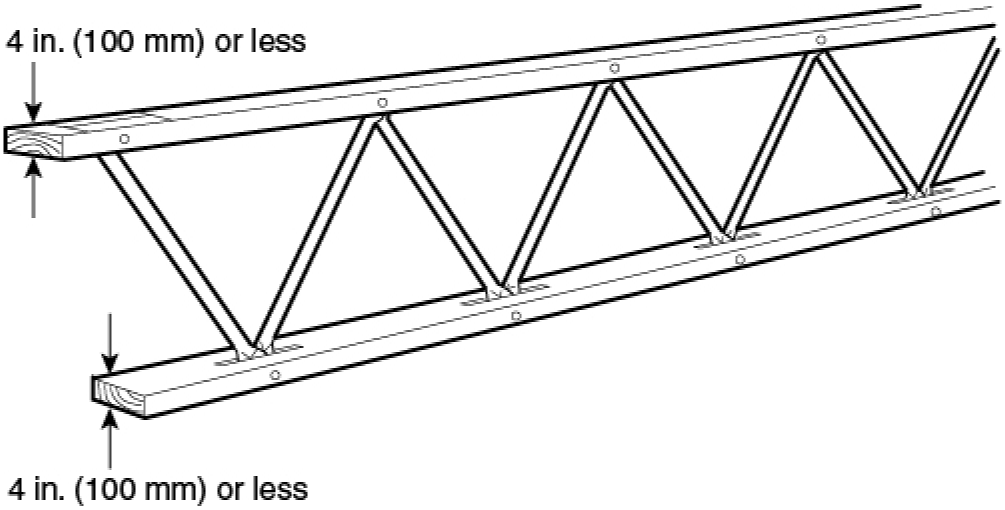


Figure A.3.3.46.2(b) Open-Web Bar Joist Construction.

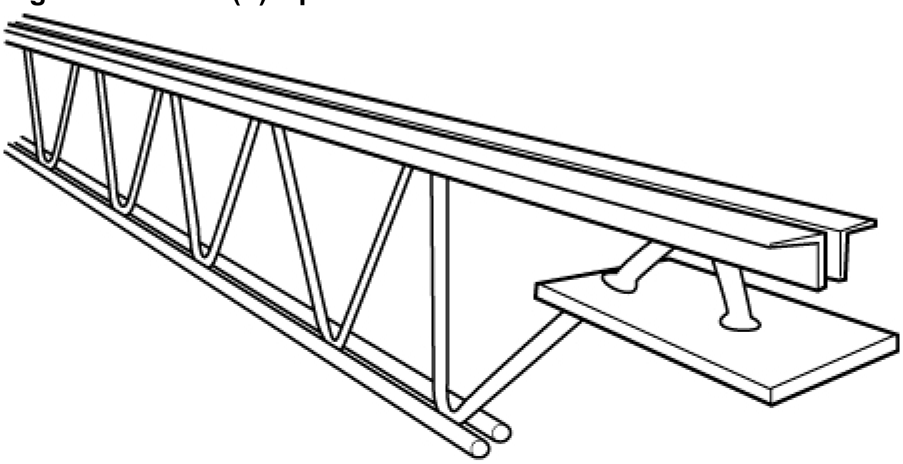
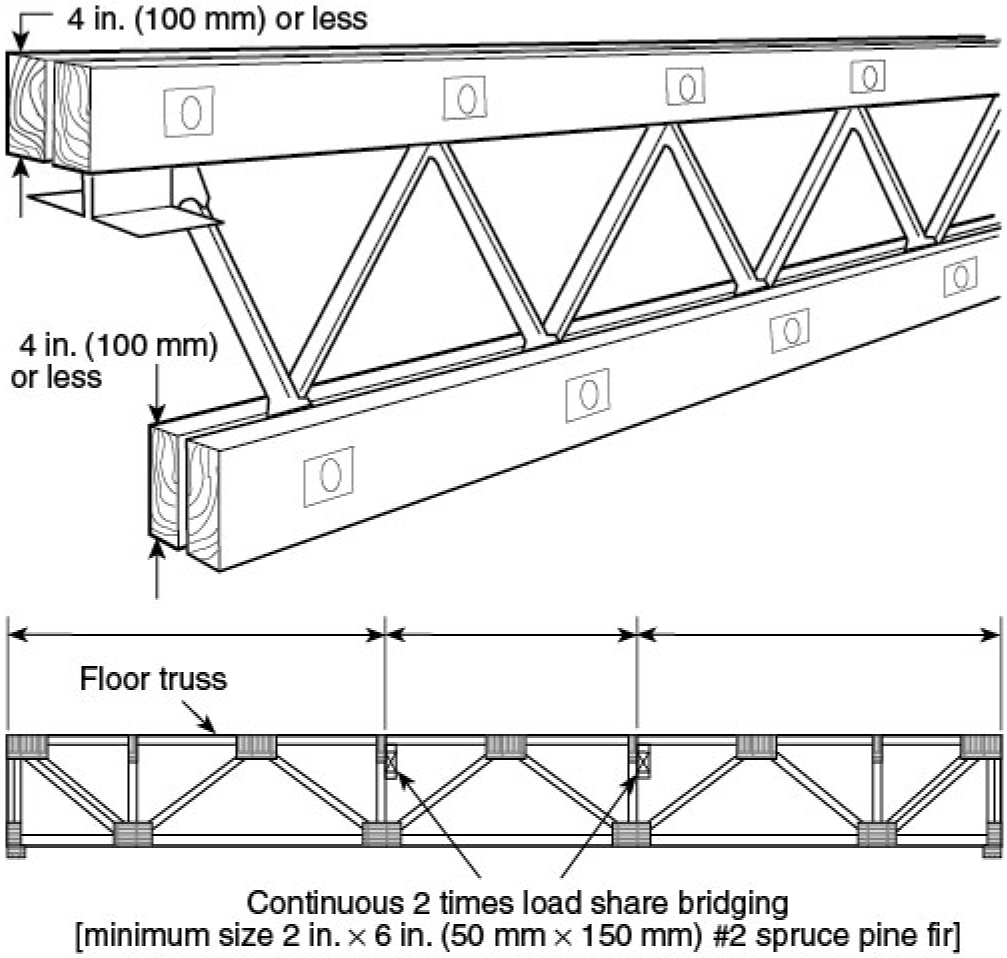


Figure A.3.3.46.2(c) Examples of Wood Truss Construction.



A.3.3.47 Container (Shipping, Master, or Outer Container).

The term *container* includes items such as cartons and wrappings. Fire-retardant containers or tote boxes do not by themselves create a need for automatic sprinklers unless coated with oil or grease. Containers can lose their fire-retardant properties if washed. For obvious reasons, they should not be exposed to rainfall. (AUT-SSD)

A.3.3.63 Draft Curtain.

Additional information about the size and installation of draft curtains can be found in NFPA 204. (AUT-SSD)

A.3.3.69 Dwelling Unit (for Sprinkler System Installations).

Common spaces such as a lounges, group cooking facilities, and group bathrooms that are for use by the occupants of the building should be considered a part of the dwelling unit. (AUT-SSI)

A.3.3.72 Encapsulation.

Totally noncombustible commodities on wood pallets enclosed only by a plastic sheet as described are not covered under this definition. Banding (i.e., stretch-wrapping around the sides only of a pallet load) is not considered to be encapsulation. Where there are holes or voids in the plastic or waterproof cover on the top of the carton that exceed more than half of the area of the cover, the term *encapsulated* does not apply. The term *encapsulated* does not apply to plastic-enclosed products or packages inside a large, nonplastic, enclosed container. (AUT-SSD)

A.3.3.80 Face Sprinklers.

All face sprinklers should be located within the rack structure. The flue spaces are generally created by the arrangement of the racks, and “walkways” should not be considered flue spaces. (AUT-SSD)

A.3.3.92 Four-Way Bracing.

A sway brace assembly could include a lateral and longitudinal brace in combination. (AUT-HBS)

A.3.3.93 Free-Flowing Plastic Materials.

Examples of free-flowing plastic materials include powder, pellets, flakes, or random-packed small objects [e.g., razor blade dispensers, 1 oz to 2 oz (28 g to 57 g) bottles]. (AUT-SSD)

A.3.3.104 High-Piled Storage.

The definition of the term *high-piled storage* is meant to be applied only in this standard to sprinkler system design and installation requirements, and does not define the same term in other codes and standards. Stockpiles in retail stores and similar locations should not be considered high-piled storage. In addition, high-piled storage requirements are intended to be limited to storage occupancies protected in accordance with Chapters 20 through 25. (AUT-SSD)

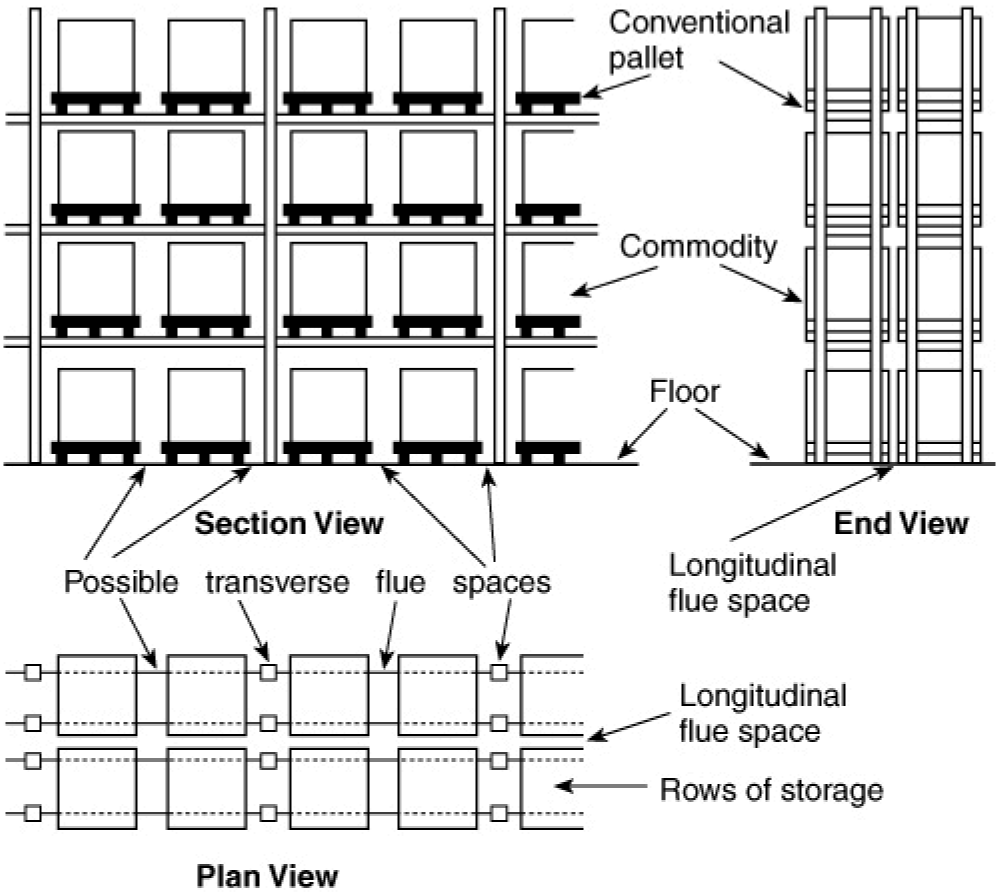
A.3.3.125 Limited-Combustible Material.

Material subject to increase in combustibility or flame spread index beyond the limits herein established through the effects of age, moisture, or other atmospheric condition is considered combustible. See NFPA 259 and NFPA 220.

A.3.3.127 Longitudinal Flue Space.

See Figure A.3.3.127. (AUT-SSD)

Figure A.3.3.127 Typical Double-Row (Back-to-Back) Rack Arrangement.



A.3.3.129 Low-Piled Storage.

This definition is not intended to address allowable design approaches and protection schemes. See A.3.3.104. (AUT-SSD)

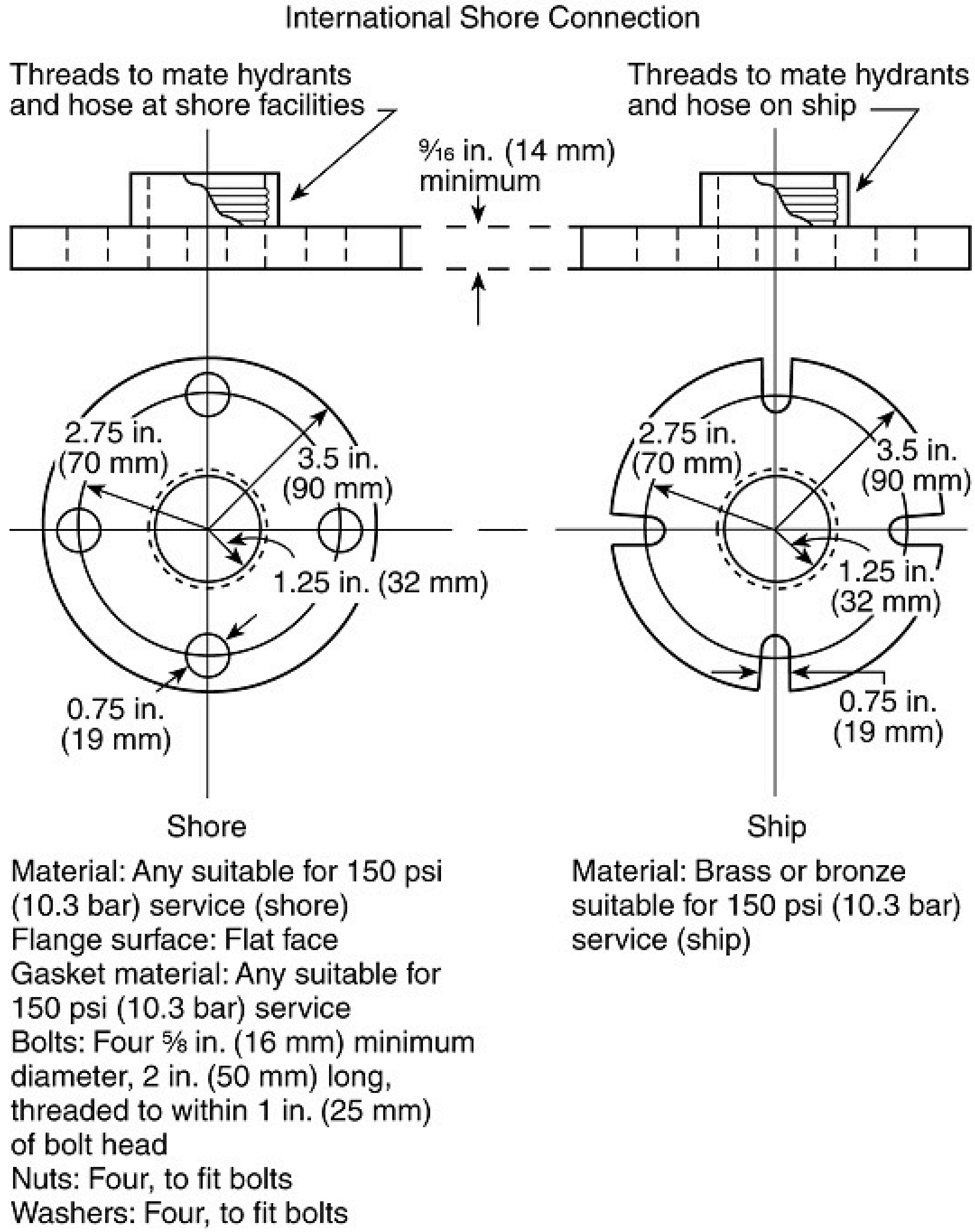
A.3.3.130.4 Heat-Sensitive Material.

The backbone of the fire protection philosophy for US 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-hour fire exposure when tested in accordance with ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials,* or UL 263, *Fire Tests of Building Construction and Materials*, are considered “heat sensitive.” (AUT-SSI)

A.3.3.130.7 International Shore Connection.

See Figure A.3.3.130.7. (AUT-SSI)

Figure A.3.3.130.7 International Shore Fire Connection.



A.3.3.130.8 Marine System.

Some types of sprinkler systems can closely resemble marine systems, such as a system installed on a floating structure that has a permanent water supply connection to a public main. For these types of systems, judgment should be used in determining if certain aspects of Chapter 26 are applicable. (AUT-SSI)

A.3.3.130.9 Marine Thermal Barrier.

A marine thermal barrier is typically referred to as a B-15 boundary. (AUT-SSI)

A.3.3.135 Miscellaneous Storage.

The sprinkler system design criteria for miscellaneous storage are covered in 4.3.1.7 and 4.3.1.4. (AUT-SSD)

A.3.3.136 Miscellaneous Tire Storage.

The limitations on the type and size of storage are intended to identify those 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 storage facilities, automotive and truck assembly plants, and mobile home assembly plants are types of facilities where miscellaneous storage could be present. (AUT-SSD)

A.3.3.143 Non-Flat Obstruction.

An example of a non-flat obstruction would be a round duct or pipe. (AUT-SSI)

A.3.3.144 Non-Solid Obstruction.

Examples of a non-solid obstruction would include (1) a cable tray where the number of cables provided in the tray allow for openings that constitute 30 percent or more of the tray's footprint, or (2) a grouped obstruction where the open space between the objects within the footprint of the grouped obstruction is 30 percent or more. (AUT-SSI)

A.3.3.156 Open-Top Container.

Open-top containers can prevent water from running across the top to storage and down the flues and can also collect water. The container will prevent water penetration to a fire in lower levels where it is needed. Rack or flue collapse can also occur if too much water is collected. Consideration should be given to the potential degree of water collection possible within the container when applying the definition of an open-top container. The following conditions should be considered:

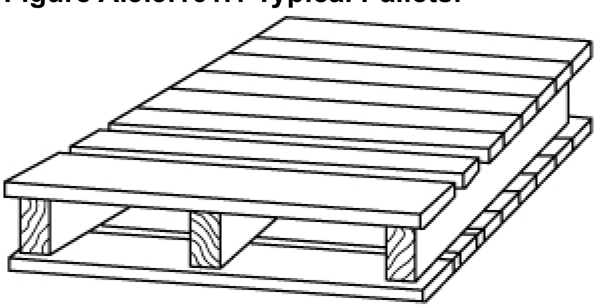
(1) Small openings at the top of containers containing such items as fresh produce are quite common and should not be considered as an open-top container.
(2) Arrangements that include open-top containers that are all located on the bottom tier of rack storage do not prevent penetration of water and should not be considered an open-top container.
(3) Containers having either wire mesh siding or large uniform openings along the bottom perimeter of each container, such that water enters the container at the same flow rate and discharge evenly into the flue spaces should not be considered as an open-top container provided the contents of the container are not water absorbent and are not capable of blocking such container openings.
(4) Open-top containers that are stored in fixed location on racks equipped with flat or domed-shaped fixed-in-place lids that are provided directly above the open-top containers and prevent water from entering the open-top container, as well as distribute water equally into all flue spaces should not be considered an open-top container.

(AUT-SSD)

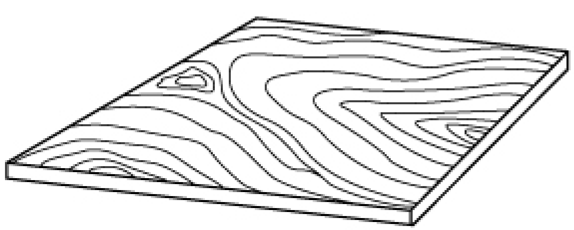
A.3.3.161.1 Conventional Pallet.

See Figure A.3.3.161.1. (AUT-SSD)

Figure A.3.3.161.1 Typical Pallets.



Conventional pallet



Solid flat bottom
wood pallet (slave pallet)

A.3.3.161.3 Reinforced Plastic Pallet.

See Figure A.3.3.161.3(a) and Figure A.3.3.161.3(b). (AUT-SSD)

Figure A.3.3.161.3(a) Cut-Away Reinforced Plastic Pallet.

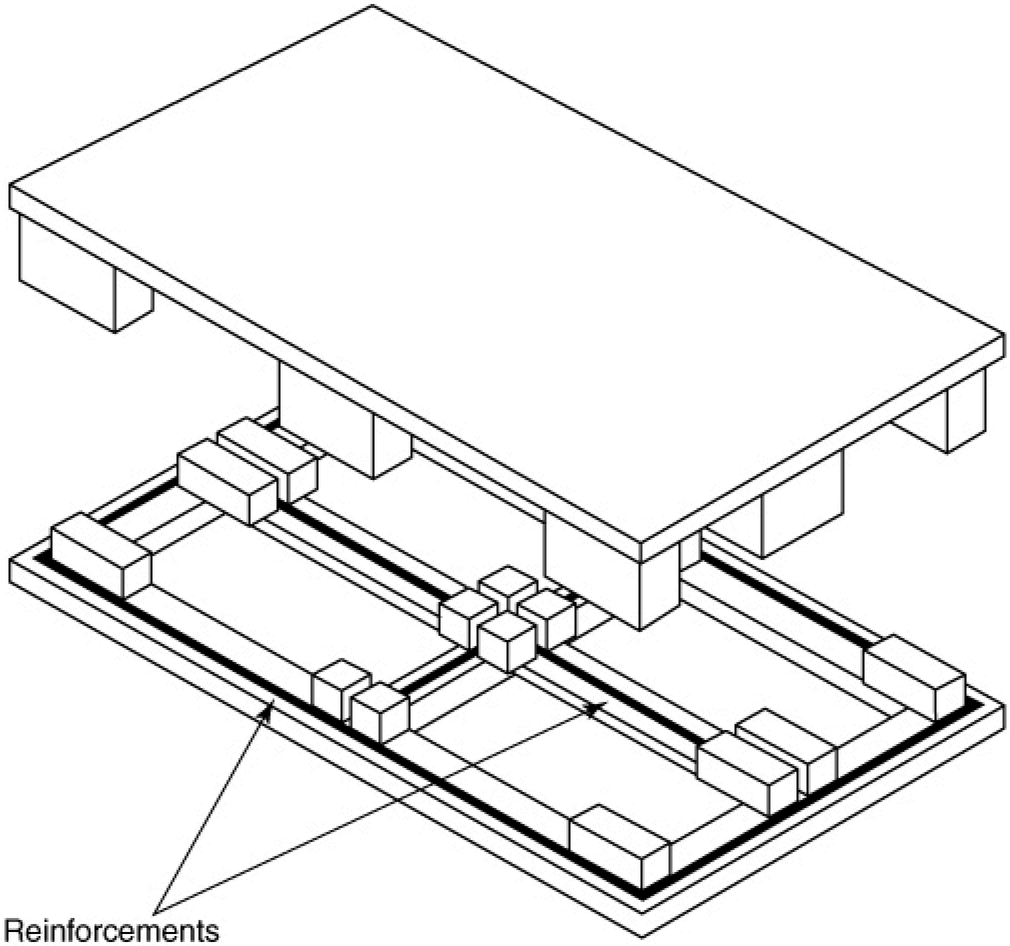
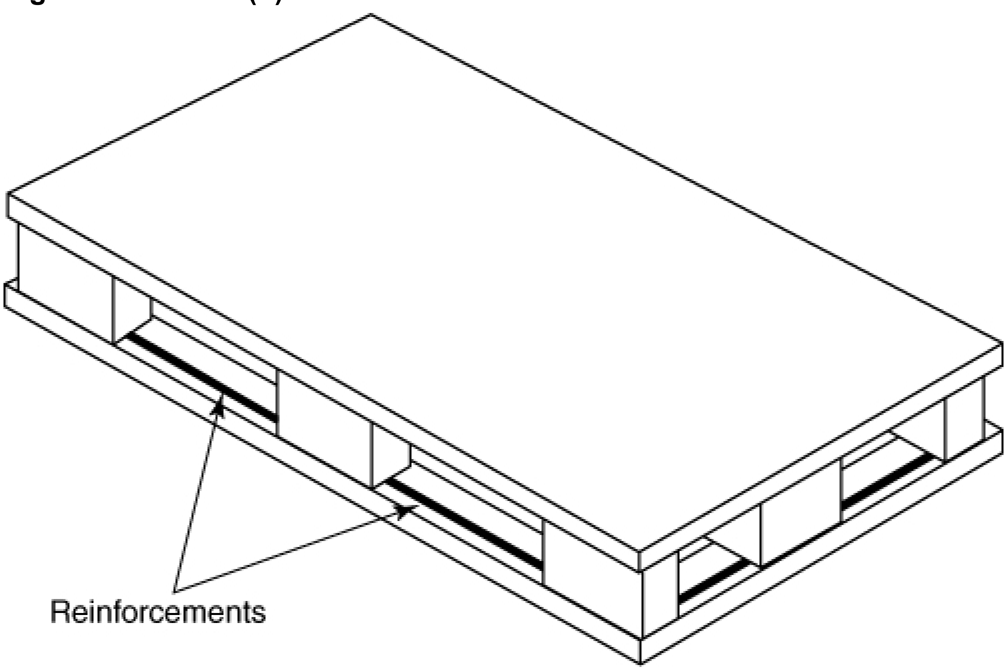


Figure A.3.3.161.3(b) Assembled Reinforced Plastic Pallet.



A.3.3.167 Pile Stability, Stable Piles.

Pile stability performance has been shown to be a difficult factor to judge prior to a pile being subjected to an actual fire. In the test work completed, compartmented cartons *(see A.3.3.44, Compartmented)* have been shown to be stable under fire conditions. Tests also indicated cartons that were not compartmented tended to be unstable under fire conditions.

Storage on pallets, compartmented storage, and plastic components that are held in place by materials that do not deform readily under fire conditions are examples of stable storage. (AUT-SSD)

A.3.3.168 Pile Stability, Unstable Piles.

Leaning stacks, crushed bottom cartons, and reliance on combustible bands for stability are examples of potential pile instability under a fire condition. An increase in pile height tends to increase instability. (AUT-SSD)

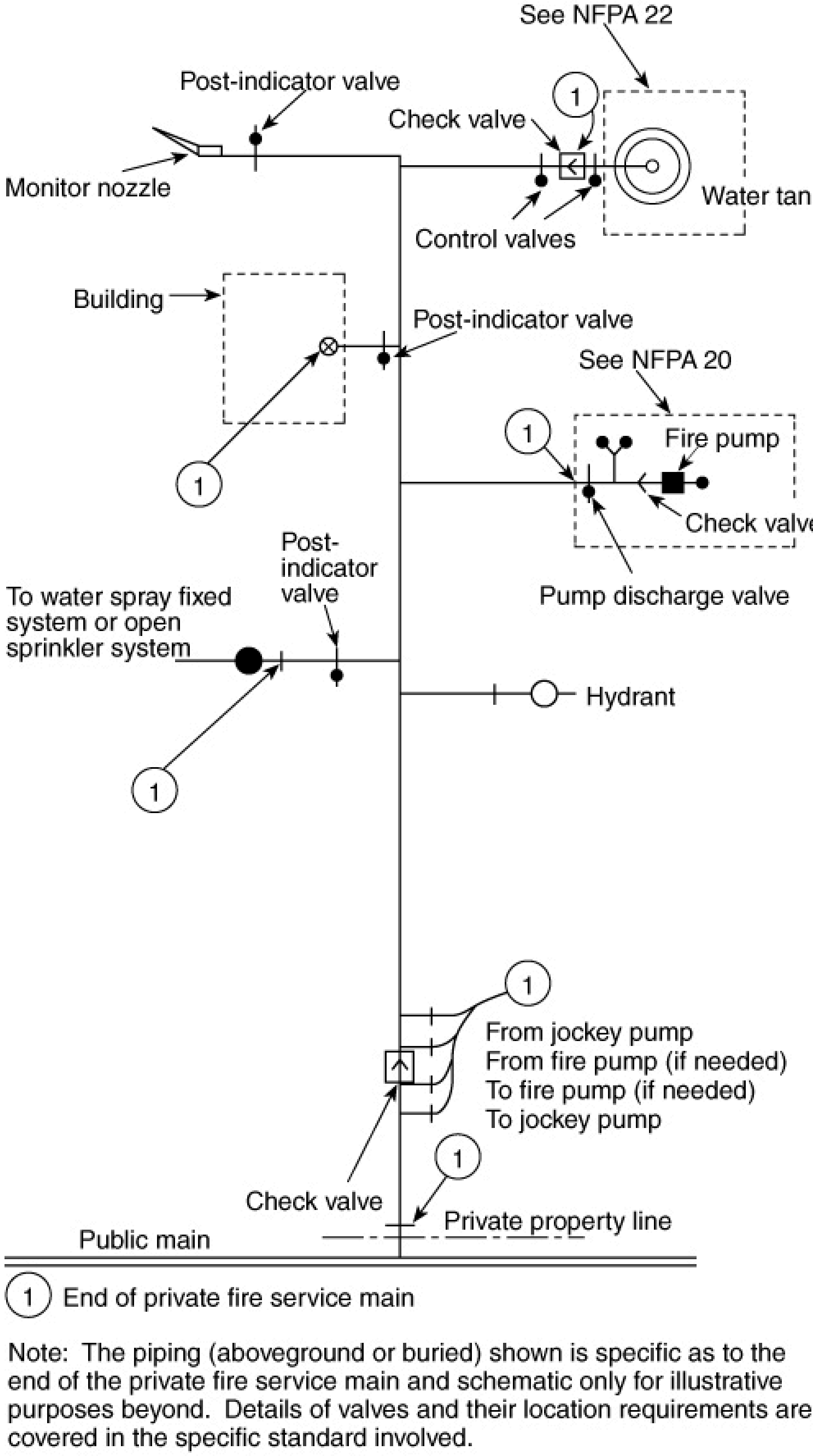
A.3.3.173 Post-Installed Anchors.

Examples of these are wedge or undercut anchors, or powder-driven studs. (AUT-HBS)

A.3.3.178 Private Fire Service Main.

See Figure A.3.3.178.

Figure A.3.3.178 Typical Private Fire Service Main.



A.3.3.179 Prying Factor.

Prying factors in NFPA 13 are utilized to determine the design loads for attachments to concrete. Prying is a particular concern for anchorage to concrete because the anchor could fail in a brittle fashion. (AUT-HBS)

A.3.3.186 Rack.

Shelving can be solid, slatted, or open. Racks can be fixed, portable, or movable. Loading can be either manual, using lift trucks, stacker cranes, or hand placement, or automatic, using machine-controlled storage and retrieval systems.

Rack storage as referred to in this standard contemplates commodities in a rack structure, usually steel. Many variations of dimensions are found. Racks can be single-, double-, or multiple-row, with or without solid shelving. The standard commodity used in most of the tests was 42 in. (1.1 m) on a side. Examples of the types of racks covered in this standard are as follows:

(1) *Double-Row Racks*. Pallets rest on two beams parallel to the aisle. Any number of pallets can be supported by one pair of beams. *[See Figure A.3.3.186(a) through Figure A.3.3.186(d).]*
(2) *Automatic Storage-Type Rack*. The pallet is supported by two rails running perpendicular to the aisle. *[See Figure A.3.3.186(e).]*
(3) *Multiple-Row Racks More Than Two Pallets Deep, Measured Aisle to Aisle*. These racks include drive-in racks, drive-through racks, flow-through racks, portable racks arranged in the same manner, and conventional or automatic racks with aisles less than 42 in. (1.1 m) wide. *[See Figure A.3.3.186(f) through Figure A.3.3.186(i).]*
(4) *Movable Racks*. Movable racks are racks on fixed rails or guides. They can be moved back and forth only in a horizontal, two-dimensional plane. A moving aisle is created as abutting racks are either loaded or unloaded, then moved across the aisle to abut other racks. *[See Figure A.3.3.186(k).]*
(5) *Cantilever Rack*. The load is supported on arms that extend horizontally from columns. The load can rest on the arms or on shelves supported by the arms. *[See Figure A.3.3.186(j).]*

Load depth in conventional or automatic racks should be considered a nominal 4 ft (1.2 m). *[See Figure A.3.3.186(b).]*

When catwalks are installed between racks, these areas are not to be considered flue spaces. (AUT-SSD)

Figure A.3.3.186(a) Conventional Pallet Rack.

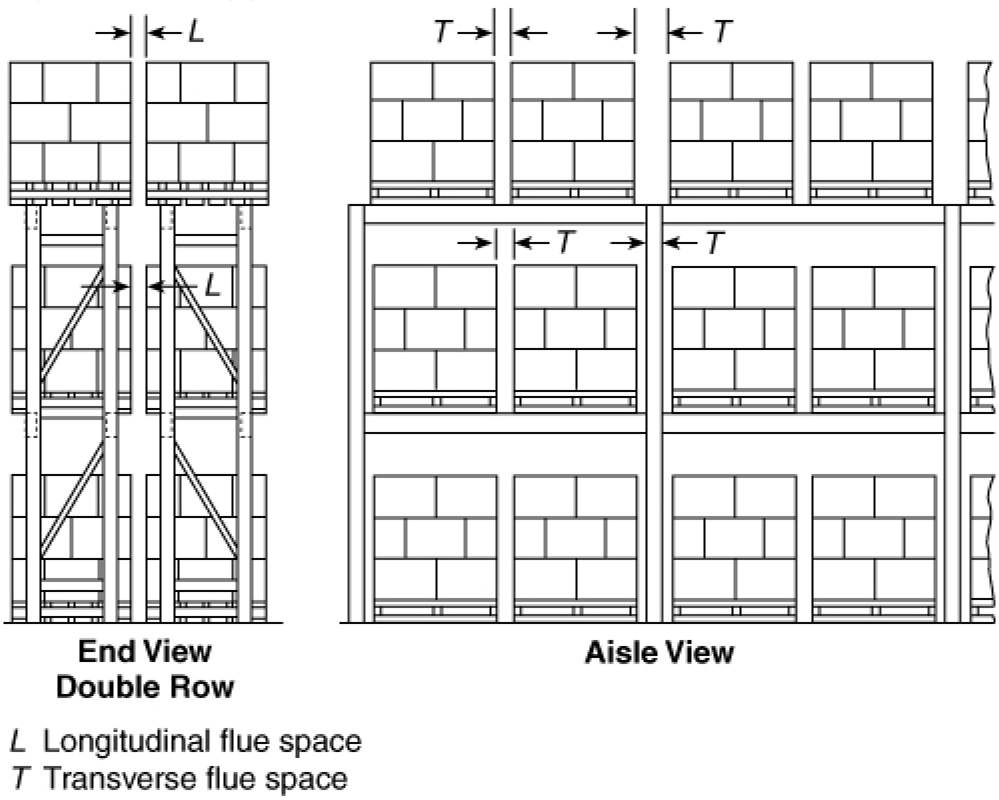
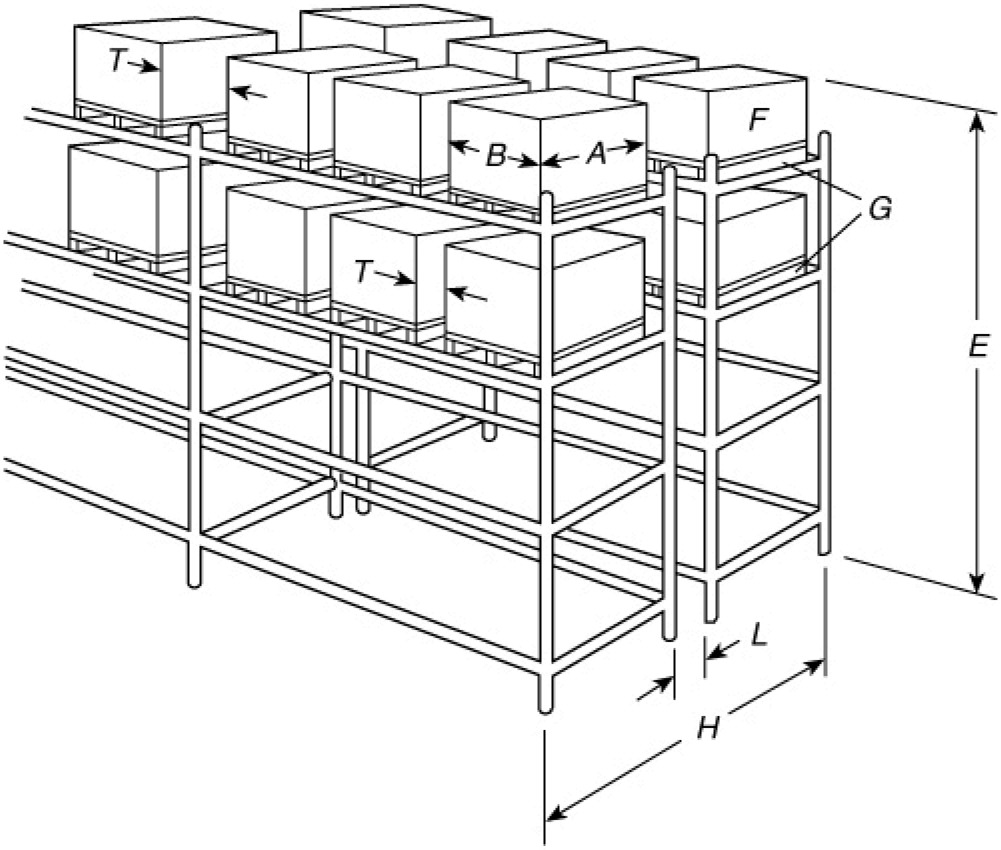
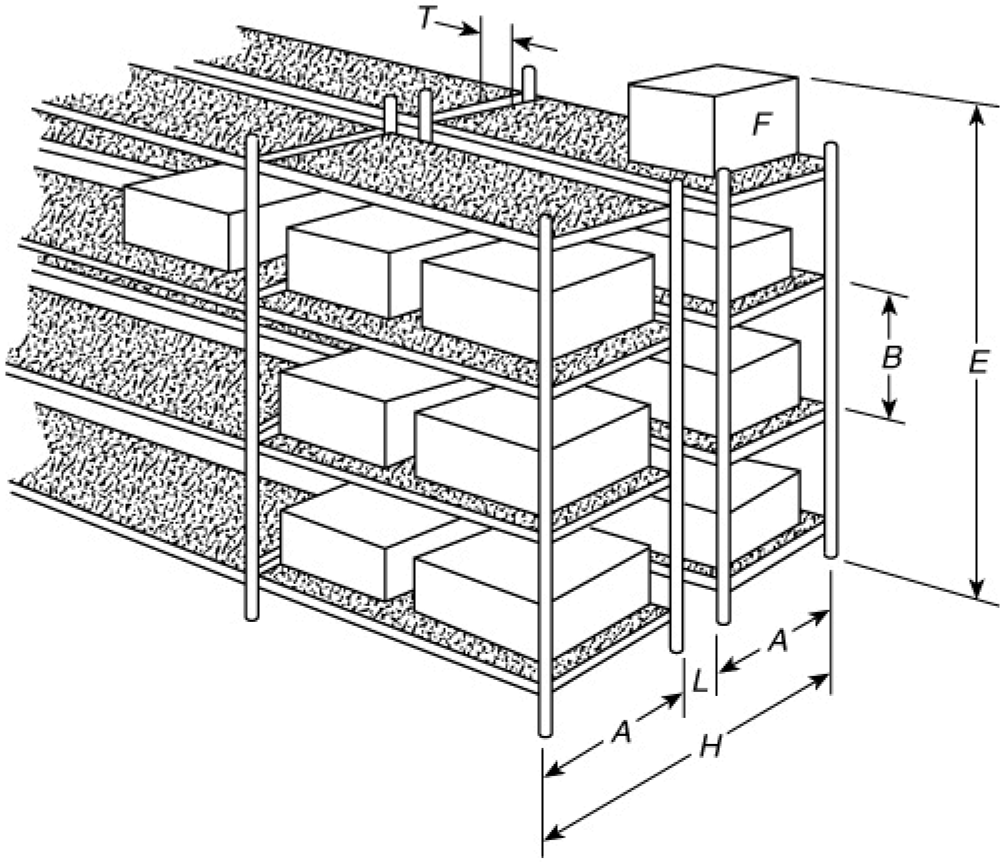


Figure A.3.3.186(b) Double-Row Racks Without Solid or Slatted Shelves.



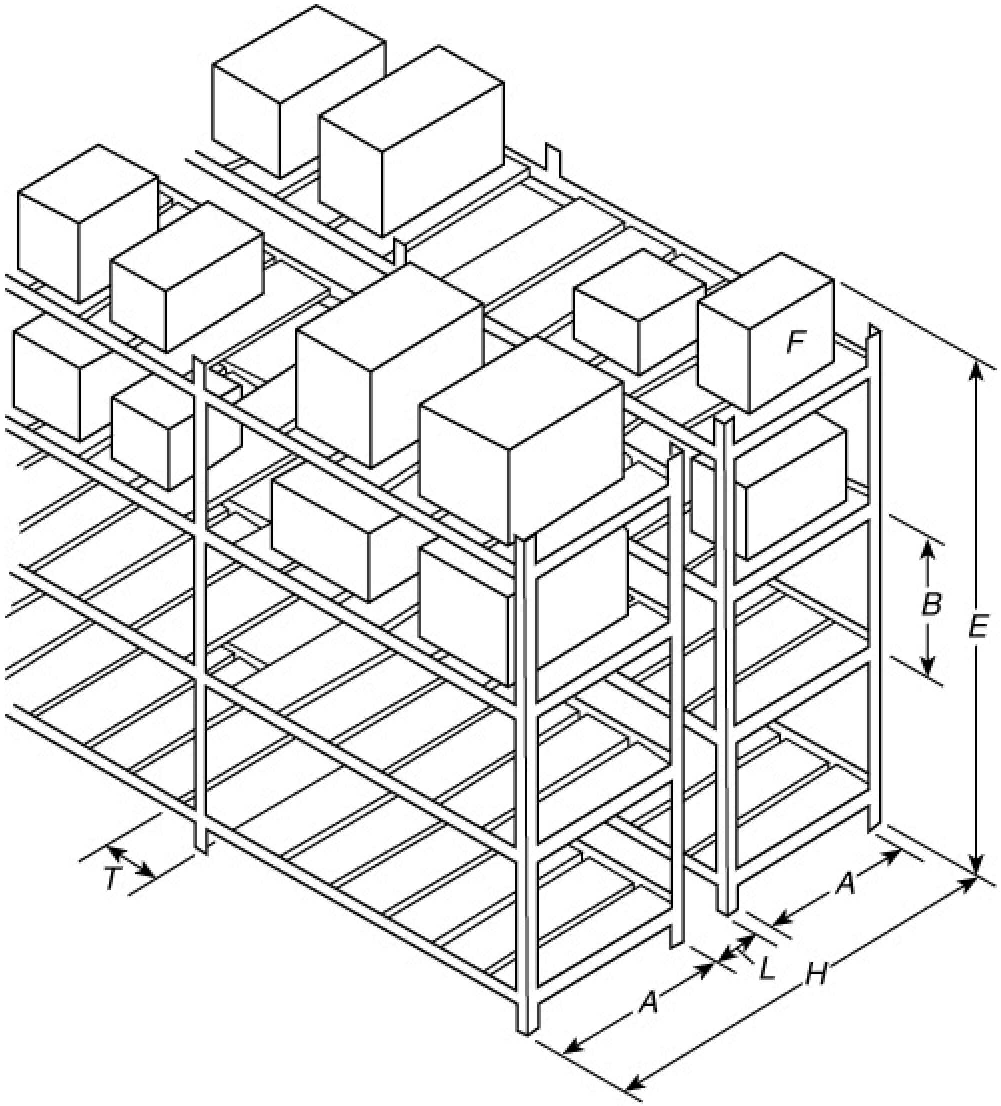
A Load depth
B Load width
E Storage height
F Commodity
G Pallet
H Rack depth
L Longitudinal flue space
T Transverse flue space

Figure A.3.3.186(c) Double-Row Racks with Solid Shelves.



A Shelf depth
B Shelf height
E Storage height
F Commodity
H Rack depth
L Longitudinal flue space
T Transverse flue space

Figure A.3.3.186(d) Double-Row Racks with Slatted Shelves.



A Shelf depth
B Shelf height
E Storage height
F Commodity
H Rack depth
L Longitudinal flue space
T Transverse flue space

Figure A.3.3.186(e) Automatic Storage-Type Rack.

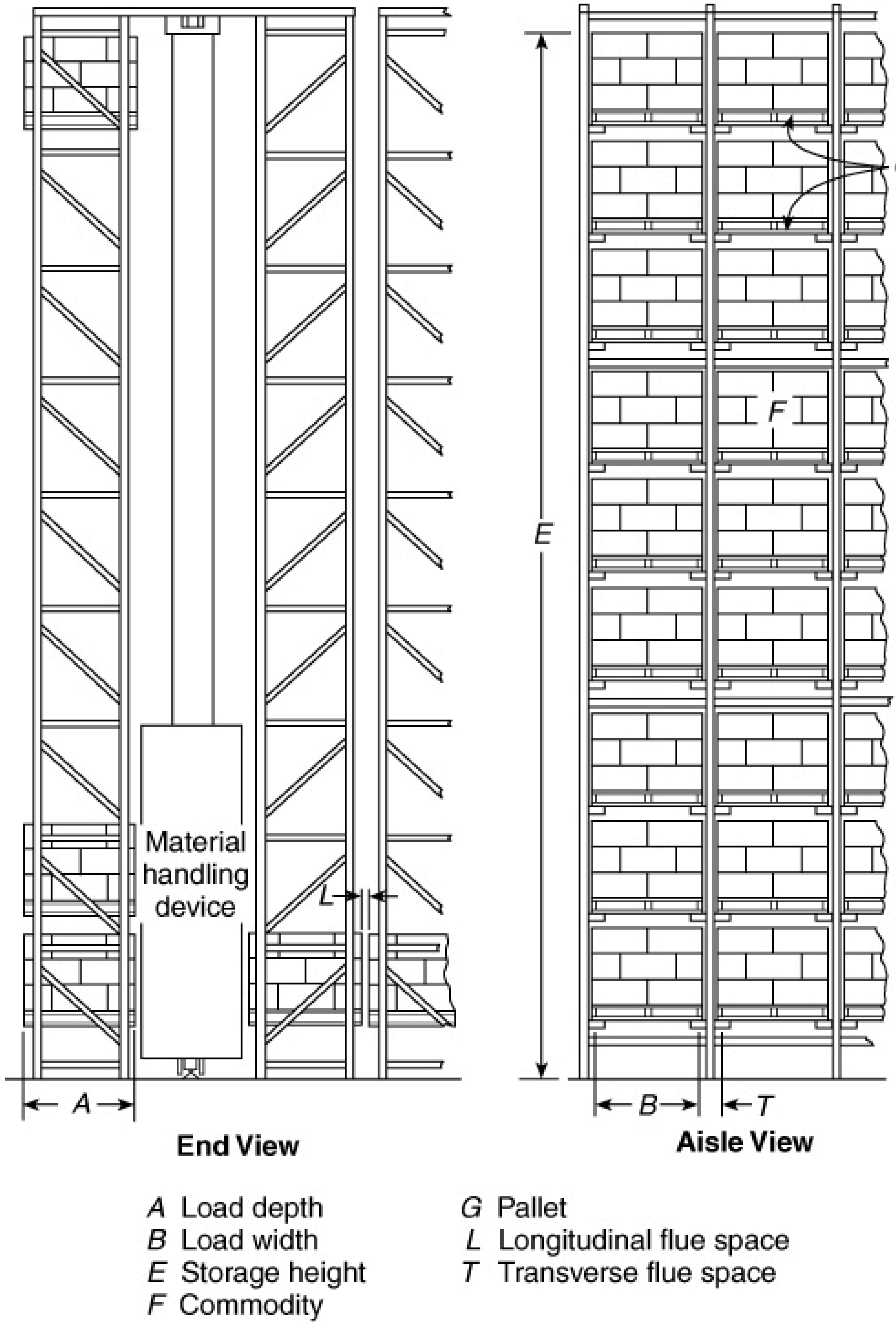
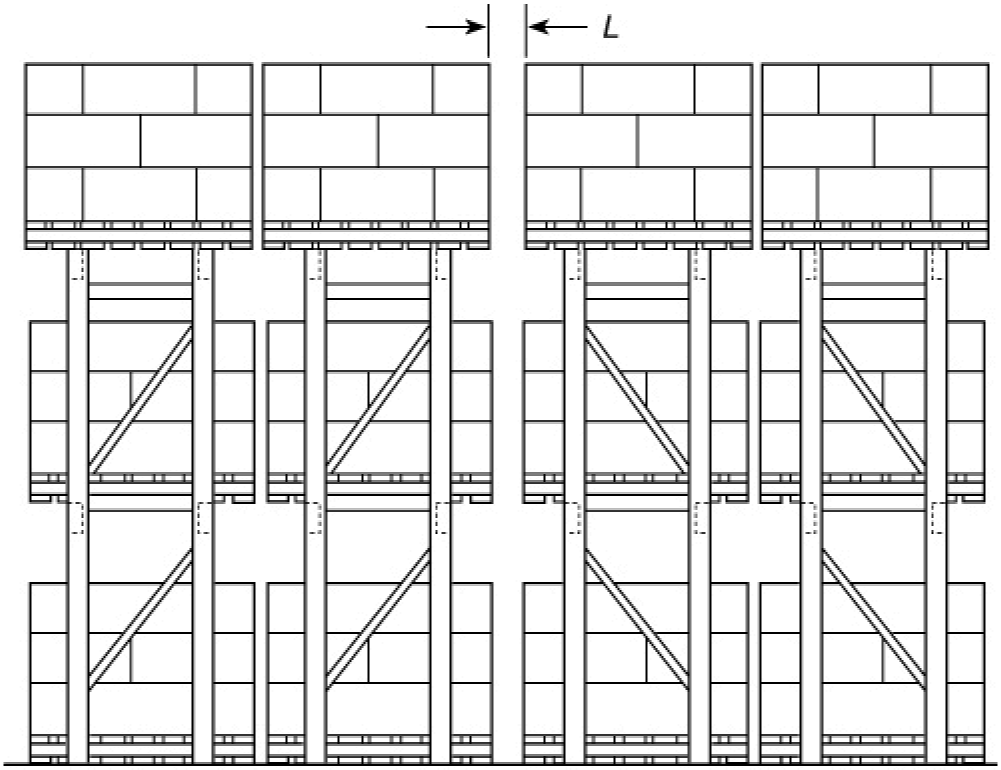


Figure A.3.3.186(f) Multiple-Row Rack Served by Reach Truck.



L Longitudinal flue space

Figure A.3.3.186(g) Flow-Through Pallet Rack.

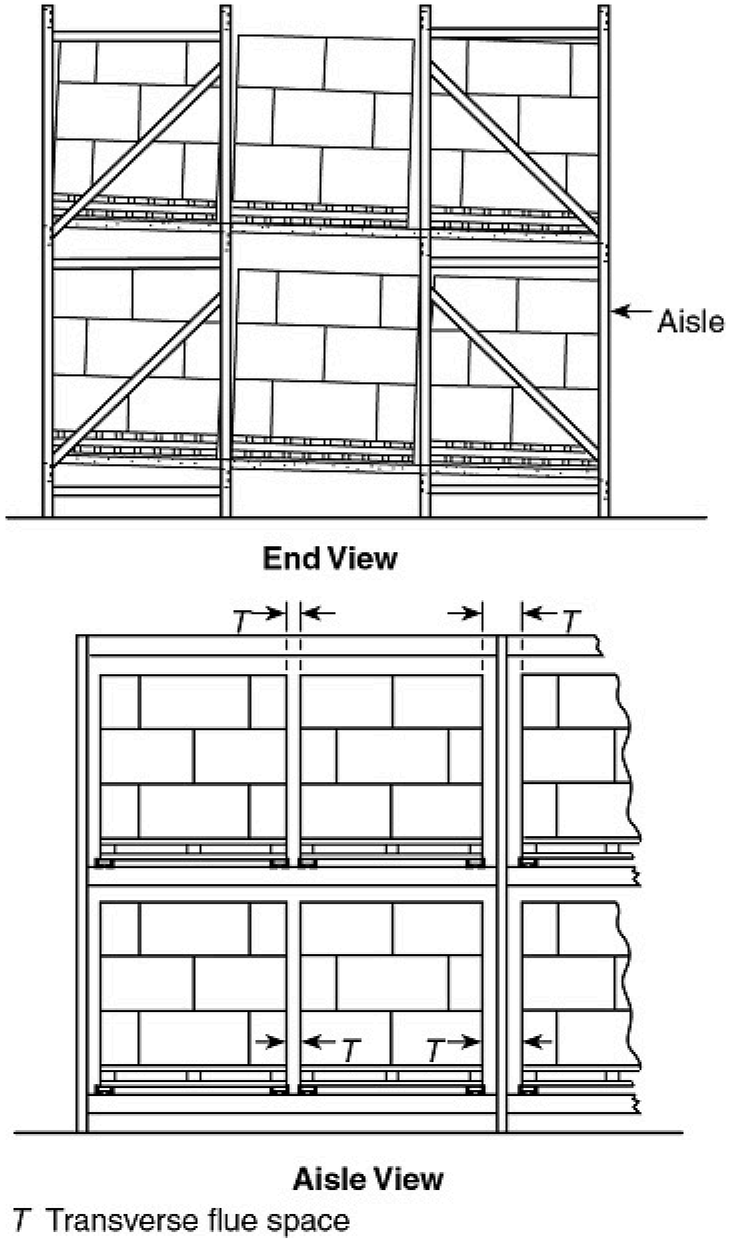


Figure A.3.3.186(h) Drive-In Rack — Two or More Pallets Deep (Fork Truck Drives into Rack to Deposit and Withdraw Loads in Depth of Rack).

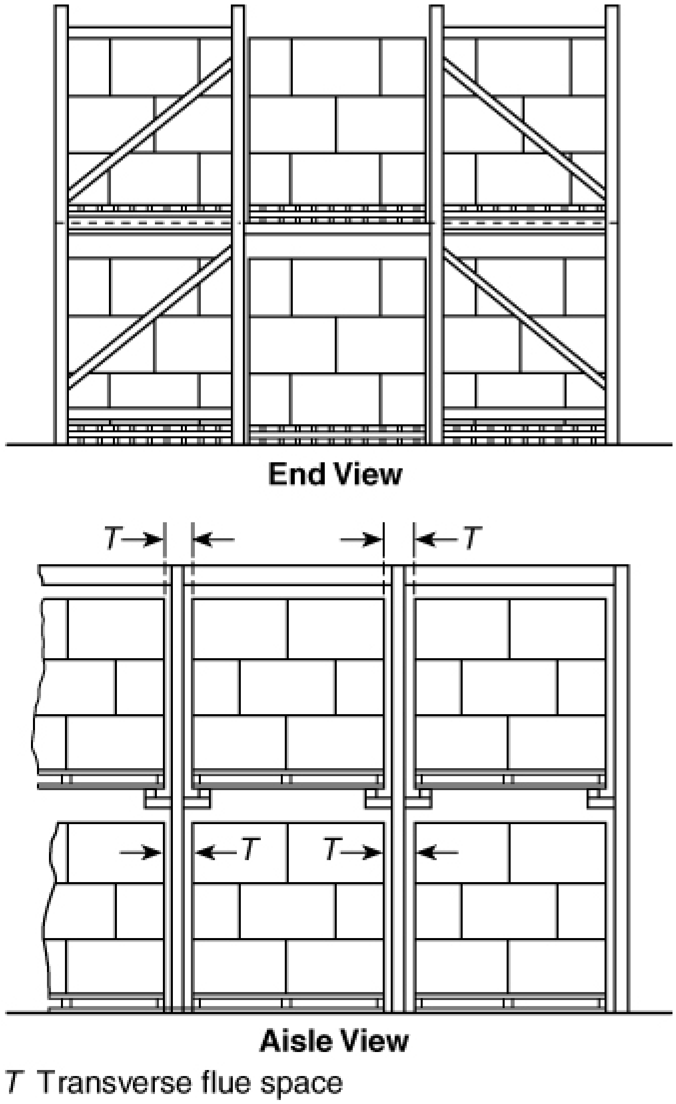


Figure A.3.3.186(i) Flow-Through Racks (Top) and Portable Racks (Bottom).

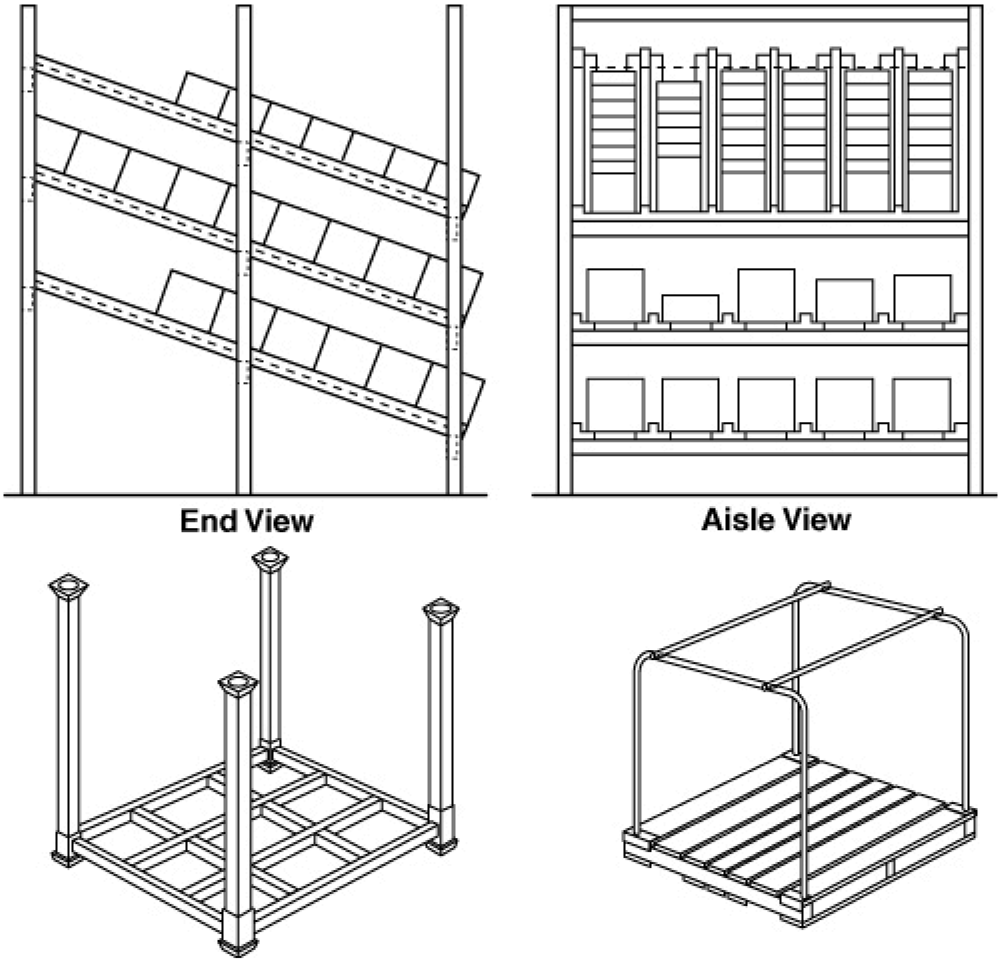


Figure A.3.3.186(j) Cantilever Rack.

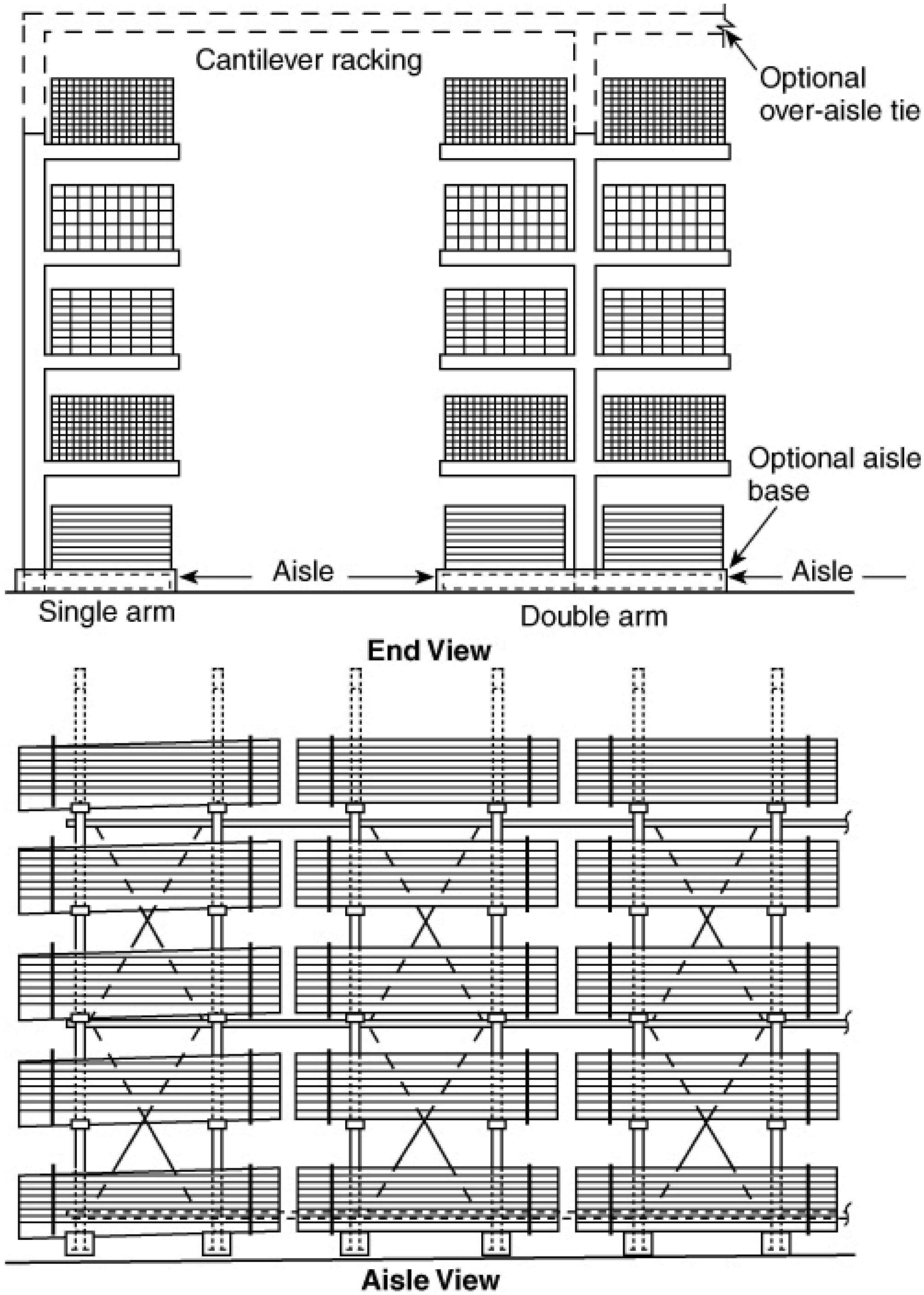
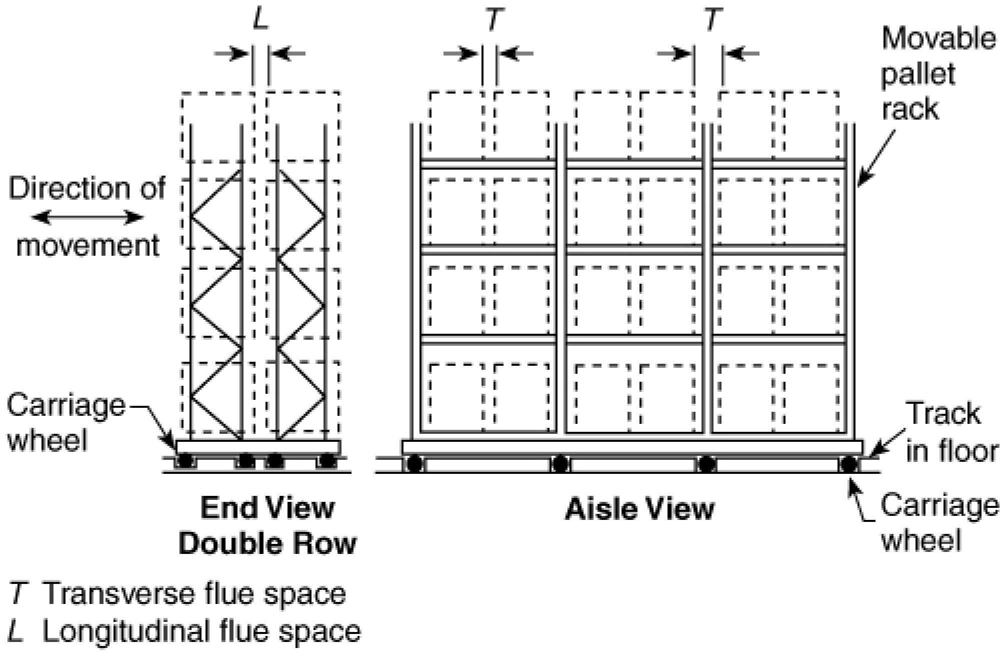


Figure A.3.3.186(k) Movable Rack.



A.3.3.189 Raw Water Source.

Examples of raw water sources are mill ponds, lakes, streams, open-top reservoirs, and so forth. Examples of non-raw water sources can include city water supplies, cisterns, pressure tanks, gravity tanks, break tanks, aquifers, and so forth. Water sources that are closed or protected from direct contact with the environment should not be considered raw. (AUT-SSD)

A.3.3.197.3 Roll Paper Storage Height.

The size of rolls and limitations of mechanical handling equipment should be considered in determining maximum storage height. (AUT-SSD)

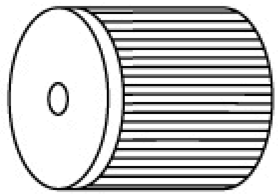
A.3.3.197.5 Wrapped Roll Paper Storage.

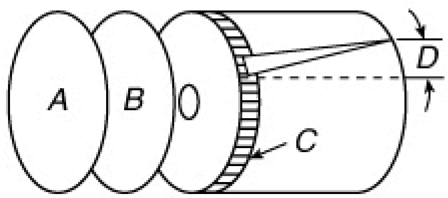
Rolls that are completely protected with a heavyweight kraft wrapper on both sides and ends are subject to a reduced degree of fire hazard. Standard methods for wrapping and capping rolls are outlined in Figure A.3.3.197.5.

In some cases, rolls are protected with laminated wrappers, using two sheets of heavy kraft with a high-temperature wax laminate between the sheets. Where using this method, the overall weight of wax-laminated wrappers should be based on the basis weight per 1000 ft^2 (93 m^2) of the outer sheet only, rather than on the combined basis weight of the outer and inner laminated wrapper sheets. A properly applied wrapper can have the effect of changing the class of a given paper to essentially that of the wrapper material. The effect of applying a wrapper to tissue has not been determined by test. (AUT-SSD)

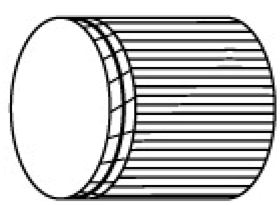
Figure A.3.3.197.5 Wrapping and Capping Terms and Methods.

Term	Description
Wrapper Exterior wrapper Body wrapper	General term for protective wrapping of sides and ends on roll.
Body wrap Sleeve wrap Wrap — do not cap	Wrapper placed around circumference of roll. No heads or caps needed.





Term	Description
Heads Headers	Protection applied to the ends of the rolls (*A* and *B*). Heads do not lap over the end of the roll.
Inside heads	Protection applied to the ends of the rolls next to the roll itself (*B*). The wrapper of the rolls is crimped down over these heads.
Outside heads	Protection applied to the ends of the rolls on the outside (*A*). This head is applied after the wrapper is crimped.
Edge protectors Edge bands	Refers to extra padding to prevent damage to roll edges (*C*).
Overwrap	The distance the body wrap or wrapper overlaps itself (*D*).
Roll cap	A protective cover placed over the end of a roll. Edges of cap lap over the end of the roll and are secured to the sides of the roll.



A.3.3.200 Rubber Tire Rack Illustrations.

Figure A.3.3.200(a) through Figure A.3.3.200(g) do not necessarily cover all possible rubber tire storage configurations.

Figure A.3.3.200(a) Typical Open Portable Tire Rack Unit.

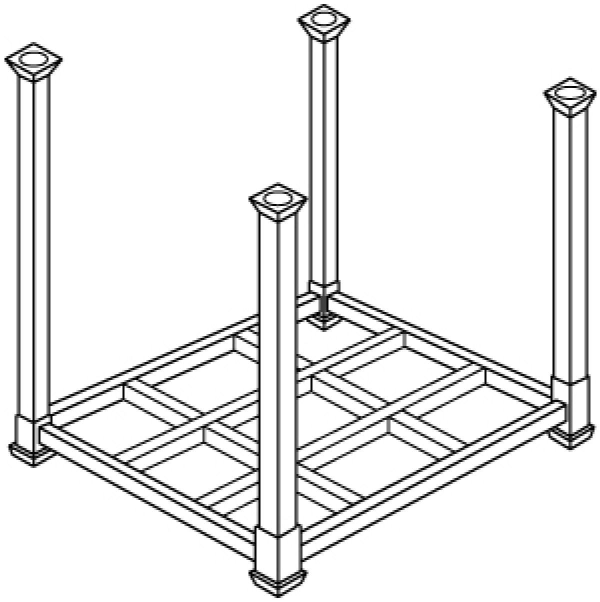


Figure A.3.3.200(b) Typical Palletized Portable Tire Rack Units.

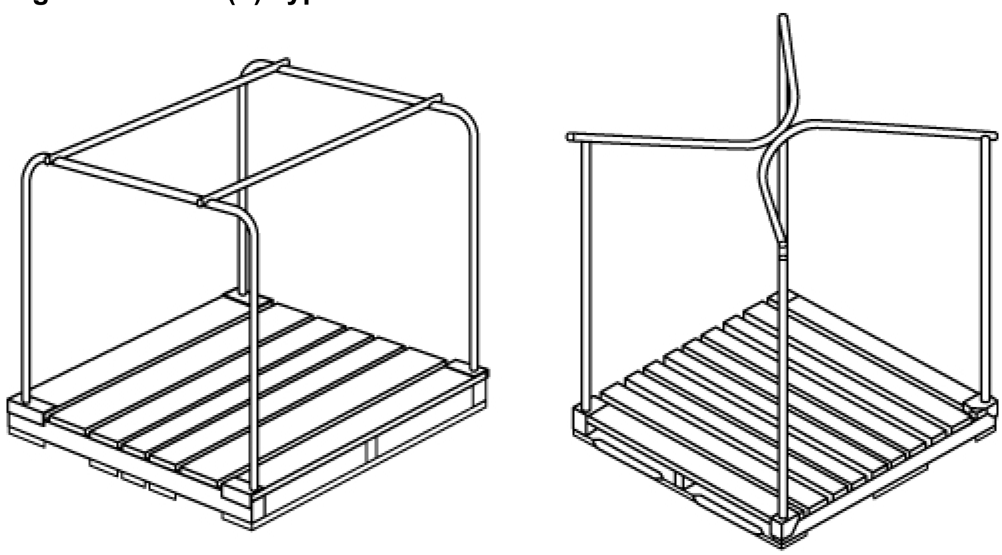


Figure A.3.3.200(c) Open Portable Tire Rack.

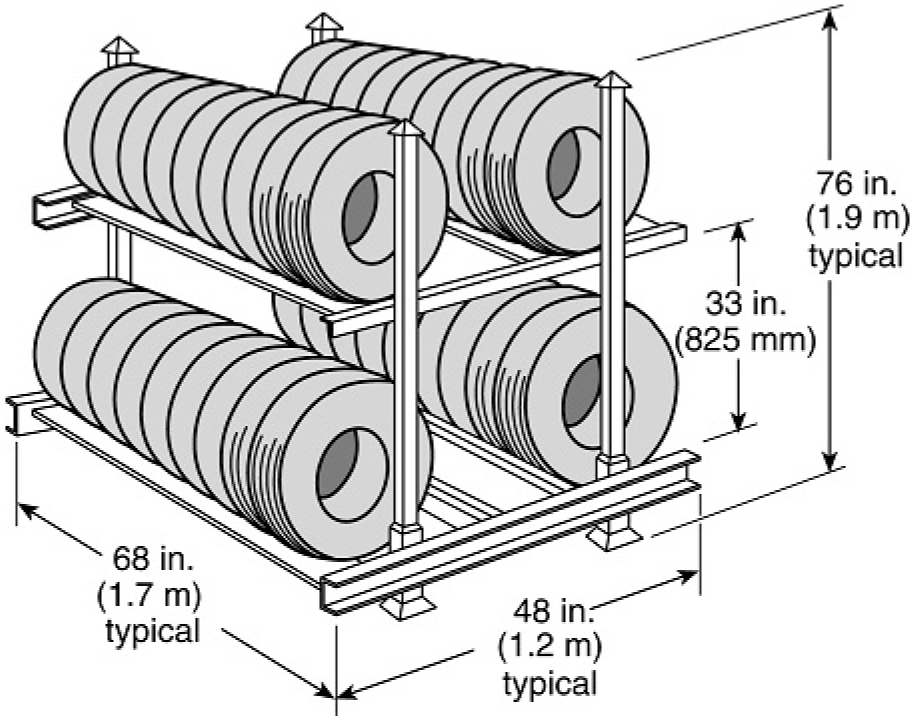


Figure A.3.3.200(d) Double-Row Fixed Tire Rack Storage.

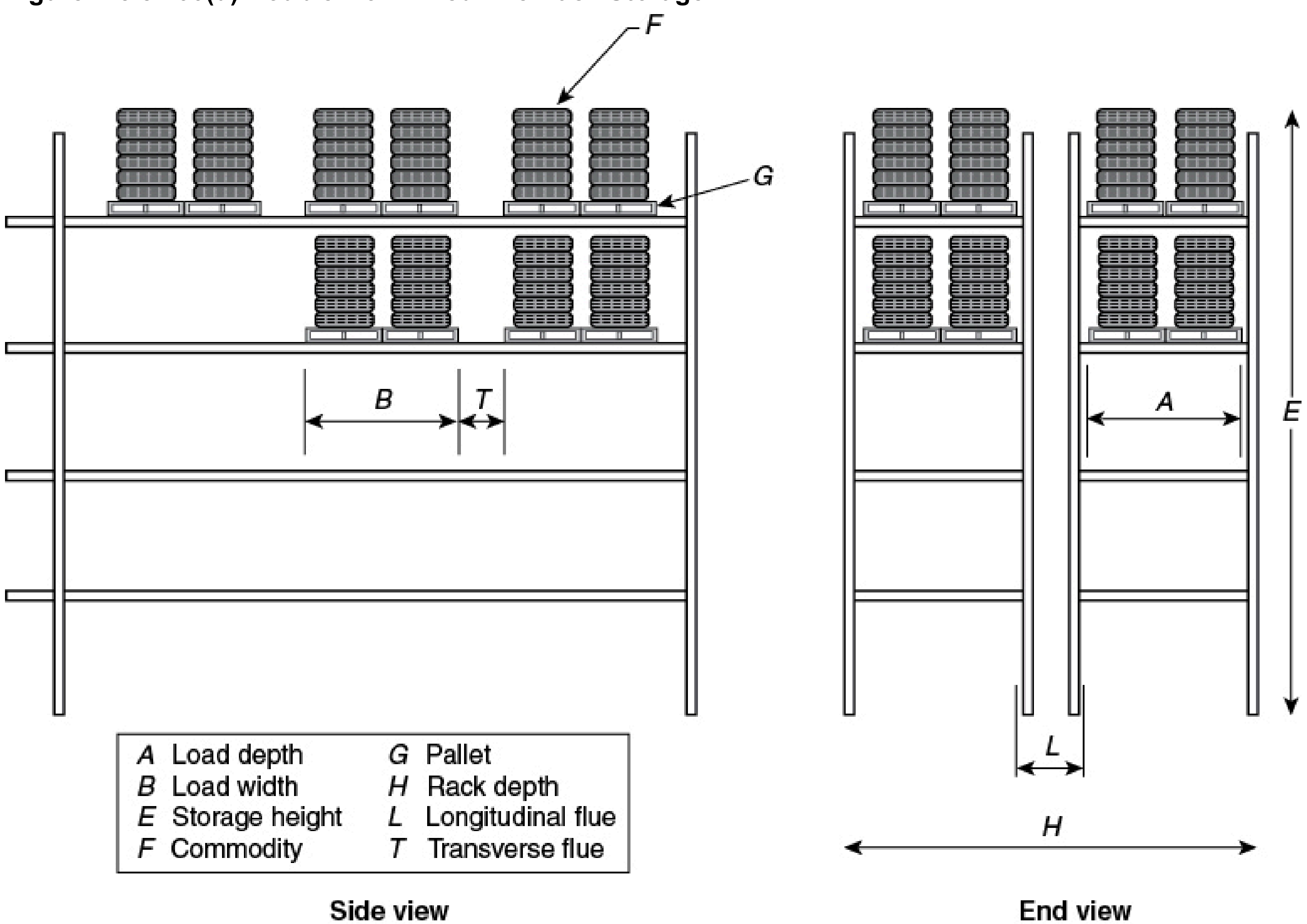


Figure A.3.3.200(e) Palletized Portable Tire Rack, On-Side Storage Arrangement (Banded or Unbanded).

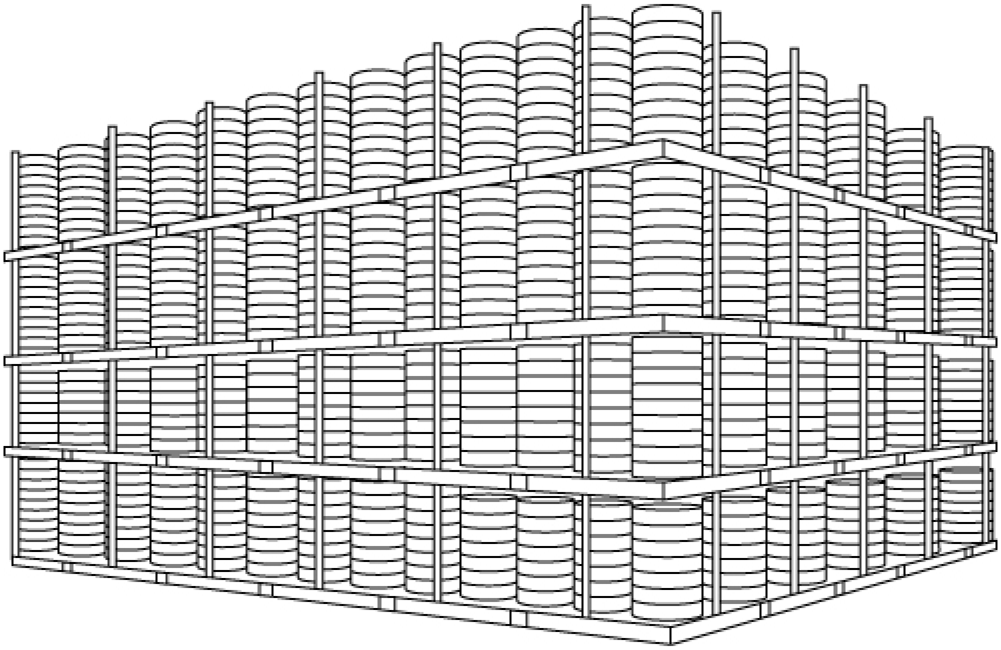


Figure A.3.3.200(f) On-Floor Storage; On-Tread, Normally Banded.

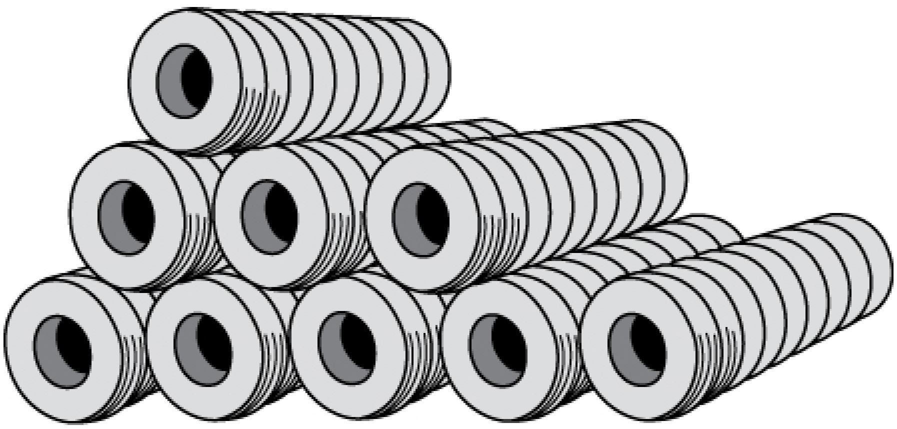
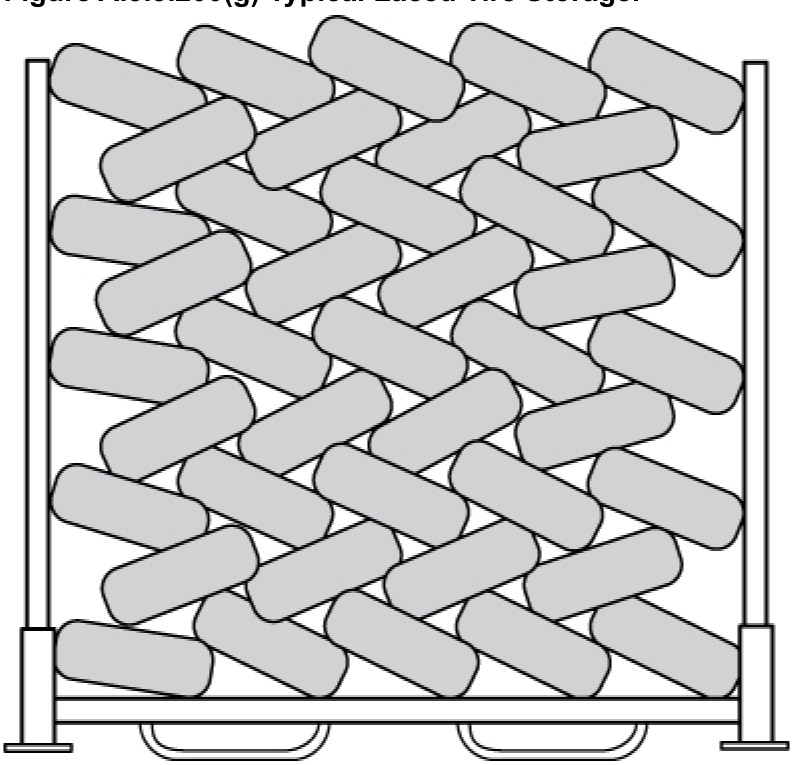


Figure A.3.3.200(g) Typical Laced Tire Storage.



A.3.3.203 Seismic Separation Assembly.

Seismic separation assemblies include traditional assemblies as shown in Figure A.18.3(a) and seismic loops as shown in Figure A.18.3(b). (AUT-HBS)

A.3.3.204 Shadow Area.

Water is not required to fall on every square inch of floor space of the occupancy. This definition establishes a term that will be used to address the rules for acceptable *dry spaces* that occur when walls interfere with the residential sprinkler's spray pattern. Angled walls, wing walls, and slightly indented walls can disrupt water discharging from a sprinkler, which does not travel only in an absolute straight line, as if it were beams of light. Where small (typically triangular) shadowed areas are formed on the floor adjacent to the wall, these shadowed areas are purely on paper and do not take into account the dynamic variables of sprinkler discharge. In order to be acceptable, the shadow area needs to be within the coverage area of a sprinkler, meaning that water would discharge to the space directly if the structural or architectural feature was not there. The purpose of allowing the shadow area is not to replace any existing obstruction requirements. Instead, the shadow area concept has been added to the standard to provide clarity to specific situations in which walls form non-rectangular-shaped rooms, as shown in Figure A.9.1.1(3)(a) and Figure A.9.1.1(3)(b).

A.3.3.205 Shelf Storage.

Shelves are usually 2 ft (600 mm) apart vertically. (AUT-SSD)

A.3.3.208 Single-Row Racks.

When a narrow rack with a depth up to 6 ft (1.8 m) is located within 24 in. (600 mm) of a wall, it is considered to have a longitudinal flue and is treated as a double-row rack. (AUT-SSD)

A.3.3.213 Small Openings.

A return air diffuser can be 4 ft by 2 ft (1.2 m by 600 mm) and meet the definition of a small opening. A linear diffuser can be longer than 4 ft (1.2 m) but is then limited to 8 in. (200 mm) in width (or least dimension). Spaces between ceiling panels of architectural features that create a concealed space must meet the same criteria. (AUT-SSI)

A.3.3.217 Solid Shelving.

The placement of loads affects the calculated area of the shelf. It is the intent to apply this definition to loads on the rack where 6 in. (150 mm) nominal flues are not provided on all four sides, regardless of whether shelving materials are present. See 20.5.3.1.2 for additional allowances for double-row racks up 25 ft (7.6 m) and for multiple-row racks of any height without a longitudinal flue space. (AUT-SSD)

A.3.3.223.2 General Sprinkler Characteristics.

The response time index (RTI) 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.

The RTI is calculated using the following:

(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
(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

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

ISO 6182-1, *Fire protection — Automatic sprinkler systems — Part 1: Requirements and test methods for sprinklers*, currently recognizes the RTI range of greater than 50 (meters-seconds)$^{1/2}$ and less than 80 (meters-seconds)$^{1/2}$ as special response. Such sprinklers can be recognized as special sprinklers under 15.2.1.

It should be recognized that the term *fast response* refers to the thermal sensitivity within the operating element of a sprinkler, not the time of operation in a particular installation. Many other factors, such as ceiling height, spacing, ambient room temperature, and distance below ceiling, affect the time of response of sprinklers. In most fire scenarios, sprinkler activation times will be shortest where the thermal elements are located 1 in. (25 mm) to 3 in. (75 mm) below the ceiling. A fast-response element is expected to operate quicker than a standard-response element in the same installation orientation. For modeling purposes, concealed sprinklers can be considered equivalent to pendent sprinklers having a similar thermal response sensitivity installed 12 in. (300 mm) below smooth unobstructed ceilings, and recessed sprinklers can be considered equivalent to pendent sprinklers having a similar thermal response sensitivity installed 8 in. (200 mm) below smooth unobstructed ceilings. (AUT-SSI)

A.3.3.223.4.1 Control Mode Density/Area (CMDA) Sprinkler.

This definition is focused on the storage application since the term CMDA is used in the storage chapters. As indicated in Chapter 20, spray sprinklers intended for storage applications requiring a design density greater than 0.34 gpm/ft (13.9 mm/min) should have a nominal K-factor of K-11.2 (K-160) or larger and be listed for storage applications. Spray sprinklers having a nominal K-factor of K-5.6 (K-80) or K-8.0 (K-115) are permitted to be used for storage applications as a CMDA sprinkler within certain design densities as described in Chapter 20.

Spray type sprinklers intended for use in accordance with the occupancy hazard density/area curves could also be considered CMDA sprinklers. However, the CMDA terminology is generally not referenced in the nonstorage chapters, and this term is not used to describe these sprinklers in the product listings. (AUT-SSI)

A.3.3.223.4.2 Control Mode Specific Application (CMSA) Sprinkler.

A large drop sprinkler is a type of CMSA sprinkler that is capable of producing characteristic large water droplets and that is listed for its capability to provide fire control of specific high-challenge fire hazards. (AUT-SSI)

A.3.3.223.4.4 Dry Sprinkler.

Under certain ambient conditions, wet pipe systems having dry pendent (or upright) sprinklers can 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.

Dry sprinklers are intended to extend into an unheated area from a wet pipe system or to be used on a dry pipe system. (AUT-SSI)

A.3.3.223.4.5 Early Suppression Fast-Response (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 Chapter 20. (AUT-SSI)

A.3.3.223.4.16 Quick-Response (QR) Sprinkler.

Quick response is a listing for sprinklers that combines the deflector, frame, and body of a spray sprinkler with a fast-response element *[see 3.3.223.2(1)(a)]* to create a technology that will respond quickly in the event of a fire and deliver water in the same fashion as other types of spray sprinklers. (AUT-SSI)

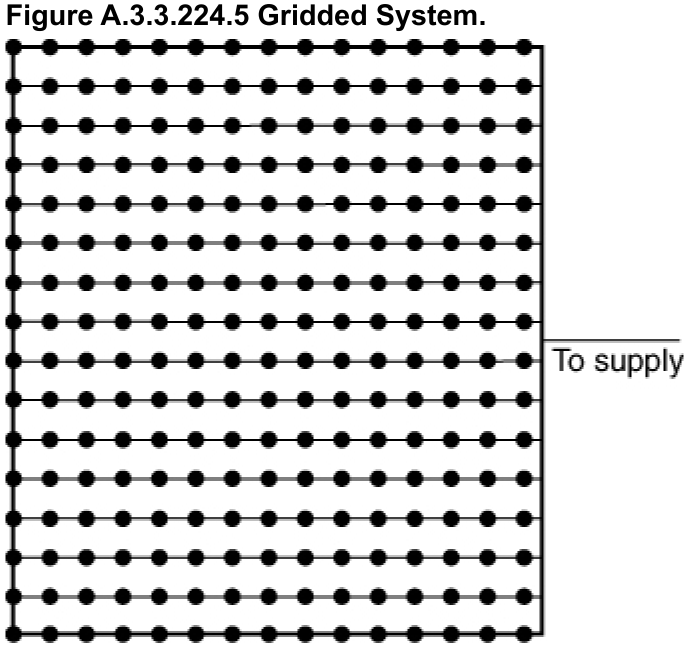
A.3.3.224 Sprinkler System.

As applied to the definition of a sprinkler system, each system riser serving a portion of a single floor of a facility or where individual floor control valves are used in a multistory building should be considered a separate sprinkler system. Multiple sprinkler systems can be supplied by a common supply main. (AUT-SSI)

A.3.3.224.5 Gridded Sprinkler System.

See Figure A.3.3.224.5. (AUT-SSD)

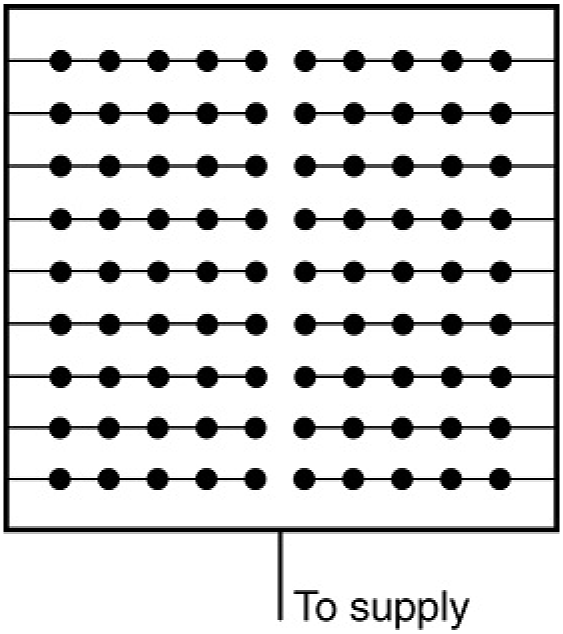
Figure A.3.3.224.5 Gridded System.



A.3.3.224.6 Looped Sprinkler System.

See Figure A.3.3.224.6. (AUT-SSD)

Figure A.3.3.224.6 Looped System.



A.3.3.224.9 Preaction Sprinkler System.

The actuating means of the valve are described in 8.3.2.1. Actuation of the detection system and sprinklers in the case of double-interlocked systems opens a valve that permits water to flow into the sprinkler piping system and to be discharged from any sprinklers that are open. (AUT-SSI)

A.3.3.237 Tiered Storage (Baled Cotton).

Untiered storage limits storage to the height of one bale, on side or on end. Sprinkler protection designed on this basis would likely prohibit future tiering without redesign of the sprinkler system. (AUT-SSD)

A.3.3.243.2 Automatic Breach Control Valve.

Also known as a *breach valve* and an *automatic breach containment valve*. (AUT-SSI)

A.3.3.243.3 Control Valve.

Control valves do not include hose valves, inspector’s test valves, drain valves, trim valves for dry pipe, preaction and deluge valves, check valves, or relief valves. (AUT-SSI)

A.3.3.243.4 Indicating Valve.

Examples are outside screw and yoke (OS&Y) gate valves, butterfly valves, and underground gate valves with indicator posts.

A.3.3.243.5 Water Control Valve.

Water control valves include dry pipe, preaction, and deluge valves. (AUT-SSI)

A.3.3.244 Vapor Corrosion Inhibitor (VCI).

VCIs are also referred to as vapor phase corrosion inhibitors, volatile corrosion inhibitors, and vapor phase inhibitors (VPI). All of these terms relate to a specific class of corrosion inhibitors. The inhibitor forms a thin protective layer through adsorption separating the pipe from the air or water and provides protection against corrosion. Other classifications include passivating (anodic), cathodic, organic, and precipitation inhibitors. VCIs are appropriate for atmospheric or gaseous corrosion. This is corrosion happening in the air-filled portion of the sprinkler system containing water vapor. Corrosion will occur when the relative humidity is greater than 60 percent. VCIs can also provide protection in partially aqueous environments (partially water-filled pipes) and aqueous environments (water-filled pipes). VCIs can inhibit anodic reactors, cathodic reactions, or both. VCIs protecting against both anodic and cathodic reactions provide the best level of protection for applications in sprinkler systems. (AUT-SSI)

A.4.2

A building constructed where the expected occupancy hazard and commodity classification of tenant uses are unknown at the time of the sprinkler system's design and installation presents special problems due to unknown factors. The design of sprinkler systems for such buildings should be carefully reviewed with the owners, builders, leasing agents, and local authorities having jurisdiction prior to the selection of design criteria and installation of the system. Consideration should be given to the available height for storage, as well as the occupancy hazards of potential tenants and their likely storage needs.

The design spectral response acceleration at short periods, S_{DS}, is defined in 3.3.59. Additional information about S_s is provided in Chapter 18.

The intent of Section 4.2 is to provide the owner's certificate for all new systems and where there is a change of occupancy and/or building use. *[See Figure A.28.1(b).]*

A.4.2(4)

Where a waterflow test was conducted to provide the water supply information, the raw data from the test should be evaluated to determine if an adjustment is appropriate. The evaluation should be based on knowledge of the water supply and engineering judgment, taking into account daily and seasonal fluctuations, not extreme conditions.

The evaluation can be based on information from the water supply authority, testing, modeling, the fire or building department, or knowledge of the water supply from having worked previously in the jurisdiction. Depending on how much the pressure changes over time at any given location, an adjustment might or might not be appropriate. For mature water supplies (ones where new development in the vicinity is unlikely because available property has been fully developed) with fairly stable water usage, or where the waterflow test was conducted at a time of low pressure already, a very small adjustment or no adjustment at all might be appropriate. For situations where the waterflow test was performed at a time of low demand when it is known that higher demands occur at other times of day or other times of the year, then a larger adjustment would be appropriate.

The evaluation to determine whether an adjustment should be made, and the size of such an adjustment if one is needed, should take into account the following variables, which will be applicable to different degrees depending on how and when the test was conducted:

(1) Maximum daily use of the water supply
(2) Peak hour demand of the water supply
(3) Water supply degradation due to planned development
(4) Time of day the test was conducted
(5) Time of year the test was conducted
(6) Elevation of the test location compared to the building where the sprinkler system will be installed
(7) Elevation of the water supply at the time of the test
(8) How close the flow generated during the test was to the system demand

There is no single specific adjustment that can be applied to every water supply that would be appropriate for every sprinkler system. The design professional needs to work in conjunction with the authority having jurisdiction to determine an appropriate adjustment. Where an authority having jurisdiction has already determined a specific buffer between test results and the demand of the sprinkler system, there is no intent to add an additional safety factor or safety margin due to this requirement. Instead, the buffer mandated by the authority having jurisdiction serves the purpose of this adjustment.

If an adjustment is determined to be appropriate, it should be applied to the waterflow test data prior to comparison with the sprinkler system demand.

Where the water supply information was obtained from another approved method instead of a waterflow test, that method should take into account daily and seasonal fluctuations, not extreme conditions. It is important to note that adjustments are not intended to handle extreme or catastrophic conditions such as water main breaks. Such extreme conditions are accounted for in NFPA 25 with impairment procedures to follow when systems are out of service.

In the absence of information from the design professional and the authority having jurisdiction, it would be appropriate to make an adjustment to the raw data from a flow test by either obtaining information from the water utility or using an arbitrary adjustment. The value to use for an arbitrary adjustment should be determined through a conversation with the authority having jurisdiction.

A.4.2(5)

Recycled or reclaimed water used in a sprinkler system should not have contaminants in the water that are combustible or that will have a detrimental effect on the sprinkler system performance or the life of the sprinkler system.

A.4.3

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.4.3.1.4

Miscellaneous storage is intended to be storage that is ancillary to the primary function of the building. One example is a manufacturing facility where storage on the manufacturing floor is limited.

A.4.3.2

Light hazard occupancies include occupancies having uses and conditions similar to the following:

(1) Animal shelters
(2) Churches
(3) Clubs
(4) Eaves and overhangs, if of combustible construction with no combustibles beneath
(5) Educational
(6) Hospitals, including animal hospitals and veterinary facilities
(7) Institutional
(8) Kennels
(9) Libraries, except large stack rooms
(10) Museums
(11) Nursing or convalescent homes
(12) Offices, including data processing
(13) Residential
(14) Restaurant seating areas
(15) Theaters and auditoriums, excluding stages and prosceniums
(16) Unused attics

Note that it is not the committee's intent to automatically equate library bookshelves with ordinary hazard occupancies or with library stacks. Typical library bookshelves of approximately 8 ft (2.4 m) in height, containing books stored vertically on end, held in place in close association with each other, with aisles wider than 30 in. (750 mm) can be considered to be light hazard occupancies. Similarly, library stack areas, which are more akin to shelf storage or record storage, as defined in NFPA 232, should be considered to be ordinary hazard occupancies.

A.4.3.3

Class I, Class II, Class III, and Class IV commodities are considered to have moderate rates of heat release, while Group A plastics are considered to have high rates of heat release. Stockpiles are considered to include display merchandise (e.g., mercantile stockpiles) and arrangements of combustibles ancillary to operations within the occupancy as opposed to dedicated storage areas where the fire loading is generally more severe.

A.4.3.3.1

Ordinary hazard (Group 1) occupancies include occupancies having uses and conditions similar to the following:

(1) Automobile showrooms
(2) Bakeries
(3) Beverage manufacturing
(4) Canneries
(5) Dairy products manufacturing and processing
(6) Electric fire pump room
(7) Electronic plants
(8) Glass and glass products manufacturing
(9) Laundries
(10) Restaurant service areas
(11) Porte cocheres
(12) Mechanical rooms

A.4.3.3.2

Ordinary hazard (Group 2) occupancies include occupancies having uses and conditions similar to the following:

(1) Agricultural facilities
(2) Automobile parking garages

(3) Barns and stables
(4) Cereal mills
(5) Chemical plants — ordinary
(6) Confectionery products
(7) Distilleries
(8) Dry cleaners
(9) Exterior loading docks (Note that exterior loading docks only used for loading and unloading of ordinary combustibles should be classified as OH2. For the handling of flammable and combustible liquidsor hazardous materials, or where utilized for storage, exterior and interior loading docks should be protected based upon the actual occupancy and the materials handled on the dock, as if the materials were actually stored in that configuration.)
(10) Feed mills
(11) Horse stables
(12) Leather goods manufacturing
(13) Libraries — large stack room areas
(14) Machine shops
(15) Metal working
(16) Mercantile
(17) Paper and pulp mills
(18) Paper process plants
(19) Piers and wharves
(20) Plastics fabrication, including blow molding, extruding, and machining; excluding operations using combustible hydraulic fluids
(21) Post offices
(22) Printing and publishing
(23) Racetrack stable/kennel areas, including those stable/kennel areas, barns, and associated buildings at state, county, and local fairgrounds
(24) Repair garages
(25) Resin application area
(26) Stages
(27) Textile manufacturing
(28) Tire manufacturing
(29) Tobacco products manufacturing
(30) Wood machining
(31) Wood product assembly

A.4.3.4.1

Extra hazard (Group 1) occupancies include occupancies having uses and conditions similar to the following:

(1) Aircraft hangars (except as governed by NFPA 409)
(2) Combustible hydraulic fluid use areas
(3) Die casting
(4) Metal extruding
(5) Plywood and particleboard manufacturing
(6) Printing [using inks having flash points below 100°F (38°C)]
(7) Rubber reclaiming, compounding, drying, milling, vulcanizing
(8) Saw mills
(9) Textile picking, opening, blending, garnetting, or carding, combining of cotton, synthetics, wool shoddy, or burlap
(10) Upholstering with plastic foams

A.4.3.4.2

Extra hazard (Group 2) occupancies include occupancies having uses and conditions similar to the following:

(1) Asphalt saturating
(2) Flammable liquids spraying
(3) Flow coating
(4) Manufactured home or modular building assemblies (where finished enclosure is present and has combustible interiors)
(5) Open oil quenching
(6) Plastics manufacturing
(7) Solvent cleaning

(8) Varnish and paint dipping
(9) Car stackers and car lift systems with two cars stacked vertically and using ceiling-only protection
(10) Diesel fire pump houses and rooms containing pump drivers and fuel tanks

A.4.3.6

Other NFPA standards contain design criteria for fire control or fire suppression *(see 4.3.6 and Chapter 2).* While these can form the basis of design criteria, this standard describes the design, installation, fabrication, calculation, and evaluation methods of water supplies that should be used for the specific design of the system.

Other NFPA standards contain sprinkler system design criteria for fire control or suppression of specific hazards. These other standards are referenced in Chapter 27.

A.4.4.1(2)

Should the system be impaired, it should be noted that the increased area will result in impairment procedures in accordance with NFPA 25 being applied to the larger area which could have operational and economic impacts on the building.

A.4.4.6

Buildings adjacent to a primary structure can be protected by extending the fire sprinkler system from the primary structure. This eliminates the need to provide a separate fire sprinkler system for small auxiliary buildings. Items that should be considered before finalizing fire sprinkler design should include the following:

(1) Actual physical distance between adjacent structures
(2) Potential for the property to be split into separate parcels and sold separately
(3) Square footage of both the primary and auxiliary structures
(4) Difficulties in providing a separate water supply to the auxiliary structure
(5) Occupancy/hazard of the auxiliary structure
(6) Ability of emergency response personnel to easily identify the structure from which waterflow is originating

A.4.5.1.1

Alternative means of determining available water supplies should be considered where drought or other concerns are present.

A.4.6

Bacterial inhibitors and other chemicals that are listed and used for the prevention and mitigation of MIC and that do not adversely affect the firefighting properties of the water or the performance of the fire sprinkler system components are not prohibited.

A.4.8

Non-system components can adversely affect the operation and longevity of the fire sprinkler system. Objects connected to the sprinkler system can displace sprinkler system piping, causing obstruction to the spray pattern of sprinklers, delay the activation of a sprinkler, or cause chemical compatibility problems that can cause the failure of sprinkler system components.

A.4.9.1

The provisions of 4.9.1 do not require inherently noncombustible materials to be tested in order to be classified as noncombustible materials. [**5000:**A.7.1.4.1]

A.4.9.1.1(1)

Examples of such materials include steel, concrete, masonry and glass. [**5000:**A.7.1.4.1.1(1)]

A.4.9.2

Material subject to increase in combustibility or flame spread index beyond the limits herein established through the effects of age, moisture, or other atmospheric condition is considered combustible. *(See NFPA 259 and NFPA 220.)* [**5000:**A.7.1.4.2]

A.5.1.3

For typical combined domestic/fire sprinkler demands, systems with 4 in. (100 mm) pipe or larger typically do not need to include the domestic demand in the calculations because it is such a small fraction of the total flow that it does not make a significant difference in the results. But for situations where 4 in. (100 mm) pipe is used for the combined domestic/fire sprinkler systems and the domestic demand is considerable, then the domestic demand should be included in the calculations. Generally, pipe that is 6 in. (150 mm) or larger can carry combined domestic/fire protection demand without any consideration for domestic demand being necessary.

A.5.1.4

Evaluation of the water supply and environmental conditions does not necessarily require a water sample analysis by a laboratory. Instead, general knowledge of the long-term condition of sprinkler systems with similar piping materials in similar environments on the same water supply can be a sufficient evaluation.

There are several options to address the effects of MIC on sprinkler systems. Some types of sprinkler pipe such as CPVC have not shown to be affected by MIC. Other types of pipe are being manufactured with a biofilm that resists the effects of MIC.

Where water supplies are treated with bacterial inhibitors, evaluation of the effects of the bacterial inhibitor on sprinkler system components (pipe, fittings, sprinklers, gaskets, valves, and seals) is just as important as evaluating the effect the bacterial inhibitor has on the organisms. Where water treatment is selected as the method to deal with MIC, all water entering the system during testing or flushing needs to be treated so that the organisms do not get a chance to establish themselves.

Since all of the conditions that can affect the growth of MIC are unknown, a plan to sample randomly selected interior positions in the system can be effective. The frequency and location of the interior inspections will depend on the extent of the known MIC problem with the same water supply and similar environmental conditions.

A.5.1.4.3

Vapor corrosion inhibitors entering a sprinkler system as vapor in the air supply are not part of the water supply. Requirements for air supply are applicable to vapor corrosion inhibitors.

A.5.1.5.2

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 in. to 3 in. (25 mm to 75 mm) clearance should be provided around the pipe and the clear space filled with asphalt mastic or similar flexible waterproofing material.

A.5.1.6

Where water meters are in the supply lines to a sprinkler system, they should be rated to deliver the proper system demand. The amount of water supplied through a water meter varies with its size and type and might not provide the required demand, regardless of the water supply available.

A.5.1.7

Where connections are made from public waterworks systems, such systems should be guarded against possible contamination as follows *(see AWWA M14, Backflow Prevention and Cross-Connection Control — Recommended Practices)*:

(1) For private fire service mains with direct connections from public waterworks mains only or with booster pumps installed in the connections from the street mains, no tanks or reservoirs, no physical connection from other water supplies, no antifreeze or other additives of any kind, and with all drains discharging to atmosphere, dry well, or other safe outlets, no backflow protection is recommended at the service connection.
(2) For private fire service mains with direct connection from the public water supply main plus one or more of the following: elevated storage tanks or fire pumps taking suction from aboveground covered reservoirs or tanks (all storage facilities are filled or connected to public water only and the water in the tanks is to be maintained in a potable condition), an approved double check valve assembly is recommended.
(3) For private fire service mains directly supplied from public mains with an auxiliary water supply such as a pond or river on or available to the premises and dedicated to fire department use; or for systems supplied from public mains and interconnected with auxiliary supplies, such as pumps taking suction from reservoirs exposed to contamination or rivers and ponds; driven wells, mills, or other industrial water systems; or for systems or portions of systems where antifreeze or other solutions are used, an approved reduced pressure zone-type backflow preventer is recommended.

Where connections are made from public waterworks systems, it might be necessary to guard against possible contamination of the public supply.

A.5.2.1

Acceptable water supplies for fire sprinkler systems must provide sufficient flow and pressure for the required duration. Many water supply sources contain sufficient flow and volume but do not possess sufficient pressure. Some acceptable water supplies, such as storage tanks located at or below grade, rivers, lakes, and reservoirs, will almost always require combination with a pump to provide the needed pressure. Fire pumps are used with other supplies such as waterworks or gravity tanks to provide additional pressure needed to meet the system demand.

A.5.2.1(7)

In an effort to help comply with efforts for sustainable and renewable building construction, some engineers and architects have suggested the use of reclaimed or recycled water to use in fire sprinkler systems rather than the potable water typically used from the public water supply. While this effort has some merit, there is a concern about the quality of the water from these recycled and reclaimed systems. The capture of rainwater is generally not considered a problem since NFPA 13 has long allowed the use of open lakes, rivers, and ponds, which are nothing more than open collections of rainwater and melted snow. But other systems that are recycling water that has been used in some industrial or other process might have contaminants that are combustible, or they might be detrimental to the sprinkler system by preventing it from working properly or accelerating corrosion. Recycled or reclaimed water should never be used in a sprinkler system until an analysis of what contaminants might be in the water has determined that nothing will be detrimental to sprinkler system performance or the expected reasonable life of the sprinkler system. When such an analysis is completed successfully, the information should be transmitted to the sprinkler contractor through the use of the Owner's Certificate required by Section 4.2.

A.5.2.2

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 might 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. 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 can be justified. Where adjustments are appropriate, the adjustments should be coordinated with the AHJ prior to the development of the working plans by the contractor.

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.

Dead-end mains should be avoided, if possible, by arranging for mains supplied from both directions. When private fire service mains are connected to dead-end public mains, each situation should be examined to determine if it is practical to request the water utility to loop the mains in order to obtain a more reliable supply.

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) — that is, 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.5.2.2, the method of conducting the flow tests is as follows:

(1) Attach the gauge to the hydrant *(A)* and obtain static pressure.
(2) Either attach a second gauge to the hydrant *(B)* or use the pitot tube at the outlet. Have hydrant *(B)* opened wide and read pressure at both hydrants.
(3) Use the pressure at *(B)* to compute the gallons 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.

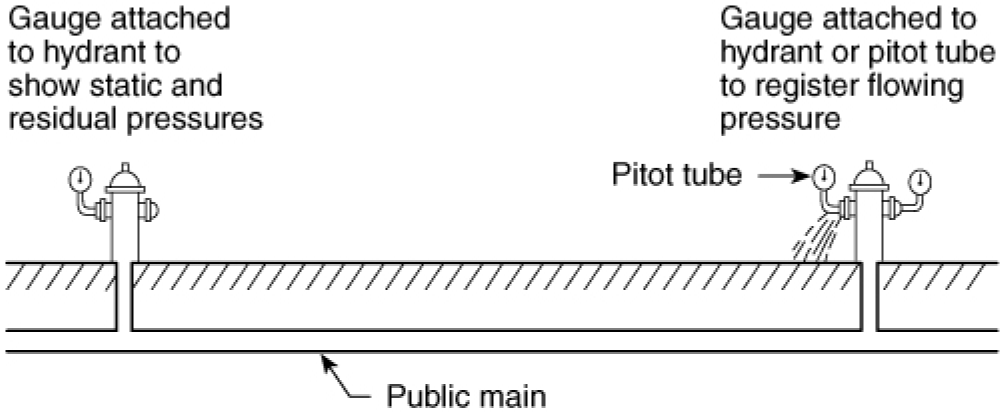
Water pressure in pounds per square inch for a given height in feet equals height multiplied by 0.433.

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 $2\frac{1}{2}$ in. (65 mm), they are sometimes smaller and occasionally larger. Underwriters Laboratories play pipe is $1\frac{1}{8}$ in. (28.6 mm) and $1\frac{3}{4}$ in. (44.5 mm) with the tip removed, but occasionally nozzles will be 1 in. (25.4 mm) or $1\frac{1}{4}$ in. (31.8 mm), and with the tip removed the opening can be only $1\frac{1}{2}$ in. (38.1 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.

Figure A.5.2.2 Method of Conducting Flow Tests.



A.5.2.2.2

An adjustment to the waterflow test data to account for daily and seasonal fluctuations, large simultaneous industrial use, future demand on the water supply system, or any other condition that could affect the water supply should be made as appropriate.

A.5.2.2.3

It is important to note that not all water supplies have a linear relationship of flow to pressure. As flow demand increases, additional water can be provided into the system through multiple pumps, causing complex geometries to the pressure and flow relationship at any given point in the system. Creating multiple flow conditions during a test and getting as close as possible to the sprinkler system demand will help in gaining a complete understanding of the water supply.

A.5.2.3

An automatically controlled vertical turbine pump taking suction from a reservoir, pond, lake, river, cistern, or well or a centrifugal pump supplied from a waterworks system connection, or tank, complies with 5.2.3.

See sections dealing with sprinkler equipment supervisory and waterflow alarm services in *NFPA 72* or other approved fire alarm code.

A.5.2.4.3

For pipe schedule systems, the air pressure to be carried and the proper proportion of air in the tank can be determined from the following formulas where:

P = air pressure carried in pressure tank

A = proportion of air in tank

H = height of highest sprinkler above tank bottom

When the tank is placed above the highest sprinkler, use the following formula:

$$P = \frac{30}{A} - 15 \qquad \text{[A.5.2.4.3a]}$$

If $A = \frac{1}{3}$, then $P = 90 - 15 = 75$ psi (5.2 bar)

If $A = \frac{1}{2}$, then $P = 60 - 15 = 45$ psi (3.1 bar)

If $A = \frac{2}{3}$, then $P = 45 - 15 = 30$ psi (2.1 bar)

When the tank is below the level of the highest sprinkler, use the following formula:

$$P = \frac{30}{A} - 15 + \frac{0.434H}{A} \qquad \text{[A.5.2.4.3b]}$$

If $A = \frac{1}{3}$, then $P = 75 + 1.30H$

If $A = \frac{1}{2}$, then $P = 45 + 0.87H$

If $A = \frac{2}{3}$, then $P = 30 + 0.65H$

The preceding respective air pressures are calculated to ensure that the last water will leave the tank at a pressure of 15 psi (1 bar) 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:

$$P_i = \frac{P_f + 15}{A} - 15 \tag{A.5.2.4.3c}$$

where:

P_i = tank pressure

P_f = pressure required from hydraulic calculations

A = proportion of air

Example: Hydraulic calculations indicate 75 psi (5.2 bar) is required to supply the system. What tank pressure will be required?

$$P_i = \frac{75 + 15}{0.5} - 15$$
$$P_i = 180 - 15 = 165 \text{ psi} \tag{A.5.2.4.3d}$$

For SI units, 1 ft = 0.3 m; 1 psi = 0.07 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 bar). If the pressure is too high, the amount of air carried in the tank will have to be increased.

Pressure tanks should be located above the top level of sprinklers but can be located in the basement or elsewhere.

A.6.2

Copper tubing (Type K) with brazed joints conforming to Table 6.2.1.1 and Table 6.3.1.1 is acceptable for underground service.

Listing and labeling. Certification organizations list or label the following:

(1) Cast iron and ductile iron pipe (cement-lined and unlined, coated and uncoated)
(2) Steel pipe
(3) Copper pipe
(4) Fiberglass filament-wound epoxy pipe and couplings
(5) Polyethylene pipe
(6) Polyvinyl chloride (PVC) pipe and couplings
(7) Reinforced concrete pipe (cylinder pipe, nonprestressed and prestressed)

[**24:**A.10.1]

A.6.2.1

The type and class of pipe for a particular underground installation should be determined through consideration of the following factors:

(1) Maximum system working pressure
(2) Maximum pressure from pressure surges and anticipated frequency of surges
(3) Depth at which the pipe is to be installed
(4) Soil conditions
(5) Corrosion
(6) Susceptibility of pipe to external loads, including earth loads, installation beneath buildings, and traffic or vehicle loads

The following pipe design manuals and standards can be used as guides:

(1) AWWA C150/A21.50, *Thickness Design of Ductile-Iron Pipe*

(2) AWWA M23, *PVC Pipe — Design and Installation*
(3) AWWA M55, *PE Pipe — Design and Installation*
(4) AWWA M41, *Ductile-Iron Pipe and Fittings*
(5) *Concrete Pipe Handbook*, American Concrete Pipe Association

[**24:**A.10.1.1]

A.6.2.2

For underground system components, a minimum system pressure rating of 150 psi (10 bar) is specified in 6.2.2, based on satisfactory historical performance. Also, this pressure rating reflects that of the components typically used underground, such as piping, valves, and fittings. Where system pressures are expected to exceed pressures of 150 psi (10 bar), system components and materials manufactured and listed for higher pressures should be used. Systems that do not incorporate a fire pump or are not part of a combined standpipe system do not typically experience pressures exceeding 150 psi (10 bar) in underground piping. However, each system should be evaluated on an individual basis. It is not the intent of this section to include the pressures generated through fire department connections as part of the maximum working pressure. [**24:**A.10.1.2]

A.6.2.3

See Table A.6.2.3. [**24:**A.10.1.3]

Table A.6.2.3 Internal Diameters (IDs) for Cement-Lined Ductile Iron Pipe

Pipe Size		OD		Pressure Class	Thickness Class	Wall Thickness		Minimum Lining Thickness*		ID with Lining	
in.	mm	in.	mm			in.	mm	in.	mm	in.	mm
3	80	3.96	100	350	51	0.25	6	$^1/_{16}$	1.6	3.34	84
3	80	3.96	100	350	52	0.28	7	$^1/_{16}$	1.6	3.28	82
3	80	3.96	100	350	53	0.31	8	$^1/_{16}$	1.6	3.22	81
3	80	3.96	100	350	54	0.34	9	$^1/_{16}$	1.6	3.16	79
3	80	3.96	100	350	55	0.37	9	$^1/_{16}$	1.6	3.1	78
3	80	3.96	100	350	56	0.4	10	$^1/_{16}$	1.6	3.04	76
4	100	4.8	100	350		0.25	6	$^1/_{16}$	1.6	4.18	105
4	100	4.8	100	350	51	0.26	7	$^1/_{16}$	1.6	4.16	104
4	100	4.8	120	350	52	0.29	7	$^1/_{16}$	1.6	4.1	103
4	100	4.8	120	350	53	0.32	8	$^1/_{16}$	1.6	4.04	101
4	100	4.8	120	350	54	0.35	9	$^1/_{16}$	1.6	3.98	100
4	100	4.8	120	350	55	0.38	10	$^1/_{16}$	1.6	3.92	98
4	100	4.8	120	350	56	0.41	10	$^1/_{16}$	1.6	3.86	97
6	150	6.90	175	350		0.25	6	$^1/_{16}$	1.6	6.28	157
6	150	6.90	175	350	50	0.25	6	$^1/_{16}$	1.6	6.28	157
6	150	6.90	175	350	51	0.28	7	$^1/_{16}$	1.6	6.22	156
6	150	6.90	175	350	52	0.31	8	$^1/_{16}$	1.6	6.16	154
6	150	6.90	175	350	53	0.34	9	$^1/_{16}$	1.6	6.1	153
6	150	6.90	175	350	54	0.37	9	$^1/_{16}$	1.6	6.04	151
6	150	6.90	175	350	55	0.4	10	$^1/_{16}$	1.6	5.98	150
6	150	6.90	175	350	56	0.43	11	$^1/_{16}$	1.6	5.92	148

Pipe Size		OD		Pressure Class	Thickness Class	Wall Thickness		Minimum Lining Thickness*		ID with Lining	
in.	mm	in.	mm			in.	mm	in.	mm	in.	mm
8	200	9.05	225	350		0.25	6	$^1/_{16}$	1.6	8.43	211
8	200	9.05	225	350	50	0.27	7	$^1/_{16}$	1.6	8.39	210
8	200	9.05	225	350	51	0.3	8	$^1/_{16}$	1.6	8.33	208
8	200	9.05	225	350	52	0.33	8	$^1/_{16}$	1.6	8.27	207
8.	200	9.05	225	350	53	0.36	9	$^1/_{16}$	1.6	8.21	205
8	200	9.05	225	350	54	0.39	10	$^1/_{16}$	1.6	8.15	204
8	200	9.05	225	350	55	0.42	11	$^1/_{16}$	1.6	8.09	202
8	200	9.05	225	350	56	0.45	11	$^1/_{16}$	1.6	8.03	201
10	250	11.1	280	350		0.26	7	$^1/_{16}$	1.6	10.46	262
10	250	11.1	280	350	50	0.29	7	$^1/_{16}$	1.6	10.4	260
10	250	11.1	280	350	51	0.32	8	$^1/_{16}$	1.6	10.34	259
10	250	11.1	280	350	52	0.35	9	$^1/_{16}$	1.6	10.28	257
10	250	11.1	280	350	53	0.38	10	$^1/_{16}$	1.6	10.22	256
10	250	11.1	280	350	54	0.41	10	$^1/_{16}$	1.6	10.16	254
10	250	11.1	280	350	55	0.44	11	$^1/_{16}$	1.6	10.1	253
10	250	11.1	280	350	56	0.47	12	$^1/_{16}$	1.6	10.04	251
12	300	13.2	330	350		0.28	7	$^1/_{16}$	1.6	12.52	313
12	300	13.2	330	350	50	0.31	8	$^1/_{16}$	1.6	12.46	312
12	300	13.2	330	350	51	0.34	9	$^1/_{16}$	1.6	12.4	310
12	300	13.2	330	350	52	0.37	9	$^1/_{16}$	1.6	12.34	309
12	300	13.2	330	350	53	0.4	10	$^1/_{16}$	1.6	12.28	307
12	300	13.2	330	350	54	0.43	11	$^1/_{16}$	1.6	12.22	306
12	300	13.2	330	350	55	0.46	12	$^1/_{16}$	1.6	12.16	304
12	300	13.2	330	350	56	0.49	12	$^1/_{16}$	1.6	12.1	303
14	350	15.3	385	250		0.28	7	$^3/_{32}$	2	14.55	364
14	350	15.3	385	300		0.3	8	$^3/_{32}$	2	14.51	363
14	350	15.3	385	350		0.31	8	$^3/_{32}$	2	14.49	362
14	350	15.3	385		50	0.33	8	$^3/_{32}$	2	14.45	361
14	350	15.3	385		51	0.36	9	$^3/_{32}$	2	14.39	360
14	350	15.3	385		52	0.39	10	$^3/_{32}$	2	14.33	358
14	350	15.3	385		53	0.42	11	$^3/_{32}$	2	14.27	357
14	350	15.3	385		54	0.45	11	$^3/_{32}$	2	14.21	355
14	350	15.3	385		55	0.48	12	$^3/_{32}$	2	14.15	354

Pipe Size		OD		Pressure Class	Thickness Class	Wall Thickness		Minimum Lining Thickness*		ID with Lining	
in.	mm	in.	mm			in.	mm	in.	mm	in.	mm
14	350	15.3	385		56	0.51	13	3/32	2	14.09	352
16	400	17.4	435	250		0.3	8	3/32	2	16.61	415
16	400	17.4	435	300		0.32	8	3/32	2	16.57	414
16	400	17.4	435	350		0.34	9	3/32	2	16.53	413
16	400	17.4	435		50	0.34	9	3/32	2	16.53	413
16	400	17.4	435		51	0.37	9	3/32	2	16.47	412
16	400	17.4	435		52	0.4	10	3/32	2	16.41	410
16	400	17.4	435		53	0.43	11	3/32	2	16.35	409
16	400	17.4	435		54	0.46	12	3/32	2	16.29	407
16	400	17.4	435		55	0.49	12	3/32	2	16.23	406
16	400	17.4	435		56	0.52	13	3/32	2	16.17	404
18	450	19.5	488	250		0.31	8	3/32	2	18.69	467
18	450	19.5	488	300		0.34	9	3/32	2	18.63	466
18	450	19.5	488	350		0.36	9	3/32	2	18.59	465
18	450	19.5	488		50	0.35	9	3/32	2	18.61	465
18	450	19.5	488		51	0.35	9	3/32	2	18.61	465
18	450	19.5	488		52	0.41	10	3/32	2	18.49	462
18	450	19.5	488		53	0.44	11	3/32	2	18.43	461
18	450	19.5	488		54	0.47	12	3/32.	2	18.37	459
18	450	19.5	488		55	0.5	13	3/32	2	18.31	458
18	450	19.5	488		56	0.53	13	3/32	2	18.25	456
20	500	21.6	540	250		0.33	8	3/32	2	20.75	519
20	500	21.6	540	300		0.36	9	3/32	2	20.69	517
20	500	21.6	540	350		0.38	10	3/32	2	20.65	516
20	500	21.6	540		50	0.36	9	3/32	2	20.69	517
20	500	21.6	540		51	0.39	10	3/32	2	20.63	516
20	500	21.6	540		52	0.42	11	3/32	2	20.57	514
20	500	21.6	540		53	0.45	11	3/32	2	20.51	513
20	500	21.6	540		54	0.48	12	3/32	2	20.45	511
20	500	21.6	540		55	0.51	13	3/32	2	20.39	510
20	500	21.6	540		56	0.54	14	3/32	2	20.33	508
24	600	25.8	645	200		0.33	8	3/32	2	24.95	624
24	600	25.8	645	250		0.37	9	3/32	2	24.87	622

Pipe Size		OD		Pressure Class	Thickness Class	Wall Thickness		Minimum Lining Thickness*		ID with Lining	
in.	mm	in.	mm			in.	mm	in.	mm	in.	mm
24	600	25.8	645	300		0.4	10	3⁄32	2	24.81	620
24	600	25.8	645	350		0.43	11	3⁄32	2	24.75	619
24	600	25.8	645		50	0.38	10	3⁄32	2	24.85	621
24	600	25.8	645		51	0.41	10	3⁄32	2	24.79	620
24	600	25.8	645		52	0.44	11	3⁄32	2	24.73	618
24	600	25.8	645		53	0.47	12	3⁄32	2	24.67	617
24	600	25.8	645		54	0.5	13	3⁄32	2	24.61	615
24	600	25.8	645		55	0.53	13	3⁄32	2	24.55	614
24	600	25.8	645		56	0.56	14	3⁄32	2	24.49	612

ID: internal diameter; OD: outside diameter.

*This table is appropriate for single lining thickness only. The actual lining thickness should be obtained from the manufacturer. [**24:**Table A.10.1.3]

A.6.2.4

Where nonmetallic underground piping is provided above grade or inside a building, the following should be considered:

(1) Exposure from direct rays of sunlight
(2) Compatibility with chemicals such as floor coatings and termiticides/insecticides
(3) Support of piping and appurtenances attached thereto (e.g., sprinkler risers, backflow preventers)

[**24:**A.10.1.4]

A.6.4.1

The following standards apply to joints used with the various types of pipe:

(1) ASME B16.1, *Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250*
(2) AWWA C111/A21.11, *Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings*
(3) AWWA C115/A21.15, *Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges*
(4) AWWA C206, *Field Welding of Steel Water Pipe*
(5) AWWA C606, *Grooved and Shouldered Joints*

[**24:**A.10.3.1]

A.6.4.5.3

Fittings and couplings are listed for specific pipe materials that can be installed underground. Fittings and couplings do not necessarily indicate that they are listed specifically for underground use. [**24:**A.10.3.5.3]

A.6.5.1.3

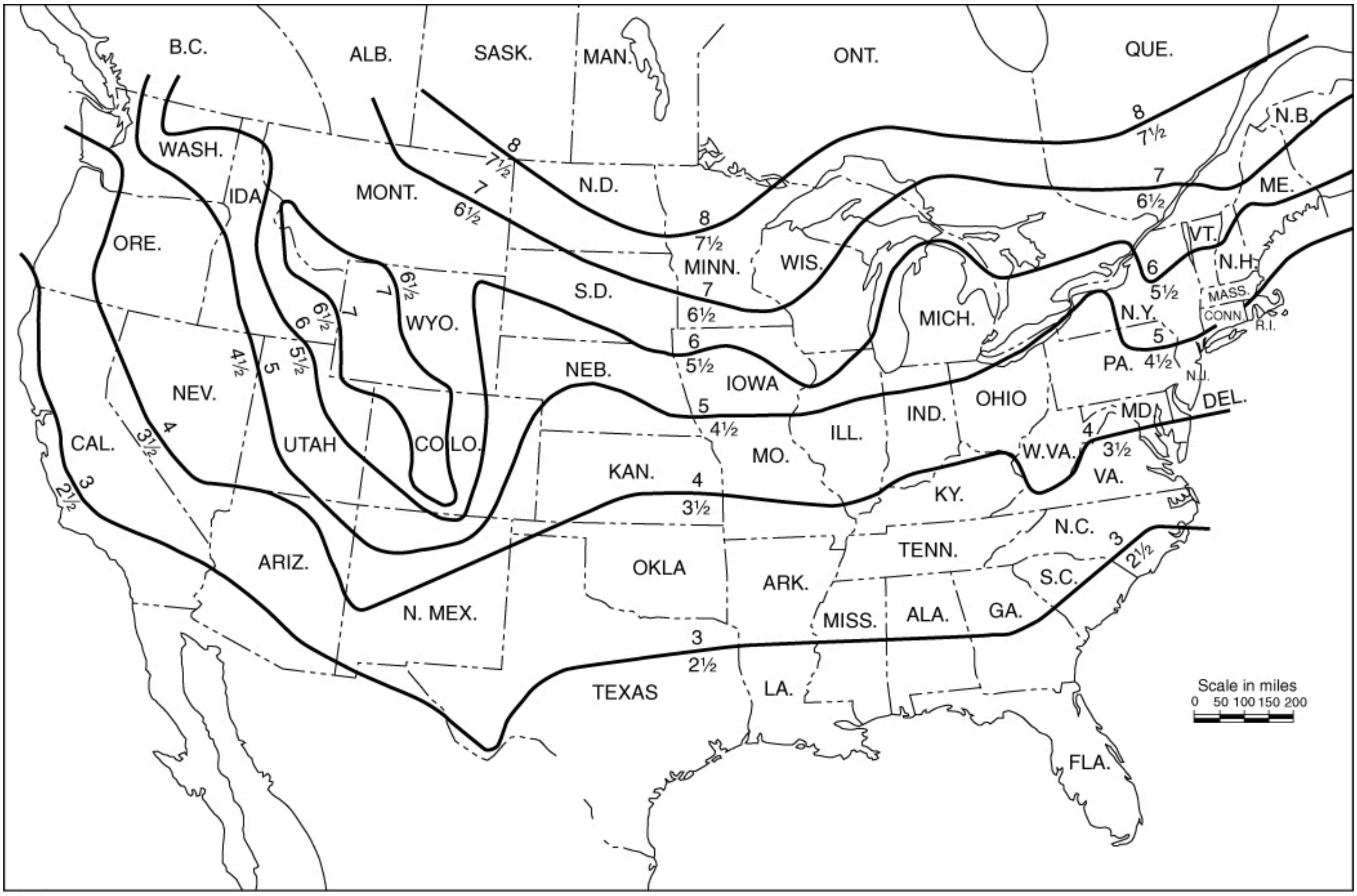
Gray cast iron is not considered galvanically dissimilar to ductile iron. Rubber gasket joints (unrestrained push-on or mechanical joints) are not considered connected electrically. Metal thickness should not be considered a protection against corrosive environments. In the case of cast iron or ductile iron pipe for soil evaluation and external protection systems, see Appendix A of AWWA C105/A21.5, *Polyethylene Encasement for Ductile-Iron Pipe Systems*.

A stainless steel in-building riser can connect to dissimilar metallic materials such as ductile iron or black steel. The product performance of many installations has not reported any instances of system failures or corrosion. [**24:**A.10.4.1.3]

A.6.5.2

As there is normally no circulation of water in private fire service mains, they require greater depth of covering than do public mains. Greater depth is required in a loose gravelly soil (or in rock) than in compact soil containing large quantities of clay. The recommended depth of cover above the top of underground yard mains is shown in Figure A.6.5.2.

Figure A.6.5.2 Recommended Depth of Cover (in feet) Above Top of Underground Yard Mains. [24:Figure A.10.4.2]



Notes:

1. For SI Units, 1 in. = 25.4 mm; 1 ft = 0.304 m.
2. Where frost penetration is a factor, the depth of cover shown averages 6 in. greater than that usually provided by the municipal waterworks. Greater depth is needed because of the absence of flow in yard mains.

In determining the need to protect aboveground piping from freezing, the lowest mean temperature should be considered. [**24:**A.10.4.2]

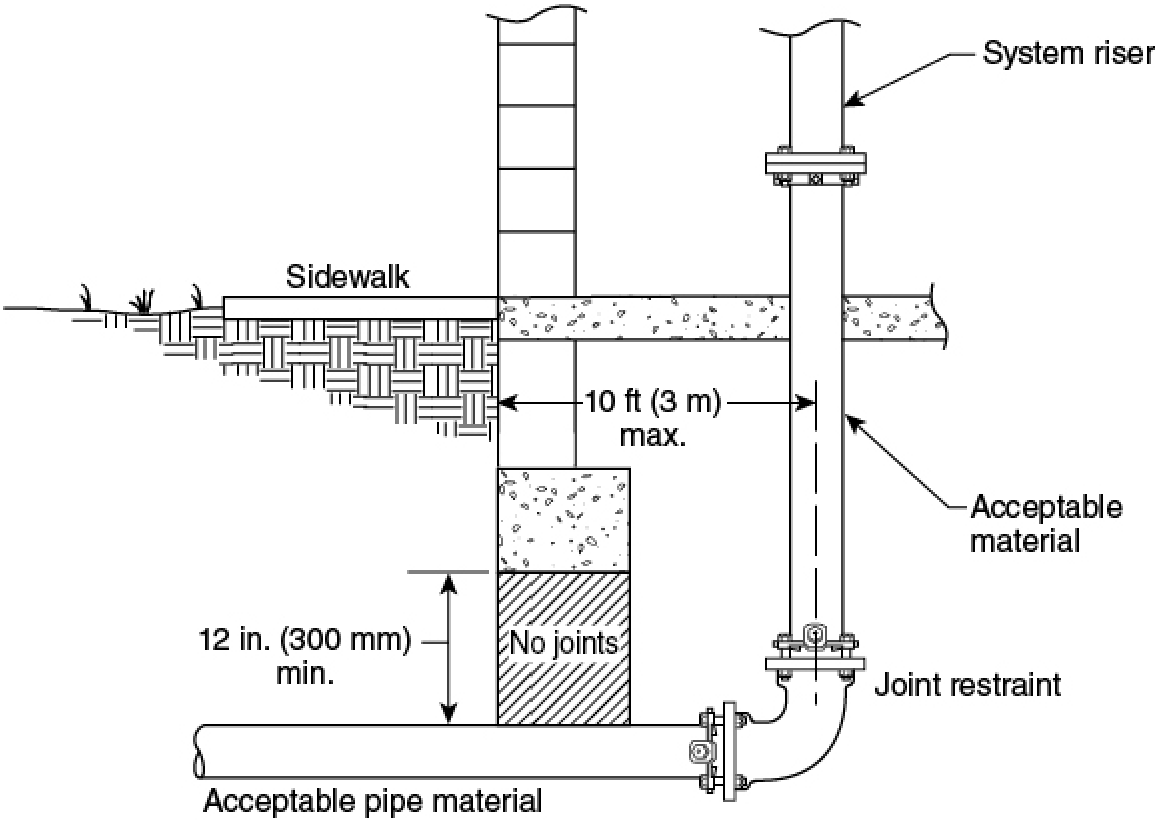
A.6.5.2.1.1

Consideration should be given to the type of soil and the possibility of settling. Also, many times the inspection of the piping might occur before final grading and fill of the installation is complete. The final grade should be verified. [**24:**A.10.4.2.1.1]

A.6.5.3.1

The intent of this section is to limit the total length of horizontal pipe beneath the building to not more than 10 ft (3 m). See Figure A.6.5.3.1. [**24:**A.10.4.3.1]

Figure A.6.5.3.1 Riser Entrance Location and Clearance. [24:Figure A.10.4.3.1]



A.6.5.3.1.1

The individual piping standards should be followed for load and bury depth, accounting for the load and stresses imposed by the building foundation. [**24:**A.10.4.3.1.1]

A.6.5.3.1.2

Sufficient clearance should be provided when piping passes beneath foundations or footers. [**24:**A.10.4.3.1.2]

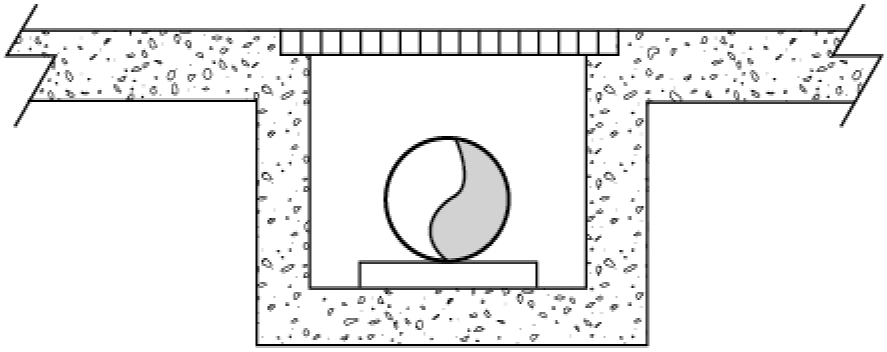
A.6.5.3.2

The design concepts in 6.5.3.2.1 through 6.5.3.2.1.3 should apply to both new installations and existing private fire service mains approved to remain under new buildings. [**24:**A.10.4.3.2]

A.6.5.3.2.1

See Figure A.6.5.3.2.1. [**24:**A.10.4.3.2.1]

Figure A.6.5.3.2.1 Private Service Main in a Covered Trench. [24:Figure A.10.4.3.2.1]



A.6.5.3.2.1.1

A grate or steel plate are common methods of accessing the trench. [**24:**A.10.4.3.2.1.1]

A.6.5.3.2.1.4

The intent of this requirement is to prevent the piping from being exposed to standing water. Draining can be accomplished by providing a floor drain, sloping the trench, or other approved method. [**24:**A.10.4.3.2.1.4]

A.6.5.3.2.3

It is the intent of this section to require a valve at each point where the pipe enters the trench when the trench traverses the entire building. Generally, if the piping terminates at a point within the building, a valve is usually provided at a riser, allowing the isolation of the pipe section in the trench. [**24:**A.10.4.3.2.3]

A.6.6.1

Where lightning protection is provided for a structure, Section 4.14 of NFPA 780 requires that all grounding media, including underground metallic piping systems, be interconnected to provide common ground potential. These underground piping systems are not permitted to be substituted for grounding electrodes but must be bonded to the lightning protection grounding system. Where galvanic corrosion is of concern, this bond can be made via a spark gap or gas discharge tube. [**24:**A.10.5.1]

A.6.6.1.1

While the use of the underground fire protection piping as the grounding electrode for the building is prohibited, *NFPA 70* requires that all metallic piping systems be bonded and grounded to disperse stray electrical currents. Therefore, the fire protection piping will be bonded to other metallic systems and grounded, but the electrical system will need an additional ground for its operation. [**24:**A.10.5.1.1]

A.6.7

It is a fundamental design principle of fluid mechanics that dynamic and static pressures, acting at changes in size or direction of a pipe, produce unbalanced thrust forces at locations such as bends, tees, wyes, dead ends, and reducer offsets. This design principle includes consideration of lateral soil pressure and pipe/soil friction, variables that can be reliably determined using current soil engineering knowledge. Refer to A.6.7.2 for a list of references for use in calculating and determining joint restraint systems.

Section 6.7 does not mandate which method of restraint should be used. This decision is left to the design professional or the owner.

Except for the case of welded joints and approved special restrained joints, such as is provided by approved mechanical joint retainer glands or locked mechanical and push-on joints, the usual joints for underground pipe are expected to be held in place by the soil in which the pipe is buried. Gasketed push-on and mechanical joints without special locking devices have limited ability to resist separation due to movement of the pipe. [**24:**A.10.6]

A.6.7.1

The use of concrete thrust blocks is one method of restraint, provided that stable soil conditions prevail and space requirements permit placement. Successful blocking is dependent on factors such as location, availability and placement of concrete, and possibility of disturbance by future excavations.

Resistance is provided by transferring the thrust force to the soil through the larger bearing area of the block so that the resultant pressure against the soil does not exceed the horizontal bearing strength of the soil. The design of thrust blocks consists of determining the appropriate bearing area of the block for a particular set of conditions. The parameters involved in the design include pipe size, design pressure, angle of the bend (or configuration of the fitting involved), and the horizontal bearing strength of the soil.

Table A.6.7.1(a) gives the nominal thrust at fittings for various sizes of ductile-iron and PVC piping. Figure A.6.7.1(a) shows an example of how thrust forces act on a piping bend.

Table A.6.7.1(a) Thrust at Fittings at 100 psi (6.9 bar) Water Pressure for Ductile Iron and PVC Pipe

Nominal Pipe Diameter [in. (mm)]	Total Pounds (Newtons)											
	Dead End		90 Degree		45 Degree		$22\frac{1}{2}$ Degree		$11\frac{1}{4}$ Degree		$5\frac{1}{8}$ Degree	
	lbf	N	lbf	N	lbf	N	lbf	N	lbf	N	lbf	N
4 (100)	1,810	8,051	2,559	11,383	1,385	6,161	706	3,140	355	1,579	162	721
6 (150)	3,739	16,632	5,288	23,522	2,862	12,731	1,459	6,490	733	3,261	334	1,486
8 (200)	6,433	28,615	9,097	40,465	4,923	21,899	2,510	11,165	1,261	5,609	575	2,558
10 (250)	9,677	43,045	13,685	60,874	7,406	32,944	3,776	16,796	1,897	8,438	865	3,848
12 (300)	13,685	60,874	19,353	86,086	10,474	46,591	5,340	23,753	2,683	11,935	1,224	5,445
14 (350)	18,385	81,781	26,001	115,658	14,072	62,595	7,174	31,912	3,604	16,031	1,644	7,313
16 (400)	23,779	105,774	33,628	149,585	18,199	80,953	9,278	41,271	4,661	20,733	2,126	9,457
18 (450)	29,865	132,846	42,235	187,871	22,858	101,677	11,653	51,835	5,855	26,044	2,670	11,877

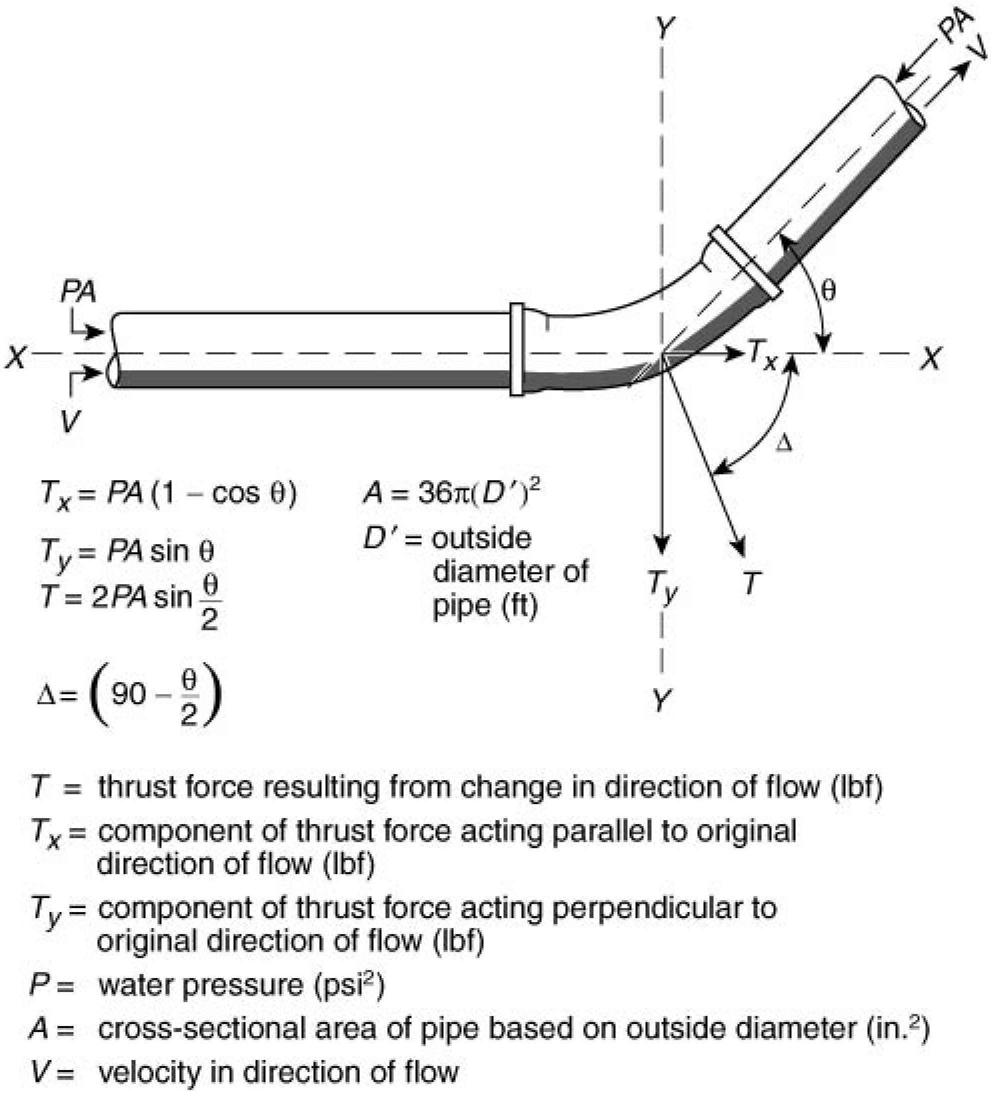
Nominal Pipe Diameter [in. (mm)]	Total Pounds (Newtons)											
	Dead End		90 Degree		45 Degree		$22\frac{1}{2}$ Degree		$11\frac{1}{4}$ Degree		$5\frac{1}{8}$ Degree	
	lbf	N	lbf	N	lbf	N	lbf	N	lbf	N	lbf	N
20 (500)	36,644	163,001	51,822	230,516	28,046	124,755	14,298	63,601	7,183	31,952	3,277	14,577
24 (600)	52,279	232,548	73,934	328,875	40,013	177,987	20,398	90,735	10,249	45,590	4,675	20,795
30 (750)	80,425	357,748	113,738	505,932	61,554	273,806	31,380	139,585	15,766	70,131	7,191	31,987
36 (900)	115,209	512,475	162,931	724,753	88,177	392,231	44,952	199,956	22,585	100,463	10,302	45,826
42 (1,050)	155,528	691,823	219,950	978,386	119,036	529,498	60,684	269,936	30,489	135,622	13,907	61,861
48 (1,200)	202,683	901,579	286,637	1,275,024	155,127	690,039	79,083	351,779	39,733	176,741	18,124	80,620

Notes:

(1) For SI units, 1 lb = 0.454 kg; 1 in. = 25 mm.

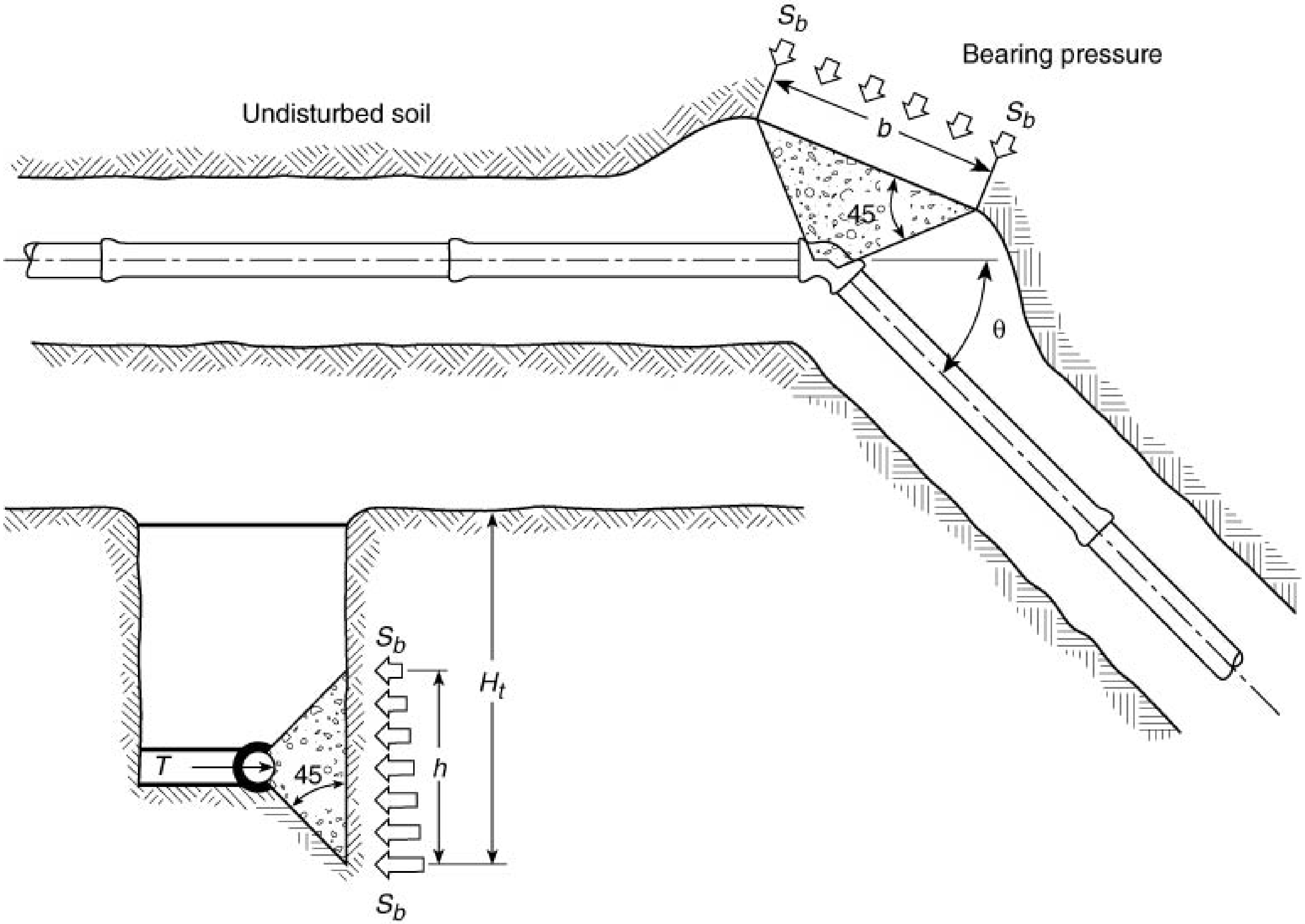
(2) To determine thrust at pressure other than 100 psi (6.9 bar), multiply the thrust obtained in the table by the ratio of the pressure to 100 psi (6.9 bar). For example, the thrust on a 12 in. (305 mm), 90-degree bend at 125 psi (8.6 bar) is 19,353 × 125/100 = 24,191 lb (10,973 kg).
[**24:**Table A.10.6.1(a)]

Figure A.6.7.1(a) Thrust Forces Acting on Bend. [24:Figure A.10.6.1(a)]



Thrust blocks are generally categorized into two groups — bearing and gravity blocks. Figure A.6.7.1(b) depicts a typical bearing thrust block on a horizontal bend. [**24:**A.10.6.1]

Figure A.6.7.1(b) Bearing Thrust Block. [24:Figure A.10.6.1(b)]



T = thrust force resulting from change in direction of flow

S_b = horizontal bearing strength of soil

h = block height

H_t = total depth to bottom of block

The following are general criteria for bearing block design:

(1) The bearing surface should, where possible, be placed against undisturbed soil.

(2) Where it is not possible to place the bearing surface against undisturbed soil, the fill between the bearing surface and undisturbed soil must be compacted to at least 90 percent Standard Proctor density.

(3) Block height *(h)* should be equal to or less than one-half the total depth to the bottom of the block *(H_t)* but not less than the pipe diameter *(D)*.

(4) Block height *(h)* should be chosen such that the calculated block width *(b)* varies between one and two times the height.

(5) Gravity thrust blocks can be used to resist thrust at vertical down bends. In a gravity thrust block, the weight of the block is the force providing equilibrium with the thrust force. The design problem is then to calculate the required volume of the thrust block of a known density. The vertical component of the thrust force in Figure A.6.7.1(c) is balanced by the weight of the block. For required horizontal bearing block areas, see Table A.6.7.1(b).

The required block area (A_b) is as follows:

[A.6.7.1a]

$$A_b = (h)(b) = \frac{T(S_f)}{S_b}$$

where:

A_b = required block area (ft^2)

h = block height (ft)

b = calculated block width (ft)

T = thrust force (lbf)

S_f = safety factor (usually 1.5)

S_b = bearing strength (lb/ft^2)

Then, for a horizontal bend, the following formula is used:

$$b = \frac{2\left(S_f\right)(P)(A)\sin\frac{\theta}{2}}{(h)\left(S_b\right)} \qquad \text{[A.6.7.1b]}$$

where:

b = calculated block width (ft)

S_f = safety factor (usually 1.5 for thrust block design)

P = water pressure (lb/in.^{2})

A = cross-sectional area of the pipe based on outside diameter

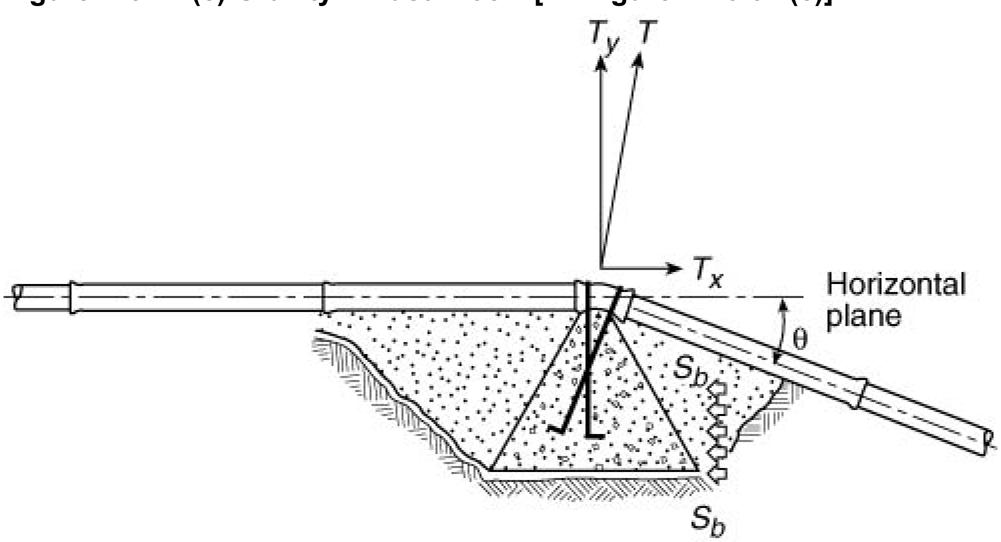
h = block height (ft)

S_b = horizontal bearing strength of soil (lb/ft^2) (in.^{2})

A similar approach can be used to design bearing blocks to resist the thrust forces at locations such as tees and dead ends. Typical values for conservative horizontal bearing strengths of various soil types are listed in Table A.6.7.1(c). [**24:**A.10.6.1]

See example A.6.7.1(c) in Table A.6.7.1(b). **[A.6.7.1c]**

Figure A.6.7.1(c) Gravity Thrust Block. [24:Figure A.10.6.1(c)]



T = thrust force resulting from change of direction of flow

T_x = horizontal component of thrust force

T_y = vertical component of thrust force

S_b = horizontal bearing strength of soil

Table A.6.7.1(b) Required Horizontal Bearing Block Area

Nominal Pipe Diameter		Bearing Block Area		Nominal Pipe Diameter		Bearing Block Area		Nominal Pipe Diameter		Bearing Block Area	
in.	mm	ft^2	m^2	in.	mm	ft^2	m^2	in.	mm	ft^2	m^2
3	80	2.6	0.24	12	300	29.0	2.7	24	600	110.9	10.3
4	100	3.8	0.35	14	350	39.0	3.6	30	750	170.6	15.8
6	150	7.9	0.73	16	400	50.4	4.7	36	900	244.4	22.7
8	200	13.6	1.3	18	450	63.3	5.9	42	1050	329.9	30.6
10	250	20.5	2	20	500	77.7	7.2	48	1200	430.0	39.9

Notes:

(1) Although the bearing strength values in this table have been used successfully in the design of thrust blocks and are considered to be conservative, their accuracy is totally dependent on accurate soil identification and evaluation. The ultimate responsibility for selecting the proper bearing strength of a particular soil type must rest with the design engineer.

(2) Values listed are based on a 90-degree horizontal bend, an internal pressure of 100 psi (6.9 bar), a soil horizontal bearing strength of 1000 lb/ft ^{2} (47.9 kN/m^2), a safety factor of 1.5, and ductile iron pipe outside diameters.

(a) For other horizontal bends, multiply by the following coefficients: for 45 degrees, 0.541; for 22$\frac{1}{2}$ degrees, 0.276; for 11$\frac{1}{4}$ degrees, 0.139.

(b) Hydrostatic test pressures should be used when modifying the thrust-force bearing block area by the ratio of the test pressure to 100 psi (6.9 bar).

(c) For other soil horizontal bearing strengths, divide by ratio to 1000 lb/ft^2(4880 kg/m^2).

(d) For other safety factors, multiply by ratio to 1.5.

Example: Using Table A.6.7.1(b), find the horizontal bearing block area for a 6 in. (150 mm) diameter, 45-degree bend with an internal pressure of 150 psi (10 bar). The soil bearing strength is 3000 lb/ft^2(14850 kg/m^2), and the safety factor is 1.5.

From Table A.6.7.1(b), the required bearing block area for a 6 in. (150 mm) diameter, 90-degree bend with an internal pressure of 100 psi (6.9 bar) and a soil horizontal bearing strength of 1000 psi (70 bar) is 7.9 ft^2 (0.73 m^2).

For example:

$$Area = \frac{7.9\ \text{ft}^2 (0.541) \dfrac{150}{100}}{\dfrac{3000}{1000}} = 2.1\ \text{ft}^2 \quad \text{[A.6.7.1c]}$$

[**24:**Table A.10.6.1(b)]

In lieu of the values for soil bearing strength shown in Table A.6.7.1(c), a designer might choose to use calculated Rankine passive pressure (P_p) or other determination of soil-bearing strength based on actual soil properties.

Table A.6.7.1(c) Horizontal Bearing Strengths

Soil	Bearing Strength, S_b lb/ft^2	Bearing Strength, S_b kN/m^2
Muck	0	0
Soft clay	1000	48
Silt	1500	72

	Bearing Strength, S_b	
Soil	lb/ft^2	kN/m^2
Sandy silt	3000	145
Sand	4000	190
Sandy clay	6000	285
Hard clay	9000	430

Note: Although the bearing strength values in this table have been used successfully in the design of thrust blocks and are considered to be conservative, their accuracy is totally dependent on accurate soil identification and evaluation. The ultimate responsibility for selecting the proper bearing strength of a particular soil type must rest with the design engineer.

[**24:**Table A.10.6.1(c)]

It can be easily shown that $T_y = PA \sin \theta$. The required volume of the block is as follows:

$$V_g = \frac{S_f PA \sin\theta}{W_m} \quad \text{[A.6.7.1d]}$$

where:

V_g = block volume (ft^3)

S_f = safety factor

P = water pressure (psi)

A = cross-sectional area of pipe interior

W_m = density of block material (lb/ft^3)

In a case such as the one shown, the horizontal component of thrust force is calculated as follows:

$$T_x = PA(1 - \cos\ \theta) \quad \text{[A.6.7.1e]}$$

where:

T_x = horizontal component of thrust force

P = water pressure (psi)

A = cross-sectional area of pipe interior

The horizontal component of thrust force must be resisted by the bearing of the right side of the block against the soil. Analysis of this aspect follows the same principles as the previous section on bearing blocks.
[**24:**A.10.6.1]

A.6.7.2

A method for providing thrust restraint is the use of restrained joints. A restrained joint is a special type of joint that is designed to provide longitudinal restraint. Restrained joint systems function in a manner similar to thrust blocks, insofar as the reaction of the entire restrained unit of piping with the soil balances the thrust forces.

The objective in designing a restrained joint thrust restraint system is to determine the length of pipe that must be restrained on each side of the focus of the thrust force, which occurs at a change in direction. This will be a function of the pipe size, the internal pressure, the depth of cover, and the characteristics of the solid surrounding the pipe. The manufacturer's installation instructions should be referenced to determine the distance from each change in direction that joints should be restrained.

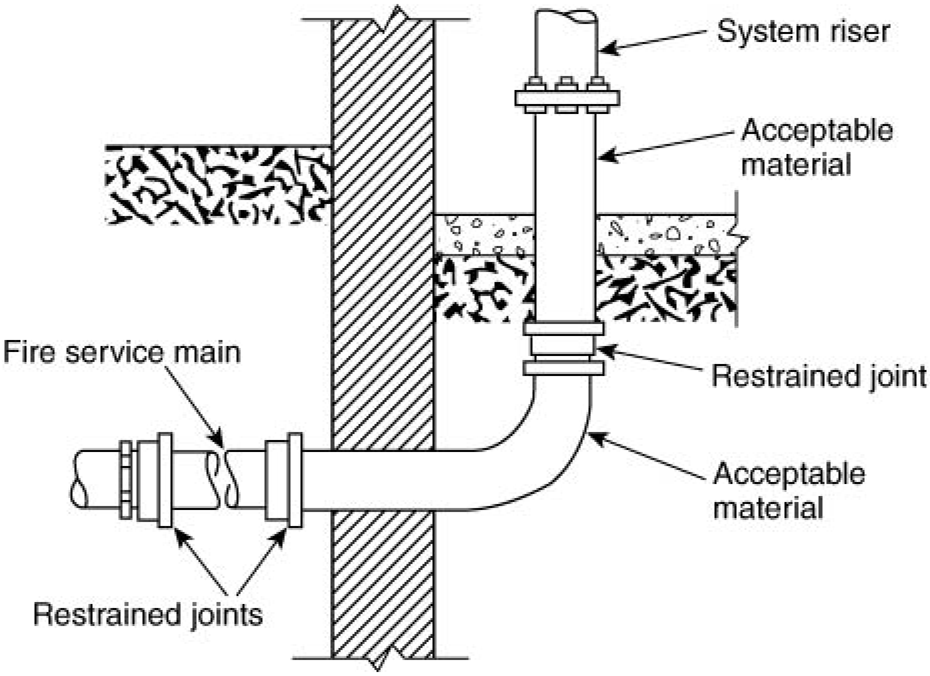
The following documents apply to the design, calculation, and determination of restrained joint systems:

(1) *Thrust Restraint Design for Ductile Iron Pipe*, Ductile Iron Pipe Research Association
(2) AWWA M41, *Ductile-Iron Pipe and Fittings*
(3) AWWA M9, *Concrete Pressure Pipe*
(4) AWWA M11, *Steel Pipe — A Guide for Design and Installation*

(5) *Thrust Restraint Design Equations and Tables for Ductile Iron and PVC Pipe*, EBAA Iron, Inc.

Figure A.6.7.2 shows an example of a typical connection to a fire protection system riser utilizing restrained joint pipe. [**24:**A.10.6.2]

Figure A.6.7.2 Typical Connection to a Fire Protection System Riser Illustrating Restrained Joints. [24:Figure A.10.6.2]



A.6.7.2.1

Examples of materials and the standards covering these materials are as follows:

(1) Clamps, steel
(2) Rods, steel
(3) Bolts, steel (ASTM A307, *Standard Specification for Carbon Steel Bolts, Studs, Threaded Rod 60,000 psi Tensile Strength*)
(4) Washers, steel, cast iron (Class A cast iron as defined by ASTM A126, *Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings*)
(5) Anchor straps, plug straps, steel
(6) Rod couplings, turnbuckles, malleable iron (ASTM A197/A197M, *Standard Specification for Cupola Malleable Iron*)

[**24:**A.10.6.2.1]

A.6.7.3

Solvent-cemented and heat-fused joints such as those used with CPVC piping and fittings are considered restrained. They do not require thrust blocks. [**24:**A.10.6.3]

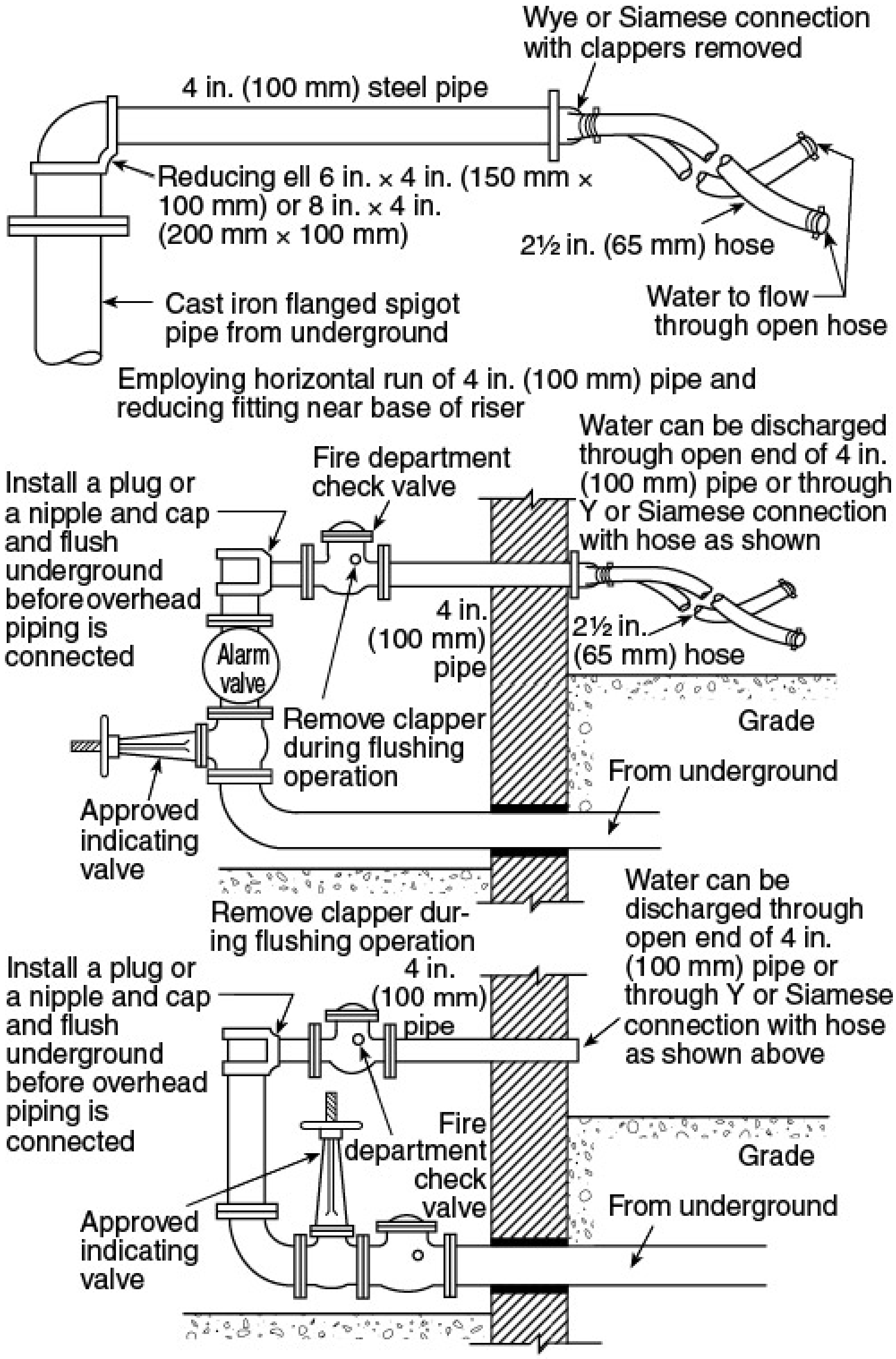
A.6.10.3

The maximum particle size allowed next to most types of pipe can be found in ASTM C136/136M, *Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates,* ASTM D2487, *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System),* AWWA M55, *PE Pipe — Design and Installation*, AWWA M23, *PVC Pipe — Design and Installation,* trade association handbooks, or manufacturers' literature. These publications typically recommend one maximum allowable particle size that applies to the bedding, embedment, and backfill, which might be different materials. The maximum particle size might be dependent on the pipe diameter. [**24:**A.10.9.3]

A.6.11.2.1

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.6.11.2.1 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 6.11.2.1.3 will produce a velocity of at least 10 ft/sec (3.0 m/sec), which is necessary for cleaning the pipe and for lifting foreign material to an aboveground flushing outlet. [**24:**A.10.10.2.1]

Figure A.6.11.2.1 Methods of Flushing Water Supply Connections. [24:Figure A.10.10.2.1]



Employing fire department connections

A.6.11.2.1.3

The velocity of approximately 10 ft/sec (3.0 m/sec) was used to develop Table 6.11.2.1.3 because this velocity has been shown to be sufficient for moving obstructive material out of the pipes. It is not important that the velocity equal exactly 10 ft/sec (3.0 m/sec), so there is no reason to increase the flow during the test for slightly different internal pipe dimensions. Note that where underground pipe serves as suction pipe for a fire pump, NFPA 20 requires greater flows for flushing the pipe. [**24:**A.10.10.2.1.3]

A.6.11.2.1.4

An example of a swab would be polyurethane foam. The manufacturer's recommended procedure should be followed when swabbing is used. [**24:**A.10.10.2.1.4]

A.6.11.2.2.1

For example, consider a sprinkler system with a connection to a public water service main for its water supply. 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 bar) 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 psi (4.8 bar), 120 psi (8.3 bar), 50 psi (3.5 bar), or 240 psi (16.5 bar).

To reduce the possibility of serious water damage in case of a break, pressure can be introduced 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 might 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 recommended test procedure is as follows: The water pressure is to be increased in 50 psi (3.5 bar) increments until the test pressure described in 6.11.2.2.1 is attained. After each increase in pressure, observations are to be made of the stability of the joints. These observations are to include such items as protrusion or extrusion of the gasket, leakage, or other factors likely to affect the continued use of a pipe in service. During the test, the pressure is not to be increased by the next increment until the joint has become stable. This applies particularly to movement of the gasket. After the pressure has been increased to the required maximum value, it is held for 2 hours while observations are made for leakage and the pressure readings are checked. [**24:**A.10.10.2.2.1]

A.6.11.2.2.4

Hydrostatic tests should be made before the joints are covered, so that any leaks can be detected. Thrust blocks should be sufficiently hardened before hydrostatic testing is begun. If the joints are covered with backfill prior to testing, the contractor remains responsible for locating and correcting any leakage in excess of that permitted. [**24:**A.10.10.2.2.4]

A.6.11.2.2.6

One acceptable means of completing this test is to utilize a pressure pump that draws its water supply from a full container. At the completion of the 2-hour test, the amount of water to refill the container can be measured to determine the amount of makeup water. In order to minimize pressure loss, the piping should be flushed to remove any trapped air. Additionally, the piping could be pressurized prior to the hydrostatic test to account for expansion, absorption, entrapped air, and so on.

The use of a blind flange or skillet is preferred for hydrostatically testing segments of new work. Metal-seated valves are susceptible to developing slight imperfections during transport, installation, and operation and thus can be likely to leak more than 1 fl oz/in. (1.2 mL/mm) of valve diameter per hour. For this reason, the blind flange should be used when hydrostatically testing. [**24:**A.10.10.2.2.6]

A.6.11.2.3

As an example, the following standards contain test requirements AWWA C600, *Installation of Ductile-Iron Water Mains and Their Appurtenances*, AWWA C602, *Cement-Mortar Lining of Water Pipelines in Place, 4 in. (100 mm) and Larger*, AWWA C900, *Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. Through 60 in (100 mm Through 1,500 mm),* or ASTM F2164, *Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure*. [**24:**A.10.10.2.3]

A.6.11.2.3.1

Examples include cut-in tees, repair sleeves, or hot taps. [**24:**A.10.10.2.3.1]

A.7.1.1

Included among items requiring listing are sprinklers, some pipe and some fittings, hangers, alarm devices, valves controlling flow of water to sprinklers, supervisory switches, and electrically operated solenoid valves. Products are typically investigated in accordance with published standards. Examples of standards used to investigate several products installed in sprinkler systems are referenced in Table A.7.1.1. This table does not include a comprehensive list of all product standards used to investigate products installed in sprinkler systems.

Table A.7.1.1 Examples of Standards for Sprinkler System Products

Category	Standard
Sprinklers	CAN/UL/ULC 199, *Automatic Sprinklers for Fire Protection Service*
	FM 2000, *Automatic Sprinklers for Fire Protection*
	FM 2030, *Residential Automatic Sprinklers for Fire Protection*

Category	Standard
	FM 2008, *Quick Response Storage Sprinklers for Fire Protection*
	FM 1632, *Telescoping Sprinkler Assemblies for Use in Fire Protection Systems for Anechoic Chambers*
Air Compressors and Vacuum Pumps	UL 1450, *Motor-Operated Air Compressors, Vacuum Pumps, and Painting Equipment*
Antifreeze and Corrosion Control	UL 2901, *Antifreeze Solutions for Use in Fire Sprinkler Systems*
	UL 2901A, *Outline of Investigation for Corrosion Control Additives for Use in Fire Sprinkler Systems*
Valves	UL 193, *Alarm Valves for Fire Protection Service*
	FM 1041, *Alarm Check Valves*
	UL 260, *Dry Pipe and Deluge Valves for Fire-Protection Service*
	FM 1021, *Dry Pipe Valves*
	FM 1020, *Automatic Water Control Valves*
	UL 262, *Gate Valves for Fire-Protection Service*
	FM 1120/1130, *Fire Service Water Control Valves (OS & Y and NRS Type Gate Valves)*
	UL 312, *Check Valves for Fire-Protection Service*
	FM 1210, *Swing Check Valves*
	UL 1091, *Butterfly Valves for Fire-Protection Service*
	FM 1112, *Indicating Valves (Butterfly or Ball Type)*
	UL 1468, *Direct Acting Pressure Reducing and Pressure Restricting Valves*
	UL 1739, *Pilot-Operated Pressure-Control Valves for Fire Protection Service*
	FM 1362, *Pressure Reducing Valves*
	FM 1011/1012/1013, *Deluge and Preaction Sprinkler Systems*
	FM 1031, *Quick Opening Devices (Accelerators, Exhausters) for Dry Pipe Valves*
	UL 1486, *Quick Opening Devices for Dry Pipe Valves for Fire Protection Service*
	UL 346, *Waterflow Indicators for Fire Protective Signaling Systems*
	FM 1042, *Vane-Type Waterflow Alarm Indicators*
	FM 1045, *Waterflow Detector Check Valves*
	FM 1140, *Quick Opening Valves $^1/_4$ Inch Through 2 Inch Nominal Size*
Hangers	UL 203, *Pipe Hanger Equipment for Fire Protection Service*
	FM 1951/1952/1953, *Pipe Hanger Components for Automatic Sprinkler Systems*
	FM 1950, *Seismic Sway Braces for Pipe, Tubing and Conduit*
	UL 203A, *Sway Brace Devices for Sprinkler System Piping*
Fittings	CAN/UL 213, *Rubber Gasketed Fittings for Fire-Protection Service*
	FM 1920, *Pipe Couplings and Fittings for Aboveground Fire Protection Systems*
	UL 1474, *Adjustable Drop Nipples for Sprinkler Systems*
	FM 1631, *Adjustable and Fixed Sprinkler Fittings $^1/_2$ Inch through 1 Inch Nominal Size*
	UL 2443, *Flexible Sprinkler Hose with Fittings for Fire Protection Service*
	FM 1637, *Flexible Sprinkler Hose with Threaded End Fittings*
Pipe — Aboveground	UL 852, *Metallic Sprinkler Pipe for Fire Protection Service*
	FM 1630, *Steel Pipe for Automatic Fire Sprinkler Systems*
	CAN/UL 1821, *Thermoplastic Sprinkler Pipe and Fittings for Fire Protection Service*

Category	Standard
	FM 1635, *Plastic Pipe and Fittings for Automatic Sprinkler Systems*
	FM 1636, *Fire Resistant Barriers for Use with CPVC Pipe and Fittings in Light Hazard Occupancies*
Pipe — Underground	CAN/UL/ULC 1285, *Pipe and Couplings, Polyvinyl Chloride (PVC), and Oriented Polyvinyl Chloride (PVCO) for Underground Fire Service*
	FM 1612, *Polyvinyl Chloride (PVC) Pipe and Fittings for Underground Fire Protection Service*
	FM 1613, *Polyethylene (PE) Pipe and Fittings for Underground Fire Protection Service*
	FM 1610, *Ductile Iron Pipe and Fittings, Flexible Fittings and Couplings*
	UL 194, *Gasketed Joints for Ductile-Iron Pipe and Fittings for Fire Protection Service*
	FM 1620, *Pipe Joints and Anchor Fittings for Underground Fire Service Mains*

A.7.1.1.5

Certain components installed in sprinkler systems are not required to be listed as their improper operation will not detrimentally affect the automatic system performance. Examples include but are not limited to drain valves, drain piping, signs, gauges, automated inspection and test devices, distance monitoring devices, fire department connections that do not use threadless couplings, and so forth.

Certain devices and equipment that could be used to perform inspection and testing procedures from a distant location are not integral to the system and do not affect system performance. Automated inspection and testing devices and equipment, such as a digital camera, might be in the riser room or attached to the system externally but are not an integral part of the system. Such devices do not need to be listed.

Certain devices and equipment that could be used to monitor system or component status from a distance are not integral to the system and do not affect system performance. Distance monitoring devices, such as an external thermometer, might be attached to the system externally and therefore are not subjected to system pressure. Such devices do not need to be listed.

A.7.2.1

The four- to six-character sprinkler identification number, with no intervening spaces, is intended to identify the sprinkler operating characteristics in lieu of the traditional laboratory approval marking (e.g., SSU, SSP, EC, QR, etc.). The number, marked on the deflector of most sprinklers and elsewhere on decorative ceiling sprinklers, consists of one or two characters identifying the manufacturer, followed by three or four digits.

Sprinkler manufacturers have identified their manufacturer designations for the listing organizations. In order to identify a manufacturer based on the Sprinkler Identification Number, see the listing at www.firesprinkler.global. Each change in K-factor, response characteristics, or deflector (distribution) characteristics results in a new sprinkler identification number. The numbers do not identify specific characteristics of sprinklers but can be referenced in the database information compiled by the listing organizations. At the plan review stage, the sprinkler identification number should be checked against such a database or the manufacturer's literature to ensure that sprinklers are being used properly and within the limitations of their listings. Field inspections can include spot checks to ensure that the model numbers on the plans are those actually installed.

A.7.2.2.1

See Table A.7.2.2.1.

Table A.7.2.2.1 Nominal Sprinkler Orifice Sizes

Nominal K-Factor		Nominal Orifice Size	
US [gpm/(psi)$^{1/2}$]	Metric [L/min/(bar)$^{1/2}$]	in.	mm
1.4	20	$\frac{1}{4}$	6.4
1.9	27	$\frac{5}{16}$	8.0
2.8	40	$\frac{3}{8}$	10
4.2	60	$\frac{7}{16}$	11
5.6	80	$\frac{1}{2}$	13

Nominal K-Factor		Nominal Orifice Size	
US [gpm/(psi)$^{1/2}$]	Metric [L/min/(bar)$^{1/2}$]	in.	mm
8.0	115	$^{17}/_{32}$	13
11.2	160	$^{5}/_{8}$	16
14.0	200	$^{3}/_{4}$	20
16.8	240	—	—
19.6	280	—	—
22.4	320	—	—
25.2	360	—	—
28.0	400	—	—
33.6	480	—	—

A.7.2.4

Information regarding the highest temperature that can be encountered in any location in a particular installation can 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 equipment in operation that produces heat.

A.7.2.4.1

Table 7.2.4.1(a)and Table 7.2.4.1(b) should not be used to determine where sprinklers with specific temperature ratings are to be installed but only to classify sprinklers according to their temperature ratings. See 9.4.2 for specific temperature rating requirements.

A.7.2.5.1

Examples of such locations include the following:

(1) Paper mills
(2) Packing houses
(3) Tanneries
(4) Alkali plants
(5) Organic fertilizer plants
(6) Foundries
(7) Forge shops
(8) Fumigation, pickle, and vinegar works
(9) Stables
(10) Storage battery rooms
(11) Electroplating rooms
(12) Galvanizing rooms
(13) Steam rooms of all descriptions, including moist vapor dry kilns
(14) Salt storage rooms
(15) Locomotive sheds or houses
(16) Driveways
(17) Areas exposed to outside weather, such as piers and wharves exposed to salt air
(18) Areas under sidewalks
(19) Areas around bleaching equipment in flour mills
(20) All portions of cold storage buildings where a direct ammonia expansion system is used
(21) Portions of any plant where corrosive vapors prevail
(22) Area over and around swimming pools, chlorine storage rooms, and pool pump rooms

A.7.2.5.1.2

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

A.7.2.5.2

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

A.7.2.6.2

The use of the wrong type of escutcheon with recessed or flush-type sprinklers can result in severe disruption of the operating characteristics, which can destroy the effectiveness of the sprinkler.

A.7.3.2

CPVC is a plastic material, and consideration is necessary when other materials or chemicals come in contact with CPVC that can cause degradation of performance of the pipe due to interaction of materials. Other construction materials include but are not limited to materials used in fabrication of the sprinkler system, additives to water supplies, cable, and wiring, and certain insecticides and fungicides. Compliance with 7.3.2 combined with following the manufacturer's guidance on installation and compatible materials will help prevent premature performance degradation of non-metallic piping. Mechanical stress caused by hanging methods or bending on non-metallic piping beyond the manufacturers recommended limitations can cause stress failure over time and should be avoided.

Other types of pipe and tube that have been investigated and listed for sprinkler applications include thermoplastic pipe and fittings. While these products can 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 thermoplastic pipe and fittings, exposure of such piping to elevated temperatures in excess of that for which it has been listed can 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 (12.1 bar).

Not all pipe or tube made to ASTM F442, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)*, is listed for fire sprinkler service. Listed pipe is identified by the logo of the listing agency.

Not all fittings made to ASTM F437, *Standard Specification for Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80*, ASTM F438, *Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40*, and ASTM F439, *Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80*, as described in 7.4.4, 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 is primarily due to the cooling effect of the discharge from the sprinklers it serves. As this discharge might not occur simultaneously with the rise in ambient temperature and, under some circumstances, can 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. It is equally important that 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 7.3.1.1 should involve consideration of many factors, including the following:

(1) Pressure rating
(2) Beam strength (hangers)
(3) Unsupported vertical stability
(4) Movement during sprinkler operation (affecting water distribution)
(5) Corrosion (internal and external), chemical and electrolytic
(6) Resistance to failure when exposed to elevated temperatures
(7) Methods of joining (strength, permanence, fire hazard)
(8) Physical characteristics related to integrity during earthquakes

A.7.3.3

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

Corrosion studies have shown that, in comparison to Schedule 40 pipe, the effective life of lightweight steel pipe can 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 for such pipe.

A.7.3.4.1

Where approved, the pipe identification can be covered with paint or other protective coatings before installation.

A.7.4.4

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.

Other construction materials include but are not limited to materials used in fabrication of the sprinkler system, additives to water supplies, cable and wiring, and certain insecticides and fungicides.

A.7.5.1.2

Some steel piping material having lesser wall thickness than specified in 7.5.1.2 has been listed for use in sprinkler systems where joined with threaded connections. The service life of such products can 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 Table 8 of ASME B1.20.1, *Pipe Threads, General Purpose, Inch*.

A.7.5.2.2

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.

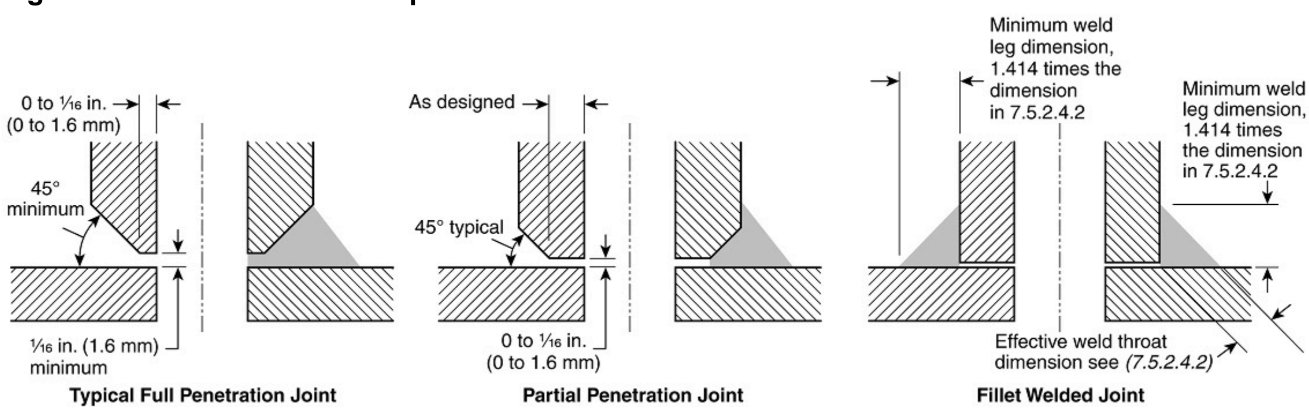
A.7.5.2.3.1

Listed, shaped, and contoured nipples meet the definition of fabricated fittings.

A.7.5.2.4.1

Partial penetration welds on outlet fitting connections are considered adequate, since there is no significant load on the joint other than that caused by pressure internal to the pipe *(see Figure A.7.5.2.4.1)*.

Figure A.7.5.2.4.1 Weld Descriptions.



A.7.5.2.4.2

The load due to the internal pressure can be accommodated with a weld that has a conservative weld throat thickness that can be calculated as follows:

$$\text{Weld throat thickness (in.)} = PD \times 0.000035 \qquad \text{[A.7.5.2.4.2]}$$

where:

P = rated system gauge pressure (psi)

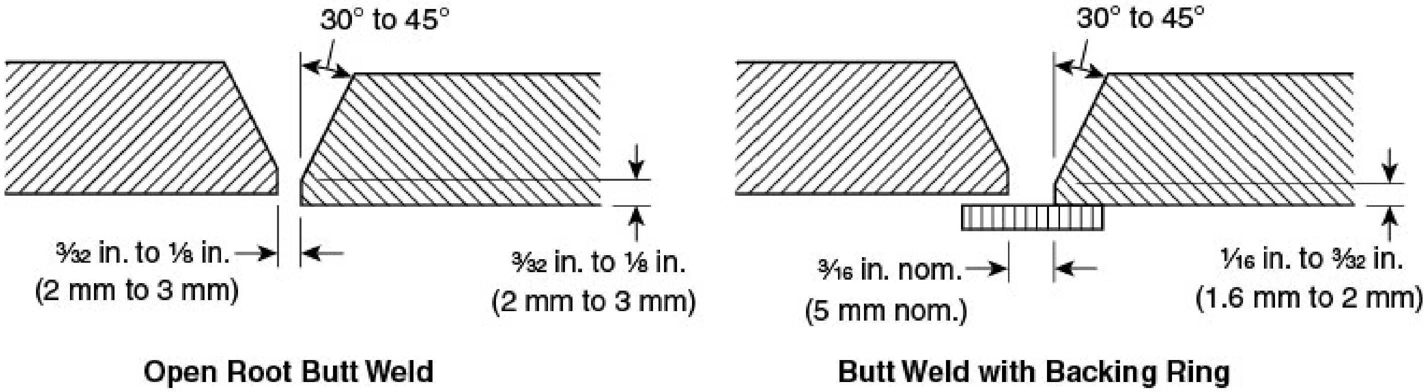
D = outside diameter (OD) of fitting (in.)

For example, if you assume a gauge pressure of 300 psi (21 bar) and the OD of the outlet fitting of 3 in. (75 mm), the result of the thickness calculation is 0.0315 in. (0.8 mm). When compared to the minimum throat thickness of $^{3}/_{16}$ in. (5 mm), there is a factor of more than 5 times the calculated thickness value.

A.7.5.2.4.3

The preparation of mating surfaces is important to the proper fabrication of a weld joint. To accomplish this, the mating surfaces for a circumferential weld butt joint should be prepared and configured so that a full penetration weld is achievable, but a partial penetration weld is acceptable. *(See Figure A.7.5.2.4.3.)*

Figure A.7.5.2.4.3 Weld Diagram.



A.7.5.2.4.8

Loose welding slag or residue should be removed from piping, but a small amount should be acceptable as it is impossible to remove all the slag, especially in long runs of pipe.

Chapter 28 covering plans and calculations permits the friction loss for a welded fitting directly connected to the sprinkler to be excluded from the sprinkler system's hydraulic calculation. Laboratory test data has revealed that welded outlet fittings with the inside diameter reduced as a result of the pipe fabrication process can substantially reduce the flow discharged from an attached sprinkler that has a large K-factor for a given inlet size. As an example, for the 1 in. (25 mm) inlet size, reducing the inside diameter of the welded fitting at the entrance from the pipe will create a greater reduction in flow through a nominal K-28 sprinkler as compared to a smaller sprinkler K-factor attached to the fitting. Similarly, the reduction in flow through for a nominal K-16.8 sprinkler as a result of a reduced diameter inside diameter of $^{3}/_{4}$ in. (20 mm) size welded outlet fitting will be greater compared to a sprinkler having a smaller nominal K-factor attached. Since the flow velocities created by a nominal K-5.6 sprinkler with a $^{1}/_{2}$ in. (15 mm) size inlet at a given pressure is much less compared to the maximum K-factor referenced for use with the $^{3}/_{4}$ in. (20 mm) and 1 in. (25 mm) size outlets, the negative impact on the flow through a nominal K-5.6 sprinkler as a result of a reduced inside diameter for a $^{1}/_{2}$ in. (15 mm) size welded outlet is substantially less.

Even though the inside diameter of a welded outlet fitting is significantly greater than the orifice of an attached sprinkler, laboratory testing has indicated that a reduction in the inside diameter of a typical $^{3}/_{4}$ in. (20 mm) and 1 in. (25 mm) size welded outlet by approximately 10 percent can reduce the flow through the largest sprinkler K-factor referenced for use with these outlets by 20 percent.

A.7.5.3.1

It is not the intent to require specific listing of every combination of grooved coupling, pipe, fitting, valve, and device, provided the standard groove dimensions as specified in CAN/UL 213, *Rubber Gasketed Fittings for Fire-Protection Service,* are used. Material strength and pressure rating of the fitting, valve, or device used with the grooved couplings should be considered when determining the appropriate application of a coupling when joining these components.

A.7.5.3.1.1

Standardized groove specifications pertain to the grooved couplings that comply with and the groove dimensions described in CAN/UL 213, *Rubber Gasketed Fittings for Fire-Protection Service*. The standard dimensions are specified in ANSI/UL 213.

A.7.5.4

The fire hazard of the brazing and soldering processes should be suitably safeguarded.

A.7.5.4.5

Soldering fluxes manufactured to the specifications required by Table 7.3.1.1 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.7.6.3

Automatic breach control valves will automatically cut off the water supply in a sprinkler system once the flow reaches a preset gpm. It is assumed that a catastrophic failure has occurred in the piping system, and the valve closes to conserve water. In a sprinkler system, flow rates can exceed those included in the hydraulic calculations when the fire department charges the fire department connection and provides supplemental flow and pressure during a fire scenario. The automatic breach control valve could shut down with the increased flow and cut off the entire water supply. These valves are also known as *breach valves* and *automatic breach containment valves*.

A.7.7.1

The intent of the 5 minute allowance is to accommodate fluctuations in water flow in large systems.

A.7.7.2

Where buildings are equipped with fire alarm systems, the requirements of the applicable fire alarm code should prevail. It is the intent of this section to also apply to electrically activated local alarm bells. The 100 second allowance is to meet the requirement of 90 second plus 10 second delay in responding to the signal from the initiating device (i.e., flow or pressure switch).

A.7.8.3

Requiring additives to be listed is not intended to preclude increasing the level of nitrogen in sprinkler systems to reduce corrosion potential.

A.8.1.1.2

Pressure gauges installed on both sides of a check valve are necessary for several reasons. They can quickly indicate an abnormal condition such as a closed valve or an inoperable check valve. If the pressure on the downstream side of a check valve is less than the pressure on the upstream side, either the pressure gauges are faulty or the check valve is inoperable. If the pressure on the upstream side of a check valve is less than the pressure on the downstream side, the pressure is trapped indicating a higher than normal pressure. This erroneous pressure will then be part of a main drain test. If a pressure gauge is installed only on the downstream side of the check valve a pressure would be indicated but the pressure on the upstream side could be 0.0 psi indicating a severe problem.

A.8.1.2.1

It is important to note that the pressure rating of the relief valve indicates an operating range of pressure for both opening and closing of the valve. Standard relief valves are required to open in a range of pressure between 90 percent and 105 percent of their rating. The valves are required to close at a pressure above 80 percent of that rating.

A.8.2

A dry pipe system should be installed only where heat is not adequate to prevent freezing of water in all parts of, or in 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 and to prevent 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.8.2.2.1.1(2)

Installation limitations of listed dry pendent sprinklers can vary with different products. Limitations should be included in product installation instructions to warn the user of the potential accumulation of water, scale, and sediment from collecting at the sprinkler.

A.8.2.3

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.8.2.3.1

The dry pipe valve and supply piping should be in an area maintained at or above 40°F (4°C). It is the intent of the committee to protect the valves from freezing. The occasional exposure of valves to short exposures of air temperatures below 40°F (4°C) that would not cause the valves to freeze does not justify the construction of a valve room.

A.8.2.4

The capacities of the various sizes of pipe given in Table A.8.2.4 are for convenience in calculating the capacity of a system.

Table A.8.2.4 Capacity of 1 ft (300 mm) of Pipe (Based on Actual Internal Pipe Diameter)

Nominal Pipe Diameter		Pipe				Nominal Pipe Diameter		Pipe			
		Schedule 40		Schedule 10				Schedule 40		Schedule 10	
in.	mm	gal	L	gal	L	in.	mm	gal	L	gal	L
3/4	20	0.028	0.11			3	80	0.383	1.45	0.433	1.64
1	25	0.045	0.17	0.049	0.19	3 1/2	90	0.513	1.94	0.576	2.18
1 1/4	32	0.078	0.30	0.085	0.32	4	100	0.660	2.50	0.740	2.80
1 1/2	40	0.106	0.40	0.115	0.43	5	125	1.040	3.94	1.144	4.33
2	50	0.174	0.66	0.190	0.72	6	150	1.501	5.68	1.649[b]	6.24
2 1/2	65	0.248	0.94	0.283	1.07	8	200	2.66[a]	10.1	2.776[c]	10.5

[a]Schedule 30.

[b]0.134 wall pipe.

[c]0.188 wall pipe.

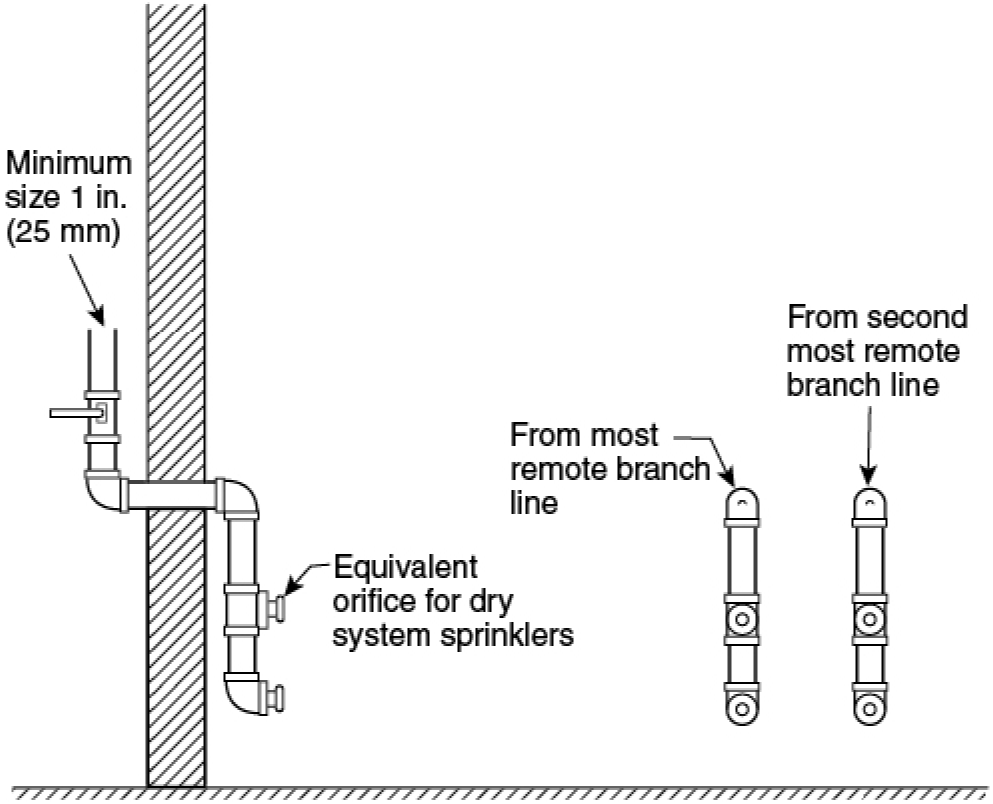
A.8.2.4.2.1

The 60-second limit does not apply to dry systems with capacities of 500 gal (1900 L) or less, nor to dry systems with capacities of 750 gal (2850 L) or less if equipped with a quick-opening device.

A.8.2.4.4

See Figure A.8.2.4.4.

Figure A.8.2.4.4 Example Manifold Arrangement (Four Sprinklers).



A.8.2.7

The compressor should draw its air supply from within the operating criteria allowed by the manufacturer of the compressor. Air piping should not be attached to the intake of the compressor unless acceptable to the compressor manufacturer and installed in accordance with 8.8.2.7. Damage, air reduction, or reduced life expectancy can result if guidelines are not followed.

A.8.2.7.2

The air can be either generated on site or from storage containers, sized to provide a reliable supply for at least 6 months of expected maintenance use.

A.8.2.7.3

When a single compressor serves multiple dry pipe systems, the 30-minute fill time is based on the single largest system.

When a single air source serves multiple dry pipe systems, the 30-minute fill time is based on the single largest system.

A.8.2.7.5.2

Temporary use of nonlisted air compressors should be permitted when listed compressors are not immediately available.

A.8.2.8.1

Air maintenance devices are unique components within the air supply and need to be listed for use. Compressors and pressure switches are not air maintenance devices.

A.8.2.9.1

The connection from an air compressor to the dry pipe valve should be of a type recommended by the manufacturer, including flexible hose, and approved by the authority having jurisdiction, taking into consideration the pressures, temperatures, and vibrations that the connection and adjacent equipment will endure.

A.8.2.10

Nitrogen systems are equipped with an air compressor capable of restoring system air pressure within 30 or 60 minutes. It is not the intent of this section to require a 98 percent concentration of nitrogen within the 30 or 60 minutes as required in 8.2.7.

A.8.3.1

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 ensure 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 that 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 method is employed, the following also apply:

(1) Dry systems can be manifolded to a deluge valve, with the protected area not exceeding 40,000 ft^2 (3720 m^2).
(2) Where a dry system is manifolded to a deluge valve, the distance between valves should be as short as possible to minimize water hammer.
(3) The dry pipe valves should be pressurized to 50 psi (3.4 bar) to reduce the possibility of dry pipe valve operation from water hammer.

A.8.3.1.1

When using electrical operating methods to actuate preaction systems and deluge systems, care should be observed in selecting the solenoid valve. This valve must be compatible with the fire detection system, including its control panel, and the preaction or deluge valve. This often involves listing with both the preaction or deluge valve manufacturer and the fire detection system manufacturer. Information regarding solenoid compatibility is included in the releasing device (panel) installation instructions.

Small preaction and deluge systems with and without separate electrical-based detection and control panels have been installed prior to the introduction of the detection system requirements of *NFPA 72* or other approved fire alarm code. Pneumatic-based actuation using heat-actuated devices (HADs), pneumatic line–type detection, and pilot sprinklers are examples of non-electric-based detectors and control devices. NFPA 13 recognizes the use and installation of these types of systems and provides guidance in producing a reliable detection and suppression system combination. Remote manual operation of combined dry pipe and preaction systems is needed because of the often very long length dimension of such systems and the long travel time to reach the control valves. Such remote manual operation speeds water into the piping network.

A.8.3.1.6

Preaction and deluge valves should be fully trip tested wherever possible. Providing a functional trip test without waterflow does not reveal other potential problems such as obstructions and/or misaligned nozzles.

A.8.3.2.3.1.4

Although the time criterion for calculated systems is not required, a test is still required to document the initial water delivery for comparison to future inspection test requirements. If the time of a single sprinkler test outlet exceeds 70 seconds, evaluation of the calculations and the system installation might be necessary.

A.8.3.2.4

Supervision, either electrical or mechanical, as used in 8.3.2.4 refers to constant monitoring of piping and detection equipment to ensure the integrity of the system. Detection devices of listed flow cycling assemblies that cause an alarm during a single open or a single ground fault condition should be considered to satisfy the supervision requirement.

A.8.3.2.6(2)

See A.8.2.2.1.1(2).

A.8.3.3

Where 8 in. (200 mm) piping is employed to reduce friction losses in a system operated by fire detection devices, a 6 in. (150 mm) preaction or deluge valve and a 6 in. (150 mm) gate valve between tapered reducers should be permitted.

A.8.3.3.3

Particular care should be taken where the manual release mechanism for more than one system or the manual fire alarm box of a fire alarm system are in close proximity and could be confused or the wrong system actuated. The manual releasing mechanism in this instance should be clearly identified as to which zone or extinguishing area it affects.

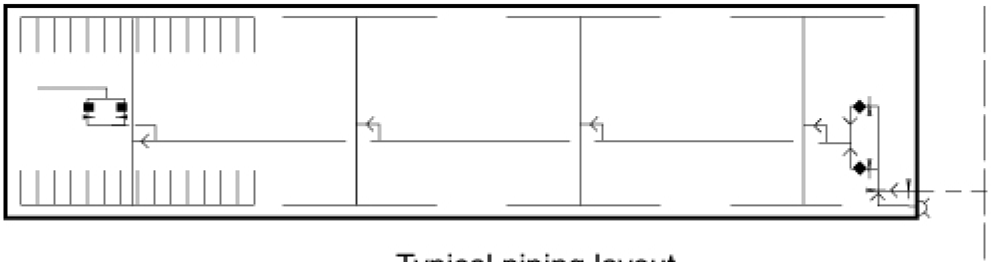
A.8.4.2

Systems described by Section 8.4 are special types of noninterlocking 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.8.4.2.1

See Figure A.8.4.2.1.

Figure A.8.4.2.1 Typical Piping Layout for Combined Dry Pipe and Preaction Sprinkler System.



Typical piping layout
(in one-story shed — 4-section system)

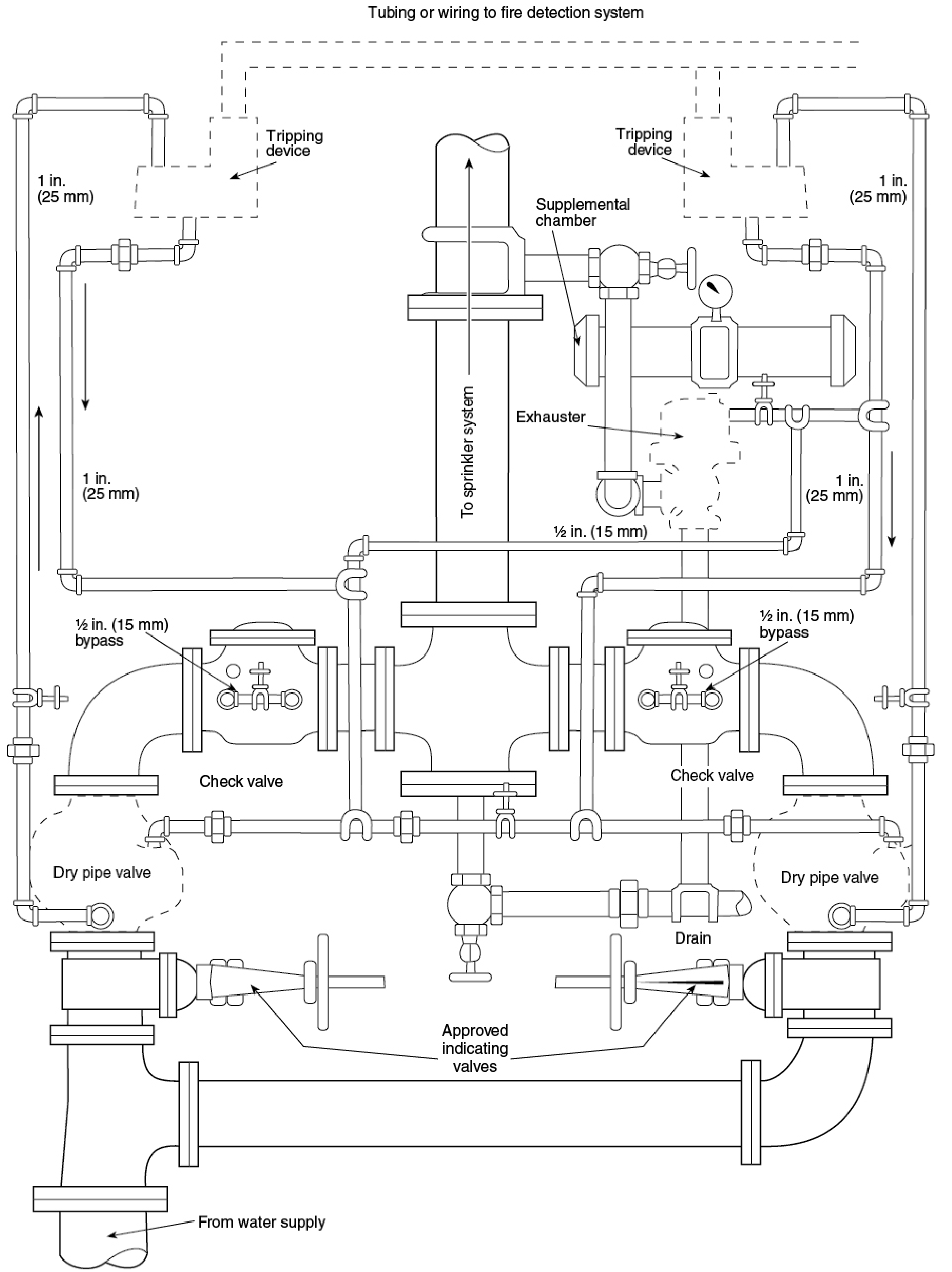
A.8.4.2.4(2)

See A.8.2.2.1.1(2).

A.8.4.3.2

Figure A.8.4.3.2 is a depiction of a valve arrangement complying with 8.4.3.2.

Figure A.8.4.3.2 Header for Dry Pipe Valves Installed in Parallel for Combined Systems; Standard Trimmings Not Shown. Arrows Indicate Direction of Fluid Flow.


Tubing or wiring to fire detection system
Tripping device
Tripping device
1 in. (25 mm)
1 in. (25 mm)
Supplemental chamber
To sprinkler system
Exhauster
1 in. (25 mm)
1 in. (25 mm)
½ in. (15 mm)
½ in. (15 mm) bypass
½ in. (15 mm) bypass
Check valve
Check valve
Dry pipe valve
Dry pipe valve
Drain
Approved indicating valves
From water supply

A.8.6

In cold climates and areas where the potential for freezing of pipes is a concern, options other than antifreeze are available. Such options include installing the pipe in warm spaces, tenting insulation over the piping [as illustrated in Figure A.9.9.1(a) through Figure A.9.9.1(f) of NFPA 13D], listed heat tracing, and the use of dry pipe systems and preaction systems.

A.8.6.1

The definition of an antifreeze system states that water will discharge after the antifreeze leaves the pipes. Systems that are all antifreeze, including tanks of antifreeze solution that will not discharge plain water, are not true antifreeze systems. Such systems should not be used without consideration to issues such as the combustibility of the antifreeze solution and the friction loss in the piping during cold conditions. Any listing associated with an antifreeze sprinkler system should address the inability for the specific antifreeze solution tested to ignite when discharged from specific sprinklers.

A.8.6.1.3

Drops connecting pendent sprinklers to branch lines can be removed and replaced in order to remove water. Additional hydrostatic testing is not required.

A.8.6.2

Listed nonmetallic sprinkler pipe and fittings should be protected from freezing with compatible listed solutions only. In addition, due to antifreeze solution limitations, other methods of freeze protection such as electric heat tracing or insulated coverings, which are approved for use on nonmetallic piping, can be used to protect nonmetallic pipes from freezing.

The following is a list of research reports that have been issued by the Fire Protection Research Foundation (FPRF) related to the use of antifreeze in sprinkler systems:

(1) *Antifreeze Systems in Home Fire Sprinkler Systems — Literature Review and Research Plan*, Fire Protection Research Foundation, June 2010
(2) *Antifreeze Systems in Home Fire Sprinkler Systems — Phase II Final Report*, Fire Protection Research Foundation, December 2010
(3) *Antifreeze Solutions Supplied through Spray Sprinklers — Final Report*, Fire Protection Research Foundation, February 2012

Table A.8.6.2 provides a summarized overview of the testing.

Table A.8.6.2 FPRF Antifreeze Testing Summary

Topic	Information
Scope of sprinklers tested	The following sprinklers were used during the residential sprinkler research program described in the report dated December 2010: (1) Residential pendent style having nominal K-factors of 3.1, 4.9, and 7.4 gpm/psi $^{1/2}$ (45, 71, and 106 lpm/bar $^{1/2}$) (2) Residential concealed pendent style having a nominal K-factor of 4.9 gpm/psi $^{1/2}$ (71 lpm/bar $^{1/2}$) (3) Residential sidewall style having nominal K-factors of 4.2 and 5.5 gpm/psi $^{1/2}$ (60 and 79 lpm/bar $^{1/2}$)
	The following sprinklers were used during the spray sprinkler research program described in the report dated February 2012: (1) Residential pendent style having a nominal K-factor of 3.1 gpm/psi $^{1/2}$ (45 lpm/bar $^{1/2}$) (2) Standard spray pendent style having nominal K-factors of 2.8, 4.2, 5.6, and 8.0 gpm/psi $^{1/2}$ (40, 60, 80, and 115 lpm/bar $^{1/2}$) (3) Standard spray concealed pendent style having a nominal K-factor of 5.6 gpm/psi $^{1/2}$ (80 lpm/bar $^{1/2}$) (4) Standard spray upright style having a nominal K-factor of 5.6 gpm/psi $^{1/2}$ (80 lpm/bar $^{1/2}$) (5) Standard spray extended coverage pendent style having a nominal K-factor of 5.6 gpm/psi $^{1/2}$ (80 lpm/bar $^{1/2}$)
Antifreeze solution concentration	<50% glycerine and <40% propylene glycol antifreeze solutions: Solutions were not tested.
	50% glycerine and 40% propylene glycol antifreeze solutions: Large-scale ignition of the sprinkler spray did not occur in tests with sprinkler discharge onto a fire having a nominal heat release rate (HRR) of 1.4 megawatts (MW). Large-scale ignition of sprinkler spray occurred in multiple tests with sprinkler discharge onto a fire having a nominal HRR of 3.0 MW.
	55% glycerine and 45% propylene glycol antifreeze solutions: Large-scale ignition of the sprinkler spray occurred in tests with sprinkler discharge onto a fire having a nominal HRR of 1.4 MW.
	> 55% glycerine and > 45% propylene glycol antifreeze solutions: Large-scale ignition of the sprinkler spray occurred in tests with sprinkler discharge onto a fire having an HRR of less than 500 kW.
	70% glycerine and 60% propylene glycol antifreeze solutions: Maximum antifreeze solution concentrations tested.

Topic	Information
Sprinkler inlet pressure	Large-scale ignition of the sprinkler discharge spray was not observed when the sprinkler inlet pressure was 50 psi or less for tests using 50% glycerine or 40% propylene glycol.
Ceiling height	When discharging 50% glycerine and 40% propylene glycol antifreeze solutions onto fires having an HRR of 1.4 MW, no large-scale ignition of the sprinkler spray was observed with ceiling heights up to 20 ft (6.1 m). When discharging 50% glycerine and 40% propylene glycol antifreeze solutions onto fires having a HRR of 3.0 MW, large-scale ignition of the sprinkler spray was observed at a ceiling height of 20 ft (6.1 m).
Fire control	The test results described in the test reports dated December 2010 and February 2012 indicated that discharging glycerine and propylene glycol antifreeze solutions onto a fire can temporarily increase the fire size until water is discharged. As a part of the residential sprinkler research described in the report dated December 2010, tests were conducted to evaluate the effectiveness of residential sprinklers to control fires involving furniture and simulated furniture. The results of these tests indicated that 50% glycerine and 40% propylene glycol antifireeze solutions demonstrated the ability to control the furniture type fires in a manner similar to water. For standard spray type sprinklers, no tests were conducted to investigate the ability of these sprinklers to control the types and sizes of fires that these sprinklers are intended to protect.

A.8.6.2.1

Where existing antifreeze systems have been analyzed and approved to remain in service, antifreeze solutions should be limited to premixed antifreeze solutions of glycerine (chemically pure or United States Pharmacopoeia 96.5 percent) at a maximum concentration of 48 percent by volume, or propylene glycol at a maximum concentration of 38 percent by volume. The use of antifreeze solutions in all new sprinkler systems should be restricted to listed antifreeze solutions only. Where existing antifreeze systems are in service, the solution concentration should be limited to those noted in A.8.6.2, and the system requires an analysis and approval of the authority having jurisdiction to remain in service. Antifreeze that is “UL certified” meets the definition of *listed* in accordance with this standard.

A.8.6.3.2

One formula for sizing the chamber is as follows. Other methods also exist.

$$\Delta L = S_V\left(\frac{D_L}{D_H} - 1\right) \quad \text{[A.8.6.3.2a]}$$

where:

ΔL = change in antifreeze solution volume (gal) due to thermal expansion

S_V = volume (gal) of antifreeze system, not including the expansion chamber

D_L = density (gm/mL) of antifreeze solution at lowest expected temperature

D_H = density (gm/mL) of antifreeze solution at highest expected temperature

This method is based on the following information:

$$\frac{P_0 \cdot V_0}{T_0} = \frac{P_1 \cdot V_1}{T_1} = \frac{P_2 \cdot V_2}{T_2} \quad \text{[A.8.6.3.2b]}$$

where:

V_{EC} = minimum required volume (gal) of expansion chamber

V_0 = air volume (gal) in expansion chamber at precharge (before installation)

V_1 = air volume (gal) in expansion chamber at normal static pressure

V_2 = air volume (gal) in expansion chamber at post-expansion pressure (antifreeze at high temperature)

P_0 = absolute precharge pressure (psia) on expansion chamber before installation

P_1 = absolute static pressure (psi) on water (supply) side of backflow preventer

P_2 = absolute maximum allowable working pressure (psi) for antifreeze system

T_0 = temperature (°R) of air in expansion chamber at precharge

T_1 = temperature (°R) of air in expansion chamber when antifreeze system piping is at lowest expected temperature

T_2 = temperature (°R) of air in expansion chamber when antifreeze system piping is at highest expected temperature

This equation is one formulation of the ideal gas law from basic chemistry. The amount of air in the expansion chamber will not change over time. The pressure, temperature, and volume of the air at different times will be related in accordance with this formula:

$$V_2 = V_1 - \Delta L \quad \text{[A.8.6.3.2c]}$$

The antifreeze in the system is essentially incompressible, so the air volume in the expansion chamber will decrease by an amount equal to the expansion of the antifreeze.

It is assumed that there is no trapped air in the system piping, so the only air in the system is in the expansion chamber. This is a conservative assumption, since more air is better. In reality, there will be at least some trapped air. However, only the air in the expansion chamber can be relied upon to be available when needed.

$$V_{EC} = V_0 \quad \text{[A.8.6.3.2d]}$$

At precharge, the chamber will be completely full of air.

$$V_{EC} = \frac{P_1 \cdot T_0 \cdot P_2 \cdot \Delta L \cdot T_1}{P_0 \cdot T_1 \left(P_2 \cdot T_1 - P_1 \cdot T_2\right)} \quad \text{[A.8.6.3.2e]}$$

In cases where the normal static pressure on the sprinkler system is close to the maximum working pressure, antifreeze systems are not advisable if the connection to the wet pipe system will incorporate a backflow device. In these cases, expansion of the antifreeze solution during warm weather will cause the antifreeze system to exceed the maximum working pressure, regardless of the size of the expansion chamber. The normal static pressure is too close to the maximum working pressure if the preceding formula for V_{EC} yields a negative result. If this occurs, use a dry pipe system instead or install a pressure-reducing valve before the backflow preventer.

A.8.6.3.3

The expansion chamber should be appropriately sized and precharged with air pressure.

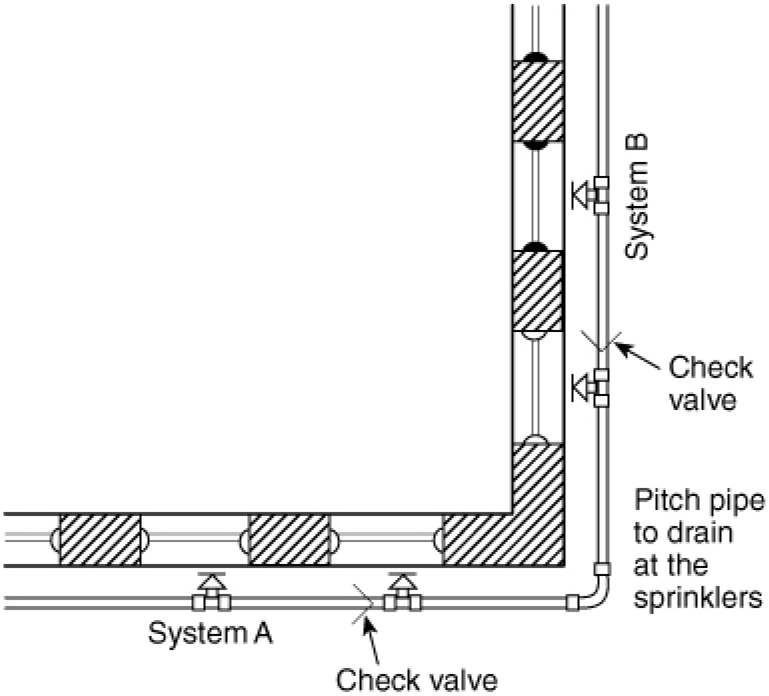
A.8.6.3.6

Systems are required by NFPA 25 to have the concentration levels checked at the supply inlet to the antifreeze system and at a remote point of the system.

A.8.7.4.2.1

See Figure A.8.7.4.2.1.

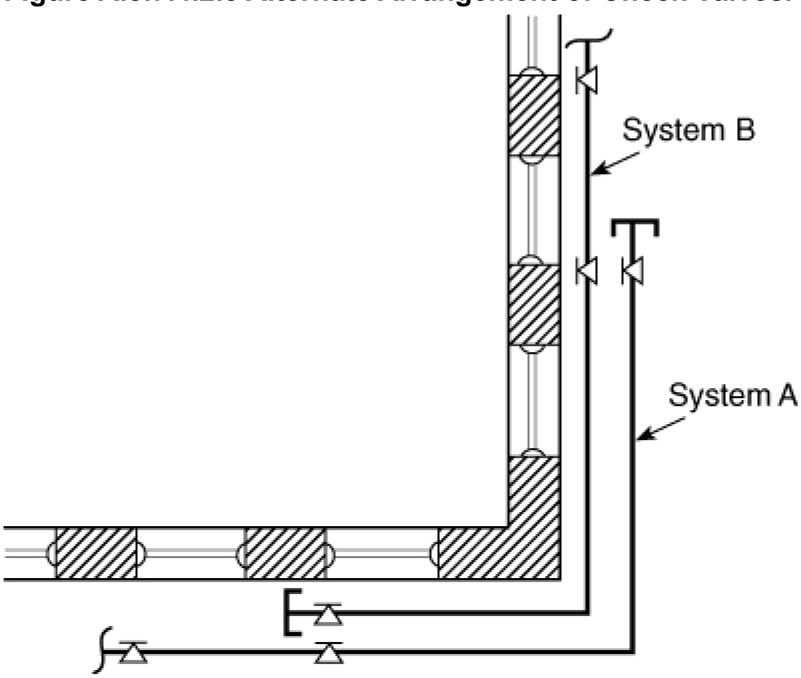
Figure A.8.7.4.2.1 Typical Arrangement of Check Valves.



A.8.7.4.2.3

See Figure A.8.7.4.2.3.

Figure A.8.7.4.2.3 Alternate Arrangement of Check Valves.



A.8.7.9

In the design of an exposure protection system, the flow rate from window and cornice sprinklers is shown in Table 8.7.9.1. The flow rates are based on the guide numbers selected from Table 4.3.7.3 of NFPA 80A, which can be utilized as the basis for determining whether exposure protection is needed.

A.8.8

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 8.8.2.1, 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, which 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 contains requirements in this matter.

A.8.8.2

The requirements in 8.8.2 are intended to minimize the chances of ice plug formation inside sprinkler system piping protecting freezers.

A.8.8.2.1.1

It is not the intent of this section to apply to a dry sprinkler. An additional pipe is not needed when a dry sprinkler penetrates a refrigerated space.

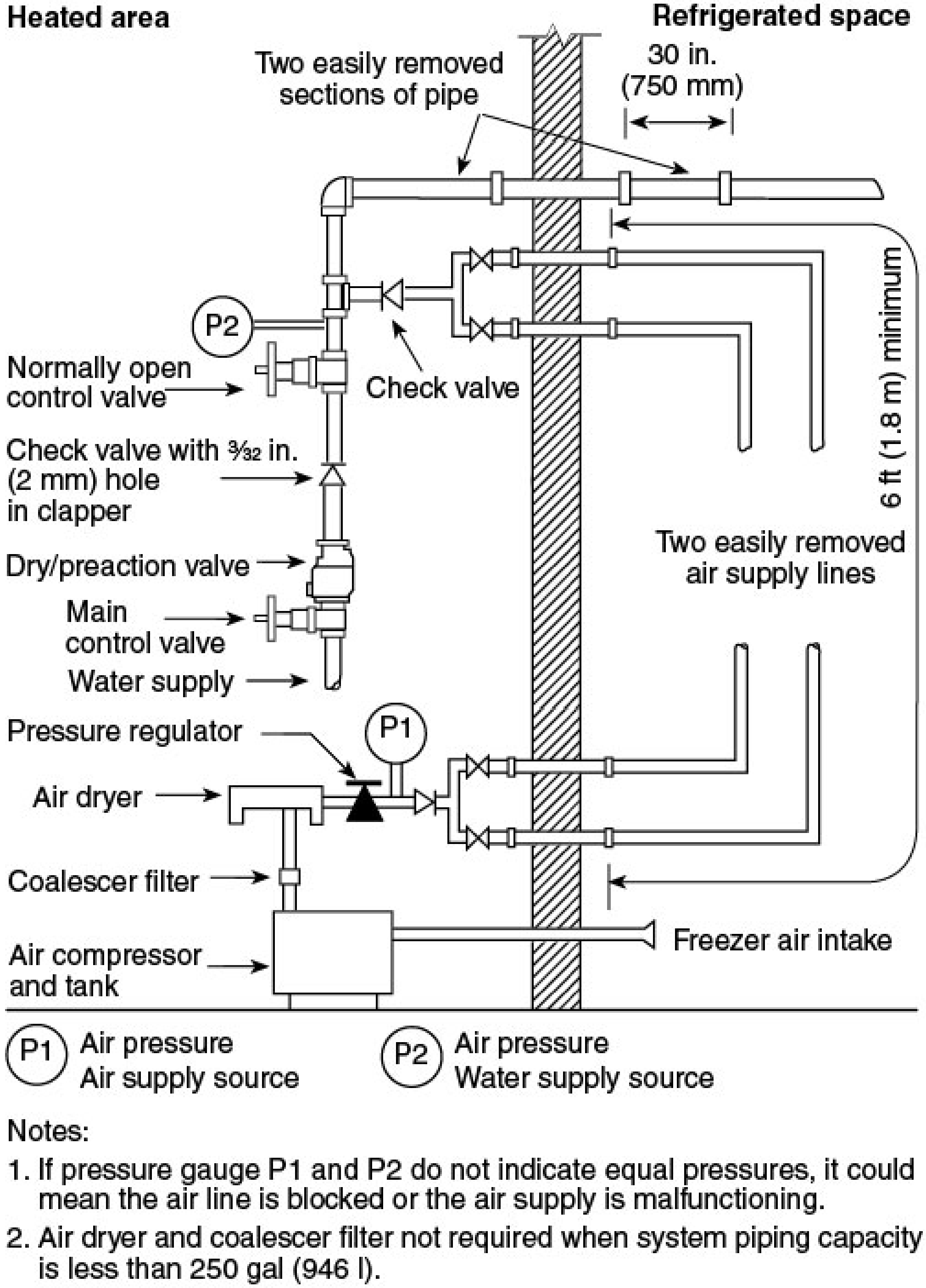
A.8.8.2.4

A higher degree of preventing the formation of ice blocks can be achieved by lowering the moisture of the air supply entering the refrigerated space to a pressure dew point of 20°F (−11°C) below the lowest nominal temperature of the refrigerated space or lower. 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 the moisture content of the air by use of air drying systems is illustrated in Figure A.8.8.2.4.

When compressors and dryers are used for an air supply, consideration should be given to pressure requirements of the regenerative dryers, compressor size, air pressure regulator capacity, and air fill rate. Application of these factors could necessitate the use of increased air pressures and a 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.

Figure A.8.8.2.4 Refrigerator Area Sprinkler Systems Used to Minimize Chances of Developing Ice Plugs.



A.8.8.2.5

A major factor contributing to the introduction of moisture into the system piping is excessive air compressor operation caused by system leakage. Where excessive compressor operation is noted or ice accumulates in the air supply piping, the system should be checked for leakage and appropriate corrective action should be taken.

A.8.8.2.6

The purpose of the check valve is to prevent evaporation of priming water into the system piping.

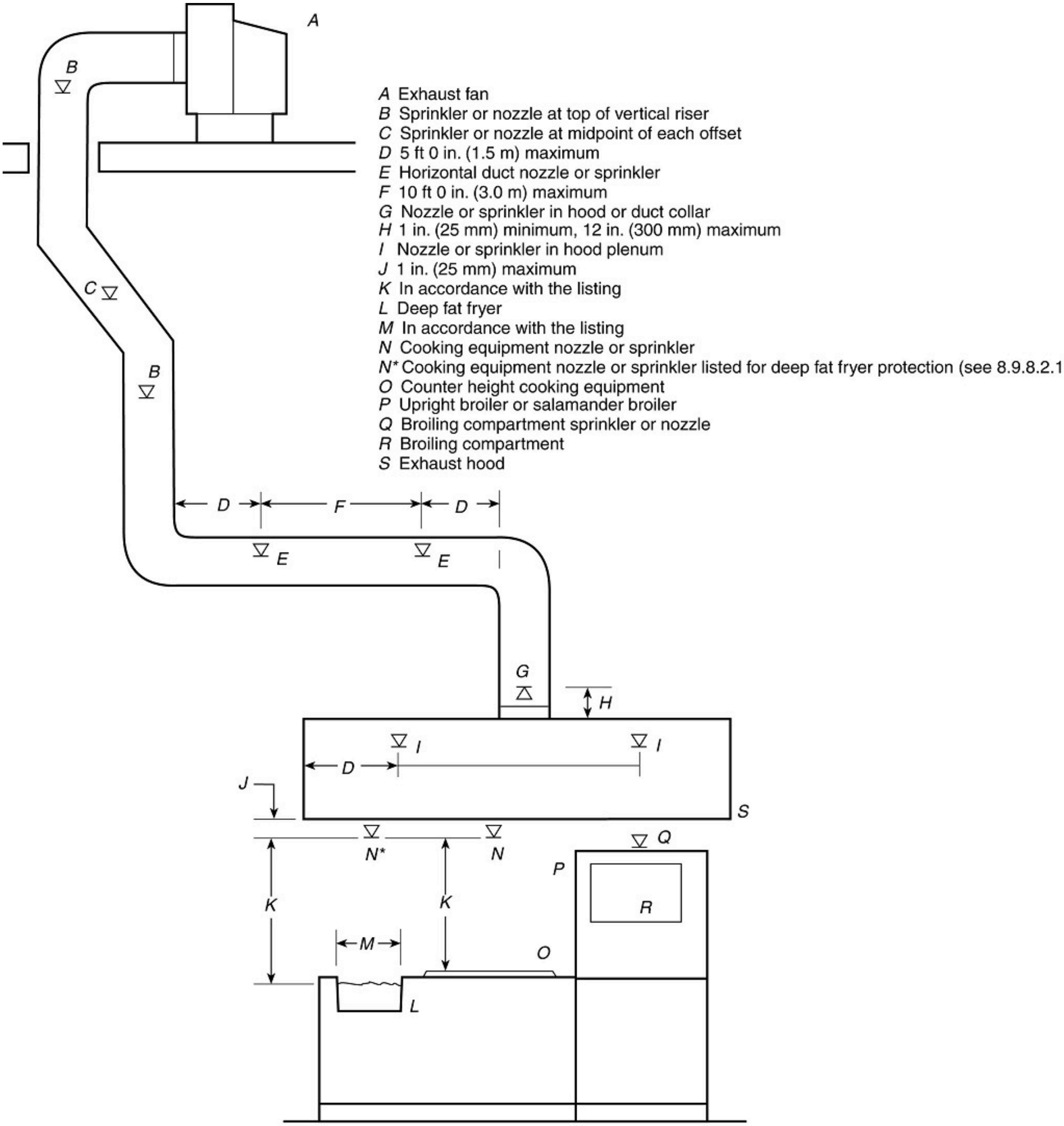
A.8.8.2.7.1

The dual lines feeding the system air entering the cold area are 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.8.8.2.4, differences in the pressures at gauge P1 and gauge P2 indicate blockage in the air supply line or other malfunctions.

A.8.9.2

See Figure A.8.9.2.

Figure A.8.9.2 Typical Installation Showing Automatic Sprinklers or Automatic Nozzles Being Used for Protection of Commercial Cooking Equipment and Ventilation Systems.



A.8.10.1.4

While it is the intent to require the detection system to operate prior to sprinklers, it is possible that in some fire scenarios the sprinklers could operate prior to the detection system. In general, the detection system, at its installed location and spacing, should be more sensitive to fire than the sprinklers.

A.9.1

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 maximums specified for the spacing and location of sprinklers 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.

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.

A.9.1.1

This standard contemplates full sprinkler protection for all areas including walk-in coolers, freezers, bank vaults, and similar areas. Other NFPA standards that mandate sprinkler installation might not require sprinklers in certain areas. Based upon experience and testing, sprinklers have been found to be effective and necessary at heights in excess of 50 ft (15 m). For a building to meet the intended level of protection afforded by NFPA 13, sprinklers must not be omitted from such high ceiling spaces. The requirements of this standard should be used insofar as they are applicable. The authority having jurisdiction should be consulted in each case. A building is considered sprinklered throughout when protected in accordance with the requirements of this standard.

In situations such as computer rooms where a gas system is installed, the sprinkler protection should not be eliminated. Many gas systems do not have the same duration requirements of a fire sprinkler system, and if the fire is not extinguished with the initial discharge, the fire could grow large enough to overpower the sprinkler system.

A.9.1.1(3)

Notwithstanding the obstruction rules provided in Chapters 9 through 14, it is not intended or expected that water will fall on the entire floor space of the occupancy.

When obstructions or architectural features interfere with the sprinkler's spray pattern, such as columns, angled walls, wing walls, slightly indented walls, and various soffit configurations, shadowed areas can occur. Where small shadowed areas are formed on the floor adjacent to their referenced architectural features, these shadowed areas are purely on paper and do not take into account the dynamic variables of sprinkler discharge. Examples of shadow areas are shown in Figure A.9.1.1(3)(a) and Figure A.9.1.1(3)(b).

Figure A.9.1.1(3)(a) Shadow Area in Corridor.

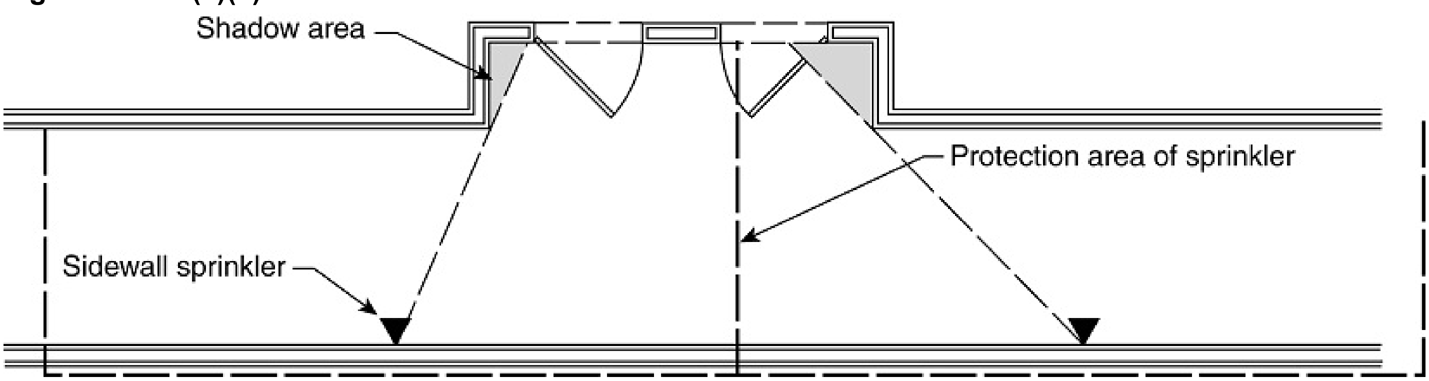
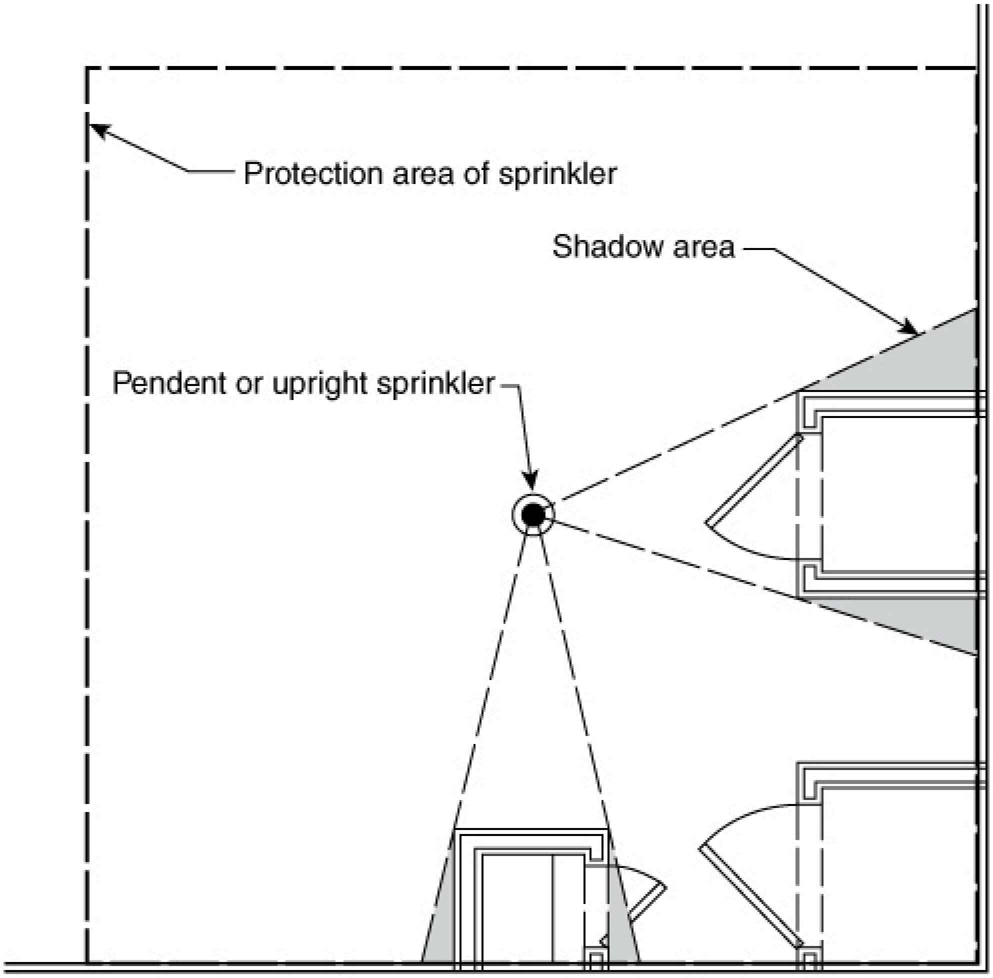


Figure A.9.1.1(3)(b) Example of Shadow Area.



A.9.2.1

Paragraphs 9.2.1.3, 9.2.1.4, and 9.2.1.5 do not require sprinkler protection because it is not physically practical to install sprinklers in the types of concealed spaces discussed in these three exceptions. To reduce the possibility of uncontrolled fire spread, consideration should be given in these unsprinklered concealed space situations to using 9.2.1.7, 9.2.1.12, and 9.2.1.14. Omitting sprinklers from combustible concealed spaces will require further evaluation of the sprinkler system design area in accordance with 19.2.3.1.5.

A.9.2.1.1

Minor quantities of combustible materials such as, but not limited to, cabling, nonmetallic plumbing piping, nonstructural wood, and so forth can be present in concealed spaces constructed of limited or noncombustible materials but should not typically be viewed as requiring sprinklers *(see 9.3.17.1)*. For example, it is not the intent of this section to require sprinklers, which would not otherwise be required, in the interstitial space of a typical office building solely due to the presence of the usual amount of cabling within the space. The use of acoustical tile ceilings does not negate that the space above the tile is a concealed space because a tile could be removed. The threshold value at which sprinklers become necessary in the concealed space is not defined.

A.9.2.1.1.2

Noncombustible spaces with non-fuel-fired equipment and access panels should be considered a concealed space and should not require sprinkler protection.

A.9.2.1.2.2

Noncombustible and limited-combustible spaces with non-fuel-fired equipment and access panels should be considered a concealed space and should not require sprinkler protection. Localized protection in accordance with 9.3.17.1.2 should be considered where fuel-fired equipment is present in these spaces.

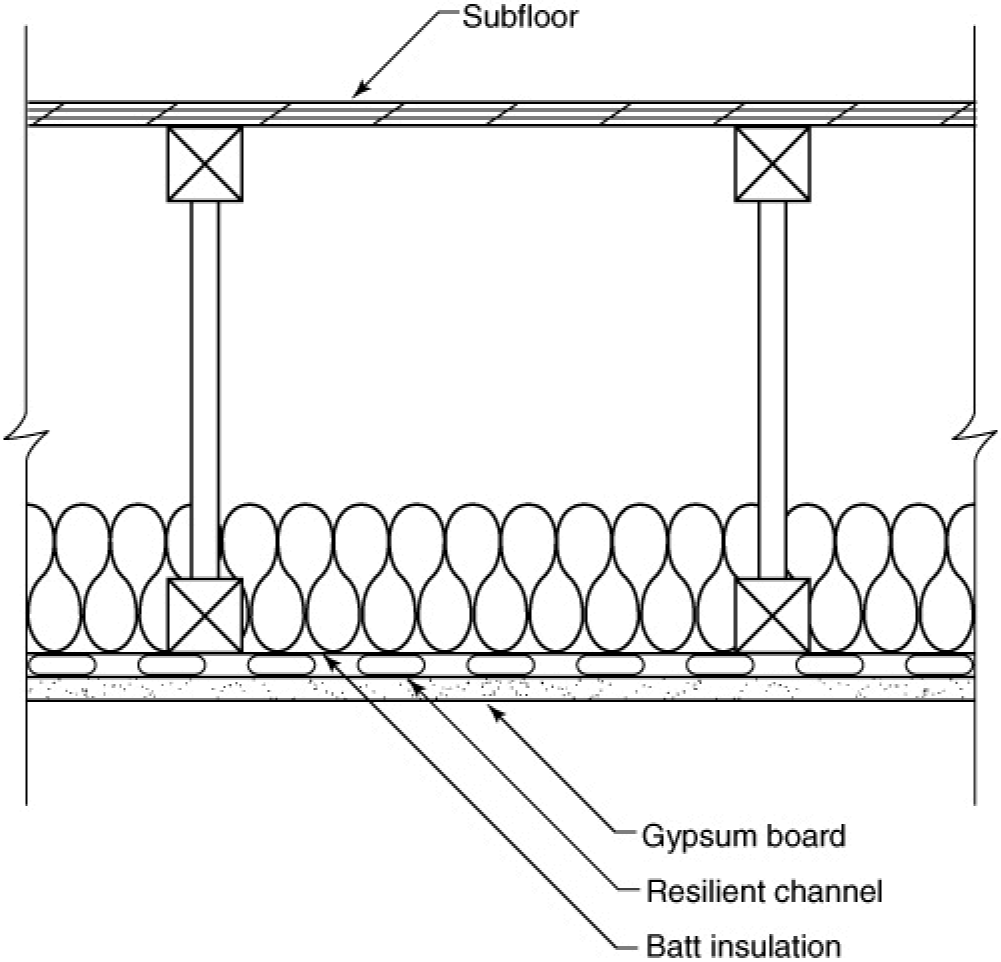
A.9.2.1.5

Solid metal purlin construction with a wood deck is one example of similar solid member construction.

A.9.2.1.6

The $3\frac{1}{2}$ in. (90 mm) of insulation is only required when the ceiling is not directly attached to the joist. The 160 ft^3 (4.5 m^3) is the volume of the individual channel excluding the portion occupied by insulation. (*See Figure A.9.2.1.6.*)

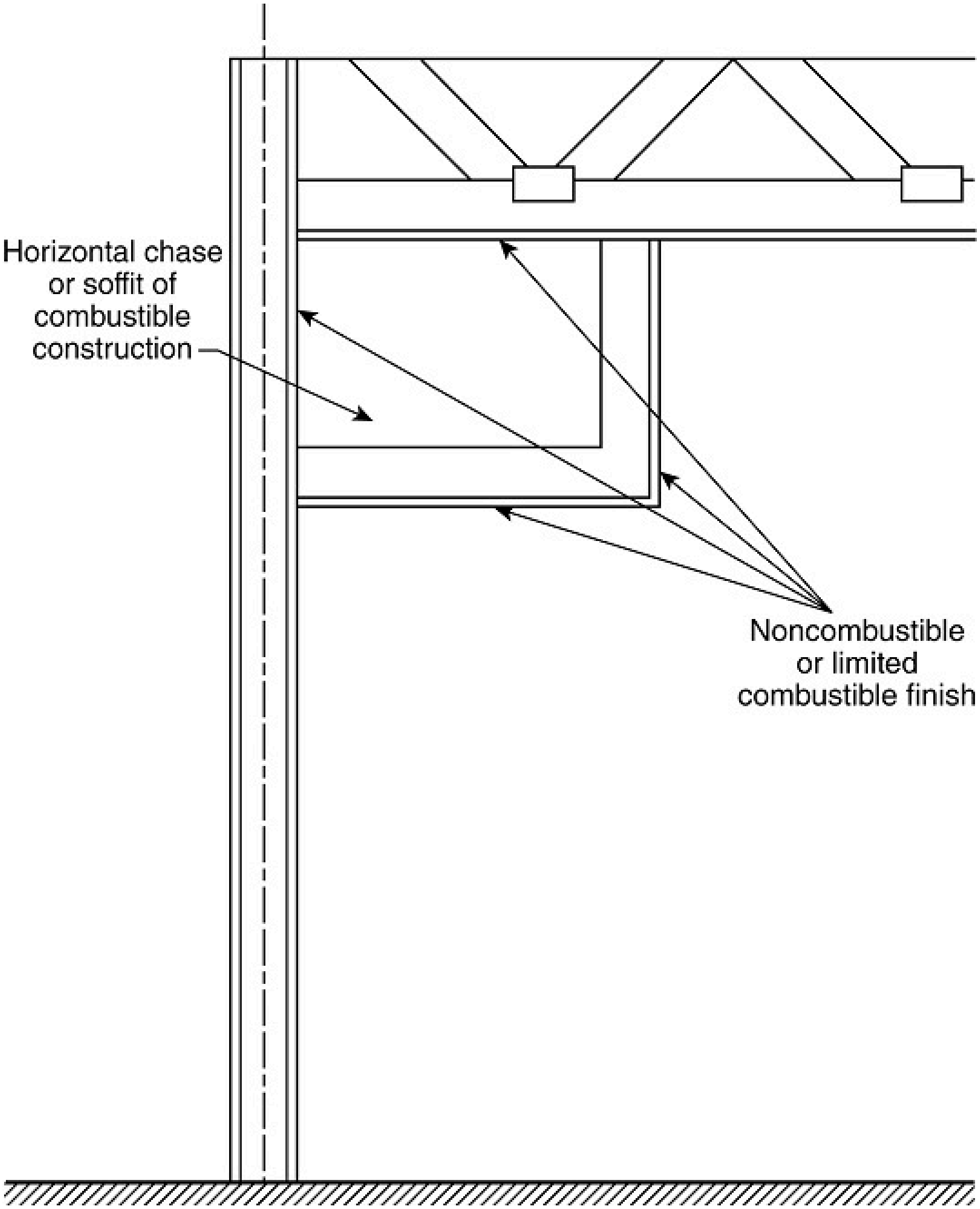
Figure A.9.2.1.6 Combustible Concealed Space Cross Section.



A.9.2.1.11

Sprinklers are allowed to be omitted from horizontal chases and soffits that have noncombustible or limited combustible finishes that can contain mechanical and or plumbing equipment, ductwork, or electrical components. The 160 ft^3 (4.5 m^3) limitation is intended to limit the movement of fire within the chase or soffit. It is not the intent of this volume limitation to require dampers or other mechanical separations within ductwork, or other equipment that are not otherwise required. See Figure A.9.2.1.11.

Figure A.9.2.1.11 Horizontal Chase or Soffit of Combustible Construction.



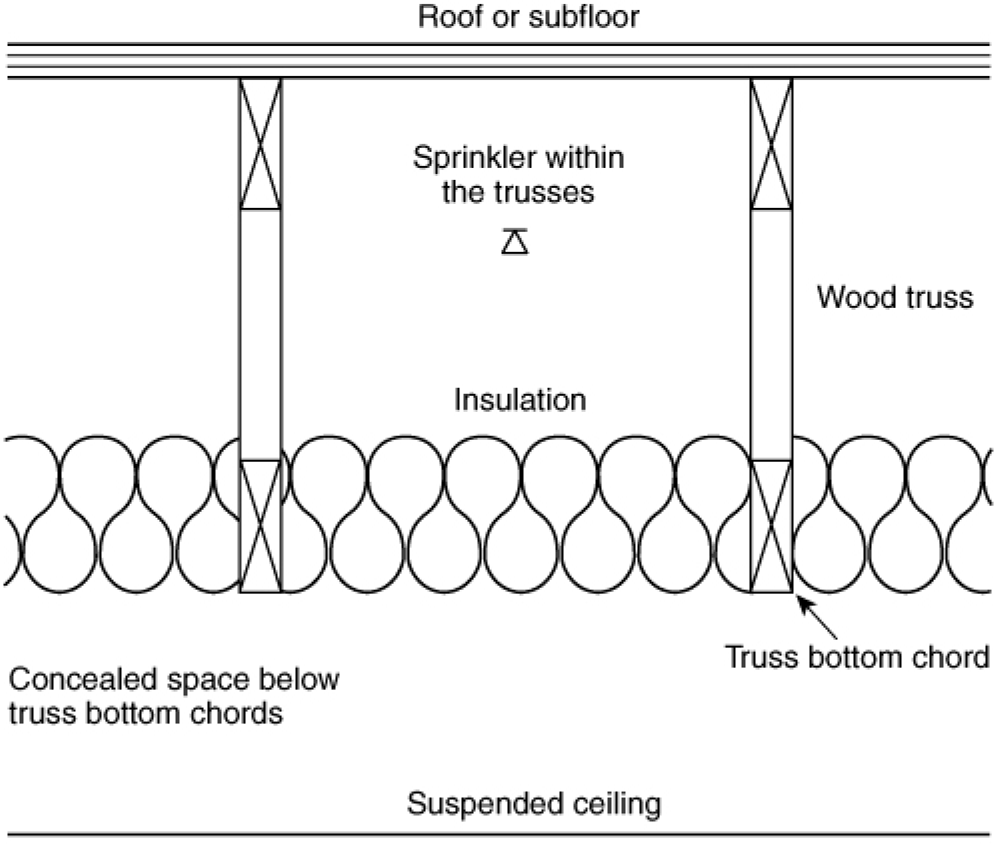
A.9.2.1.13

The allowance to omit sprinklers for fire retardant–treated wood requires a pressure-treated application. It does not apply to coated applications.

A.9.2.1.18

See Figure A.9.2.1.18 for one example.

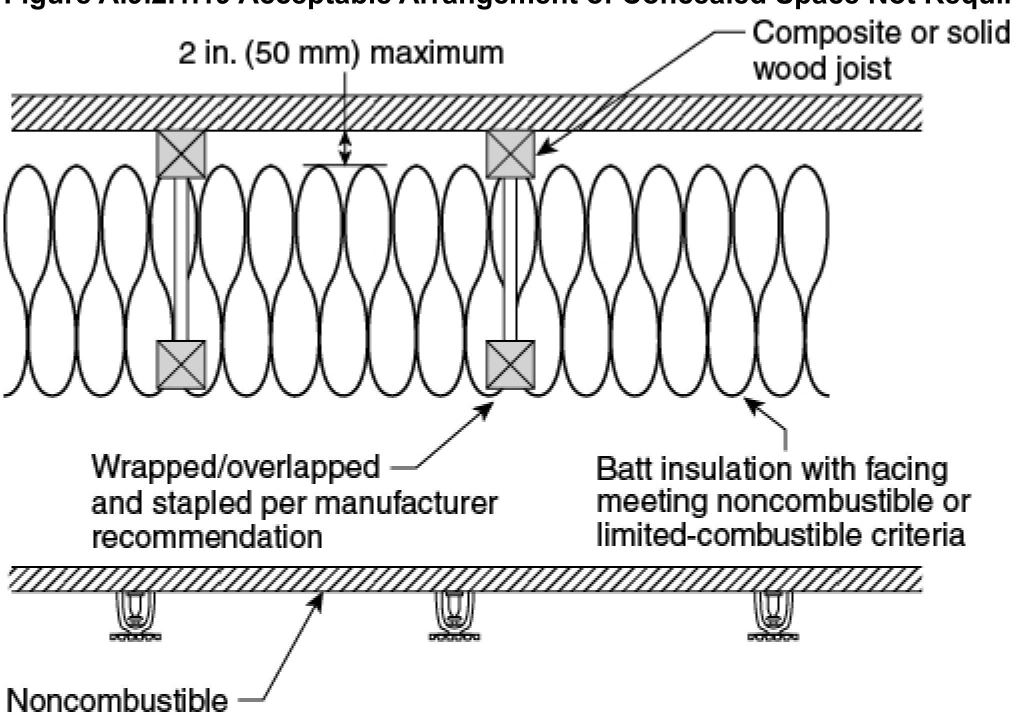
Figure A.9.2.1.18 One Acceptable Arrangement of Concealed Space in Truss Construction Not Requiring Sprinklers.



A.9.2.1.19

See Figure A.9.2.1.19.

Figure A.9.2.1.19 Acceptable Arrangement of Concealed Space Not Requiring Sprinklers.



A.9.2.3

Exterior projections include, but are not limited to, exterior roofs, canopies, porte-cocheres, balconies, decks, or similar projections. Sprinklers should not be required beneath trellis overhangs or similar construction not capable of collecting heat to aid in the operation of the sprinkler.

A.9.2.3.1

Vehicles that are temporarily parked are not considered storage. Areas located at drive-in bank windows or porte-cocheres at hotels and motels normally do not require sprinklers where there is no occupancy above, where the area is entirely constructed of noncombustible or limited-combustible materials or fire retardant–treated lumber, and where the area is not the only means of egress.

A.9.2.4.1.1

A door is not required in order to omit sprinklers as long as the bathroom complies with the definition for compartment.

A.9.2.5.2

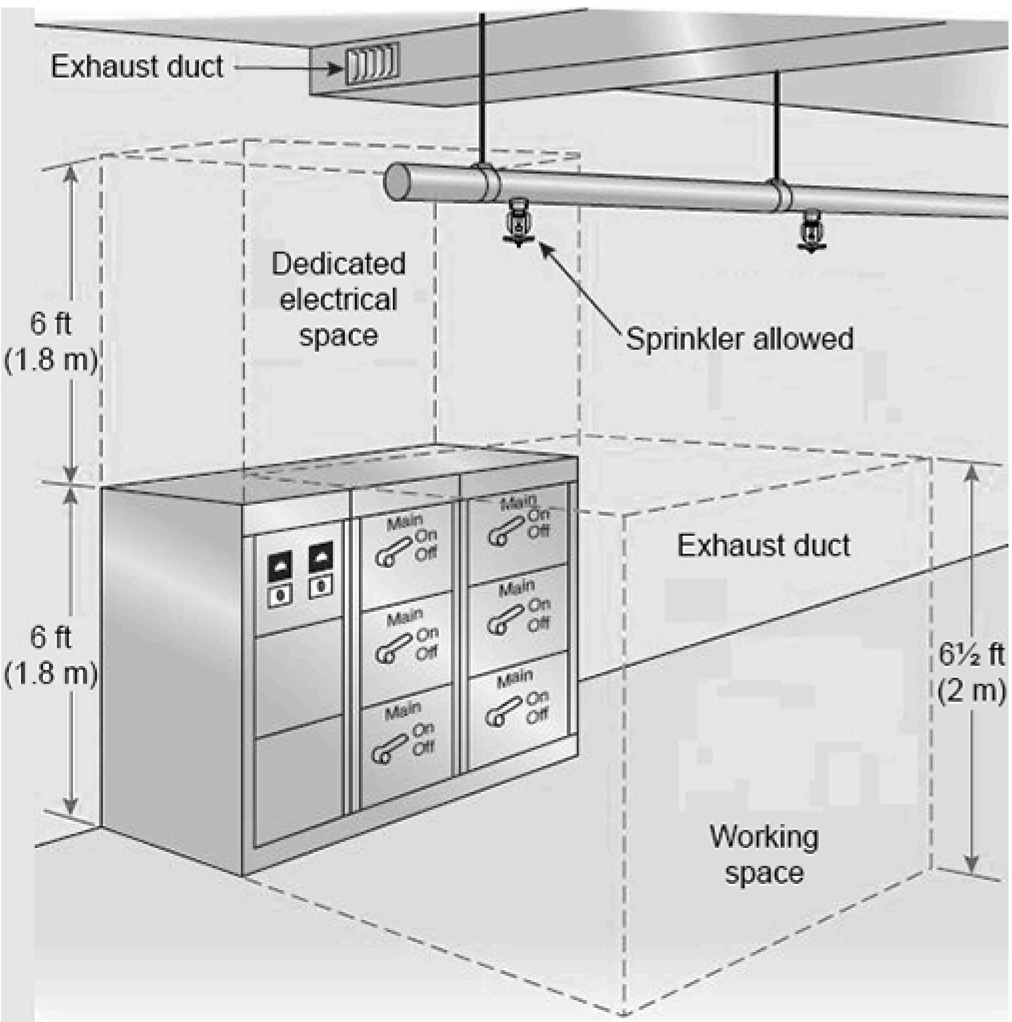
This exception is limited to hospitals as nursing homes, and many limited-care facilities can have more combustibles within the closets. The limited amount of clothing found in the small clothes closets in hospital patient rooms is typically far less than the amount of combustibles in casework cabinets that do not require sprinkler protection, such as nurse servers. In many hospitals, especially new hospitals, it is difficult to make a distinction between clothes closets and cabinet work. The exception is far more restrictive than similar exceptions for hotels and apartment buildings. NFPA 13 already permits the omission of sprinklers in wardrobes *(see 9.2.9)*. It is not the intent of this paragraph to affect the wardrobe provisions of NFPA 13. It is the intent that the sprinkler protection in the room covers the closet as if there was no door on the closet *(see 9.5.3.2)*.

A.9.2.6

Sprinklers and sprinkler piping is permitted in and is permitted to pass through an electrical room as long as the piping is not within the “dedicated electrical space” as defined by *NFPA 70*.

In 110.26(E)(1)(a) of *NFPA 70*, a dedicated electrical space is defined as the space equal to the width and the depth of the equipment extending from the floor to a height of 6 ft (1.8 m) above the equipment or the structural ceiling, whichever is lower. This section further states that no foreign systems are allowed in this zone. So, as long as the sprinkler piping does not run through this dedicated electrical space, it can go in and out of the electric room without issue. Paragraph 110.26(E)(1)(b) of *NFPA 70* allows foreign systems in the area above the dedicated electrical space as long as the electrical equipment is properly protected against leaks or breaks in the foreign system. So the sprinkler piping can run above the dedicated electrical space [6 ft (1.8 m) above equipment] as long as the equipment below is protected from leaks. Additionally, sprinklers and sprinkler piping are not permitted to be located directly within the working space for the equipment as defined by *NFPA 70*. See Figure A.9.2.6.

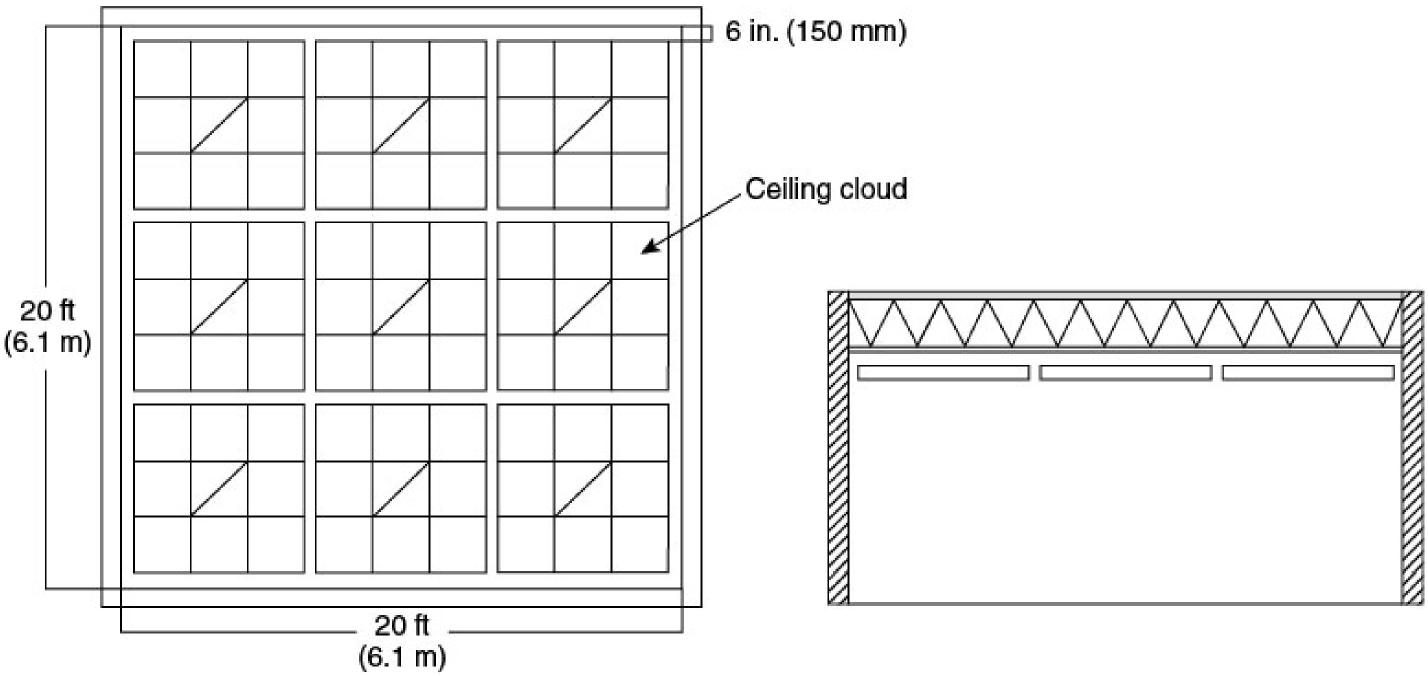
Figure A.9.2.6 The Working Space and the Dedicated Electrical Space.



A.9.2.7.1

An opening in the ceiling can be located along a wall or can occur between panels to give an architectural effect such as a floating ceiling. Fire modeling results have shown that there will be heat loss to the space above the ceiling when the openings are too large. The modeling results indicate that sprinklers should activate on the lower ceiling level when the opening dimension is no greater than 1 in. per ft (8 mm/m) of elevation above the floor. When an opening between ceiling panels, or a ceiling panel and a wall, are any larger, the space above the ceiling panels should not be considered a concealed space. Figure A.9.2.7.1 shows plan and elevation views of a cloud ceiling installation.

Figure A.9.2.7.1 Cloud Ceiling Openings.



A.9.2.7.1(1)

To determine the maximum allowed gap distance for omission of sprinklers above cloud ceilings, the following formula can be used:

$$A / B = X \quad \text{[A.9.2.7.1(1)]}$$

where:

A = inches of gap between clouds or between a cloud and a wall

B = ceiling height

X = maximum inches of gap

Example:

A = 9 in. 225 maximum gap dimension

B = 14 ft (4.3 m) ceiling height

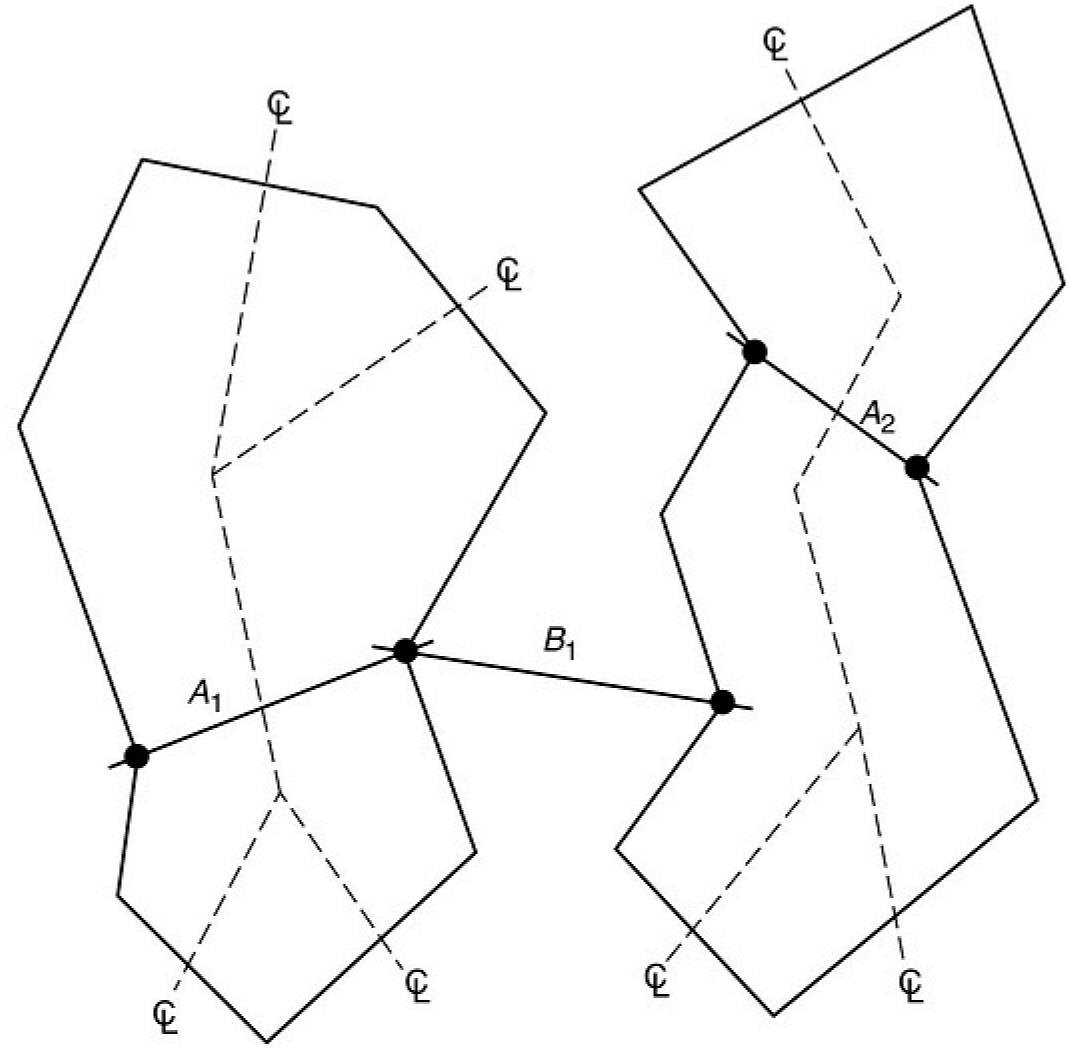
X = 0.64 in. (16 mm) of gap/ft of ceiling height

Therefore, ≤0.75 in. (19 mm) of gap/ft of ceiling height spacing used.

A.9.2.7.2.5

The research testing and modeling used to determine the base data used for Table 9.2.7.1 is based on rectangular and equally spaced cloud configurations. Nonrectangular shapes are allowed to be considered with this section; however, the minimum width of the cloud and maximum width of the gap should be used to determine the worst geometric shape creating a conservative approach. Figure A.9.2.7.2.5 provides an example of an irregular cloud.

Figure A.9.2.7.2.5 Irregular Shaped Cloud Dimensioning.



A = Minimum cloud width B = Maximum open width

A.9.2.9

Furniture includes such items as portable wardrobe units, lockers, cabinets, or trophy cases.

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, this standard views these units as pieces of furniture rather than as a part of the structure; thus, sprinklers are not required.

A.9.2.10.1

These isolated spaces are similar to hearing testing booths, lactation rooms, phone booths, or pods and are not used for storage. Miscellaneous furniture, wastebaskets, and other nonstorage items are allowed in the space. *Isolated* is intended to mean that units should not be located adjacent to each other and are physically separated.

A.9.2.11

Equipment having access for routine maintenance should not be considered as intended for occupancy. This includes a service corridor space within rooftop air handling unit enclosures, accessible through a standard height side-hinged door.

A.9.2.14.6

Elevator cars that have been constructed in accordance with ASME A17.1/CSA B44, *Safety Code for Elevators and Escalators,* 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 index of 0 to 75 and a smoke-developed index of 0 to 450, when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*.

A.9.3.3.2

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

A.9.3.4.1.2

Sprinklers at each floor level landing should be positioned to protect both the floor level landing and any intermediate landing.

A.9.3.4.2.3.1

There are several methods of preventing storage under the bottom landing/riser of stairs. These can be permanent walls separating the space or railings installed to prevent storage. Simply placing a sign indicating no storage allowed is insufficient.

A.9.3.4.3

See Figure A.9.3.4.3(a) and Figure A.9.3.4.3(b). Sprinklers would be required in the case shown in Figure A.9.3.4.3(a) but not in the case shown in Figure A.9.3.4.3(b).

Figure A.9.3.4.3(a) Noncombustible Stair Shaft Serving Two Sides of Fire Wall.

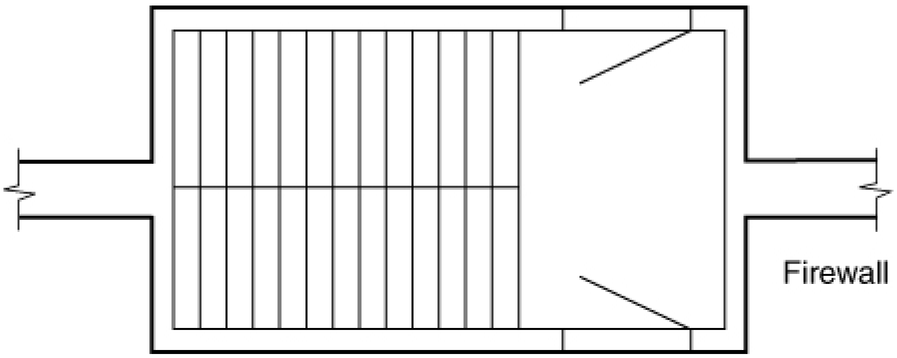
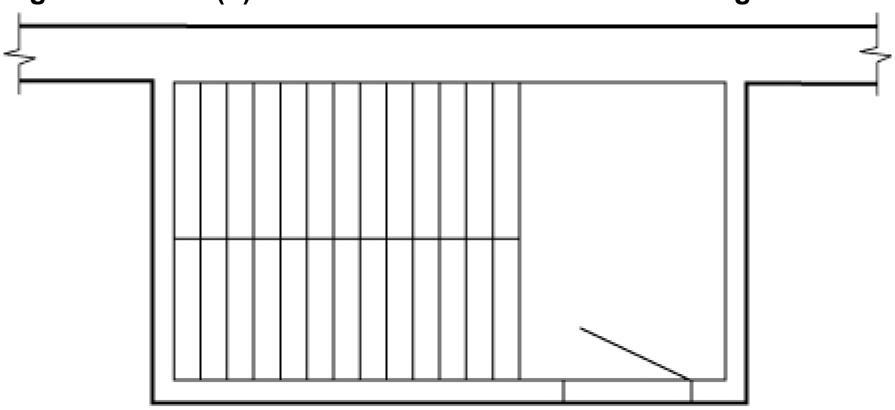


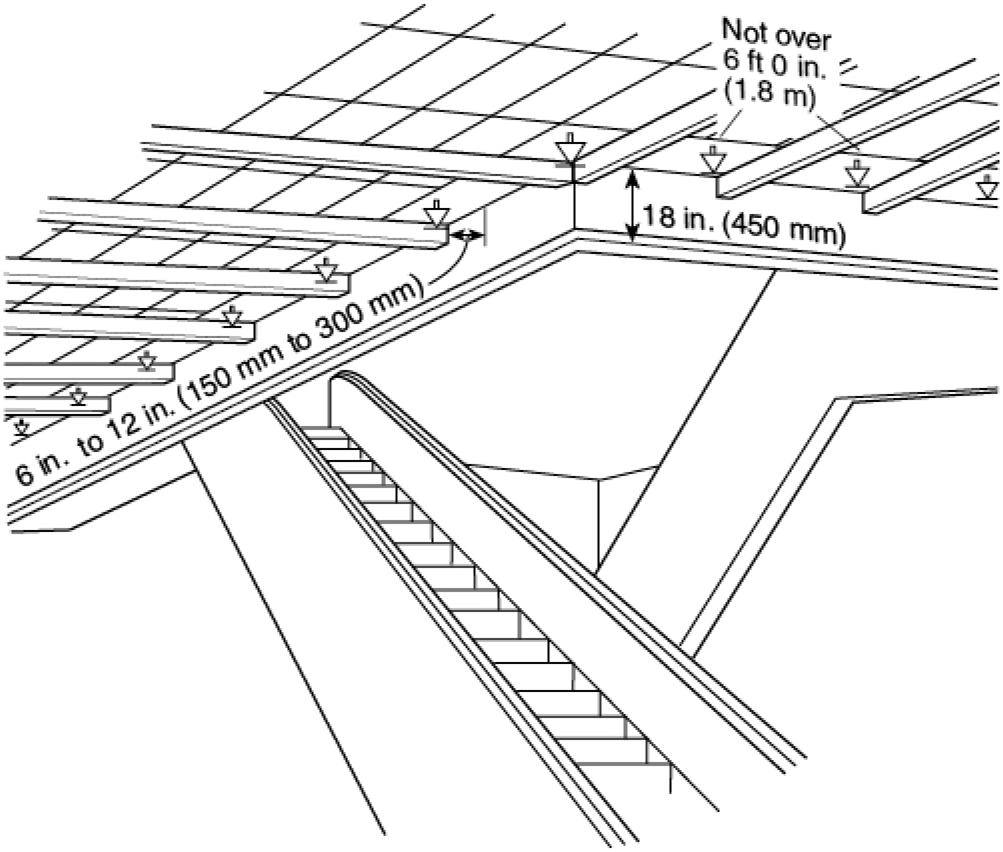
Figure A.9.3.4.3(b) Noncombustible Stair Shaft Serving One Side of Fire Wall.



A.9.3.5

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.9.3.5.)*

Figure A.9.3.5 Sprinklers Around Escalators.



A.9.3.5.1

It is the intent of this section to require closely spaced sprinklers and draft curtains to openings where protection or enclosure is required by building and life safety codes.

A.9.3.7

Library stacks are high-density book storage areas and should not be confused with the typical library bookshelves and aisles in the general browsing areas. Examples of record storage include medical or paper records.

A.9.3.8

The combustible materials present inside industrial ovens and furnaces can be protected by automatic sprinklers. Wet sprinkler systems are preferred. However, water-filled piping exposed to heat within an oven or furnace can incur deposition and buildup of minerals within the pipe. If the oven or furnace could be exposed to freezing temperatures, dry pendent sprinklers are an alternative to wet pipe systems. Another option is to use a dry pipe system.

The preferred arrangement for piping is outside of the oven; the sprinkler should be installed in the pendent position. The sprinkler temperature rating should be at least 50°F (10°C) greater than the high-temperature limit setting of the oven or applicable zone. As a minimum, the sprinkler system inside the oven or furnace should be designed to provide 15 psi (1 bar) with all sprinklers operating inside the oven/furnace. Sprinkler spacing on each branch line should not exceed 12 ft (3.7 m).

A.9.3.10

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.9.3.11.1

There are ceiling panels and ceiling materials that have been investigated as a ceiling material in accordance with UL Subject 723S, *Outline of Investigation for Drop-Out Ceilings Installed Beneath Automatic Sprinklers*, or as FM Class Number 4651, *Plastic Suspended Ceiling Panels*. Such ceiling panels and ceiling materials are designed such that the activation of the sprinkler and the ability of the sprinkler discharge to reach the hazard being protected are not adversely impacted.

A.9.3.11.4

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

A.9.3.11.5

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.9.3.12

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 with orifice sizes selected to provide a flow rate as close as possible to, but not less than, 20 gpm (75 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 should 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 mm) — 4 sprinklers

1¼ in. (32 mm) — 6 sprinklers

1½ in. (40 mm) — 10 sprinklers

2 in. (50 mm) — 20 sprinklers

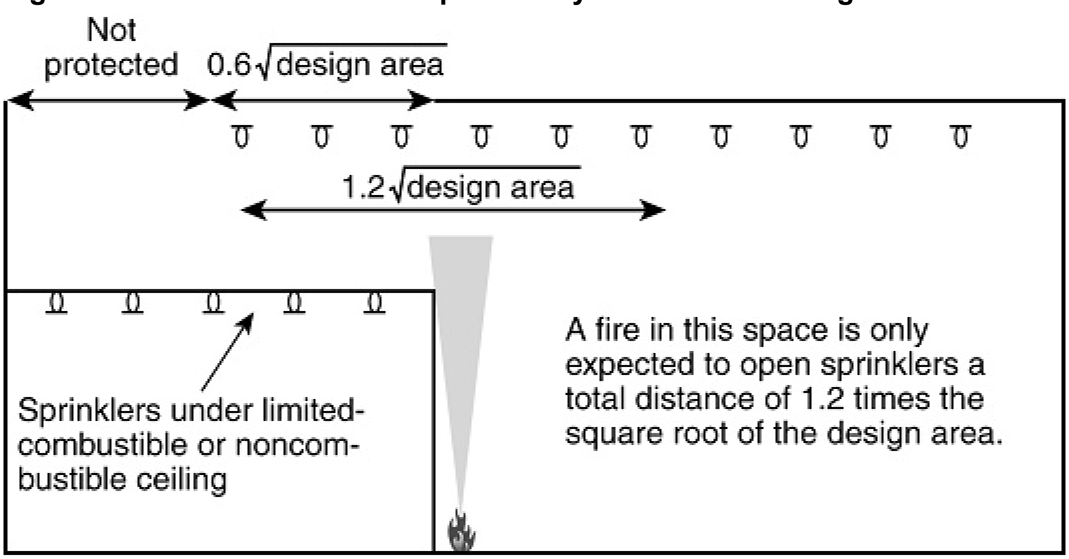
2½ in. (65 mm) — 40 sprinklers

3 in. (80 mm) — 80 sprinklers

A.9.3.14.3

See Figure A.9.3.14.3.

Figure A.9.3.14.3 Extension of Sprinkler System Above Ceiling.



A.9.3.15

It is not the intent of this section to apply to sprinkler protection of glass atrium enclosures and pedestrian walkways that are permitted by NFPA *101* or to apply to model building codes protected by standard spray sprinklers that are installed in accordance with the special provisions set forth in those codes for atrium construction. In some cases, sprinkler protected assemblies as an alternative to a required fire-rated wall or window assembly could require the approval of the building official.

A.9.3.16.2

Plastic covers might not meet the noncombustible or limited-combustible requirement for ceiling pockets as required in Chapters 10 through Chapter 14.

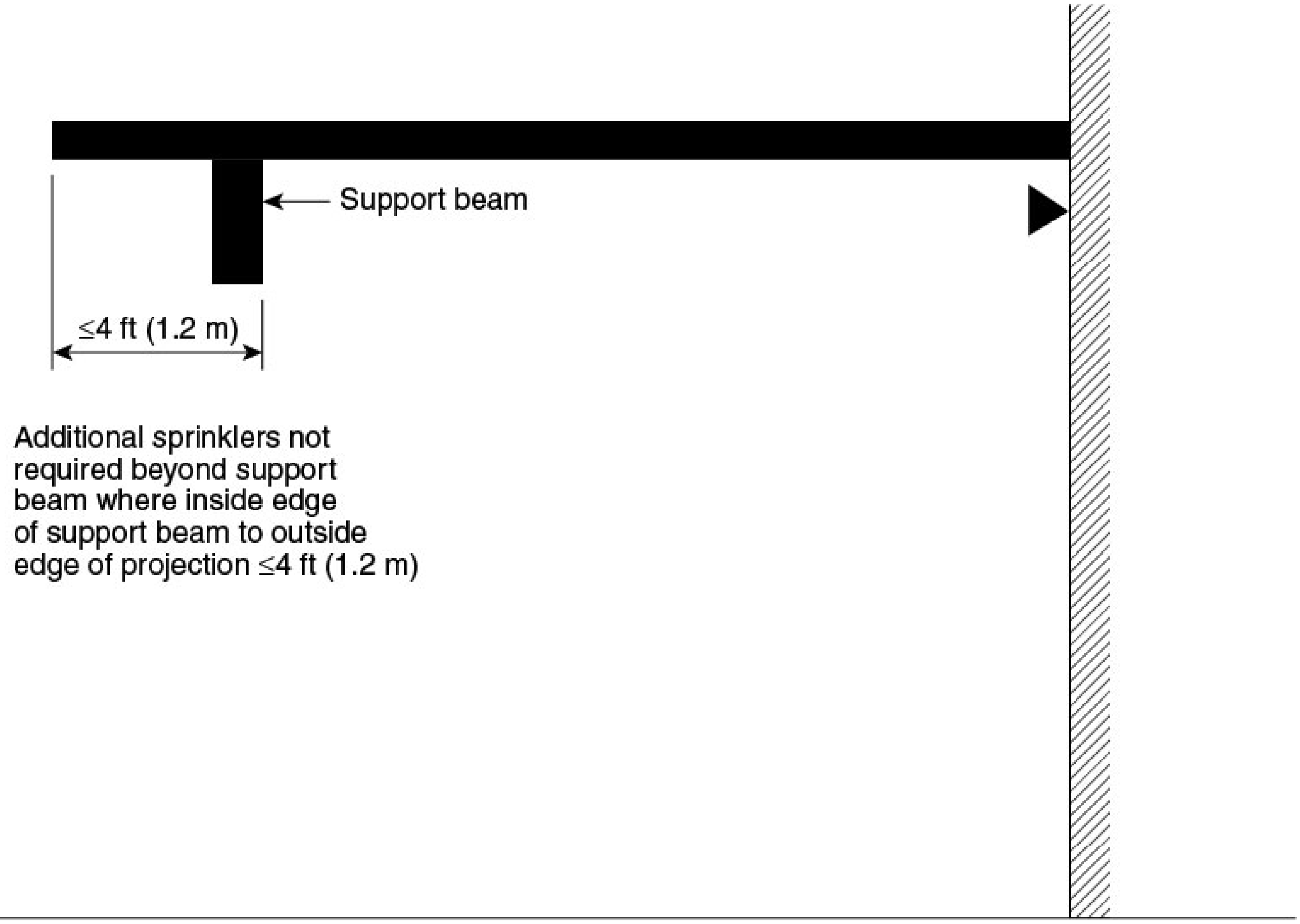
A.9.3.17.1.1

Utilities and other building services can be located within the concealed spaces.

A.9.3.19.1

Sprinkler protection under exterior projections should not be required to spray beyond the support beam on the exterior edge of the exterior projection as long as the maximum distance from the interior edge of support beam to the exterior edge of the projection does not exceed 4 ft (1.2 m). An additional line of sprinklers on the exterior edge is not required due to obstruction rules. This is considered a reasonable level of protection because sprinklers are located between the structure and the exterior edge. See Figure A.9.3.19.1.

Figure A.9.3.19.1 Exterior Projection with Sprinklers.



A.9.3.19.2

Short-term transient storage, such as that for delivered packages, and the presence of planters, newspaper machines, and so forth, should not be considered for storage or handling of combustibles. The presence of combustible furniture on balconies for occupant use should not require sprinkler protection.

A.9.3.20

This requirement to install sprinklers on exterior balconies, attached exterior decks, and ground floor patios serving dwelling units is consistent with the requirements in the *International Building Code* and NFPA 13R.

A.9.3.20.1

Type V construction generally refers to buildings constructed with structural elements entirely or partially wood or other similar combustible material.

A.9.4.1.1

Whenever possible, sprinklers should be installed in piping after the piping is placed in its final position and secured by hangers in accordance with this standard.

A.9.4.1.3

The purpose of this requirement is to minimize the obstruction of the discharge pattern.

A.9.4.1.5.1

Protective caps and straps are intended to provide temporary protection for sprinklers during shipping and installation.

A.9.4.1.5.2

Protective caps and straps can be removed from upright sprinklers, from sprinklers that are fitted with sprinkler guards, and from sprinklers that are not likely to be subject to damage due to construction activities or other events. In general, protective caps and straps should not be removed until construction activities or other events have progressed to the point where the sprinklers will not be subjected to conditions that could cause them to be damaged. Consideration should be given to leaving the protective caps and straps in place where other construction work is expected to take place, adjacent to the sprinklers following their installation, until that activity is complete. Protective caps and straps on sidewall and pendent sprinklers, for example, should be left in place pending installation of the wall and ceiling systems and then removed as finish escutcheons are being installed. In retrofit applications, with minimal follow-on trade construction activity, and with upright sprinklers, it would be reasonable to remove the caps and straps immediately following the installation on the sprinkler piping.

A.9.4.2.1

It is acceptable to install ordinary-temperature sprinklers throughout a building, intermediate-temperature sprinklers throughout a building, or a mix of ordinary- and intermediate-temperature sprinklers throughout a building.

A.9.4.2.5

A diffuser in ceiling sheathing labeled by the manufacturer as “horizontal discharge” has directional vanes to move air further along the ceiling, and sprinklers located within the 2 ft 6 in. (750 mm) radius should have an intermediate-temperature rating. See Figure A.9.4.2.5(a) through Figure A.9.4.2.5(d).

Figure A.9.4.2.5(a) Ordinary-Temperature Sprinkler over Recessed Fireplace.

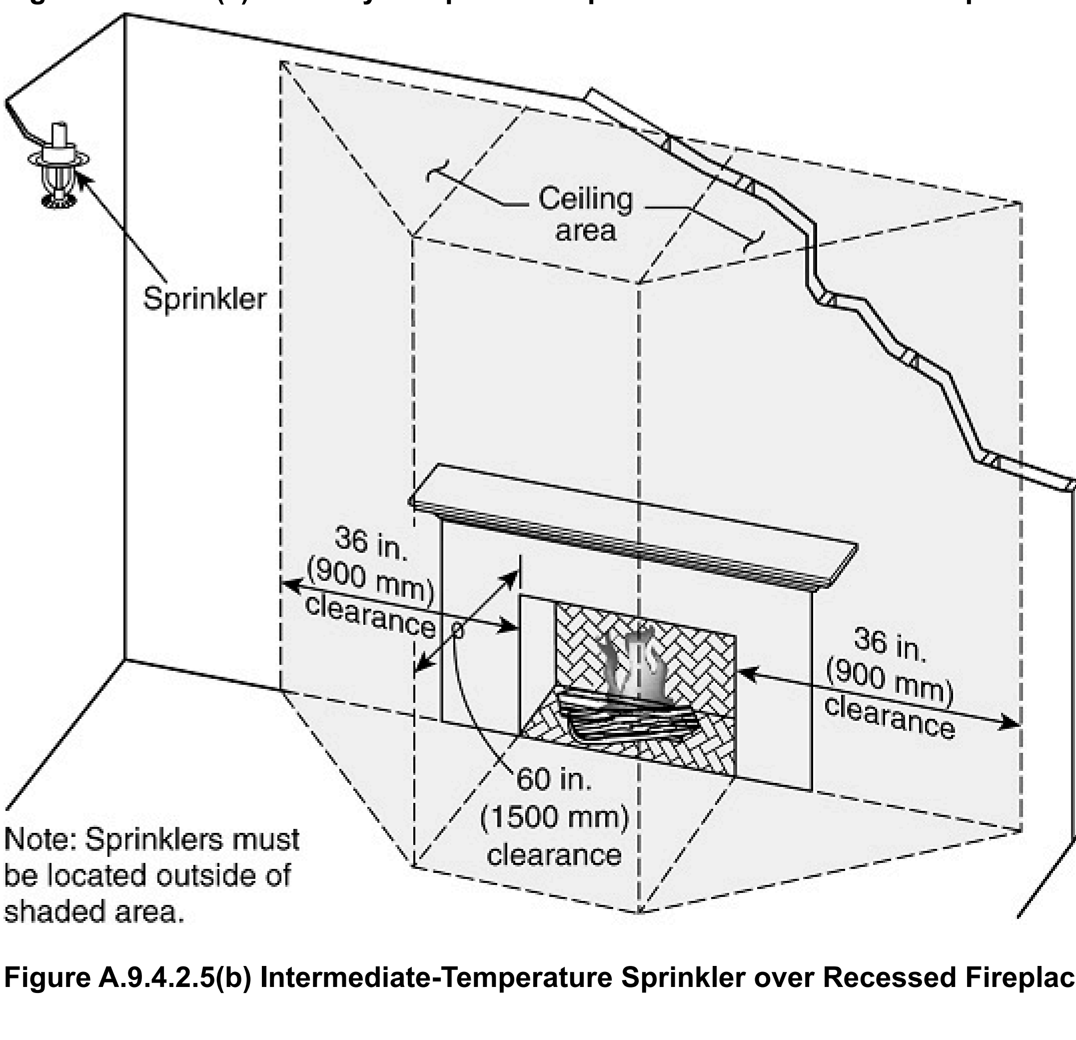


Figure A.9.4.2.5(b) Intermediate-Temperature Sprinkler over Recessed Fireplace.

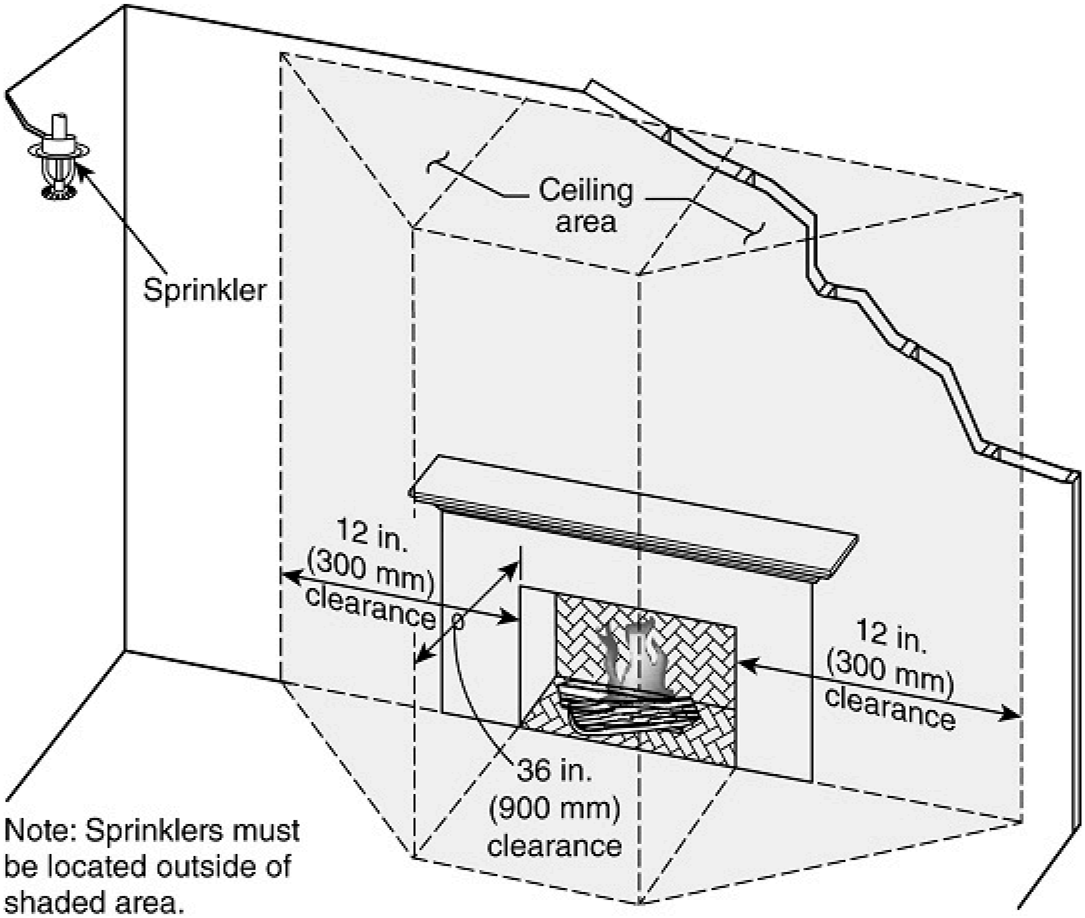


Figure A.9.4.2.5(c) Ordinary-Temperature Sprinkler over Open Fireplace.

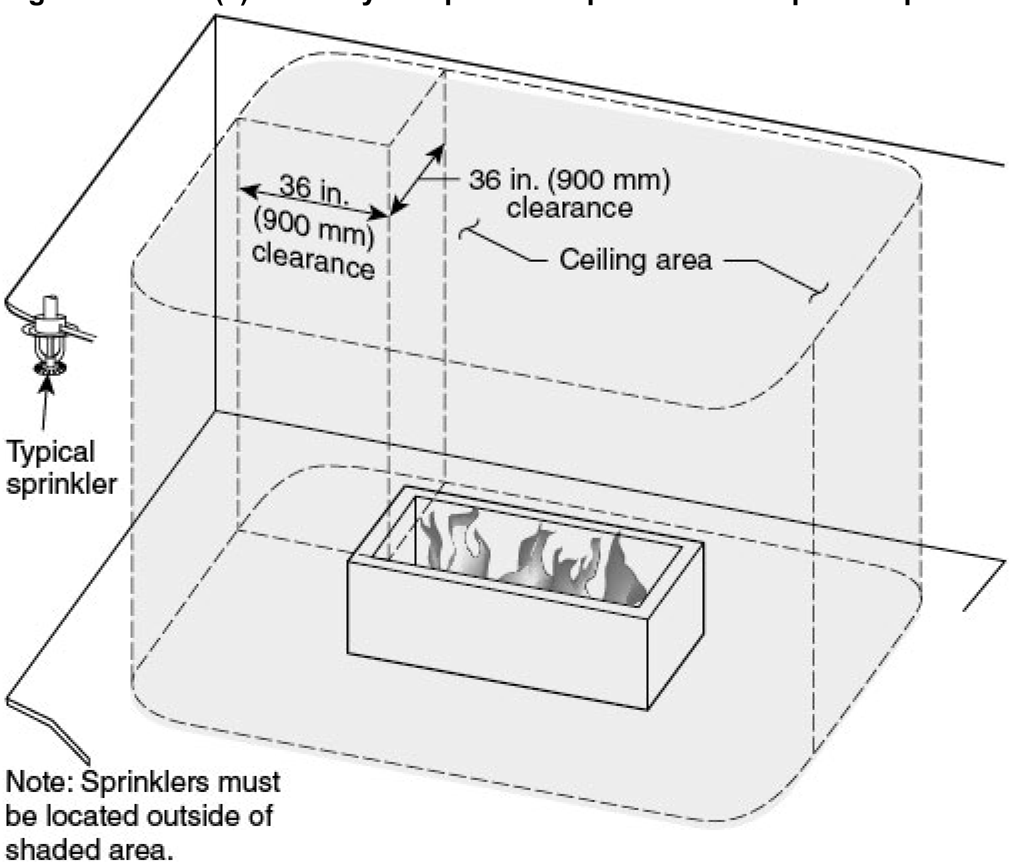
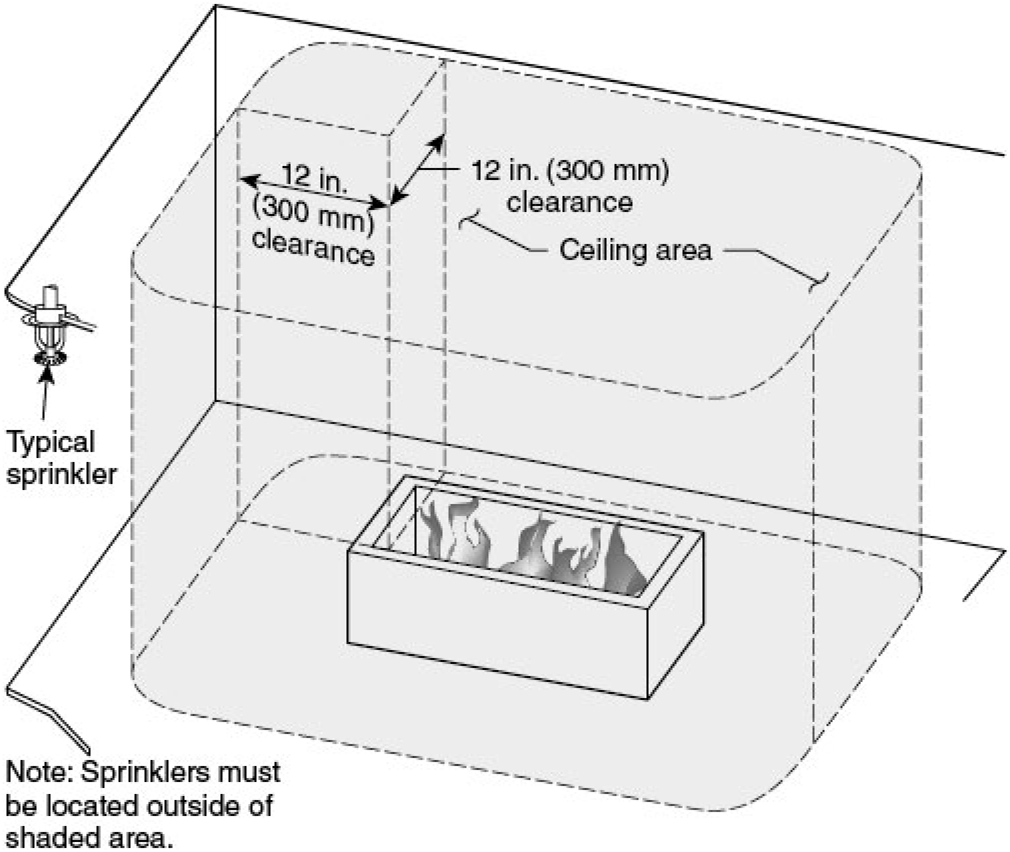


Figure A.9.4.2.5(d) Intermediate-Temperature Sprinkler over Open Fireplace.



A.9.4.2.5(1)

Areas used for hot yoga facilities, steam rooms, saunas, indoor areas containing hot tubs, and similar heated areas should be evaluated to determine the potential maximum ambient temperature before selection of sprinkler temperature rating to be installed in the space.

A.9.4.2.7

Where high temperature–rated sprinklers are installed at the ceiling, high temperature–rated sprinklers also should extend beyond storage in accordance with Table A.9.4.2.7.

Table A.9.4.2.7 Distance Beyond Perimeter of Storage for High Hazard Occupancies Protected with High Temperature–Rated Sprinklers

Design Area		Distance	
ft^2	m^2	ft	m
2000	185	30	9.1
3000	280	40	12
4000	370	45	14
5000	465	50	15
6000	555	55	17

A.9.5.1.3

Small areas created by architectural features include items such as planter box windows, wing walls, and similar features.

A.9.5.3.2.3

Furniture includes such items as portable wardrobe units, lockers, cabinets, and trophy cases.

A.9.5.4.1

Batt insulation creates an effective thermal barrier and can be considered the ceiling/roof deck when determining distances between deflector and ceiling. The insulation needs to be installed in each pocket (not just above the sprinkler) and attached to the ceiling/roof in such a manner that it will not fall out during a fire prior to sprinkler activation.

A.9.5.4.1.4

The rules describing the maximum distance permitted for sprinklers below ceilings must be followed. The concept of placing a small “heat collector” above a sprinkler to assist in activation is not appropriate, nor is it contemplated in this standard. There is evidence that objects above a sprinkler will delay the activation of the sprinkler where fires are not directly below the sprinkler (but are still in the coverage area of the sprinkler). One of the objectives of the standard is to cool the ceiling near the structural members with spray from a nearby sprinkler, which is not accomplished by a sprinkler far down from the ceiling, and a heat collector will not help this situation.

A.9.5.4.3(3)

Computer simulations and full-scale fire tests as documented in the report entitled *Protection of Storage Under Sloped Ceilings Phase III: Large-Scale Testing Summary and Guidance*, written based on a project supported by the Fire Protection Research Foundation, have demonstrated the advantage of having sprinkler deflectors installed parallel to the floor when the slope of a ceiling over a storage occupancy exceeds 2 in 12. This orientation allows the water flux applied to a storage array to closely match the water flux obtained at the test labs, which were conducted under a horizontal flat ceiling. The previously referenced test program did not investigate the impact of sprinkler orientation parallel to the ceiling for nonstorage occupancies. While there are advantages to having sprinklers installed parallel to the floor when the slope of a ceiling exceeds 2 in 12, the sprinklers used to protect nonstorage occupancies have deflectors that create water flux distribution patterns that are significantly different than sprinklers used to protect storage. As nonstorage occupancies were not part of the scope of the Fire Protection Research Foundation project on sloped ceilings, coupled with the additional cost to install sprinklers with their deflectors parallel to the floor, the requirement to install sprinkler deflectors parallel to the floor under ceilings having a slope that exceeds 2 in 12 was limited to storage occupancies.

When this standard uses the term *parallel to the floor of the storage area*, it intends for this to be horizontal. In some cases, the floor of the building might have a slight slope to drain spilled fluids, but the intent of the standard is not to match this slope but have the deflectors be installed horizontally to comply with this requirement.

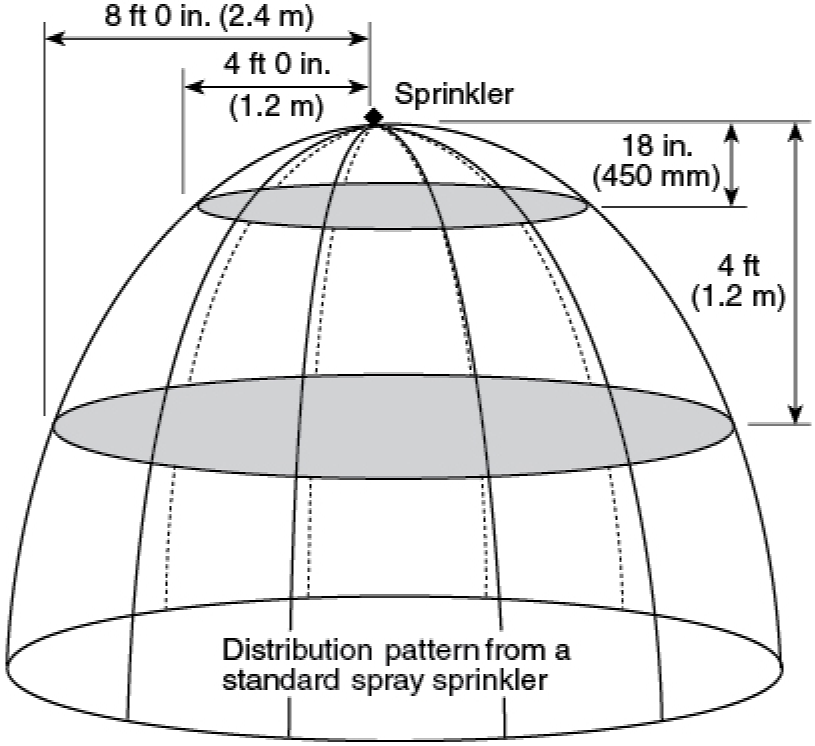
A.9.5.5.1

See Figure A.9.5.5.1 for a representation of a typical spray sprinkler pattern.

NFPA 13 strives to minimize the effect of obstructions through the use of specific criteria in 9.5.5, 10.2.8, 10.3.6, 11.2.5, 11.3.6, 12.1.10, 12.1.11, 13.2.7, and 14.2.10. The obstruction criteria for storage sprinklers in 13.2.7 and 14.2.10 is the most stringent. For other types of sprinklers, dry spaces caused by obstructions such as columns and wall configurations will occur and can comply with the standard. The general rules known as the Three Times Rule and the Four Times Rule define *shadow areas* that are acceptable behind obstructions like columns and walls. Tests have shown that the larger the column, the larger the shadow area behind the column will be and the longer it will take for sprinklers on the other side of the column to react to the fire behind the column. In a very large compartment, the delay could become unacceptable. The delay in sprinkler response can be minimized with smaller columns, with smaller compartments, or by putting sprinklers on the other side of the column.

Where offset walls create shadow areas, the sprinkler does not appear to be significantly delayed in activation. Tests have shown that once the sprinkler activates, water will not cover all areas behind the obstructions.

Figure A.9.5.5.1 Sprinkler Discharge Pattern Development for Standard Upright or Pendent Spray Sprinklers.



A.9.5.5.2

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

Where the obstruction criteria established by this standard are followed, sprinkler spray patterns will not necessarily get water to every square foot of space within a room.

A.9.5.5.3.1

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.9.5.5.3.2.1

When obstructions are located more than 18 in. (450 mm) below the sprinkler deflector, an adequate spray pattern develops and obstructions up to and including 4 ft (1.2 m) wide do not require additional protection underneath. Examples are ducts, decks, open grate flooring, catwalks, cutting tables, overhead doors, soffits, ceiling panels, and other similar obstructions.

Where multiple levels of ducts, pipes, or other similar horizontal obstructions over 4 ft (1.2 m) wide are stacked vertically, additional levels of automatic sprinkler protection between the vertical levels are not required. A single level of sprinklers beneath the lowest level of the obstruction is adequate, provided that the obstructions are noncombustible and the combustible materials are not stored between the levels.

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.9.5.5.3.2.2

A conference table is an example of an obstruction that is not fixed in place.

A.9.5.5.3.4.1

See Figure A.9.5.5.3.4.1(a) and Figure A.9.5.5.3.4.1(b).

Figure A.9.5.5.3.4.1(a) Sprinkler Location Below Obstruction.

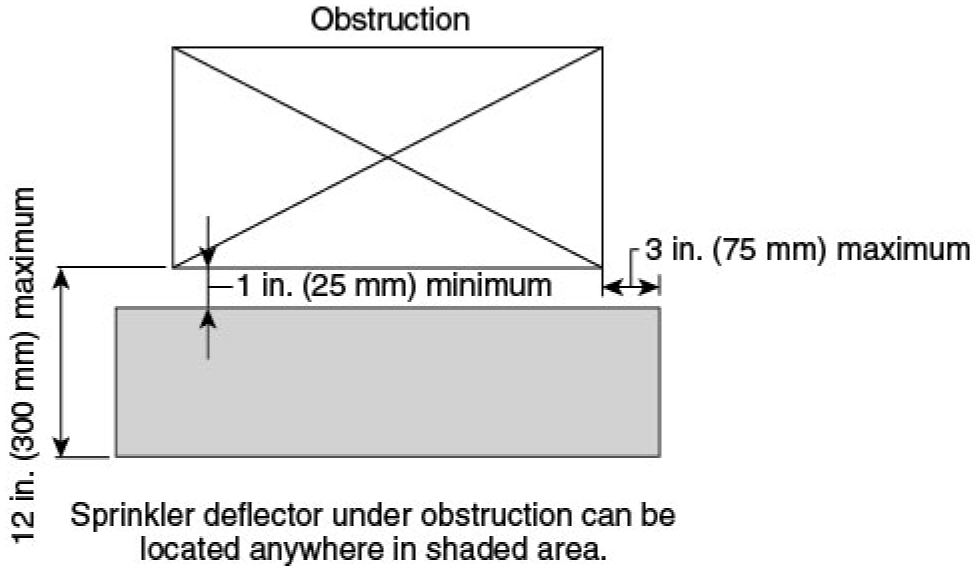
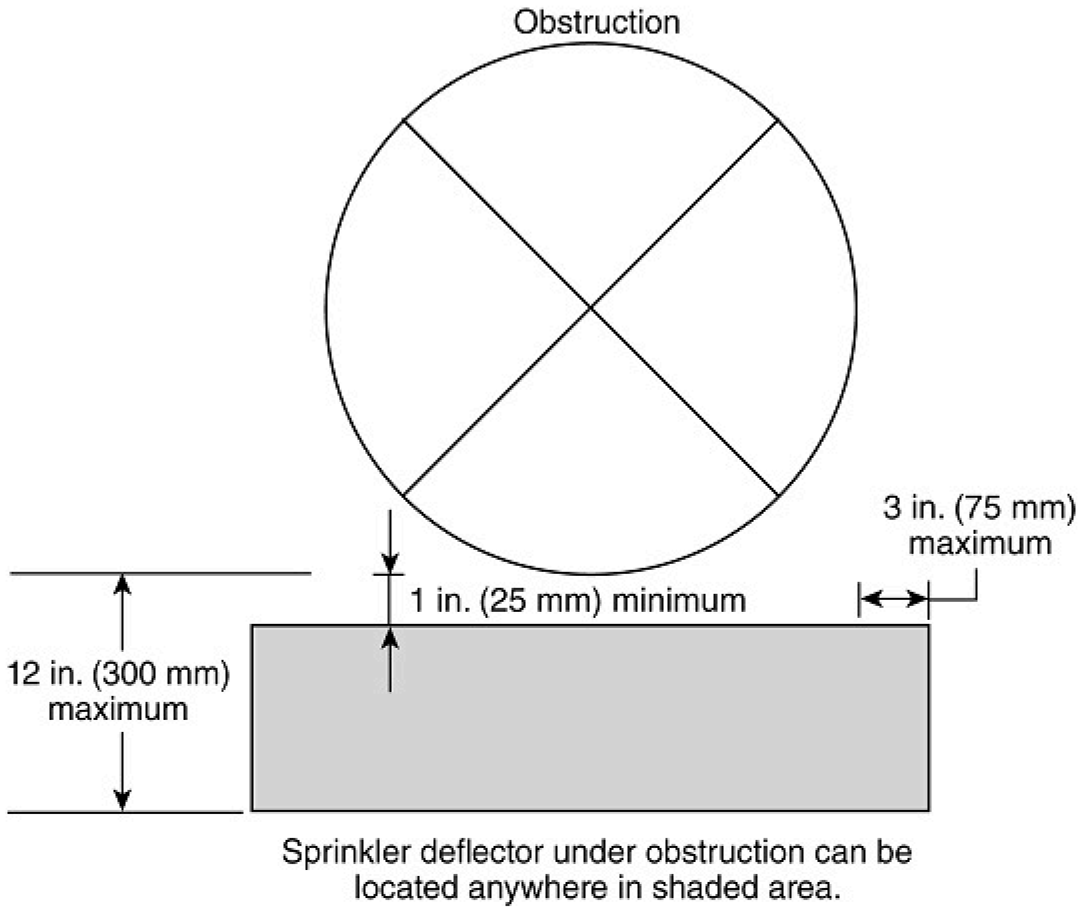


Figure A.9.5.5.3.4.1(b) Sprinkler Location Below Circular Obstruction.



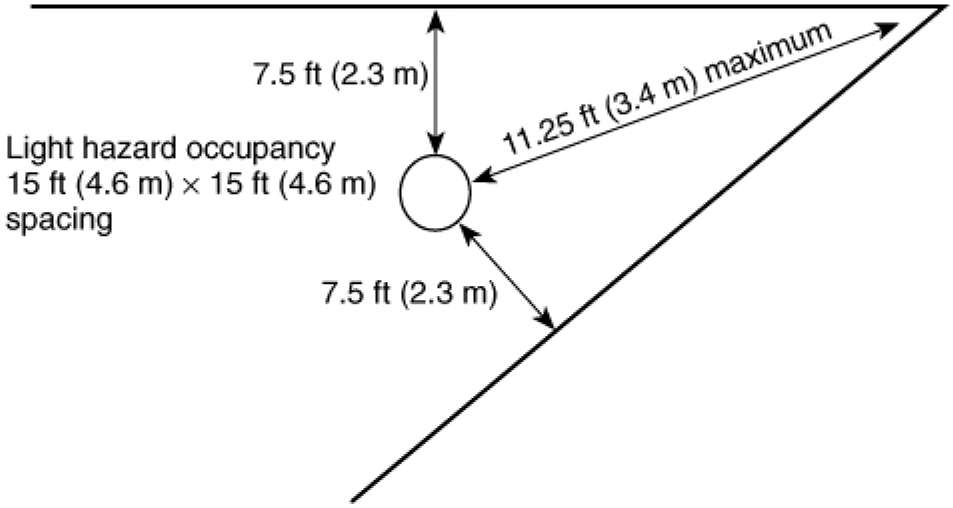
A.10.2.4.2.1

When the spacing between sprinklers perpendicular to the slope exceeds 8 ft (2.4 m), it is necessary to increase the minimum density or sprinkler operating pressure as noted in Table 10.2.4.2.1(a) and in 10.2.7.1.4. Time to sprinkler activation and water distribution can be affected within combustible concealed spaces with sloped roofs or ceilings in these combustible concealed spaces, especially where wood joist rafters or wood truss construction is used. To reduce the probability of fires in these combustible concealed spaces involving the combustible roof or ceiling construction above standard spray sprinklers, more stringent spacing and installation guidelines apply.

A.10.2.6.2.2

The example in Figure A.10.2.6.2.2 is for a light hazard occupancy. However, the irregular-shaped room allowance also applies to ordinary and extra hazard occupancies.

Figure A.10.2.6.2.2 Maximum Distance from Walls.



A.10.2.6.2.3

Examples of sprinklers in small rooms are shown in Figure A.10.2.6.2.3(a), Figure A.10.2.6.2.3(b), Figure A.10.2.6.2.3(c), and Figure A.10.2.6.2.3(d). The area of coverage of the sprinkler, as determined by dividing the area of the room by the number of sprinklers, cannot exceed the maximum area of coverage for the sprinkler being utilized in the small room.

Figure A.10.2.6.2.3(a) Small Room Provision — One Sprinkler.

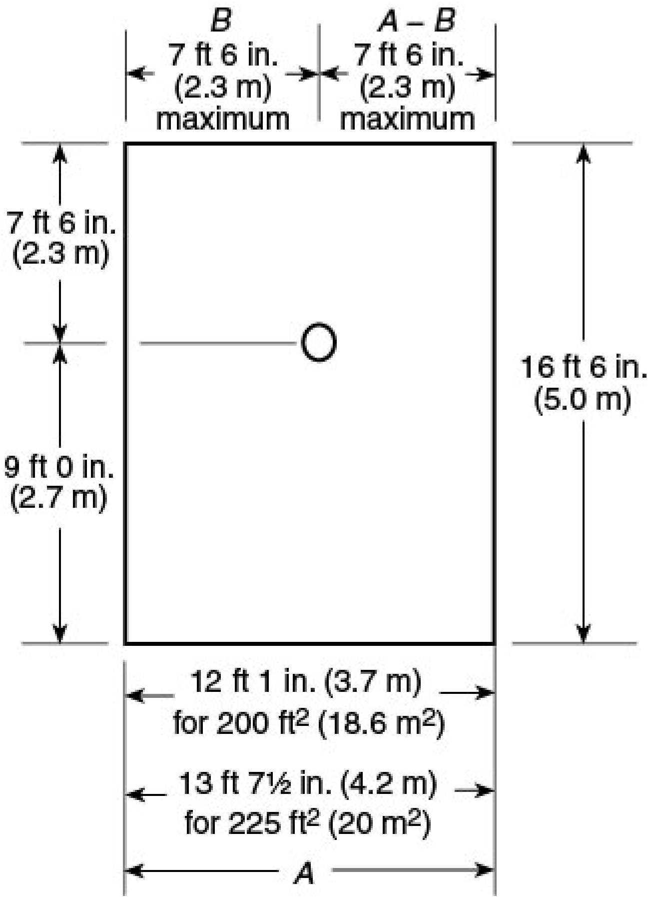


Figure A.10.2.6.2.3(b) Small Room Provision — Two Sprinklers Centered Between Sidewalls.

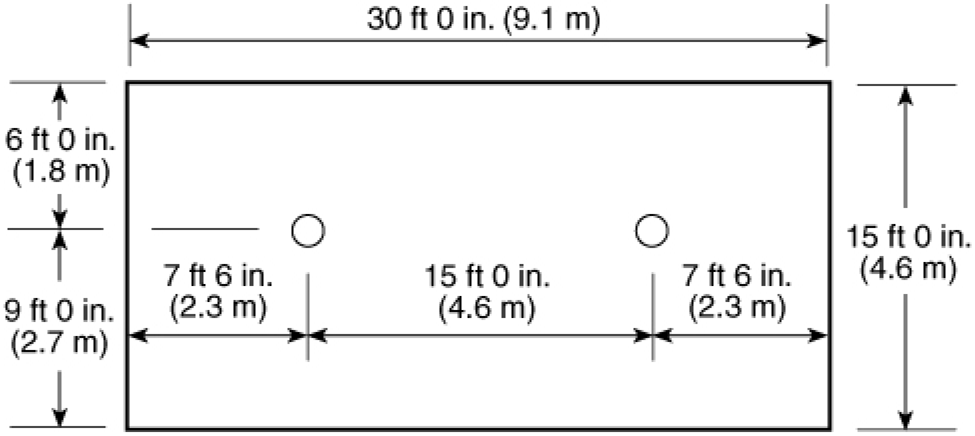


Figure A.10.2.6.2.3(c) Small Room Provision — Two Sprinklers Centered Between Top and Bottom Walls.

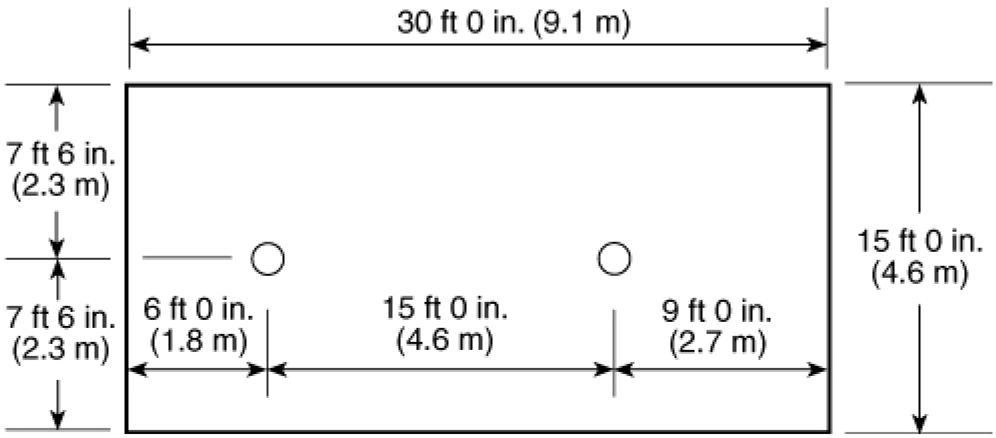
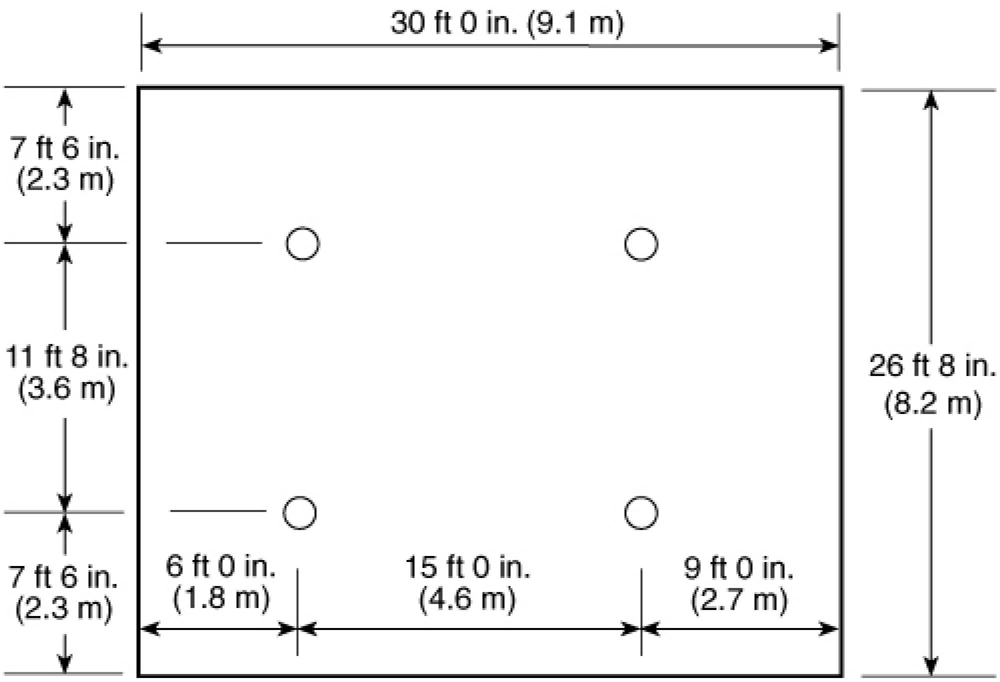


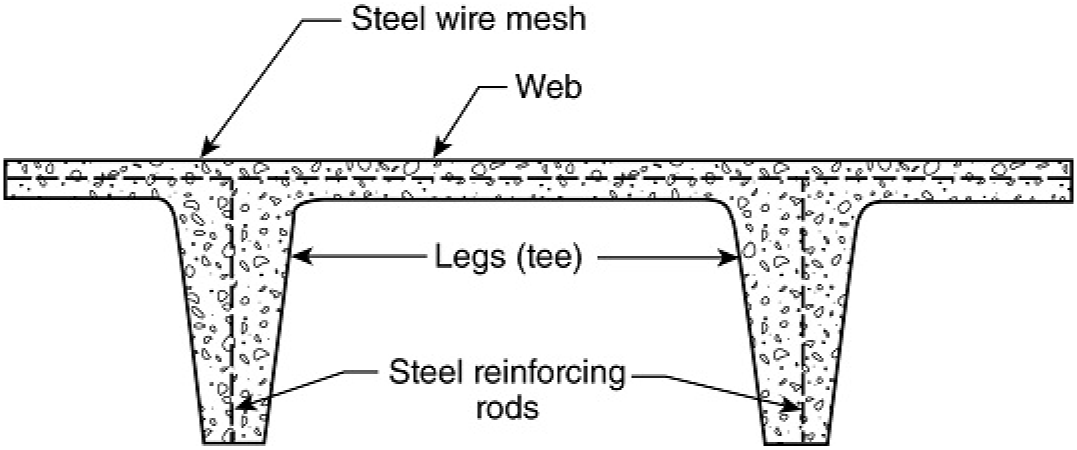
Figure A.10.2.6.2.3(d) Small Room Provision — Four Sprinklers.



A.10.2.7.1.2(5)

For concrete joists spaced less than 3 ft (900 mm) on center, the rules for obstructed construction shown in 10.2.7.1.2 apply. For concrete tee construction with stems spaced less than 7 ft 6 in. (2.3 m) on center, the sprinkler deflector can be located at or above a horizontal plane 1 in. (25 mm) below the bottom of the stems of the tees. This includes sprinklers located between the stems. [*See Figure A.10.2.7.1.2(5).*]

Figure A.10.2.7.1.2(5) Typical Concrete Joist Construction.



A.10.2.7.1.3.2

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 (900 mm) down the slope from the peak because of the effect of venting on sprinkler sensitivity.

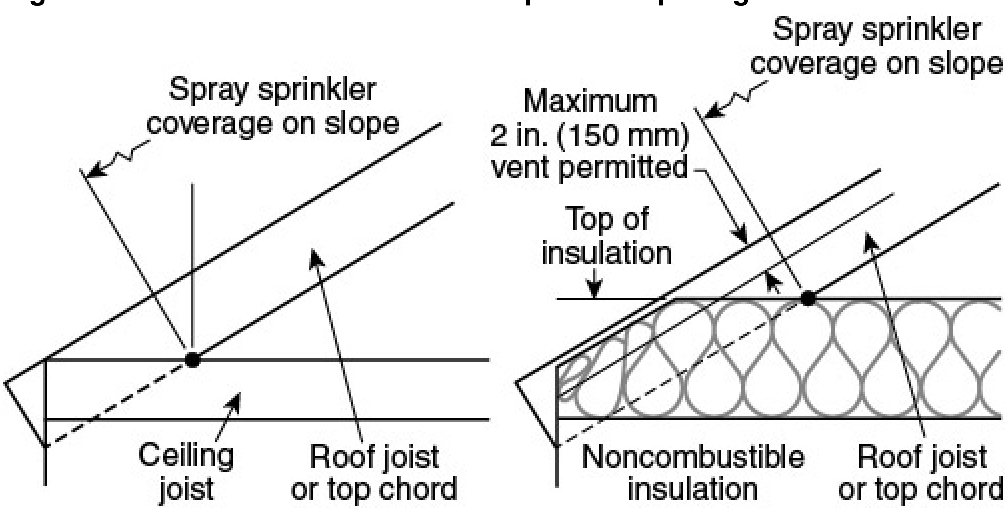
A.10.2.7.1.3.3

Generally, where applying the requirements of this section, a surface having a slope greater than or equal to 18 in 12 is needed.

A.10.2.7.1.4.3

Attic width and sprinkler spacing should be measured from the point of intersection between the bottom of the top cord of the roof joist or truss and the top of the ceiling joist or noncombustible insulation. *(See Figure A.10.2.7.1.4.3.)*

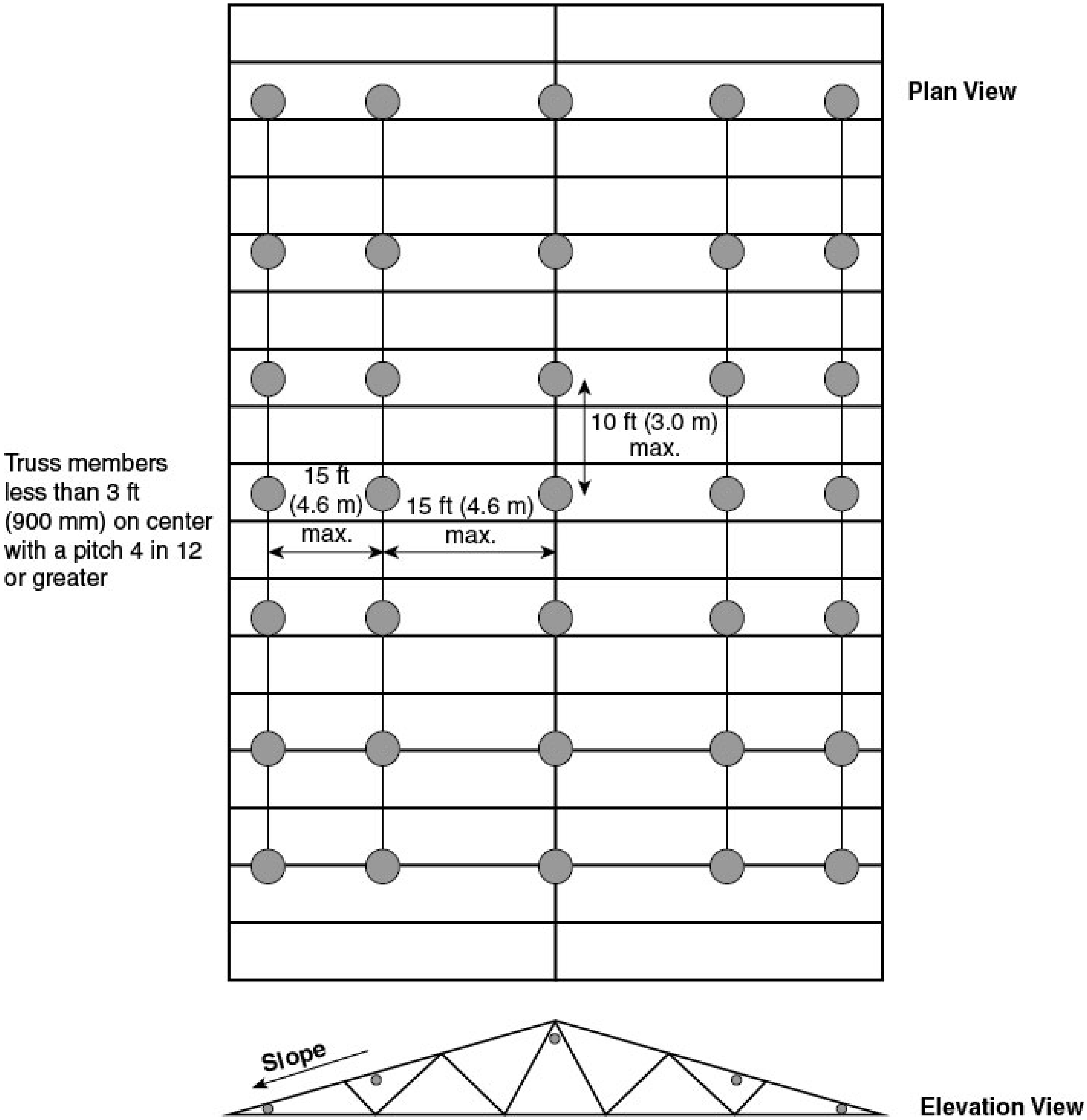
Figure A.10.2.7.1.4.3 Attic Width and Sprinkler Spacing Measurements.



A.10.2.7.1.4.4

See Figure A.10.2.7.1.4.4.

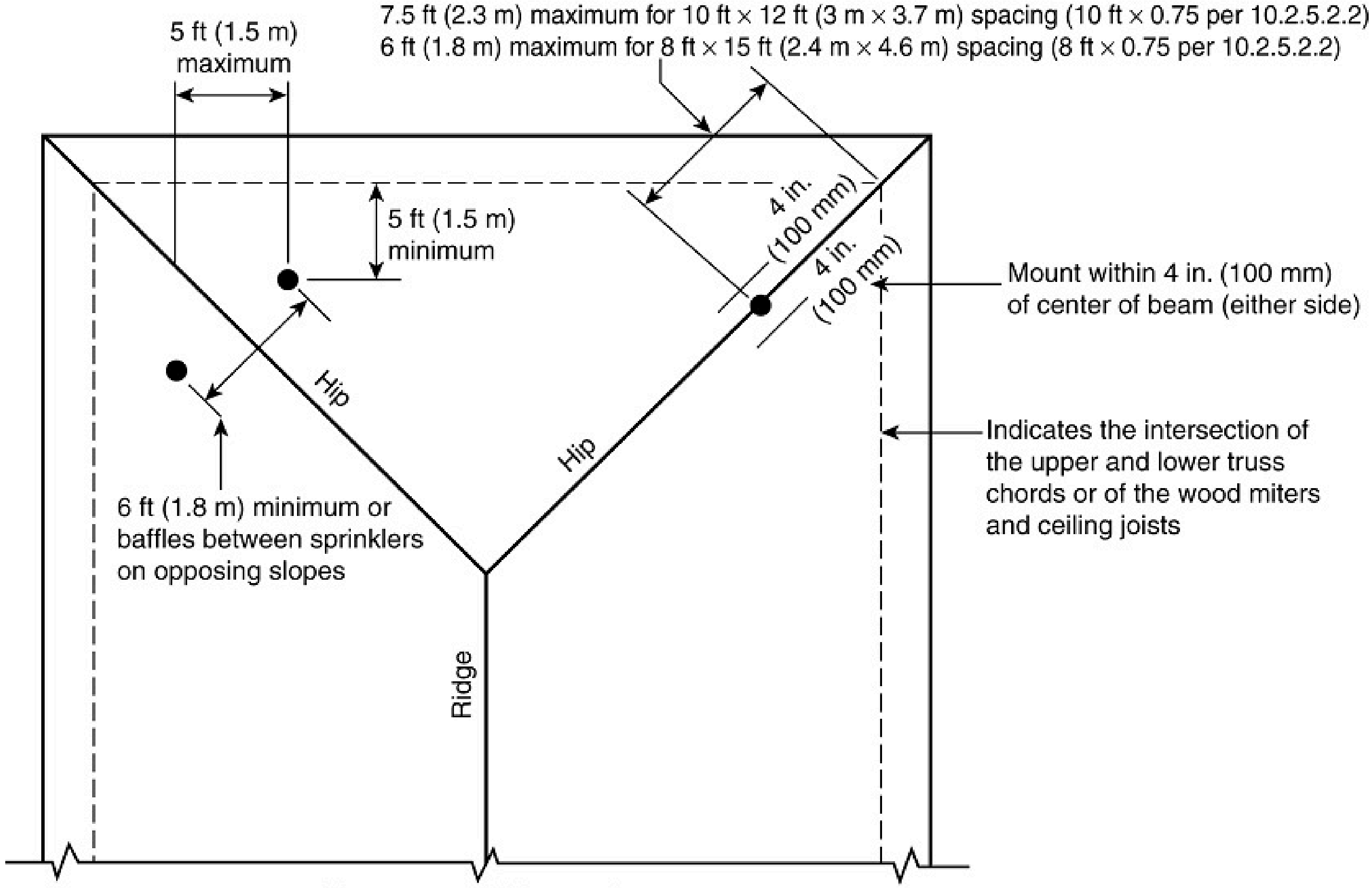
Figure A.10.2.7.1.4.4 Protection Area and Maximum Spacing of Sprinklers Under Sloped Roof.



A.10.2.7.1.4.5

See Figure A.10.2.7.1.4.5.

Figure A.10.2.7.1.4.5 Hip Roof Installations.



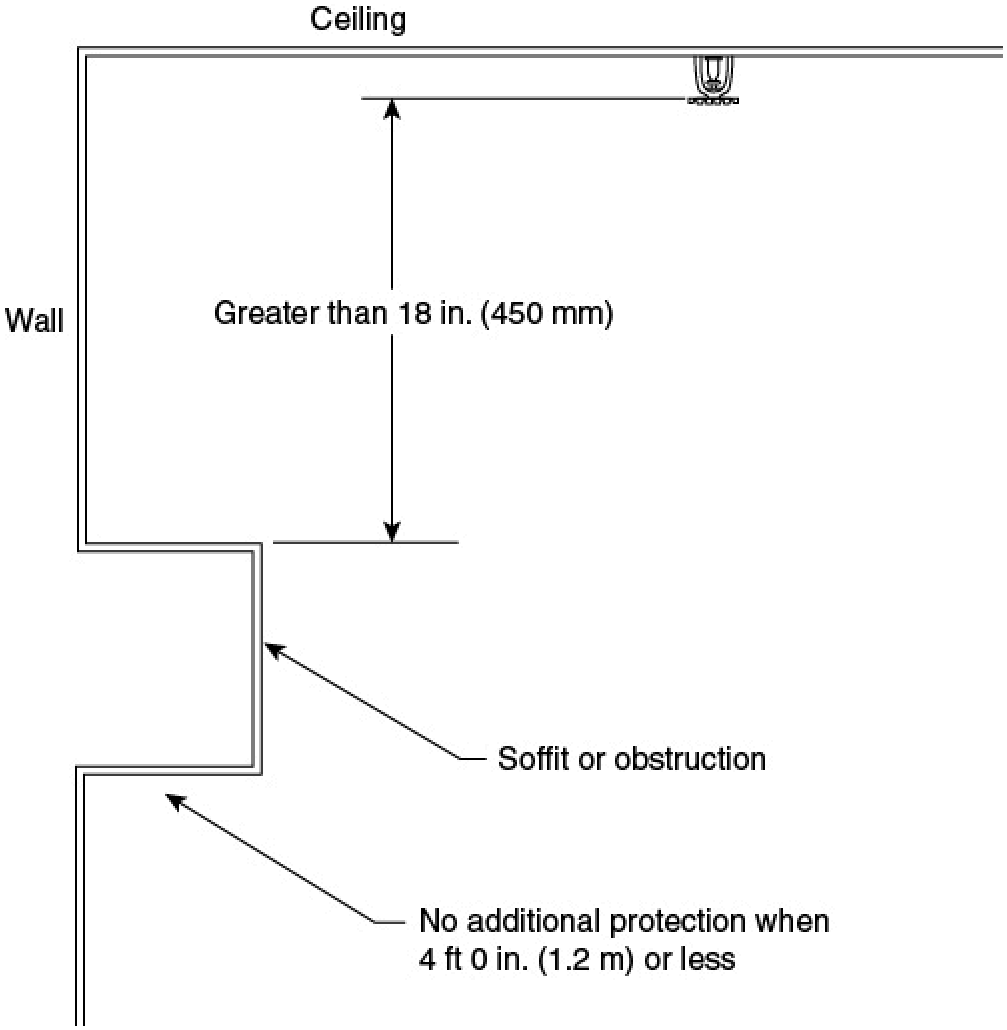
Hip corner sprinkler spacing

A.10.2.8.2

The intent of 10.2.8.2(3) is to apply to soffits that are located within the 18 in. (450 mm) plane from the sprinkler deflector. A soffit or other obstruction (i.e., shelf) located against a wall that is located entirely below the 18 in. (450 mm) plane from the sprinkler deflector should be in accordance with A.10.2.8.2. *(See Figure A.10.2.8.2.)*

The sprinkler should be located at least 4 in. (100 mm) away from the face of the soffit as if it were a wall.

Figure A.10.2.8.2 Soffit/Obstruction Against Wall Greater Than 18 in. (450 mm) Below Deflector.



A.10.2.8.3.1.3

It is often difficult to maintain the 18 in. (450 mm) clearance from the bottom of the deflector to items located in alcoves and under soffits (e.g., vending machines, file cabinets, bookcases, workstations). Given the small area in an alcove or under a soffit that has a limited protection area of 50 ft^2 (4.5 m^2) or less, the sprinkler will provide adequate coverage within these small spaces regardless of the lack of clearance as long as the deflector is at least 1 in. (25 mm) above the obstruction.

A.10.2.8.3.1.4

The rules of 10.2.8.3.1.4 (known as the Three Times Rule) have been written to apply to obstructions where the sprinkler can be expected to get water to both sides of the obstruction without allowing a significant shadow area on the other side of the obstruction. This works for small noncontinuous obstructions and for continuous obstructions where the sprinkler can throw water over and under the obstruction, such as the bottom chord of an open truss or joist. For solid continuous obstructions, such as a beam, the Three Times Rule is ineffective since the sprinkler cannot throw water over and under the obstruction. Sufficient water must be thrown under the obstruction to adequately cover the floor area on the other side of the obstruction. To ensure this, compliance with the rules of 10.2.8.2 is necessary.

A.10.2.8.3.1.11

The housing unit of the ceiling fan is expected to be addressed by the Three Times Rule.

A.10.2.8.3.2.2

Testing has shown that privacy curtains supported from the ceiling by mesh fabric do not obstruct the distribution pattern in a negative way as long as the mesh is 70 percent or more open and extends from the ceiling a minimum of 22 in. (550 mm).

A.10.2.9.1

The 18 in. (450 mm) clearance is not intended to apply to vehicles in parking structures.

A.10.2.10.1

Ceiling features in unobstructed construction that are protected by sprinklers in the lower ceiling elevation when the higher ceiling elevation is within 12 in. (300 mm) of the deflectors or greater for sprinklers with greater listed distances from the higher ceiling should not be considered unprotected ceiling pockets.

A.10.2.10.2(4)

It is the intent of this section to allow compartments with multiple pockets, where the cumulative volume of the pockets exceeds 1000 ft^3 (28 m^3) and separated from each other by 10 ft (3.05 m) or more and still be permitted to be unprotected because with these values, a sprinkler would be required between such pockets. For smaller pockets where the cumulative volume does not exceed 1000 ft^3 (28 m^3), there is no reason to separate the pockets by any specific distance because they are not worse than a single pocket that is 1000 ft^3 (28 m^3).

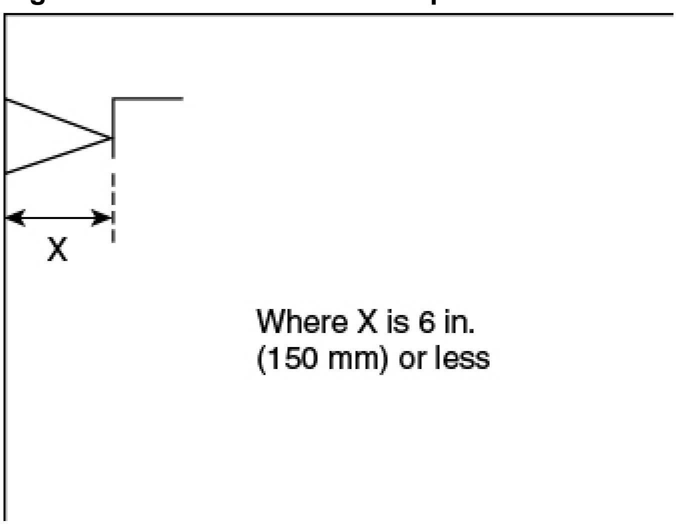
A.10.3.2(9)

Where sprinkler protection is provided under each level of cars, the ceiling sprinklers should be designed based upon the occupancy classification of parking garages. Not all car stackers or car lift systems will be able to have a sidewall sprinkler installed due to car stacker design or operation. The sidewall sprinklers must be installed meeting the requirements in the body of the standard including 9.5.5.3.2.3. A performance-based design is allowed with proper documentation to show equivalent protection. If the car stacker or car lift system design and/or operation prohibits the coverage under the cars, then the overhead system would be required to be designed to Extra Hazard Group 2 occupancy classification *[see A.4.3.4.2(9)]*.

A.10.3.5.1.2.1

The 6 in. (150 mm) as referenced is measured from the wall to the vertical plane representing the surface of attachment of the deflector. See Figure A.10.3.5.1.2.1.

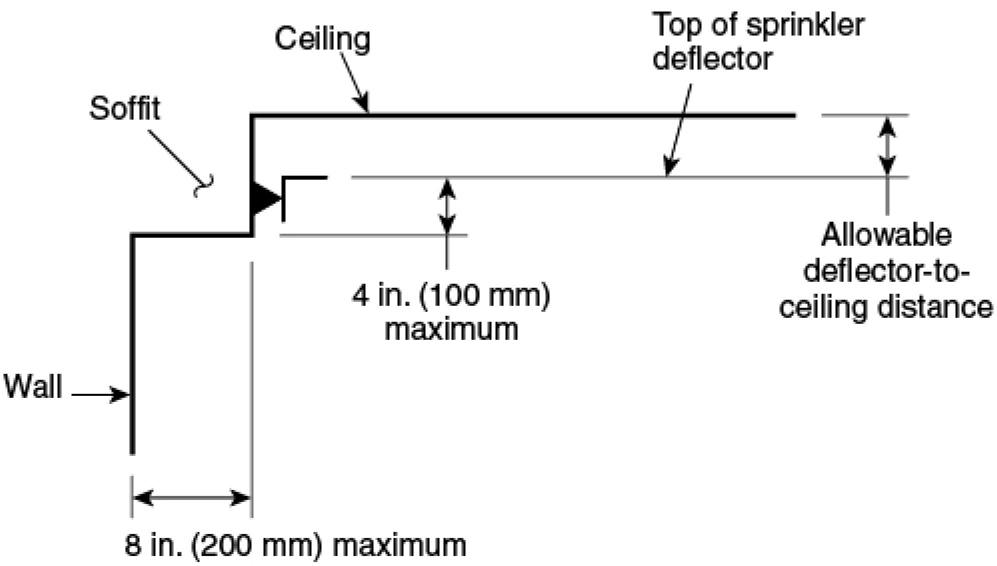
Figure A.10.3.5.1.2.1 Sidewall Sprinkler Deflector Measurement From Walls.



A.10.3.5.1.3.2

See Figure A.10.3.5.1.3.2.

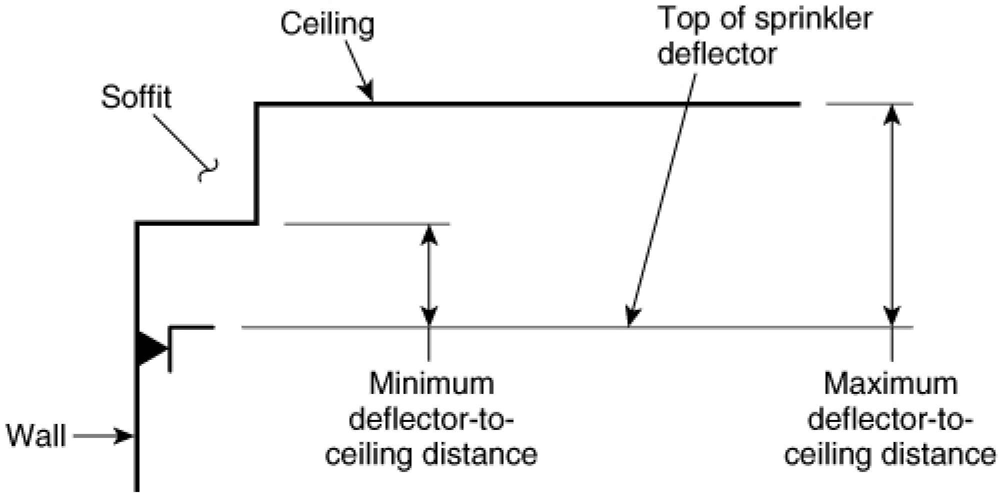
Figure A.10.3.5.1.3.2 Location Sidewalls with Respect to Soffits — Sidewall in Soffit.



A.10.3.5.1.3.3

See Figure A.10.3.5.1.3.3.

Figure A.10.3.5.1.3.3 Location Sidewalls with Respect to Soffits — Sidewall Under Soffit.



A.10.3.5.1.4

The requirements in 10.3.5.1.4 were developed from years of experience with NFPA 13 obstruction requirements and an additional test series conducted by the National Fire Sprinkler Association with the help of Tyco International (Valentine and Isman, *Kitchen Cabinets and Residential Sprinklers*, National Fire Sprinkler Association, November 2005), which included fire modeling, distribution tests, and full-scale fire tests. The test series showed that pendent sprinklers definitely provide protection for kitchens, even for fires that start under the cabinets. The information in the series was less than definitive for sidewall sprinklers, but distribution data show that sprinklers in the positions in this standard provide adequate water distribution in front of the cabinets and that sidewall sprinklers should be able to control a fire that starts under the cabinets. When protecting kitchens or similar rooms with cabinets, the pendent sprinkler should be the first option. If pendent sprinklers cannot be installed, the next best option is a sidewall sprinkler on the opposite wall from the cabinets, spraying in the direction of the cabinets. The third best option is the sidewall sprinkler on the same wall as the cabinets, on a soffit flush with the face of the cabinet. The last option should be putting sprinklers on the wall back behind the face of the cabinet because this location is subject to being blocked by items placed on top of the cabinets. It is not the intent of the committee to require sprinklers under kitchen cabinets.

A.10.3.6.2.1.3

The rules of 10.3.6.2.1.3 (known as the Three Times Rule) have been written to apply to obstructions where the sprinkler can be expected to get water to both sides of the obstruction without allowing a significant shadow area on the other side of the obstruction. This works for small noncontinuous obstructions and for continuous obstructions where the sprinkler can throw water over and under the obstruction, such as the bottom chord of an open truss or joist. For solid continuous obstructions, such as a beam, the Three Times Rule is ineffective since the sprinkler cannot throw water over and under the obstruction. Sufficient water must be thrown under the obstruction to adequately cover the floor area on the other side of the obstruction. To ensure this, compliance with the rules of 10.3.6.1.2 is necessary.

A.10.3.6.2.1.6

The housing unit of the ceiling fan is expected to be addressed by the Three Times Rule.

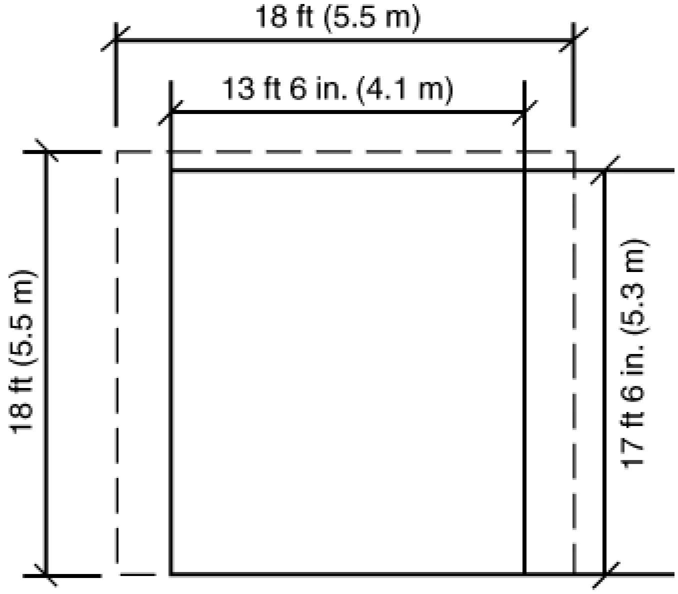
A.10.3.6.2.2.1

Testing has shown that privacy curtains supported from the ceiling by mesh fabric do not obstruct the distribution pattern in a negative way as long as the mesh is 70 percent or more open and extends from the ceiling a minimum of 22 in. (550 mm).

A.11.2.2.1

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 (0.6 m) increments up to 20 ft (6.1 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. (4.1 m) wide and 17 ft 6 in. (5.3 m) long as indicated in Figure A.11.2.2.1, a sprinkler that is listed to protect an area of 18 ft × 18 ft (5.5 m × 5.5 m) must be selected. The flow used in the calculations is then selected as the flow required by the listing for the selected coverage.

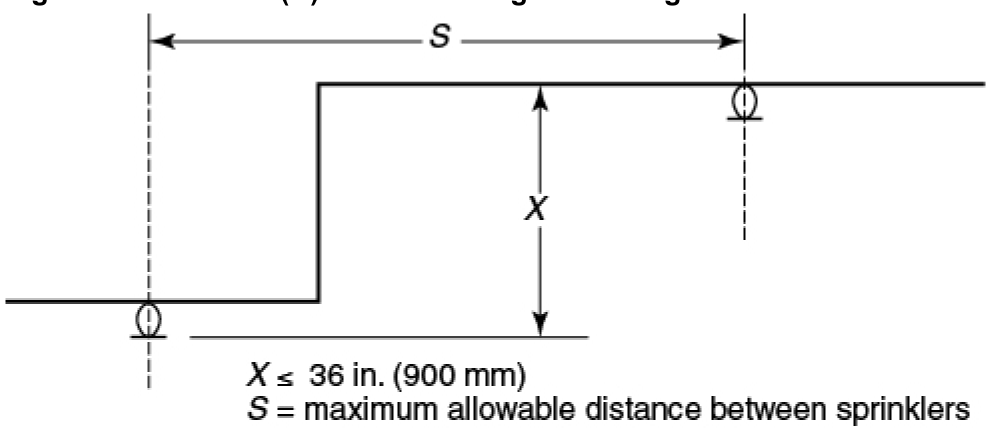
Figure A.11.2.2.1 Determination of Protection Area of Coverage for Extended Coverage Upright and Pendent Sprinklers.



A.11.2.4.1.1.4(A)

See Figure A.11.2.4.1.1.4(A).

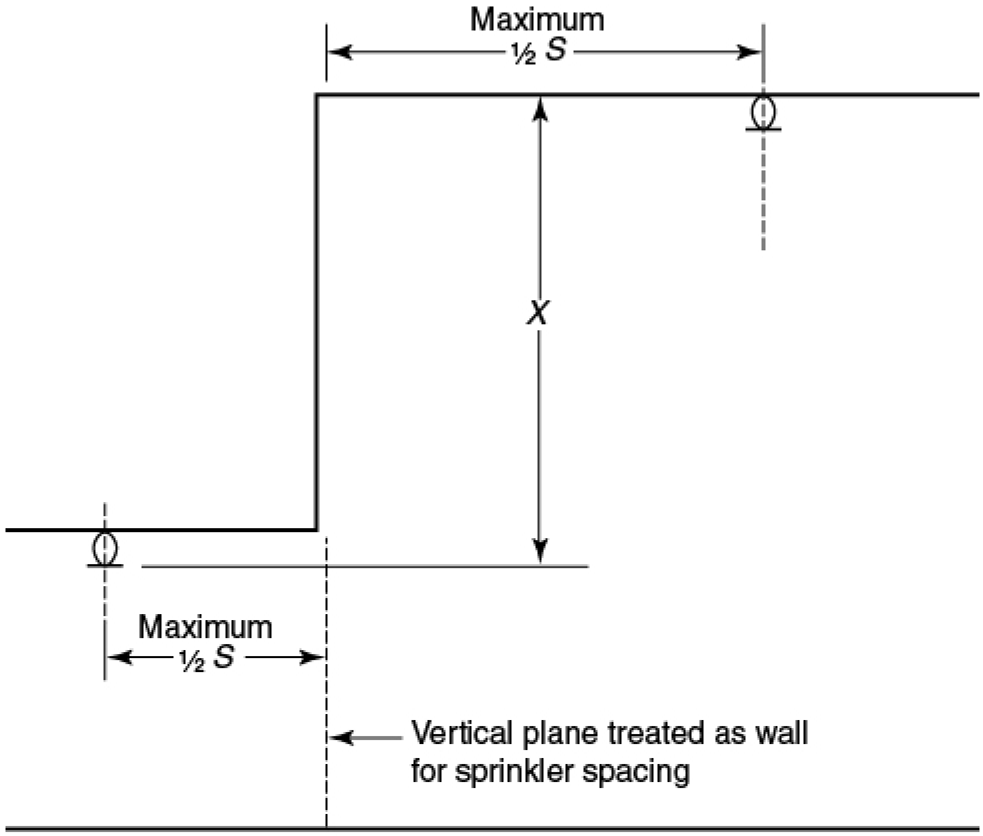
Figure A.11.2.4.1.1.4(A) Vertical Change in Ceiling Elevation Less Than or Equal to 36 in. (900 mm).



A.11.2.4.1.1.4(B)

See Figure A.11.2.4.1.1.4(B).

Figure A.11.2.4.1.1.4(B) Vertical Change in Ceiling Elevation Greater Than 36 in. (900 mm).



X > 36 in. (900 mm)
S = maximum allowable distance between sprinklers

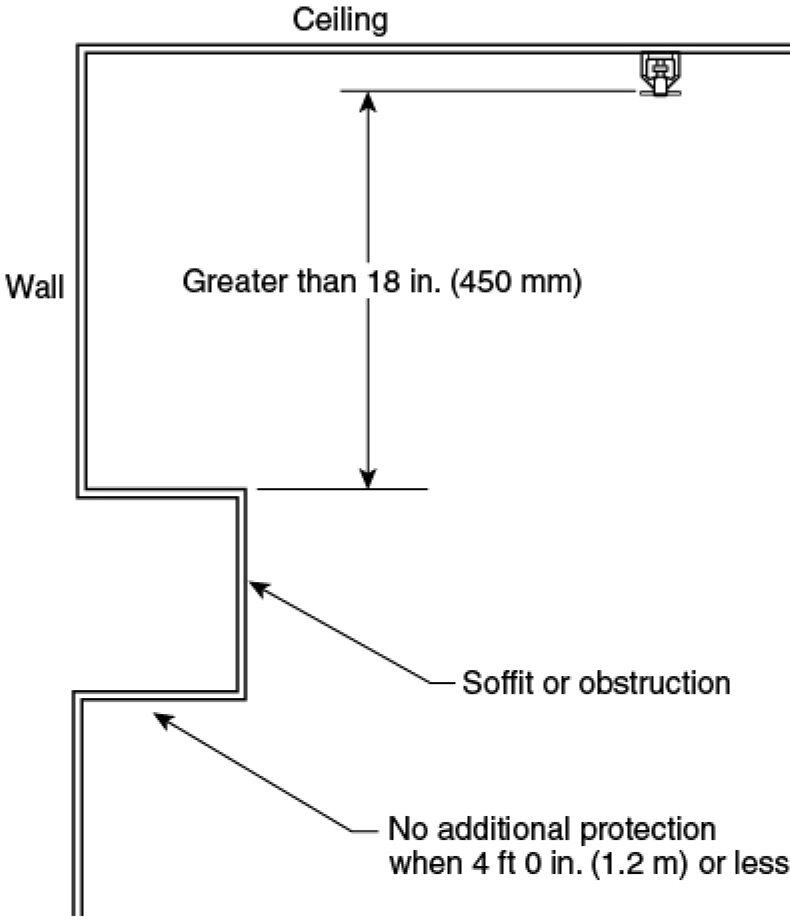
A.11.2.4.1.3

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 (900 mm) down the slope from the peak because of the effect of venting on sprinkler sensitivity.

A.11.2.5.1.2

The intent of 11.2.5.1.2(3) is to apply to soffits that are located within the 18 in. (450 mm) plane from the sprinkler deflector. A soffit or other obstruction (i.e., shelf) located against a wall that is located entirely below the 18 in. (450 mm) plane from the sprinkler deflector should be in accordance with 9.5.5.3. *(See Figure A.11.2.5.1.2.)*

Figure A.11.2.5.1.2 Soffit/Obstruction Against Wall Greater Than 18 in. (450 mm) Below Deflector.



A.11.2.5.2.1.3

The rules of 11.2.5.2.1.3 (known as the Four Times Rule) have been written to apply to obstructions where the sprinkler can be expected to get water to both sides of the obstruction without allowing a significant shadow area on the other side of the obstruction. This works for small noncontinuous obstructions and for continuous obstructions where the sprinkler can throw water over and under the obstruction, such as the bottom chord of an open truss or joist. For solid continuous obstructions, such as a beam, the Four Times Rule is ineffective since the sprinkler cannot throw water over and under the obstruction. Sufficient water must be thrown under the obstruction to adequately cover the floor area on the other side of the obstruction. To ensure this, compliance with the rules of 11.2.5.1.2 is necessary.

A.11.2.5.2.1.9

The housing unit of the ceiling fan is expected to be addressed by the Four Times Rule.

A.11.2.5.2.2.1

Testing has shown that privacy curtains supported from the ceiling by mesh fabric do not obstruct the distribution pattern in a negative way as long as the mesh is 70 percent or more open and extends from the ceiling a minimum of 22 in. (550 mm).

A.11.2.6.1

The 18 in. (450 mm) does not apply to vehicles in parking structures.

A.11.2.7.1

Ceiling features in unobstructed construction that are protected by sprinklers in the lower ceiling elevation when the higher ceiling elevation is within 12 in. (300 mm) of the deflectors or greater for sprinklers with greater listed distances from the higher ceiling should not be considered unprotected ceiling pockets.

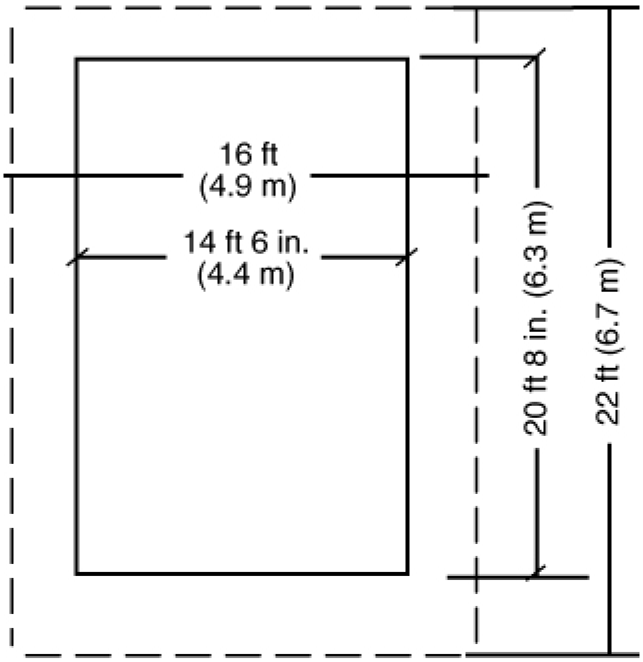
A.11.2.7.2(4)

It is the intent of this section to allow compartments with multiple pockets, where the cumulative volume of the pockets exceeds 1000 ft^3 (28 m^3) and separated from each other by 10 ft (3 m) or more and still be permitted to be unprotected because with these values, a sprinkler would be required between such pockets. For smaller pockets where the cumulative volume does not exceed 1000 ft^3 (28 m^3), there is no reason to separate the pockets by any specific distance because they are not worse than a single pocket that is 1000 ft^3 (28 m^3).

A.11.3.3.1

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 (0.6 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. (4.4 m) wide and 20 ft 8 in. (6.3 m) long as indicated in Figure A.11.3.3.1, a sprinkler that is listed to protect an area of 16 ft × 22 ft (4.9 m × 6.7 m) must be selected. The flow used in the calculations is then selected as the flow required by the listing for the selected coverage.

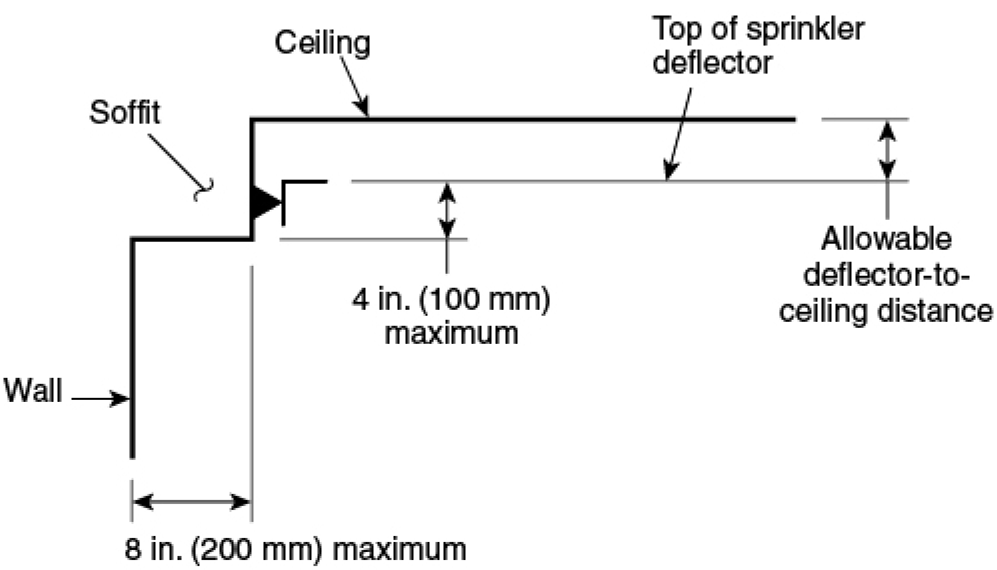
Figure A.11.3.3.1 Determination of Protection Area of Coverage for Extended Coverage Sidewall Sprinklers.



A.11.3.5.1.3.1

See Figure A.11.3.5.1.3.1.

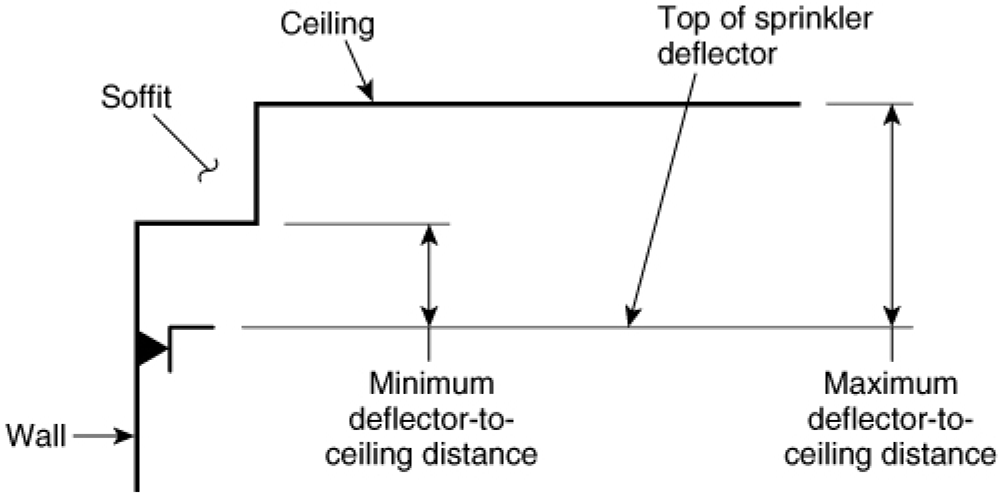
Figure A.11.3.5.1.3.1 Location of Extended Coverage Sidewalls with Respect to Soffits — Sidewall in Soffit.



A.11.3.5.1.3.2

See Figure A.11.3.5.1.3.2.

Figure A.11.3.5.1.3.2 Location of Extended Coverage Sidewalls with Respect to Soffits — Sidewall Under Soffit.



A.11.3.5.1.4

The requirements in 11.3.5.1.4 were developed from years of experience with NFPA 13 obstruction requirements and an additional test series conducted by the National Fire Sprinkler Association with the help of Tyco International (Valentine and Isman, *Kitchen Cabinets and Residential Sprinklers*, National Fire Sprinkler Association, November 2005), which included fire modeling, distribution tests, and full-scale fire tests. The test series showed that pendent sprinklers definitely provide protection for kitchens, even for fires that start under the cabinets. The information in the series was less than definitive for sidewall sprinklers, but distribution data show that sprinklers in the positions in this standard provide adequate water distribution in front of the cabinets and that sidewall sprinklers should be able to control a fire that starts under the cabinets. When protecting kitchens or similar rooms with cabinets, the pendent sprinkler should be the first option. If pendent sprinklers cannot be installed, the next best option is a sidewall sprinkler on the opposite wall from the cabinets, spraying in the direction of the cabinets. The third best option is the sidewall sprinkler on the same wall as the cabinets, on a soffit flush with the face of the cabinet. The last option should be putting sprinklers on the wall back behind the face of the cabinet because this location is subject to being blocked by items placed on top of the cabinets. It is not the intent of the committee to require sprinklers under kitchen cabinets.

A.11.3.6.2.1.3

The rules of 11.3.6.2.1.3 (known as the Four Times Rule) have been written to apply to obstructions where the sprinkler can be expected to get water to both sides of the obstruction without allowing a significant shadow area on the other side of the obstruction. This works for small noncontinuous obstructions and for continuous obstructions where the sprinkler can throw water over and under the obstruction, such as the bottom chord of an open truss or joist. For solid continuous obstructions, such as a beam, the Four Times Rule is ineffective since the sprinkler cannot throw water over and under the obstruction. Sufficient water must be thrown under the obstruction to adequately cover the floor area on the other side of the obstruction. To ensure this, compliance with the rules of 11.3.6.1.2 is necessary.

A.11.3.6.2.1.6

The housing unit of the ceiling fan is expected to be addressed by the Four Times Rule.

A.11.3.6.2.2.1

Testing has shown that privacy curtains supported from the ceiling by mesh fabric do not obstruct the distribution pattern in a negative way as long as the mesh is 70 percent or more open and extends from the ceiling a minimum of 22 in. (550 mm).

A.11.3.6.3

When obstructions are located more than 18 in. (450 mm) below the sprinkler deflector, an adequate spray pattern develops and obstructions up to and including 4 ft (1200 mm) wide do not require additional protection underneath. Examples are ducts, decks, open grate flooring, catwalks, cutting tables, overhead doors, soffits, ceiling panels, and other similar obstructions.

A.12.1.1

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 increments from 12 ft to 20 ft (3.7 m to 6.1 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. (4.1 m) wide and 17 ft 6 in. (5.3 m) long, a sprinkler that is listed to protect a rectangular area of 14 ft × 18 ft (4.3 m × 5.5 m) or a square area of 18 ft × 18 ft (5.5 m × 5.5 m) must be selected. The flow used in the calculations is then selected as the flow required by the listing for the selected coverage.

Residential sprinklers can be used in corridors that lead to dwelling units. However, the corridors that lead to dwelling units can also lead to other hazards that are not dwelling units and can still be protected with residential sprinklers. An example would be in a hotel occupancy where the corridor immediately leading to the guest rooms also has doors to rooms such as conference rooms, housekeeping closets, laundry rooms, back of house offices, and so forth.

A.12.1.6

Residential sprinklers should be used in compliance with their listing limits. Where there are no listed residential sprinklers for a particular arrangement, other design approaches from NFPA 13 should be utilized, such as using quick-response sprinklers.

A.12.1.10.2.1.3

The rules of 12.1.10.2.1.3 (known as the Four Times Rule) have been written to apply to obstructions where the sprinkler can be expected to get water to both sides of the obstruction without allowing a significant shadow area on the other side of the obstruction. This works for small noncontinuous obstructions and for continuous obstructions where the sprinkler can throw water over and under the obstruction, such as the bottom chord of an open truss or joist. For solid continuous obstructions, such as a beam, the Four Times Rule is ineffective since the sprinkler cannot throw water over and under the obstruction. Sufficient water must be thrown under the obstruction to adequately cover the floor area on the other side of the obstruction. To ensure this, compliance with the rules of 12.1.10.1.2 is necessary.

A.12.1.10.2.1.9

The housing unit of the ceiling fan is expected to be addressed by the Three Times Rule or the Four Times Rule.

A.12.1.10.2.3

See A.9.1.1(3), Figure A.9.1.1(3)(a), and Figure A.9.1.1(3)(b).

A.12.1.11.1.5

The requirements in 12.1.11.1.5 were developed from years of experience with NFPA 13 obstruction requirements and an additional test series conducted by the National Fire Sprinkler Association with the help of Tyco International (Valentine and Isman, *Kitchen Cabinets and Residential Sprinklers*, National Fire Sprinkler Association, November 2005), which included fire modeling, distribution tests, and full-scale fire tests. The test series showed that pendent sprinklers definitely provide protection for kitchens, even for fires that start under the cabinets. The information in the series was less than definitive for sidewall sprinklers, but distribution data shows that sprinklers in the positions in this standard provide adequate water distribution in front of the cabinets and that sidewall sprinklers should be able to control a fire that starts under the cabinets. When protecting kitchens or similar rooms with cabinets, the pendent sprinkler should be the first option. If pendent sprinklers cannot be installed, the next best option is a sidewall sprinkler on the opposite wall from the cabinets, spraying in the direction of the cabinets. The third best option is the sidewall sprinkler on the same wall as the cabinets on a soffit flush with the face of the cabinet. The last option should be putting sprinklers on the wall back behind the face of the cabinet because this location is subject to being blocked by items placed on top of the cabinets. It is not the intent of the committee to require sprinklers under kitchen cabinets.

A.12.1.11.2.1.3

The rules of 12.1.11.2.1.3 (known as the Four Times Rule) have been written to apply to obstructions where the sprinkler can be expected to get water to both sides of the obstruction without allowing a significant shadow area on the other side of the obstruction. This works for small noncontinuous obstructions and for continuous obstructions where the sprinkler can throw water over and under the obstruction, such as the bottom chord of an open truss or joist. For solid continuous obstructions, such as a beam, the Four Times Rule is ineffective since the sprinkler cannot throw water over and under the obstruction. Sufficient water must be thrown under the obstruction to adequately cover the floor area on the other side of the obstruction. To ensure this, compliance with the rules of 12.1.10.1.2 is necessary.

A.12.1.11.2.1.7

The housing unit of the ceiling fan is expected to be addressed by the Four Times Rule.

A.12.1.11.2.2

Floor-mounted obstructions can be parallel or perpendicular to the wall with the sidewall sprinkler.

A.13.2.4

Tests involving areas of coverage over 100 ft^2 (9 m^2) for CMSA sprinklers are limited in number, and use of areas of coverage over 100 ft^2 (9 m^2) should be carefully considered.

A.13.2.5.1

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.13.2.5.4.2

Sprinklers within the same beam channel should be spaced based on the minimum spacing permitted.

A.13.2.6.1

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. (175 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. (175 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. (175 mm). For open wood joist construction, the optimum clearance between deflectors and the bottom of joists is $3\frac{1}{2}$ in. (90 mm).

A.13.2.7

To a great extent, CMSA 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.13.2.7.2.1

The obstruction rules are essentially the same for CMSA and ESFR sprinklers other than 13.2.7.2.2. Even though Chapter 13 covers CMSA sprinklers, the user is directed to Chapter 14 for the other obstruction rules.

A.13.2.7.2.2

The rules of 13.2.7.2.2 (known as the Three Times Rule) have been written to apply to obstructions (e.g., webs and chord members, pipe, columns, and fixtures) where the sprinkler can be expected to get water to both sides of the obstruction without allowing a significant shadow area on the other side of the obstruction. This works for small noncontinuous obstructions and for continuous obstructions where the sprinkler can throw water over and under the obstruction, such as the bottom chord of an open truss or joist. For solid continuous obstructions, such as a beam, the Three Times Rule is ineffective since the sprinkler cannot throw water over and under the obstruction to adequately cover the floor area on the other side of the obstruction. To ensure this, compliance with the rules of 14.2.10.2 is necessary.

A.14.2.6

It is not the intent of this section to allow ESFR sprinklers to be adjusted to light or ordinary spacing criteria. However, it does allow flexibility for spacing to walls, when walls are added to create light or ordinary hazard areas to existing ESFR systems.

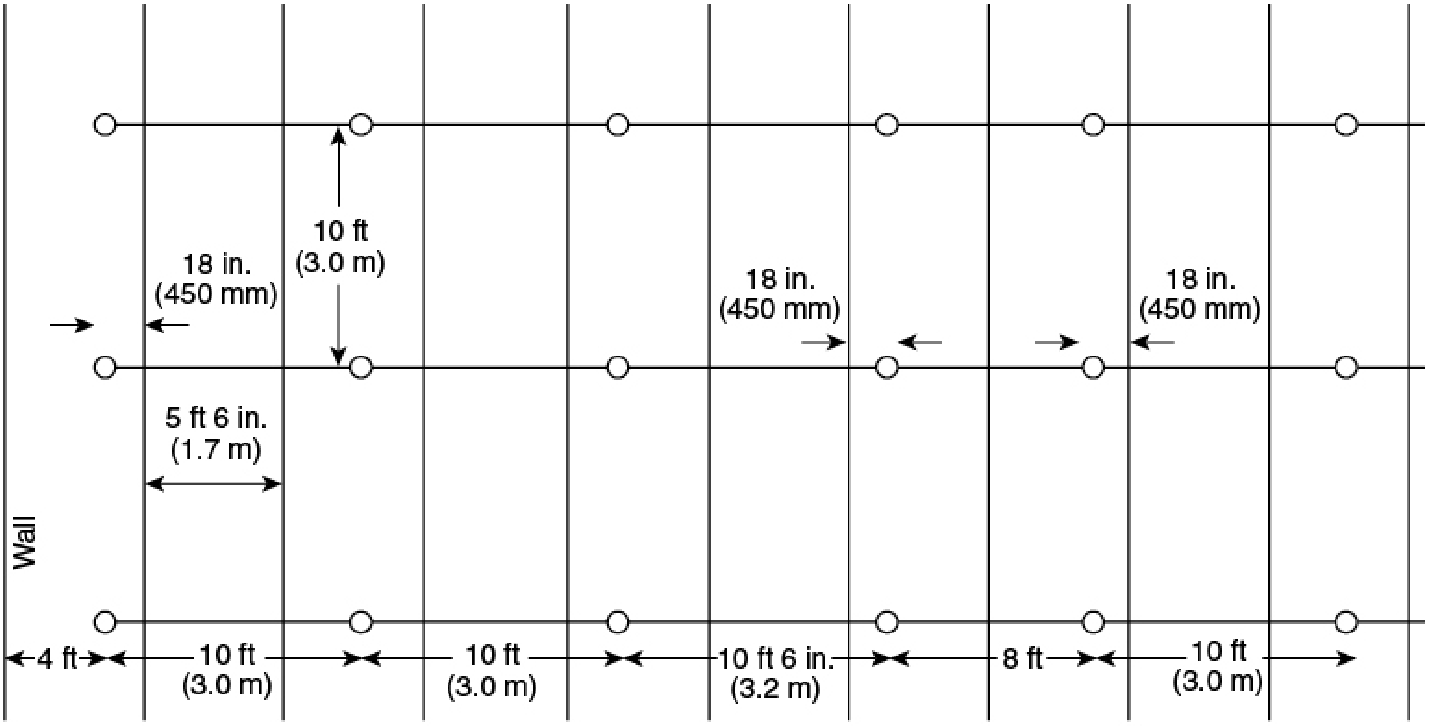
A.14.2.7.2.1

Storage in single-story or multistory buildings can be permitted, provided the maximum ceiling/roof height as specified in Table 14.2.7.2.1 is satisfied for each storage area.

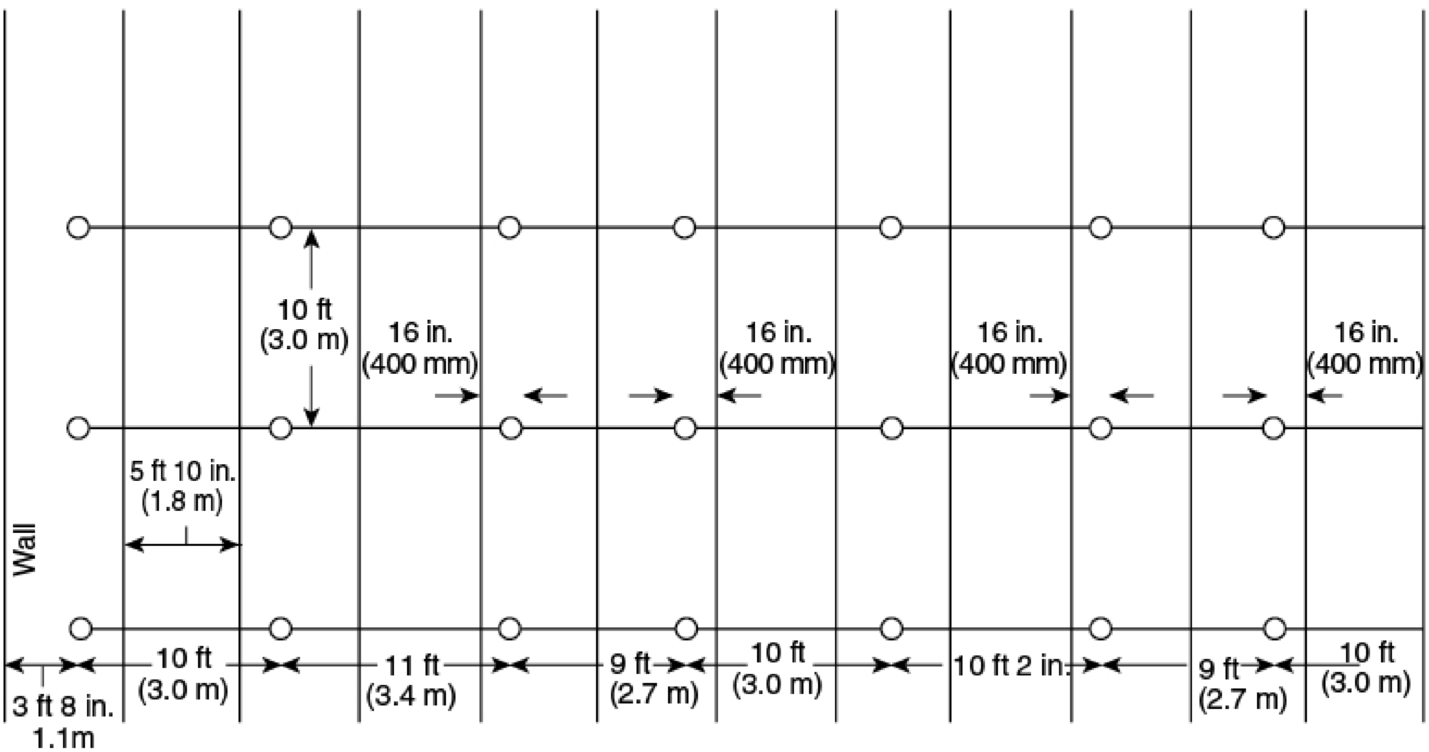
A.14.2.7.2.3

See Figure A.14.2.7.2.3.

Figure A.14.2.7.2.3 ESFR Sprinkler Spacing Within Trusses and Bar Joists.



Example 1 of ESFR "Shift" Rule (bar joists or trusses 5 ft 6 in. (1.7 m) o.c.)
Measurement shown is from centerline for ease of illustration; actual measurement to obstruction is to near edge of structural member.



Example 2 of ESFR "Shift" Rule (bar joists or trusses 5 ft 10 in. o.c.)
Measurement shown is from centerline for ease of illustration; actual measurement to obstruction is to near edge of structural member.

A.14.2.7.3.1

Examples of solid structural members are beams, stem, and so forth.

A.14.2.8.4.1

Examples of solid structural members are beams, stem, and so forth.

A.14.2.10

The obstruction rules of 14.2.10 have been primarily written to address horizontal obstructions like ducts and lights where the sprinkler needs to spray under the obstruction or get water both over and under the obstruction. For vertical obstruction situations like columns where the water needs to get to two sides of the obstruction, the guidance in 14.2.10 to keep the sprinklers at least 12 in. (300 mm) from obstructions up to 12 in. (300 mm) wide and to keep the sprinkler 24 in. (600 mm) from obstructions over 12 in. (300 mm) to 24 in. (600 mm) wide can be used. For obstructions like columns that are more than 24 in. (600 mm) wide, a sprinkler should be placed on the opposite side of the obstruction while following the minimum and maximum spacing requirements of 14.2.7.

A.14.2.10.1.3

Examples of high-piled storage are rack structures and solid-piled storage.

A.14.2.10.3.2

For example, a 1 in. (25 mm) diameter conduit would need to be 3 in. (75 mm) from the nearest pipe or conduit to be considered as an individual obstruction. Otherwise, the pipes and/or conduits would be considered as a group when applying the obstruction criteria in 14.2.10.3.1.

A.14.2.10.3.5.1

The installation of supplemental sprinklers below non-flat or non-solid obstructions using linear spacing that is less than the required minimum spacing indicated for the sprinkler is acceptable for this application. This is due to the lack of heat collection under the obstruction. As a result, the intent of the close spacing of the supplemental sprinklers is to allow the sprinkler closest to the point of fire origin to operate in a timely fashion, similar to an in-rack sprinkler, and provide the amount of sprinkler discharge needed to the fire area below the obstruction in order to obtain either fire control or fire suppression. As a result, sprinkler skipping due to the close spacing of these sprinklers is not a concern.

A.15.1.3

Automatic systems using open sprinklers or open nozzles are reliant on the separate detection system installed in the appropriate range from the ceiling that collects the heat or byproducts produced by the fire. The sprinklers or nozzles still need to be arranged for appropriate coverage of the hazard and with respect to any obstructions so that the spray pattern can develop and reach the hazard.

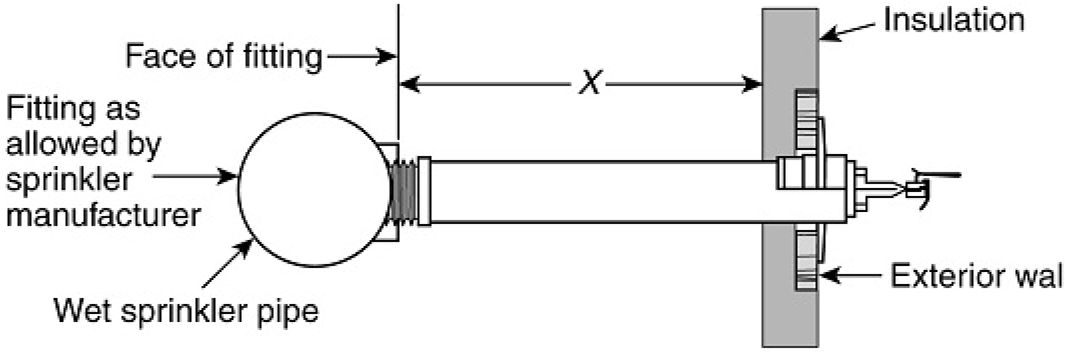
A.15.2.4

The development and use of test data to evaluate special use conditions at an approved testing laboratory that evaluate the performance of listed sprinklers under special use conditions can be used as a basis to demonstrate the equivalency of a proposed usage.

A.15.3.1

Dry sprinklers must be of sufficient length to avoid freezing of the water-filled pipes due to conduction along the barrel. The values of exposed barrel length in Table 15.3.1(a) and Table 15.3.1(b) have been developed using an assumption of a properly sealed penetration and an assumed maximum wind velocity on the exposed sprinkler of 30 mph (48 km/h). Where higher wind velocity is expected, longer exposed barrel lengths will help avoid freezing of the wet piping. The total length of the barrel of the dry sprinkler must be longer than the values shown in Table 15.3.1(a) and Table 15.3.1(b) because the length shown in the tables is the minimum length of the barrel that needs to be exposed to the warmer ambient temperature in the heated space. See Figure A.15.3.1(a), Figure A.15.3.1(c), and Figure A.15.3.1(e) for examples of where to measure the exposed barrel length for a sidewall sprinkler penetrating an exterior wall and Figure A.15.3.1(b) and Figure A.15.3.1(d) for examples of where to measure the exposed barrel length for a pendent sprinkler penetrating a ceiling or top of a freezer.

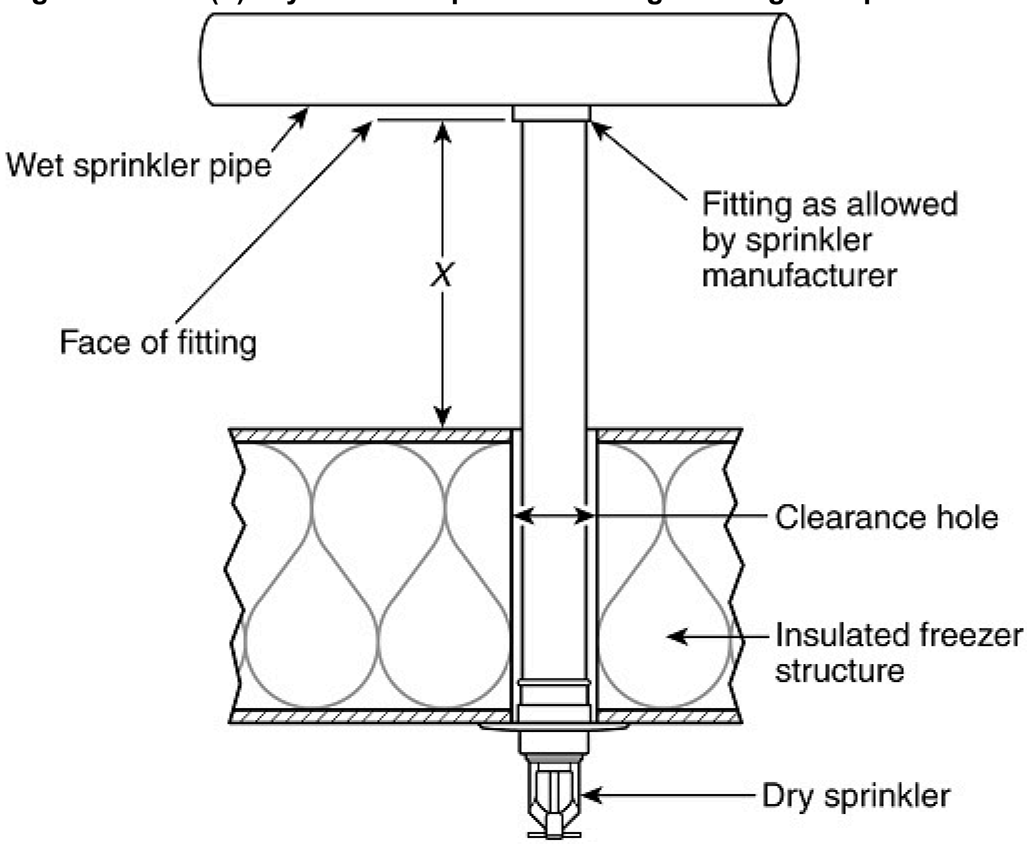
Figure A.15.3.1(a) Dry Sidewall Sprinkler Through Wall.



X = Minimum exposed barrel length

X is measured from the face of the sprinkler fitting
to the inside surface of the exterior wall or insulation —
whichever is closer to the fitting.

Figure A.15.3.1(b) Dry Pendent Sprinkler Through Ceiling or Top of Freezer.



X = Minimum exposed barrel length

X is measured from the face of the sprinkler fitting
to the inside surface of the exterior wall or insulation —
whichever is closer to the fitting.

Figure A.15.3.1(c) Dry Sidewall Sprinkler Through Wall

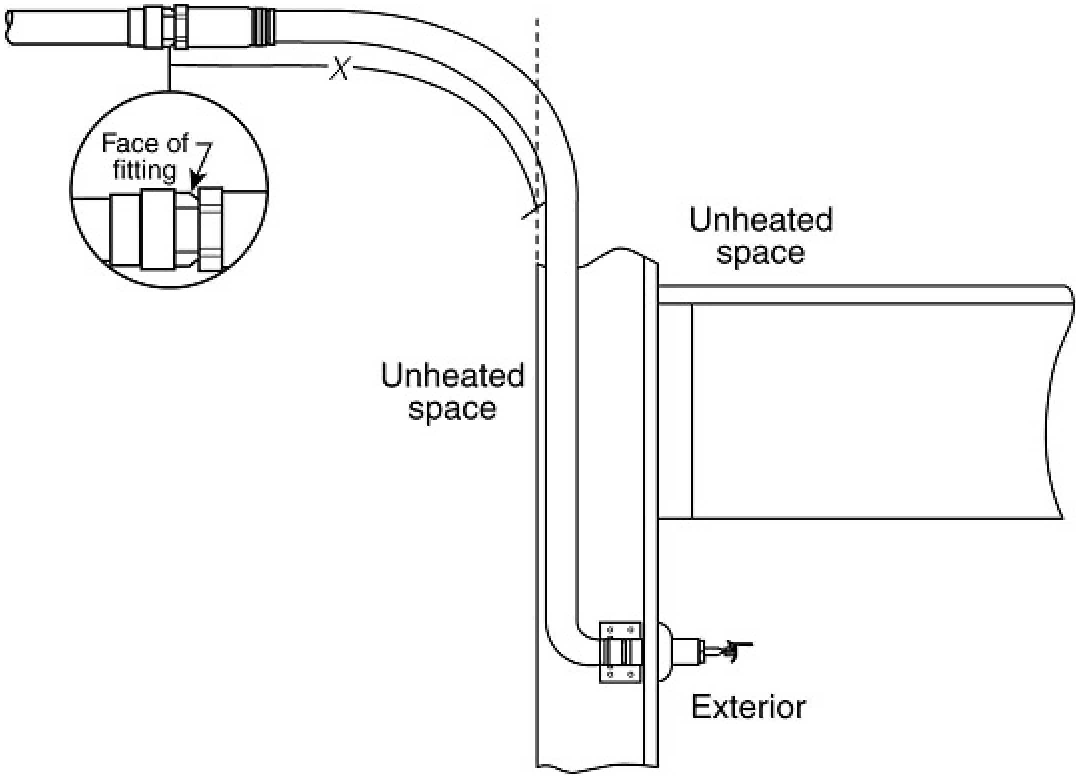


Figure A.15.3.1(d) Dry Pendent Sprinkler Through Ceiling.

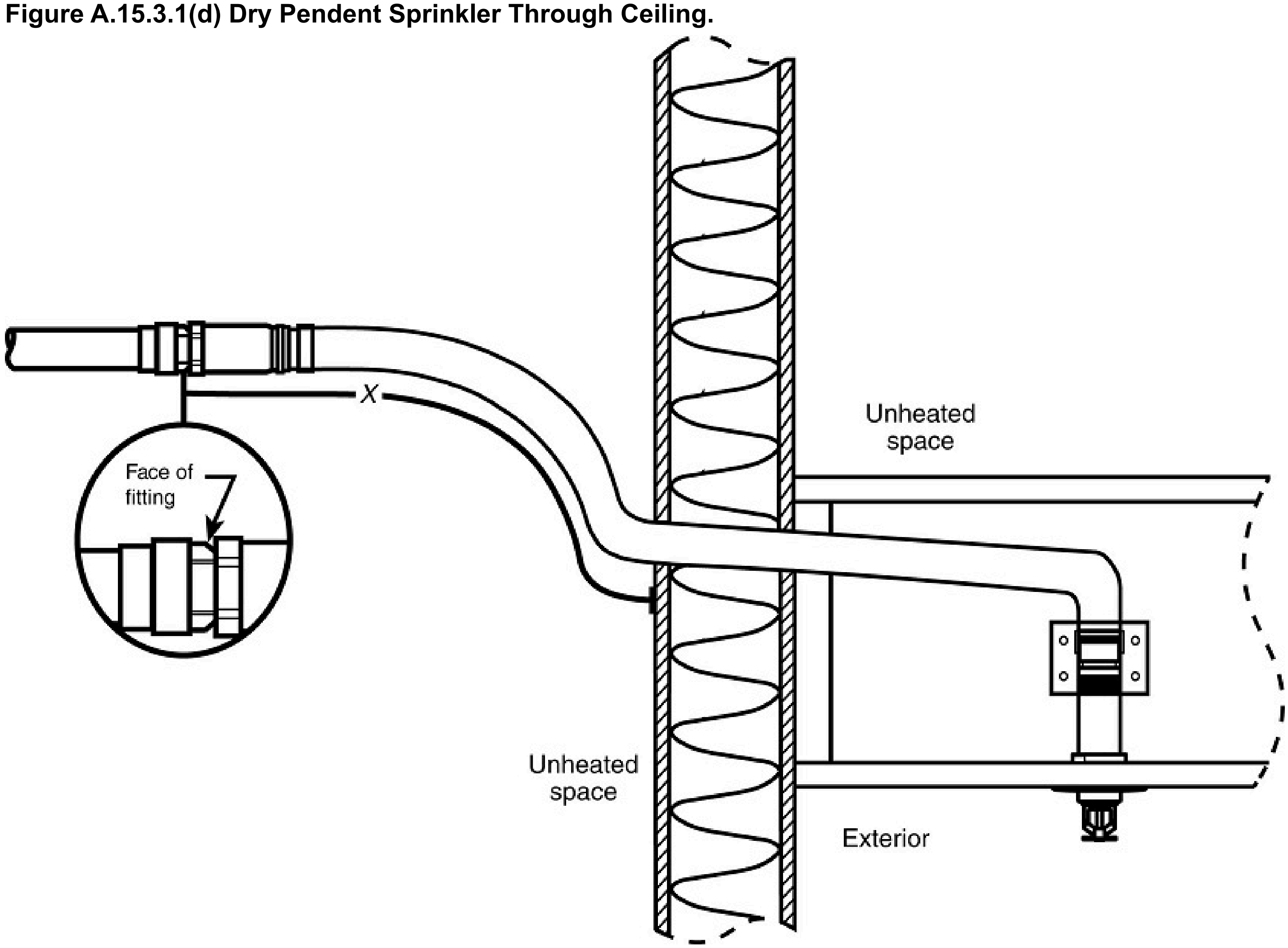
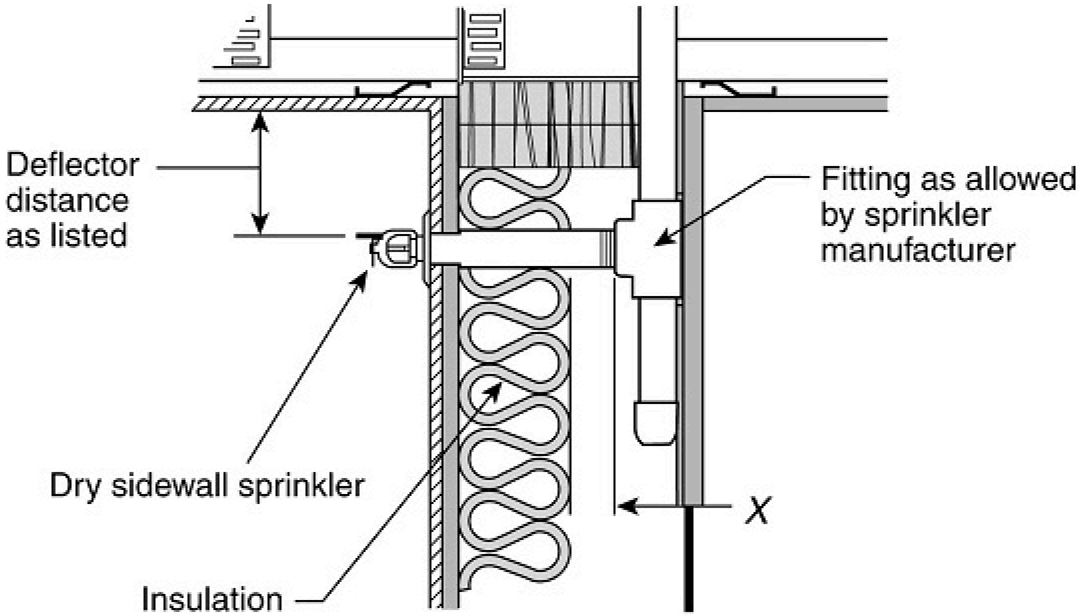


Figure A.15.3.1(e) Dry Sidewall Sprinkler Through Wall.



A.15.3.3

The clearance space around the sprinkler barrel should be sealed to avoid leakage of air into the freezing area that could result in the formation of condensate around the sprinkler frame that could inhibit or cause premature operation. See Figure A.15.3.3(a) and Figure A.15.3.3(b).

Figure A.15.3.3(a) Dry Sprinkler Seal Arrangement — Seal on Exterior of Freezer Structure.

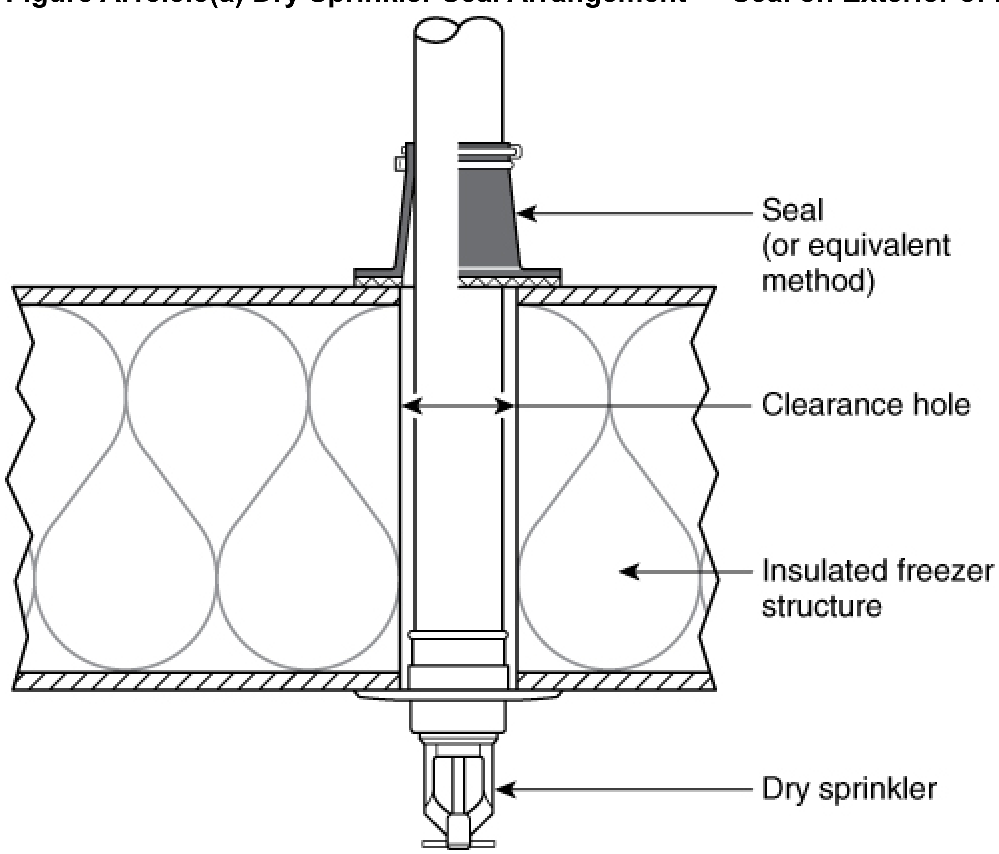
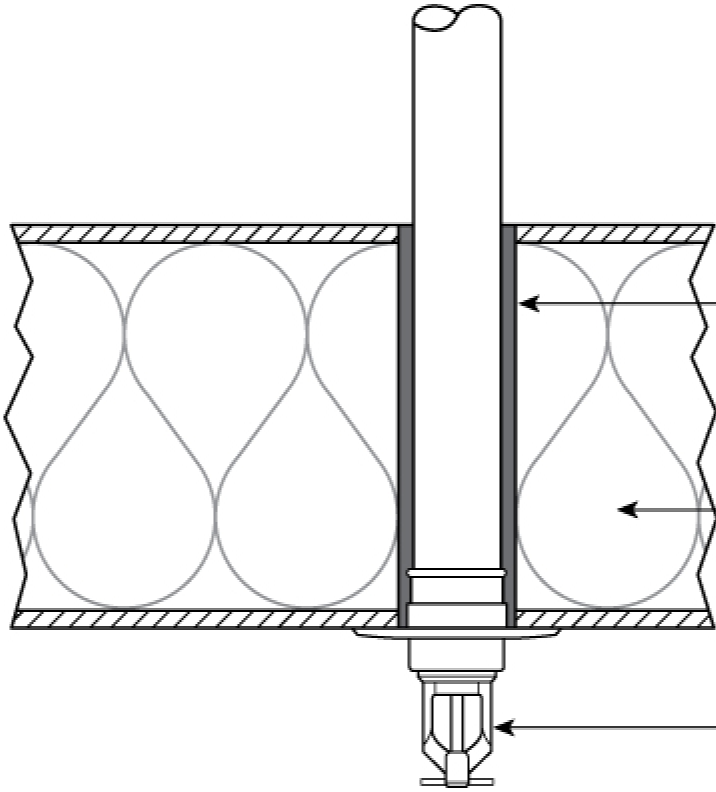


Figure A.15.3.3(b) Dry Sprinkler Seal Arrangement — Seal Within Freezer Structure.



A.15.3.4

Generally dry sprinklers are installed in tees. Dry sprinklers should never be installed in 90-degree elbows. Some manufacturers allow installation of dry sprinklers in couplings, CPVC adapters, and so forth.

A.16.1.1

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.16.2.1.1

Sprinklers should be permitted to be reinstalled when the sprinkler being removed from the system remains attached to the original fitting or welded outlet or can be removed by a grooved connection, provided care has been taken to ensure the sprinkler has not been damaged. Flexible hose connections are considered a fitting.

In new installations, where sprinklers are installed on pendent drop nipples or sidewall sprinklers prior to final cut-back, protective caps and/or straps should remain in place until after the drop nipple has been cut to fit to the final ceiling elevation.

A.16.2.2.1

Examples of such locations include the following:

(1) Paper mills
(2) Packing houses
(3) Tanneries
(4) Alkali plants
(5) Organic fertilizer plants
(6) Foundries
(7) Forge shops
(8) Fumigation, pickle, and vinegar works
(9) Stables
(10) Storage battery rooms
(11) Electroplating rooms
(12) Galvanizing rooms
(13) Steam rooms of all descriptions, including moist vapor dry kilns
(14) Salt storage rooms
(15) Locomotive sheds or houses
(16) Driveways

(17) Areas exposed to outside weather, such as piers and wharves exposed to salt air
(18) Areas under sidewalks
(19) Areas around bleaching equipment in flour mills
(20) All portions of cold storage buildings where a direct ammonia expansion system is used
(21) Portions of any plant where corrosive vapors prevail
(22) Area over and around swimming pools, chlorine storage rooms, and pool pump rooms

A.16.2.2.1.1

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

A.16.2.4.2

Plastic bags should not be used for this purpose due to the fact that shrinkage prior to development of temperatures needed to ensure sprinkler activation can interfere with proper sprinkler operation and development of spray patterns. The prohibition against plastic bags should include polypropylene bags commonly marketed as “cello” bags. True cellophane degrades rather than melts and, like paper, does not display shrinkage.

A.16.2.5.2

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.16.2.7.1

It is the intent of this section to require spare sprinklers and associated manufacturer’s sprinkler wrenches based on the facility as opposed to individual buildings or systems. Spare sprinklers for campus arrangements such as schools, hospitals, or multifamily complexes should be located under the owner’s control and are not necessarily required to be provided at each building or riser location. A sufficiently sized cabinet(s) capable of meeting the requirements for a single building is adequate. The spare sprinkler cabinet should contain all the various types found on the property based on in the quantities prescribed in Chapter 16.

A.16.2.7.6

One sprinkler wrench design can be appropriate for many types of sprinklers and should not require multiple wrenches of the same design.

A.16.2.7.7.1

The minimum information in the list contained in the spare sprinkler cabinet should be marked with the sprinkler identification described in 7.2.1; a general description of the sprinkler, including upright, pendent, residential, ESFR, and so forth; the quantity of each type of sprinkler installed in the property; the quantity of sprinklers that is to be maintained in the spare sprinkler cabinet; and a sprinkler wrench type.

An example of the list is shown in Figure A.16.2.7.7.1.

Figure A.16.2.7.7.1 Sample List.

Sprinklers Contained in this Cabinet

Sprinkler Identification, SIN	General Description	Temperature Rating, °F	Sprinkler Quantity Maintained	Sprinkler Wrench Type	Sprinkler Quantity in the Property
TY9128	Extended coverage, K-25, upright	165	6	W-Type 1 sprinkler wrench	20
VK494	Residential concealed pendent	155	6	Standard sprinkler wrench 21475MB	20

A.16.3.1

It is not the intent of this section to apply the minimum pipe size requirements to all devices and appurtenances. Devices such as valve trim, air maintenance devices, and air hoses can have nominal sizes less than those prescribed in 16.3.1.

A.16.3.2

See Table A.16.3.2.

Table A.16.3.2 Steel Pipe Dimensions

Nominal Pipe Size		Outside Diameter		Schedule 5				Schedule 10[a]				Schedule 30				
				Inside Diameter		Wall Thickness		Inside Diameter		Wall Thickness		Inside Diameter		Wall Thickness		I Di
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	ir
½[b]	15	0.840	21.3	—	—	—	—	0.674	17.1	0.083	2.1	—	—	—	—	0.6
¾[b]	20	1.050	26.7	—	—	—	—	0.884	22.4	0.083	2.1	—	—	—	—	0.8
1	25	1.315	33.4	1.185	30.1	0.065	1.7	1.097	27.9	0.109	2.8	—	—	—	—	1.0
1¼	32	1.660	42.2	1.530	38.9	0.065	1.7	1.442	36.6	0.109	2.8	—	—	—	—	1.3
1½	40	1.900	48.3	1.770	45.0	0.065	1.7	1.682	42.7	0.109	2.8	—	—	—	—	1.6
2	50	2.375	60.3	2.245	57.0	0.065	1.7	2.157	54.8	0.109	2.8	—	—	—	—	2.0
2½	65	2.875	73.0	2.709	68.8	0.083	2.1	2.635	66.9	0.120	3.0	—	—	—	—	2.4
3	80	3.500	88.9	3.334	84.7	0.083	2.1	3.260	82.8	0.120	3.0	—	—	—	—	3.0
3½	90	4.000	101.6	3.834	97.4	0.083	2.1	3.760	95.5	0.120	3.0	—	—	—	—	3.5
4	100	4.500	114.3	4.334	110.1	0.083	2.1	4.260	108.2	0.120	3.0	—	—	—	—	4.0
5	125	5.563	141.3	—	—	—	—	5.295	134.5	0.134	3.4	—	—	—	—	5.0
6	150	6.625	168.3	6.407	162.7	0.109	2.8	6.357	161.5	0.134[c]	3.4	—	—	—	—	6.0
8	200	8.625	219.1	—	—	—	—	8.249	209.5	0.188[c]	4.8	8.071	205.0	0.277[d]	7.0	7.9
10	250	10.750	273.1	—	—	—	—	10.370	263.4	0.188[c]	4.8	10.140	257.6	0.307[d]	7.8	10.(
12	300	12.750	—	—	—	—	—	—	—	—	—	12.090	—	0.330[c]	—	11.(

[a]Schedule 10 defined to 5 in. (127 mm) nominal pipe size by ASTM A135, *Standard Specification for Electric-Resistance-Welded Steel Pipe*.

[b]These values applicable when used in conjunction with 30.5.1 and 30.5.2.

[c]Wall thickness specified in 16.3.2.

[d]Wall thickness specified in 16.3.3.

A.16.3.6

See Table A.16.3.6.

Table A.16.3.6 Copper Tube Dimensions

Nominal Tube Size		Outside Diameter		Type K				Type L				Type M			
				Inside Diameter		Wall Thickness		Inside Diameter		Wall Thickness		Inside Diameter		Wall Thickness	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
¾	20	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

Nominal Tube Size		Outside Diameter		Type K Inside Diameter		Type K Wall Thickness		Type L Inside Diameter		Type L Wall Thickness		Type M Inside Diameter		Type M Wall Thickness	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
1	25	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	32	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	40	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	50	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	65	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	80	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	90	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	100	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	125	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	150	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	200	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	250	10.130	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

A.16.3.10.4

When fabricating steel pipe for a combination (CPVC–steel) system, the cutting oil and lubricants can cause performance degradation of the CPVC piping. Cutting oils and lubricants found to be compatible are available and should be used.

A.16.3.13.1

Outlets meeting the requirements of this standard should be provided in anticipation of the final finished area.

A.16.3.13.2

Providing 1 in. (25 mm) minimum outlets with bushings can provide for future changes in building uses or occupancies.

A.16.4.1.1

Water-filled piping can be run in spaces above heated room, such as attics, even if the space above the room is not heated itself. Insulation can be located above the pipe to trap the heat from below and prevent the pipe from freezing. It is important not to bury the piping in the insulation because if too much insulation ends up between the pipe and the heated space, the insulation will prevent the heat from getting to the pipe. This method of protecting the pipe is acceptable to this standard.

A.16.4.1.1.1

The internal temperature and duration of exposure that water-filled piping could be subjected to, under freezing conditions, in an unconditioned space should be carefully considered and approved by the AHJ.

Dependable sources of information on historic temperatures include the following:

(1) National Oceanic and Atmospheric Administration — National Climatic Data Center
(2) National Weather Service
(3) Plant Hardiness Zone Maps (See Oregon State University)
(4) American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
(5) Other approved sources

A.16.4.1.4

Requirements for heat tracing and associated controls intended for the fire protection application can be found in UL 515A, *Outline of Investigation for Electrical Resistance Trace Heating and Associated Controls for Use in Sprinkler and Standpipe Systems*. Also, since heat tracing has the potential to overheat sprinklers and system piping as well as adversely impact the sprinkler discharge characteristics, heating tracing use for branch lines is required to be specifically listed for this use.

A.16.4.2

Where approved, the pipe identification can be covered with paint or other protective coatings before installation.

A.16.4.2.1

Being exposed to the outside atmosphere is not necessarily a corrosive environment. 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 using 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 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.16.4.3

Protection should be provided in any area of a structure or building that poses a degree of hazard greater than that normal to the general occupancy of the building or structure. These areas include areas for the storage or use of combustibles or flammables; toxic, noxious, or corrosive materials; and heat-producing appliances.

A.16.4.4(4)

Nail plates should only cover the stud or structural member that the pipe is penetrating — the nail plate should not extend past the width of the member. Only the length of the nail plate along the member should be extended a minimum of 2 in. (50 mm).

A.16.7

A manual or automatic air venting valve can be a reasonable approach on wet pipe sprinkler systems to reduce corrosion activity. The purpose of the air venting valve is to exhaust as much trapped air as possible from a single location every time the system is filled. The objective of venting is to reduce the amount of oxygen trapped in the system that will fuel corrosion and microbial activity. It is neither the intent nor practical to exhaust all trapped air from a single location on a wet pipe sprinkler system; however, more than one vent can be used on a system at the designer's discretion. Interconnection of branch line piping for venting purposes is not necessary. An inspector's test valve can serve this purpose.

The air venting valve should be located where it will be most effective. System piping layout will guide the designer in choosing an effective location for venting. In order to effectively accomplish venting, it is necessary to choose a location where the greatest volume of trapped air is vented during the first fill and each subsequent drain and fill event. The vent connection to the system should be located off the top of horizontal piping at a high point in the system; however, the vent connection can also be effectively located off the side of a riser or riser nipple at a high point in the system.

Manual air venting valves should be accessible. The manual air venting valve should be located at an accessible point and preferably not over 7 ft (2.1 m) above the floor. Automatic air valves are not required to comply with the accessibility requirement of manual air venting valves; however, it is recommended the designer locate automatic air vents over areas without ceilings, above a lay-in ceiling, or above an access panel.

Each wet pipe sprinkler system should be vented every time the system is filled.

A.16.8.2.1

CPVC is a plastic material and consideration is necessary when other materials or chemicals come in contact with CPVC that can cause degradation of performance of the fitting due to interaction of materials. Compliance with 7.4.3 combined with following manufacturer’s guidance on installation and compatible materials will help prevent premature performance degradation of non-metallic fittings. Mechanical stress caused by hanging methods or bending on non-metallic piping beyond the manufacturer's recommended limitations can cause stress failure over time and should be avoided.

A.16.8.2.2

When fabricating steel pipe for a system using non-metallic and steel pipe, the cutting oil and lubricants can cause performance degradation of the non-metallic fitting.

A.16.8.3

The rupture strength of cast-iron fittings 2 in. (50 mm) in size and smaller and malleable iron fittings 6 in. (150 mm) in size and smaller is sufficient to provide an adequate factor of safety.

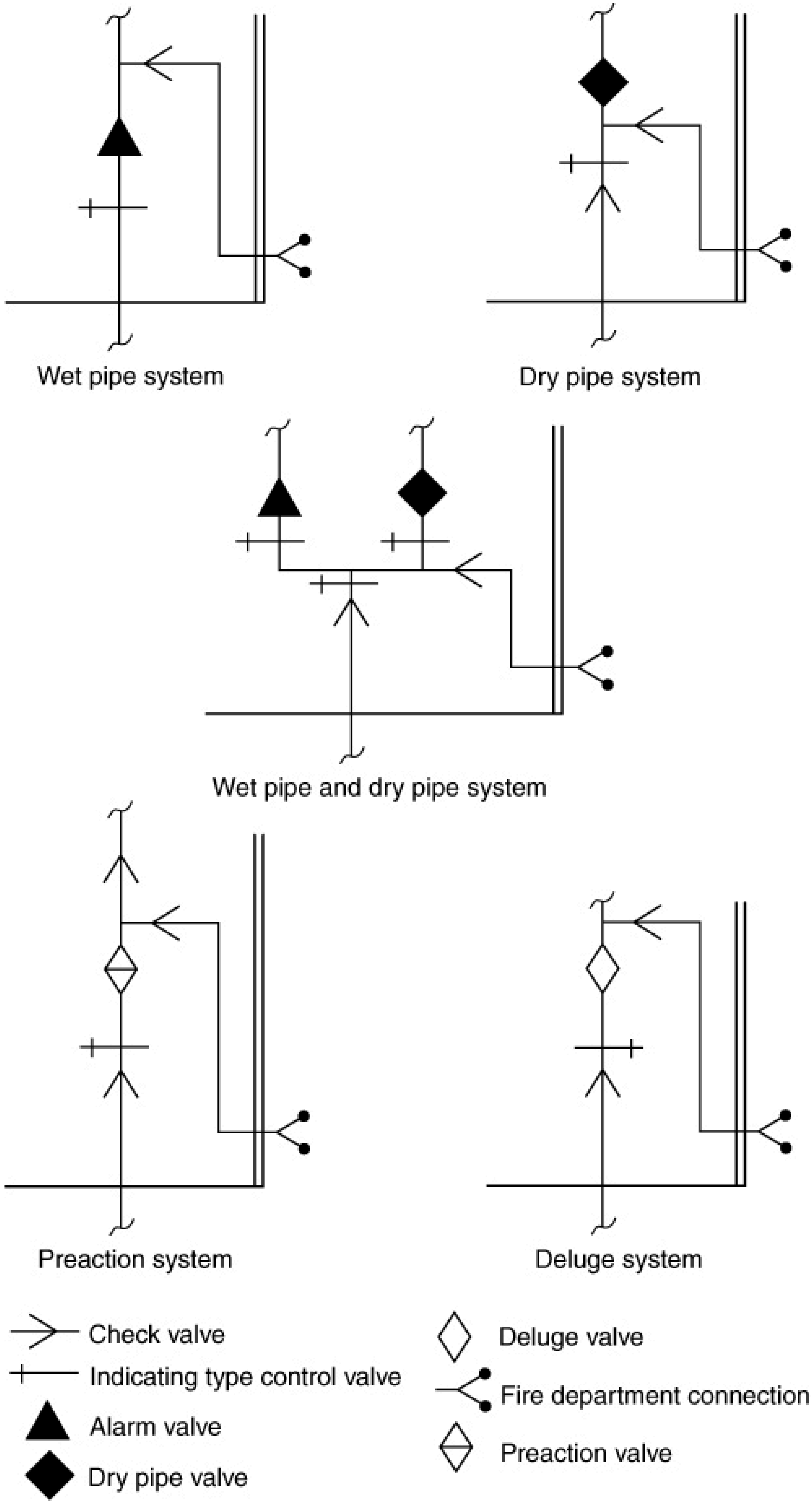
A.16.8.8.1

Rigid ceilings are ceilings that could include cleanroom ceiling structures, freezers, steel, concrete, masonry, wood, gypsum board, or similar rigid materials. These ceilings typically have a penetration for the sprinkler, and it would be difficult to inappropriately relocate the sprinkler.

A.16.9.3

See Figure A.16.9.3.

Figure A.16.9.3 Examples of Acceptable Valve Arrangements.



A.16.9.3.1

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.

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:

(1) Listed indicating valves at each connection into the building at least 40 ft (12 m) from buildings if space permits
(2) Control valves installed in a cutoff stair tower or valve room accessible from outside
(3) Valves located in risers with indicating posts arranged for outside operation
(4) Key-operated valves in each connection into the building

A.16.9.3.3

The management is responsible for the supervision of valves controlling water supply for fire protection and should exert every effort to see that the valves are maintained in the normally open position. This effort includes special precautions to ensure that protection is promptly restored by completely opening valves that are necessarily closed during repairs or alterations. The precautions apply equally to valves controlling sprinklers and other fixed water-based fire suppression systems, hydrants, tanks, standpipes, pumps, street connections, and sectional valves.

Either one or a combination of the methods of valve supervision described in the following list is considered essential to ensure that the valves controlling fire protection systems are in the normally open position. The methods described are intended as an aid to the person responsible for developing a systematic method of determining that the valves controlling sprinkler systems and other fire protection devices are open.

Continual vigilance is necessary if valves are to be kept in the open position. Responsible day and night employees should be familiar with the location of all valves and their proper use.

The authority having jurisdiction should be consulted as to the type of valve supervision required. Contracts for equipment should specify that all details are to be subject to the approval of the authority having jurisdiction.

(1) *Central Station Supervisory Service.* Central station supervisory service systems involve complete, constant, and automatic supervision of valves by electrically operated devices and circuits continually under test and operating through an approved outside central station, in compliance with *NFPA 72* or other approved fire alarm code. It is understood that only such portions of *NFPA 72* or other approved fire alarm code that relate to valve supervision should apply.
(2) *Proprietary Supervisory Service Systems.* Proprietary supervisory service systems include systems where the operation of a valve produces some form of signal and record at a common point by electrically operated devices and circuits continually under test and operating through a central supervising station at the property protected, all in compliance with the standards for the installation, maintenance, and use of local protective, auxiliary protective, remote station protective, and proprietary signaling systems. It is understood that only portions of the standards that relate to valve supervision should apply.

The standard method of locking, sealing, and tagging valves to prevent, so far as possible, their unnecessary closing, to obtain notification of such closing, and to aid in restoring the valve to normal condition is a satisfactory alternative to valve supervision. The authority having jurisdiction should be consulted regarding details for specific cases.

Where electrical supervision is not provided, locks or seals should be provided on all valves and should be of a type acceptable to the authority having jurisdiction.

Seals can be marked to indicate the organization under whose jurisdiction the sealing is conducted. All seals should be attached to the valve in such a manner that the valves cannot be operated without breaking the seals. Seals should be of a character to prevent injury in handling and to prevent reassembly when broken. When seals are used, valves should be inspected weekly. The authority having jurisdiction can require a valve tag to be used in conjunction with the sealing.

A padlock, with a chain where necessary, is especially desirable to prevent unauthorized closing of valves in areas where valves are subject to tampering. When such locks are employed, valves should be inspected monthly.

If valves are locked, any distribution of keys should be restricted to only those directly responsible for the fire protection system. Multiple valves should not be locked together; they should be individually locked.

The individual performing the inspections should determine that each valve is in the normal position, properly locked or sealed, and so note on an appropriate record form while still at the valve. The authority having jurisdiction should be consulted for assistance in preparing a suitable report form for this activity.

Identification signs should be provided at each valve to indicate its function and what it controls.

The position of the spindle of OS&Y valves or the target on the indicator valves cannot be accepted as conclusive proof that the valve is fully open. The opening of the valve should be followed by a test to determine that the operating parts have functioned properly.

The test consists of opening the main drain valve and permitting free flow of water until the gauge reading becomes stationary. If the pressure drop is excessive for the water supply involved, the cause should be determined immediately and the proper remedies taken. When sectional valves or other special conditions are encountered, other methods of testing should be used.

If it becomes necessary to break a seal for emergency reasons, the valve, following the emergency, should be opened by the person responsible for the fire protection of the plant, or his or her designated representative, and this person should apply a seal at the time of the valve opening. This seal should be maintained in place until such time as the authority having jurisdiction can replace it with one of its own.

Seals or locks should not be applied to valves reopened after closure until such time as the inspection procedure is carried out.

Where water is shut off to the sprinkler or other fixed water-based fire suppression systems, a guard or other qualified person should be placed on duty and required to continuously patrol the affected sections of the premises until such time as protection is restored.

During specific critical situations, a person should be stationed at the valve so that the valve can be reopened promptly if necessary. It is the intent of this section that the person remain within sight of the valve and have no other duties beyond this responsibility. This procedure is considered imperative when fire protection is shut off immediately following a fire.

An inspection of all other fire protection equipment should be made prior to shutting off water in order to make sure it is in operative condition.

In case of changes to fire protection equipment, all possible work should be done in advance of shutting off the water so that final connections can be made quickly and protection restored promptly. Many times it will be found that by careful planning open outlets can be plugged and protection restored on a portion of the equipment while the alterations are being made.

Where changes are being made in underground piping, all possible piping should be laid before shutting off the water for final connections. Where possible, temporary feed lines, such as temporary piping for reconnection of risers by hose lines, and so forth, should be used to afford maximum protection. The plant, public fire department, and other authorities having jurisdiction should be notified of all impairments to fire protection equipment.

A.16.9.3.4

It might be necessary to provide valves located in pits with an indicator post extending above grade or other means so that the valve can be operated without entering the pit.

A.16.9.4

Where check valves are buried, they should be made accessible for maintenance. This can be accomplished by a valve pit or any means that renders the valve accessible. See Figure A.16.9.5.

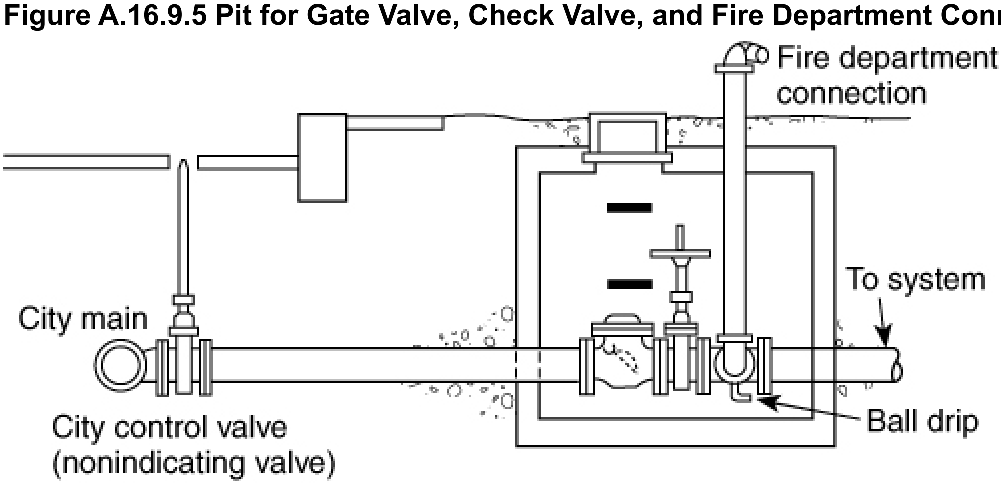
A.16.9.4.4

Where a system having only one dry pipe valve is supplied with city water and a 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.16.9.5

See Figure A.16.9.5. For additional information on controlling valves, see NFPA 22.

Figure A.16.9.5 Pit for Gate Valve, Check Valve, and Fire Department Connection.



A.16.9.5.5

For additional information on controlling valves, see NFPA 22.

A.16.9.6

Check valves on tank or pump connections, when located underground, can be placed inside of buildings and at a safe distance from the tank riser or pump, except in cases where the building is entirely of one fire area, when it is ordinarily considered satisfactory to locate the check valve overhead in the lowest level.

A.16.9.7.3

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.16.9.7.5.2

Hose connections on a standpipe or on a fire pump test header can be utilized for the full flow test.

A.16.9.7.5.3

Providing another means is at the discretion of the designer in consultation with the owner or developer. Any number of arrangements would be acceptable as long as the flow through the pressure-reducing valve can be measured to verify it is equal to or greater than the system demand. One example is the use of the fire department connection as long as it will accommodate the required flow and the check valve has a bypass with a shut-off valve provided for this purpose.

A.16.9.8

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

(1) Listed indicating valves at each connection into the building at least 40 ft (12 m) from buildings if space permits
(2) Control valves installed in a cutoff stair tower or valve room accessible from outside
(3) Valves located in risers with indicating posts arranged for outside operation
(4) Key-operated valves in each connection into the building

Post-indicator valves should be located not less than 40 ft (12 m) from buildings. When post-indicator valves cannot be placed at this distance, they are permitted to be located closer, or wall post-indicator valves can be used, provided they are set in locations by blank walls where the possibility of injury by falling walls is unlikely and from which people are not likely to be driven by smoke or heat. Usually, in crowded plant yards, they can be placed beside low buildings, near brick stair towers, or at angles formed by substantial brick walls that are not likely to fall.

A.16.9.9.2

A valve wrench with a long handle should be provided at a convenient location on the premises.

A.16.9.11

The intent of 16.9.11 is to provide assistance in determining the area of a building served by a particular control valve.

A.16.9.11.3.1

Care should be taken to ensure that all water supplies are isolated before work begins. Work on systems by shutting one valve and not knowing about another valve could result in unexpected water discharge.

A.16.10.1

All piping should be arranged where practicable to drain to the main drain valve.

A.16.10.4

Figure A.16.10.4(a) is an example of an unacceptable arrangement. Because it will not give a true residual reading, it will indicate an excessive pressure drop. Figure A.16.10.4(b) is an example of an acceptable drain connection for a system riser.

Figure A.16.10.4(a) Unacceptable Pressure Gauge Location.

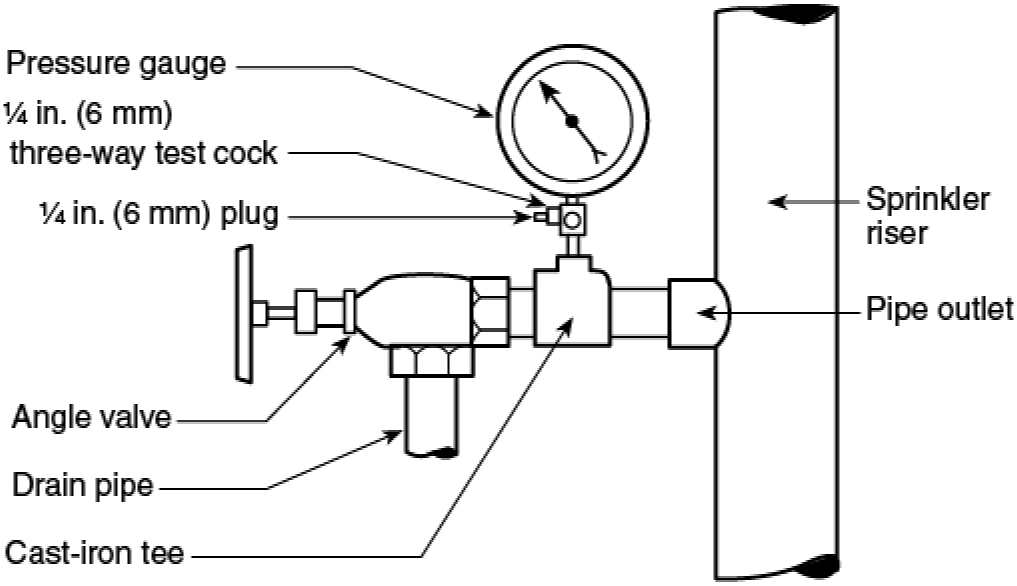
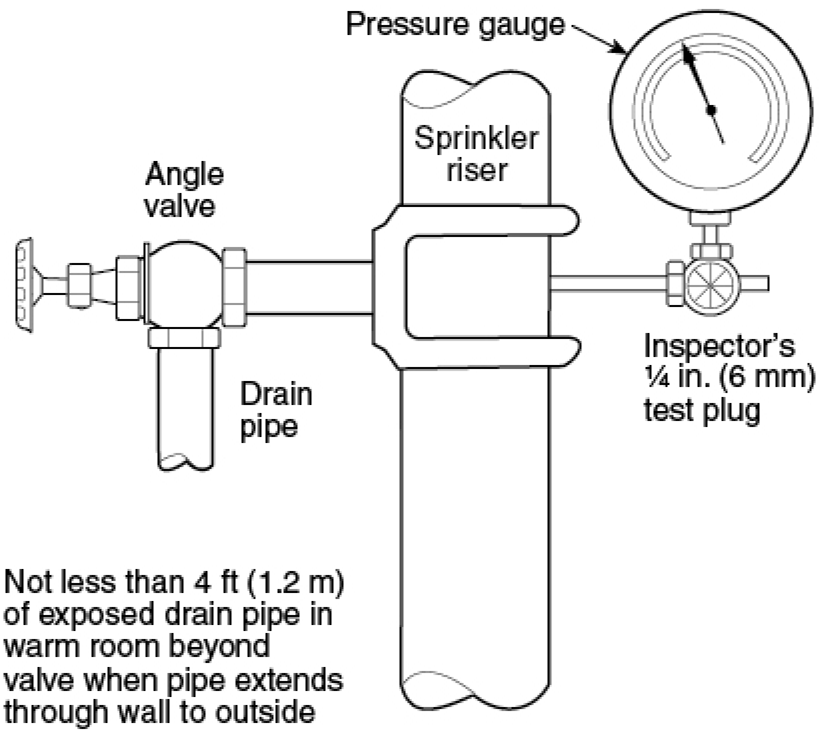


Figure A.16.10.4(b) Drain Connection for System Riser.



A.16.10.4.2

Sizing the main drain connection so that it can flow the sprinkler system demand flow rate provides a practical means for performing the forward flow test of the backflow device as required by 16.14.5.1.

A.16.10.5.3.4

The requirements of 16.10.5.3.4 should not apply since there is no water condensate to collect in the barrel of a dry sprinkler. Moisture inside the pipe will freeze when located in areas that maintain a freezing temperature.

A.16.10.6.1

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 wastewater 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.16.11.1.1

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

Outside alarms might not be necessary where the sprinkler system is used as part of a central station, auxiliary, remote station, or proprietary signaling fire alarm system, utilizing listed audible inside alarm devices.

A.16.11.1.2

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

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

A.16.11.2

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 16.11.10.)*

Approved identification signs, as shown in Figure A.16.11.2, 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.16.11.2 Identification Sign.

A.16.11.3.4

The surge of water that occurs when the valve trips can seriously damage the device. Paddle-type waterflow devices are also permitted to be installed on wet systems that supply auxiliary dry pipe and/or preaction systems.

A.16.11.7

Switches that will silence electric alarm-sounding devices by interruption of electric current are not desirable; however, if such means are provided, then the electric 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 electric circuit interruption.

A.16.11.8

Water motor-operated devices should be located as near as practicable to the alarm valve, dry pipe valve, or other waterflow detection device. The total length of the pipe to these devices should not exceed 75 ft (23 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.16.11.10

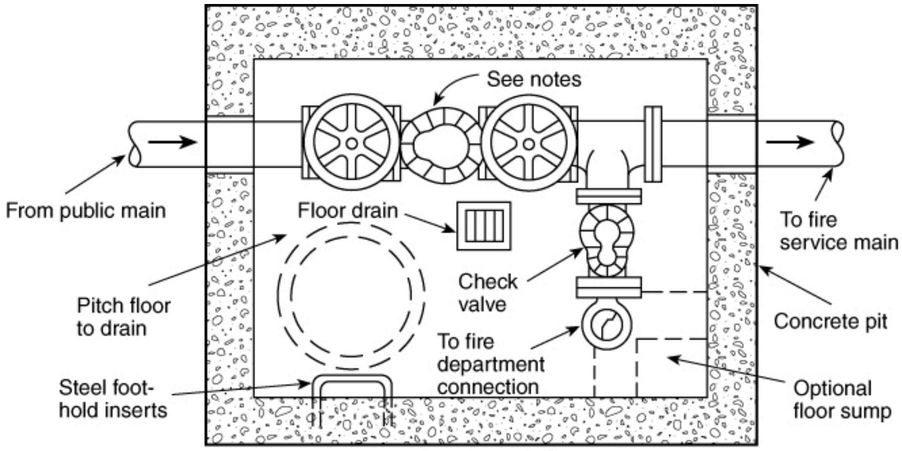
Monitoring should include but not be limited to control valves, building temperatures, fire pump power supplies and running conditions, and water tank levels and temperatures. Pressure supervision should also be provided on pressure tanks.

Check valves can be required to prevent false waterflow signals on floors where sprinklers have not activated — for example, floor systems interconnected to two supply risers.

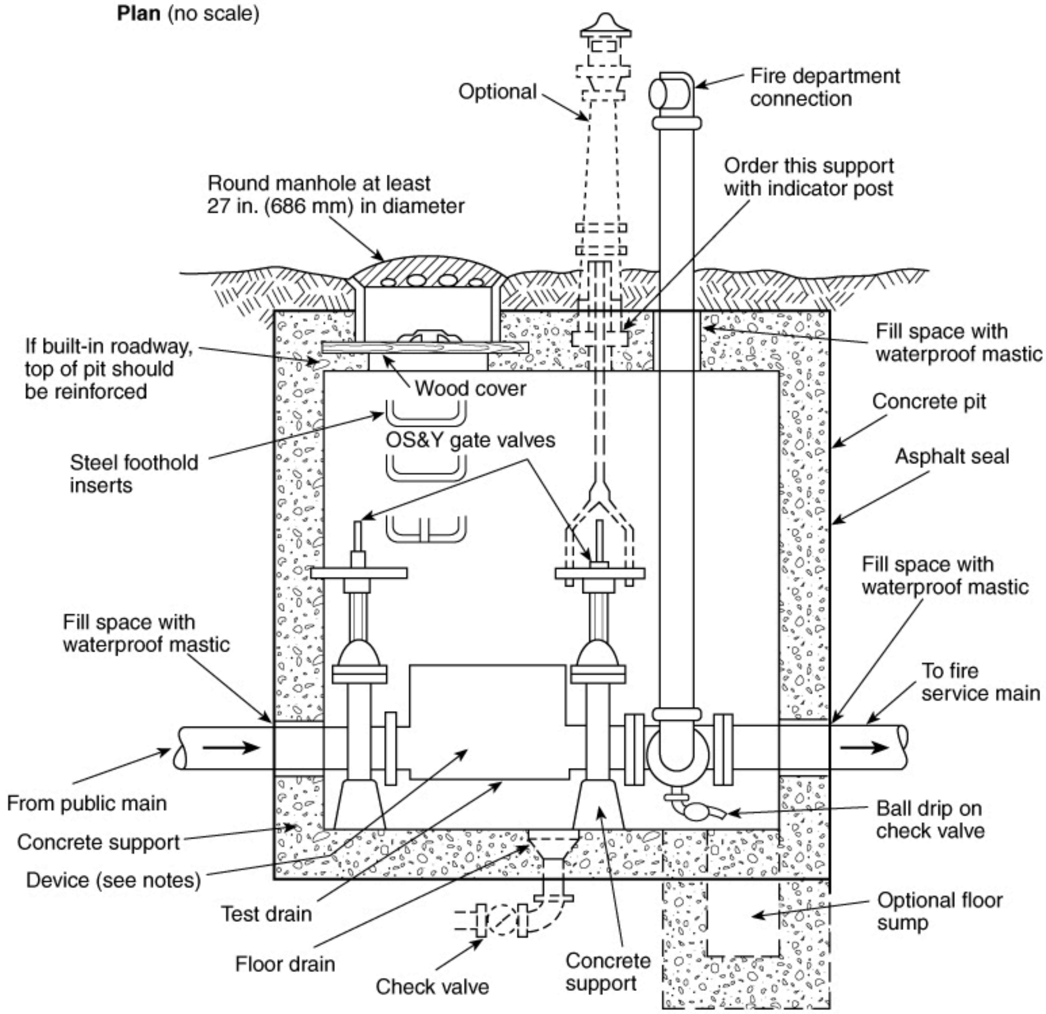
A.16.12

The fire department connection should be located not less than 18 in. (500 mm) and not more than 4 ft (1.2 m) above the level of the adjacent grade or access level. Typical fire department connections are shown in Figure A.16.12. See NFPA 13E.

Figure A.16.12 Typical City Water Pit — Valve Arrangement.



Plan (no scale)



Section (no scale)

Notes:

1. Various backflow prevention regulations accept different devices at the connection between public water mains and private fire service mains.
2. The device shown in the pit could be any or a combination of the following:
   (a) Gravity check valve
   (b) Detector check valve
   (c) Double check valve assembly
   (d) Reduced pressure zone (RPZ) device
   (e) Vacuum breaker
3. Some backflow prevention regulations prohibit these devices from being installed in a pit.
4. In all cases, the device(s) in the pit should be approved or listed as necessary. The requirements of the local or municipal water department should be reviewed prior to design or installation of the connection.
5. Pressure drop should be considered prior to the installation of any backflow prevention devices.

A.16.12.1

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 a 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.16.12.3.1

The purpose of the fire department connection is to supplement the water supply but not necessarily provide the entire sprinkler system demand. Fire department connections are not intended to deliver a specific volume of water.

A.16.12.4

The purpose of a fire department connection is to supplement the pressure to an automatic fire sprinkler system. It is not the intent to size the fire department connection piping based on system demand. For multiple system risers supplied by a manifold, the fire department connection need not be larger than that for an individual system.

A.16.12.5

The check valve should be located to maximize accessibility and minimize freezing potential. It is recommended that the check valve be located to reduce the length of nonpressurized pipe in the fire department connection supply line.

A.16.12.5.1

The fire department connection should be connected to the system riser. For single systems, it is an acceptable arrangement to attach the fire department connection to any point in the system, provided the pipe size meets the requirements of 16.12.4.

A.16.12.5.5

Figure A.16.12.5.5(a) and Figure A.16.12.5.5(b) depict fire department connections to the underground pipe.

Figure A.16.12.5.5(a) Fire Department Connection to Underground Piping for a Single System.

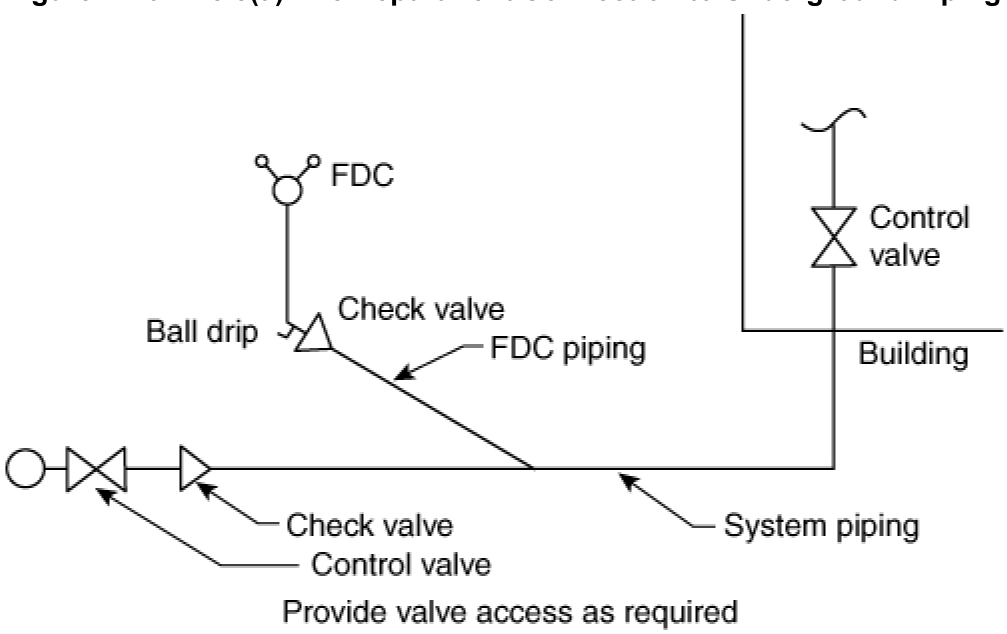
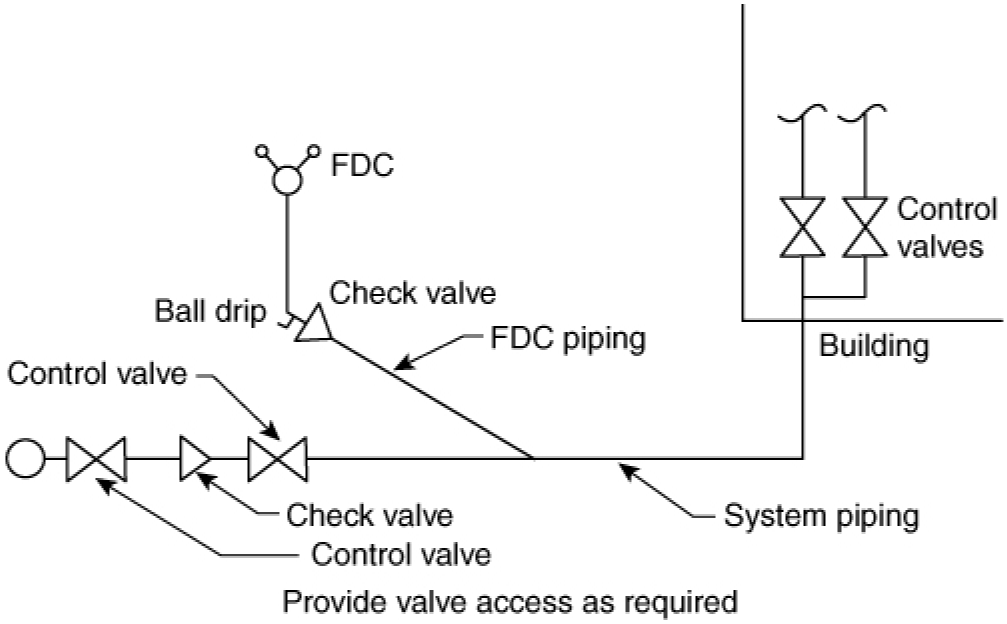


Figure A.16.12.5.5(b) Fire Department Connection to Underground Piping for Multiple Systems.



A.16.12.5.7

Obstructions to fire department connections include but are not limited to buildings, fences, posts, shrubbery, other fire department connections, gas meters, and electrical equipment.

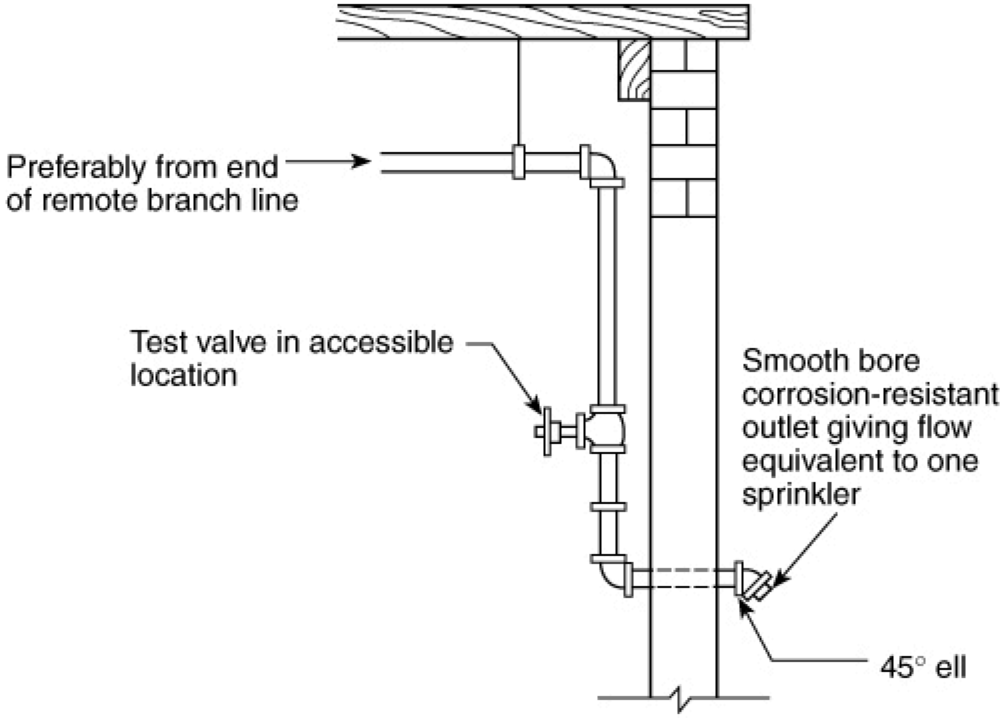
A.16.12.7

In cases where water in the piping between the system side and the fire department connection check valve would be trapped, an auxiliary drain is required.

A.16.14.1

The purpose of this alarm test connection is to make sure the alarm device is sensitive enough to determine the flow from a single sprinkler and sound an alarm. The purpose of this test connection is not to ensure that water will flow through the entire system. When this test connection is installed on the upper story, and at the end of the most remote branch line, the user is able to tell that there is water flowing in one path through the system, but there is no assurance that water will flow to other branch lines. Putting the test connection at the most remote portion of the system causes the introduction of fresh oxygen into a large part of the system each time the alarm is tested and increases the corrosion that will occur in the piping. 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 Figure A.16.14.1(a) and Figure A.16.14.1(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.

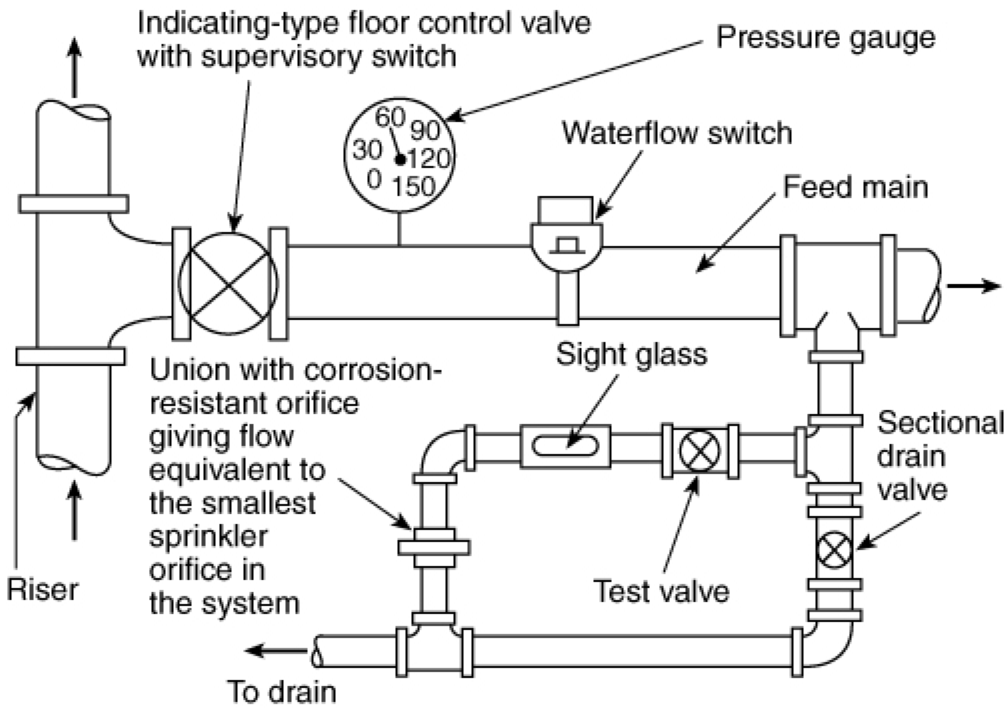
Figure A.16.14.1(a) System Test Connection on Wet Pipe System.



Elevation

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.

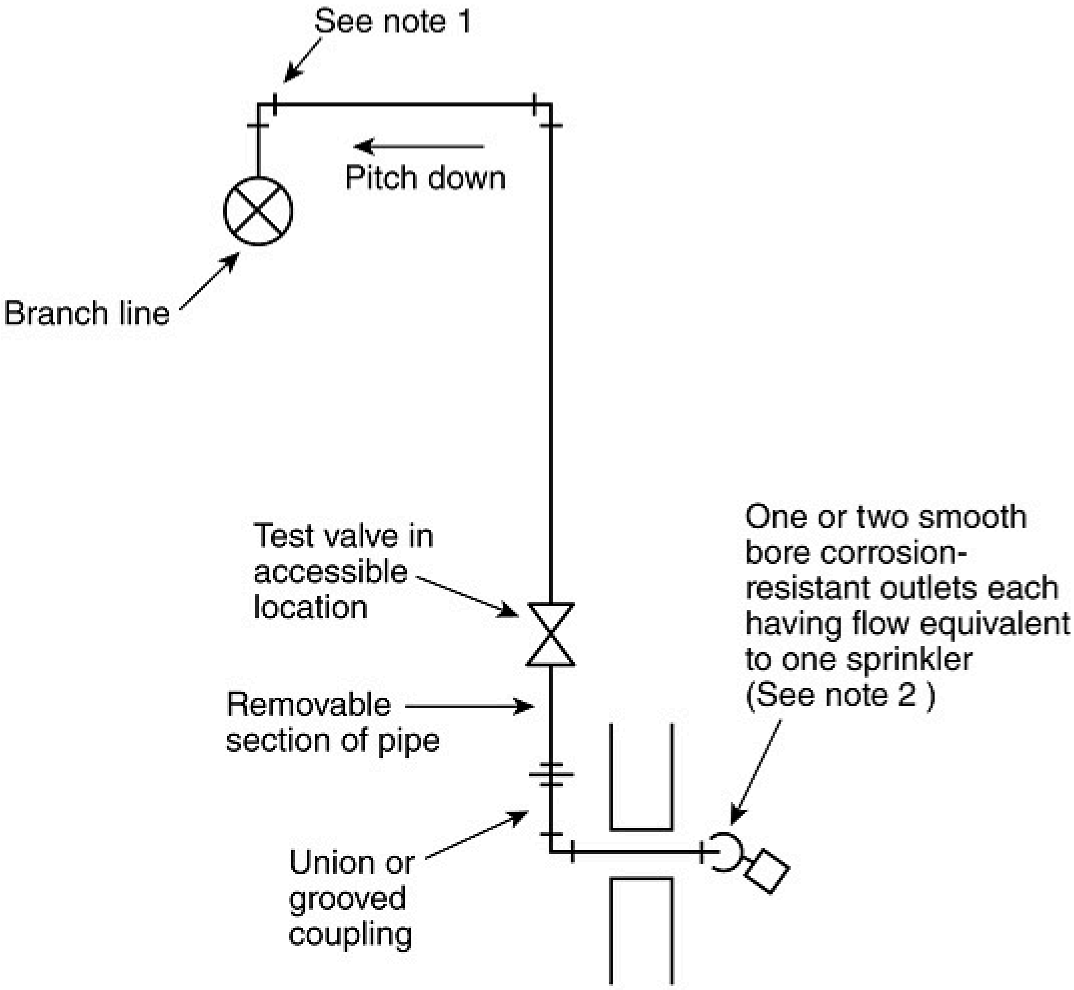
Figure A.16.14.1(b) Zone Control Station System Test Connection on Wet Pipe System.



A.16.14.2

Specific water delivery time, when required, is based upon the actual or calculated flow from a particular number of sprinklers. The system test connection shall be provided with that number of smooth-bore orifices. See Figure A.16.14.2.

Figure A.16.14.2 System Test Connection on Dry Pipe System.



Note 1: To minimize condensation of water in the drop to the test connection, provide a nipple-up off of the branch line.
Note 2: For four orifice test connection, provide a second two orifice test connection supplied from the next adjacent branch line.

A.16.14.2.4

An evaluation of the location of the remote branch line should be performed with consideration to volume and distance of piping network to ensure the most demanding or worst-case scenario is selected.

A.16.14.5

Where backflow prevention devices are installed, they should be in an accessible location to provide for inspection, testing, service, and maintenance. When a backflow prevention device is retroactively installed on a pipe schedule system, the revised hydraulic calculation still follows the pipe schedule method of 19.3.2 with the inclusion of friction loss for the device.

A.16.14.5.1

System demand refers to flow rate and pressure. This test is only concerned with testing at the proper flow rate.

A.16.14.5.1.2

Hose connections on a standpipe or on a fire pump test header can be utilized for the full flow test.

A.16.14.5.1.3

Providing another means is at the discretion of the designer in consultation with the owner or developer. Any number of arrangements would be acceptable as long as the flow through the backflow prevention valve can be measured to verify it is equal to or greater than the system demand. One example is the use of the fire department connection as long as it will accommodate the required flow and the check valve has a bypass with a shut-off valve provided for this purpose.

A.16.15.1.1

One and one-half inch (40 mm) fire hose packs are not required unless designated by the authority having jurisdiction, as it is not likely that such hoses will be adequately maintained for safe use by first responders. Civilian workers who are not properly trained in firefighting techniques are expected to evacuate the building in the event of a fire.

A.16.15.1.4

This standard covers 1½ in. (40 mm) hose connections for use in storage occupancies and other locations where standpipe systems are not required. Where Class II standpipe systems are required, see the appropriate provisions of NFPA 14 with respect to hose stations and water supply for hose connections from sprinkler systems.

A.16.15.2.2

See Figure A.16.15.2.2(a), Figure A.16.15.2.2(b), and Figure A.16.15.2.2(c).

Figure A.16.15.2.2(a) Acceptable Piping Arrangement for Combined Sprinkler/Standpipe System. [14:Figure A.6.3.5(a)]

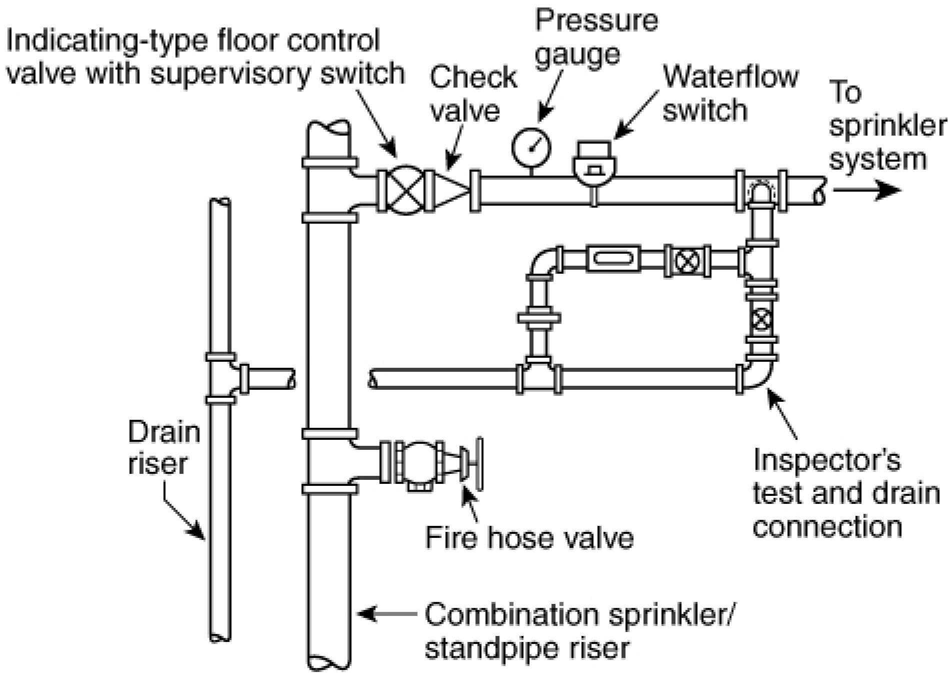


Figure A.16.15.2.2(b) Acceptable Piping Arrangement for Combined Sprinkler/Standpipe System. [14:Figure A.6.3.5(b)]

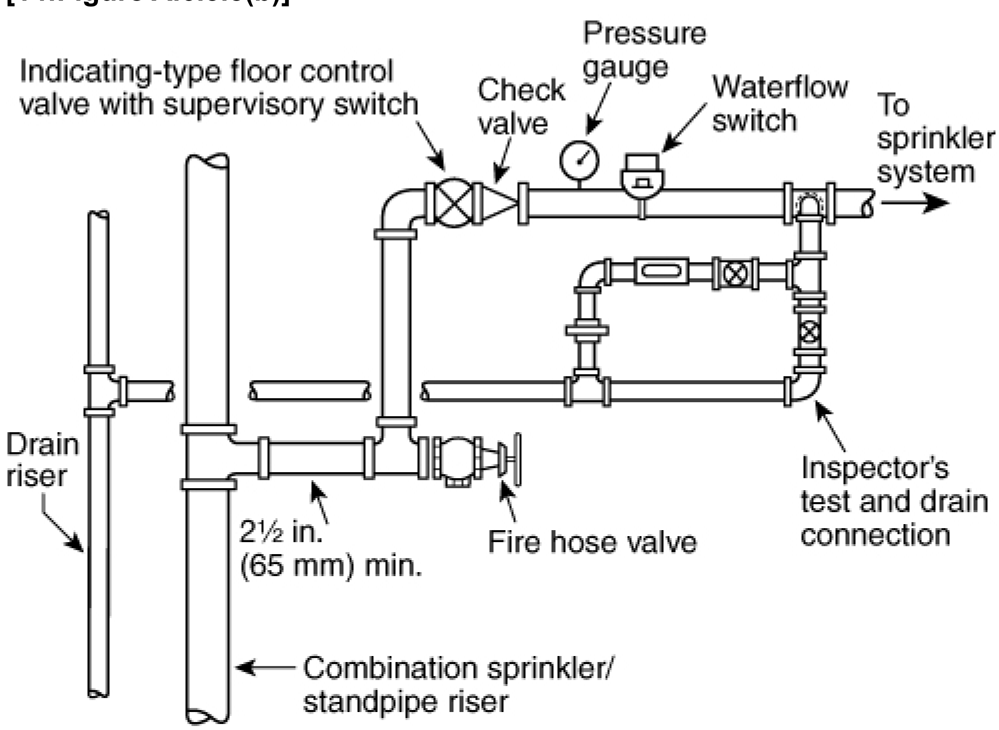
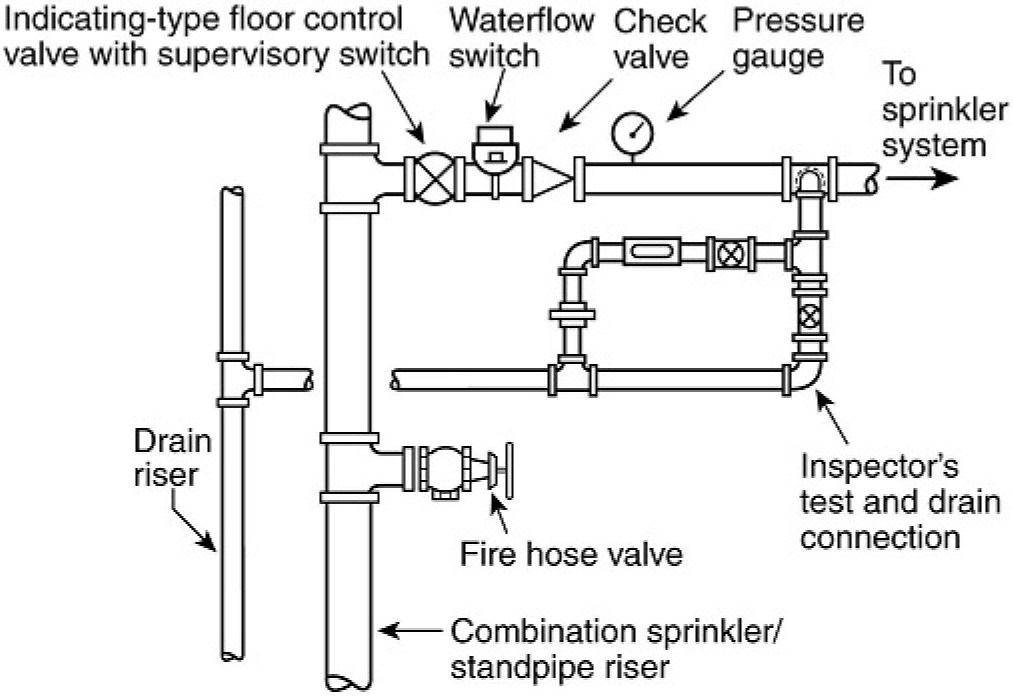


Figure A.16.15.2.2(c) Acceptable Piping Arrangement for Combined Sprinkler/Standpipe System.



A.16.16.2

While the use of the sprinkler system piping as the grounding electrode for the building is prohibited, *NFPA 70* requires that all metallic piping systems be bonded to disperse stray electrical currents. Therefore, the sprinkler system piping might be bonded to other metallic systems.

A.16.17

Table A.16.17 is a summary of the requirements for signs in NFPA 13.

Table A.16.17 Sprinkler System Signage Summary

Section	Sign Location	Sign Information/Requirements
16.9.11	Control valves Drain valves Test connection valves	Identification sign Sign must be made of weatherproof metal or rigid plastic and attached with corrosion-resistant wire or chain
8.6.1.4 and 8.6.1.5	Antifreeze system main valve	Indicate the following: Antifreeze manufacturer Antifreeze type Antifreeze concentration
16.9.3.5	Control valves	Indicate valve function Indicate system being controlled
16.10.5.3.7	Dry valve Preaction valve	Number of low point drains Location of each drain
16.12.5.6	Fire department connections not serving the whole building	Indicate portion of the building served by the fire department connection
16.12.5.8	All fire department connections	Indicate systems served by the fire department connection Indicate system pressure demand [for systems requiring more than 150 psi (10 bar)] Letters must be 1 in. (25 mm) in height
29.4	Alarm valve	Indicate the following:

Section	Sign Location	Sign Information/Requirements
	Dry pipe valve Preaction valve Deluge valve	Location of the design area or areas Size (area) of or number of sprinklers in the design area Discharge densities over the design area or areas Required flow and residual pressure demand at the base of the riser Occupancy classification or commodity classification and maximum permitted storage height and configuration Hose stream allowance The installing contractor Sign must be made of weatherproof metal or rigid plastic and attached with corrosion-resistant wire or chain
29.6	System control riser Antifreeze loops Auxiliary systems Control valves	Indicate the following: Name and location of the facility protected Occupancy classification Commodity classification Presence of high-piled and/or rack storage Maximum height of storage planned Aisle width planned Encapsulation of pallet loads Presence of solid shelving Flow test data Presence of flammable/combustible liquids Presence of hazardous materials Presence of other special storage Location of venting valve Location of auxiliary drains and low point drains on dry pipe and preaction systems Sign must be made of weatherproof metal or rigid plastic and attached with corrosion-resistant wire or chain
31.2.7.5	Fire department connection (FDC)	18 in. × 18 in. (450 mm × 450 mm) sign FDC symbol from NFPA 170 Located at connection in plain sight from shore access point
A.16.11.2	Central station, auxiliary, remote station, or proprietary protective signaling systems	Recommended: Located near the device Direct people to call police or fire department when bell rings

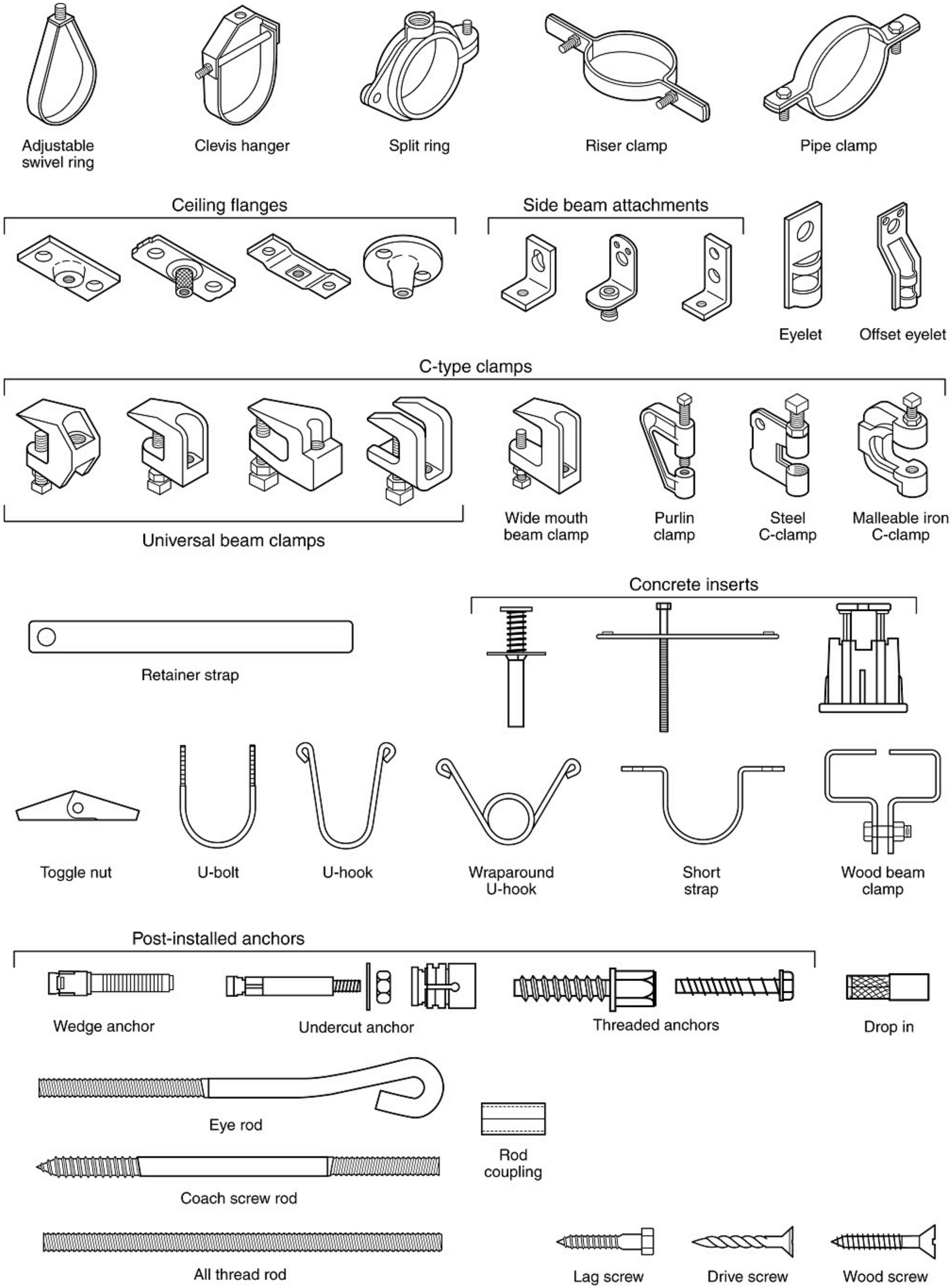
A.17.1

Throughout Chapter 17, metric units have been included where practicable. There are subjects, (e.g., section modulus) where a metric conversion might not be useful. In such situations, it is recommended to consult local requirements and products to determine whether support components are adequate for the loads, including appropriate safety factors.

See Figure A.17.1. As an alternative to the conventional method of hanging pipe from the structure using attachments and rod, the piping can be simply laid on the structural member, provided the structure can adequately support the added load in accordance with 17.4.1.3.1 and the maximum distance between supports required by Chapter 17 is not exceeded. Listed pipe should still be installed and supported in accordance with its listing limitations.

To prevent movement, the pipe should be secured with an approved device to the structure and located such that the system piping remains in its original location and position.

Figure A.17.1 Common Types of Acceptable Hangers.


Adjustable
swivel ring
Clevis hanger
Split ring
Riser clamp
Pipe clamp
Ceiling flanges
Side beam attachments
Eyelet
Offset eyelet
C-type clamps
Universal beam clamps
Wide mouth
beam clamp
Purlin
clamp
Steel
C-clamp
Malleable iron
C-clamp
Concrete inserts
Retainer strap
Toggle nut
U-bolt
U-hook
Wraparound
U-hook
Short
strap
Wood beam
clamp
Post-installed anchors
Wedge anchor
Undercut anchor
Threaded anchors
Drop in
Eye rod
Rod
coupling
Coach screw rod
All thread rod
Lag screw
Drive screw
Wood screw

A.17.1.3.1

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 non-system components from sprinkler piping. NFPA 13 provides the option to support sprinkler piping from other sprinkler piping where the requirements of 17.1.2 are met.

A.17.1.4.1

A shared support assembly can be in the form of a pipe rack structure, a trapeze assembly, pipe stand, or other similar assembly. It is not the intent of this section for a building structure to be considered a shared support assembly. Storage racks are not intended to be considered a shared support assembly.

A.17.1.4.1.4

It is not the intent of 17.1.4.1 to apply to flexible sprinkler hose fittings or ceiling systems.

A.17.1.6.1

The listing requirements for water-based fire protection system hanger components include five times the weight of water-filled piping plus 250 lb (115 kg). However, once the listing is achieved, manufacturers often present their data in simple terms of what size pipe can be supported. The published loads in technical data sheets often represent one times the load of the piping that can be supported at maximum hanger spacing. If the product has been listed for use with fire protection systems, it has been shown to accommodate five times the weight of the water-filled pipe plus 250 lb (115 kg).

A.17.1.6.2

Generic items utilized with hanger rods and fasteners are not required to be listed. These include items such as bolts, screws, washers, nuts, and lock nuts.

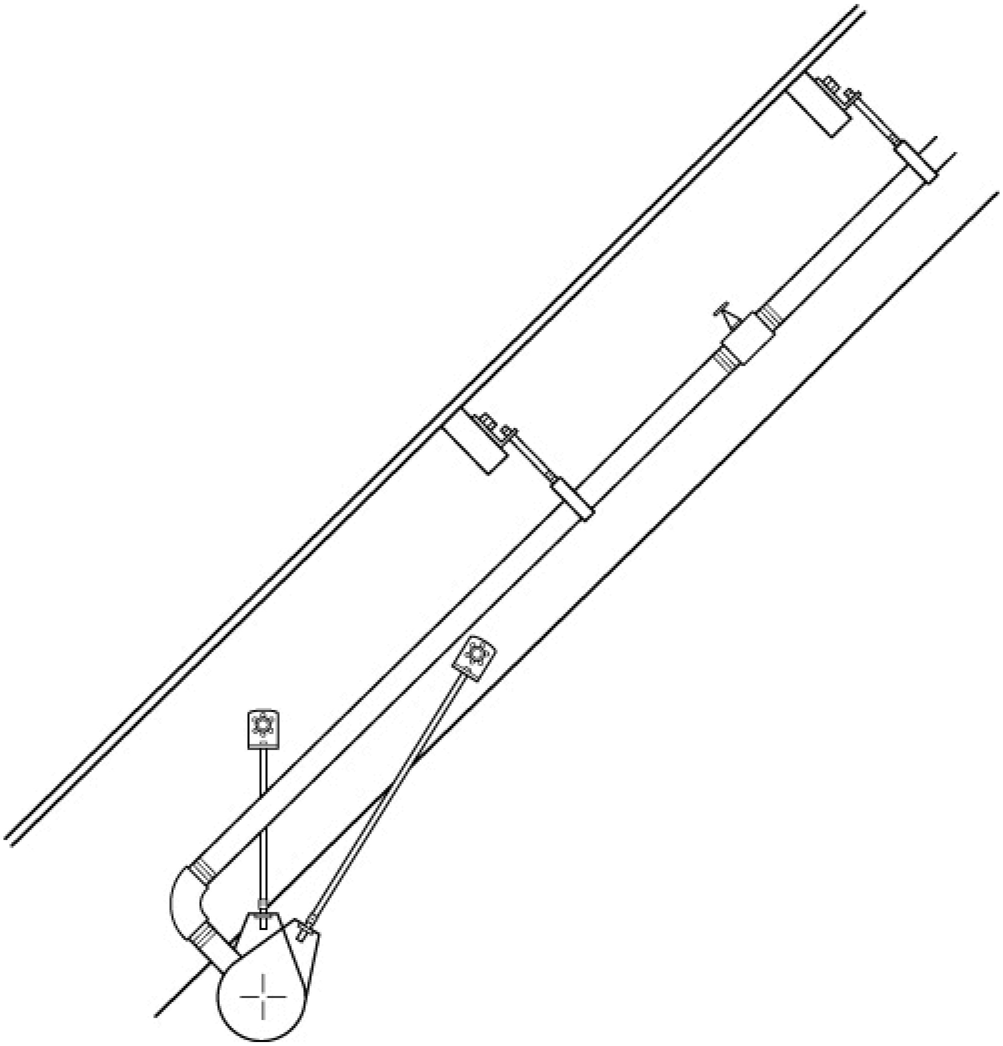
A.17.1.6.3

Generic items utilized with hanger rods and fasteners are not required to be listed. These include items such as bolts, screws, washers, nuts, and lock nuts.

A.17.2.1.3(1)

Hanger rods are intended only to be loaded axially (along the rod). Lateral loads can result in bending, weakening, and even breaking of the rod. Additional hangers or restraints could be necessary to minimize nonaxial loads that could induce bending or deflection of the rods. See Figure A.17.2.1.3(1) for an example of additional hangers utilized to minimize nonaxial loads.

Figure A.17.2.1.3(1) Example of Additional Hangers Utilized to Minimize Nonaxial Loads.



A.17.2.2

In areas that are subject to provisions for earthquake protection, the fasteners in concrete will need to be prequalified. See 18.7.8 for information.

A.17.2.2.9.3

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

For existing structures with concrete tested to the appropriate testing standards at the time of construction, the compressive strength of the concrete should be tested and deemed adequate. The structural capacity of existing concrete might not be known. In such cases, such capacity should be confirmed prior to relying on the structure to properly accommodate the intended load of sprinkler system attachments.

A.17.2.3.1

Powder-driven studs should not be used in steel of less than $^{3}/_{16}$ in. (5 mm) total thickness.

A.17.3

Table 17.3.1(a) assumes that the load from 15 ft (5 m) of water-filled pipe, plus 250 lb (115 kg), is located at the midpoint of the span of the trapeze member, with a maximum allowable bending stress of 15 ksi (103 MPa). If the load is applied at other than the midpoint, for the purpose of sizing the trapeze member, an equivalent length of trapeze can be used, derived from the following formula:

$$L = \frac{4ab}{a+b} \quad \text{[A.17.3]}$$

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 can be added. The table values are based on the trapeze being a single continuous member.

A.17.3.6

Hanger components are sized based upon an ultimate strength limit of 5 times the weight of water-filled pipe plus 250 lb (115 kg). The section moduli used to size the trapeze member are based on a maximum bending stress, which provides an acceptable level of safety that is comparable to that of the other hanger components.

A.17.4

To enhance permanence, proper hanger installation is important. Installation procedures should meet industry standards of practice and craftsmanship. For example, hanger assemblies are straight, perpendicular to the pipe, uniformly located, and snug to the structure with fasteners fully engaged.

A.17.4.1.1.1

Fasteners used to support sprinkler system piping should not be attached to ceilings of gypsum or other similar soft material.

A.17.4.1.3

The method used to attach the hanger to the structure and the load placed on the hanger should take into account any limits imposed by the structure. Design manual information for pre-engineered structures or other specialty construction materials should be consulted, if appropriate.

System mains hung to a single beam, truss, or purlin can affect the structural integrity of the building by introducing excessive loads not anticipated in the building design. Also, special conditions such as collateral and concentrated load limits, type or method of attachment to the structural components, or location of attachment to the structural components might need to be observed when hanging system piping in pre-engineered metal buildings or buildings using other specialty structural components such as composite wood joists or combination wood and tubular metal joists.

The building structure is only required to handle the weight of the water-filled pipe and components, while the hangers are required to handle 5 times the weight of the water-filled pipe. In addition, a safety factor load of 250 lb (115 kg) is added in both cases. The difference in requirements has to do with the different ways that loads are calculated and safety factors are applied.

When sprinkler system loads are given to structural engineers for calculation of the structural elements in the building, they apply their own safety factors in order to determine what structural members and hanging locations will be acceptable.

In contrast, when sprinkler system loads are calculated for the hangers themselves, there is no explicit safety factor, so NFPA 13 mandates a safety factor of 5 times the weight of the pipe.

A.17.4.1.3.3

Examples of areas of use include cleanrooms, suspended ceilings, and exhaust ducts.

A.17.4.1.3.3.3

The committee evaluation of flexible sprinkler hose fittings supported by suspended ceilings was based on information provided to the committee showed that the maximum load shed to the suspended ceiling by the flexible hose fitting was approximately 6 lb (2.7 kg) and that a suspended ceiling meeting ASTM C635/C635M, *Standard Specification for Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-In Panel Ceilings*, and installed in accordance with ASTM C636/C636M, *Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels*, can substantially support that load. In addition, the supporting material showed that the flexible hose connection can be attached to the suspended ceilings because it allows the necessary deflections under seismic conditions.

A.17.4.1.3.3.4

An example of language for the label is as follows:

CAUTION: DO NOT REMOVE THIS LABEL.

Relocation of this device should only be performed by qualified and/or licensed individuals that are aware of the original system design criteria, hydraulic criteria, sprinkler listing parameters, and knowledge of the state and local codes including NFPA 13 installation standards. Relocation of the device without this knowledge could adversely affect the performance of this fire protection and life safety system.

A.17.4.1.4.1

Piping in excess of 1 in. (25 mm) shall be permitted to be supported from a metal deck if the method of attachment and ability of the deck to support loads as specified in 17.4.1.3.1 are approved by a registered professional engineer.

A.17.4.2

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.

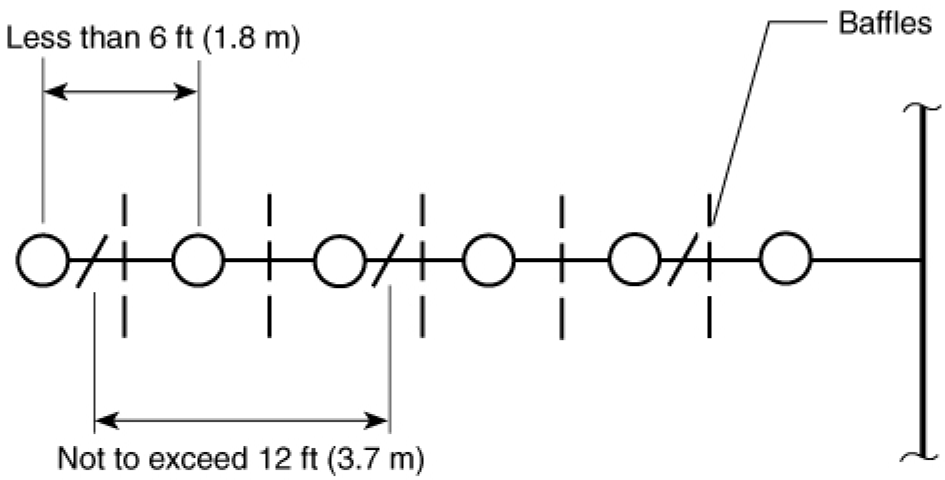
A.17.4.3.2

The hangers required by Chapter 9 are intended to accommodate general loading such as check valves, control valves, or dry or deluge valves. Where additional equipment such as backflow prevention assemblies and other devices with substantial loads are added, additional hangers should be considered.

A.17.4.3.2.2

See Figure A.17.4.3.2.2.

Figure A.17.4.3.2.2 Distance Between Hangers.



A.17.4.3.2.4

The “starter length” is the first piece of pipe on a branch line between the main, riser nipple, or drop and the first sprinkler. Starter pieces that are less than 6 ft (1.8 m) in length do not need a hanger of their own because they are supported by the main. However, if the intermediate hanger on the main is omitted, the starter piece needs to have a hanger because the main is going to be supported from the branch lines. The starter lengths can also apply to other piping, such as drains and test connections.

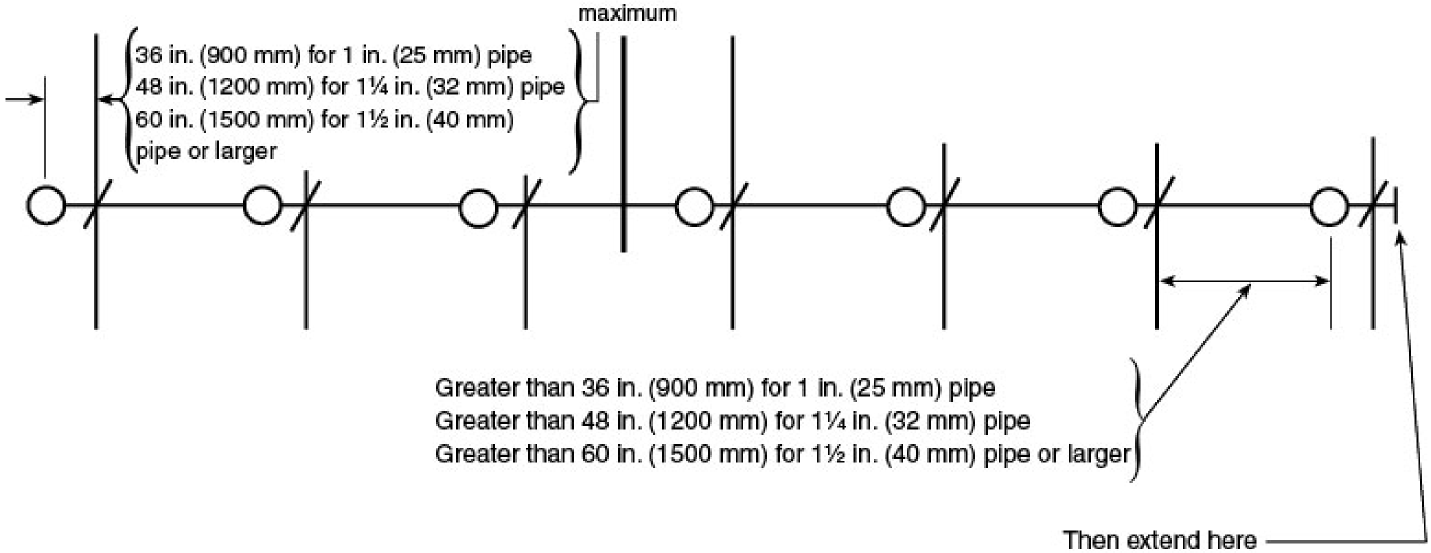
A.17.4.3.2.5

When a branchline contains offsets, sections of pipe are considered adequately supported by the hangers on the adjacent pipe sections when the overall distance between hangers does not exceed the requirements in Table 17.4.2.1(a) and Table 17.4.2.1(b). The cumulative distance includes changes in horizontal direction. Multiple consecutive sections of pipe should be permitted to omit hangers.

A.17.4.3.4

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 has specific requirements for piping support to include additional pipe bracing of sprinklers. *(See Figure A.17.4.3.4.)*

Figure A.17.4.3.4 Distance from Sprinkler to Hanger.



A.17.4.3.4.4

See Figure A.17.4.3.4.4(a) and Figure A.17.4.3.4.4(b).

Figure A.17.4.3.4.4(a) Distance from Sprinkler to Hanger Where Maximum Pressure Exceeds 100 psi (6.9 bar) and Branch Line Above Ceiling Supplies Pendent Sprinklers Below Ceiling.

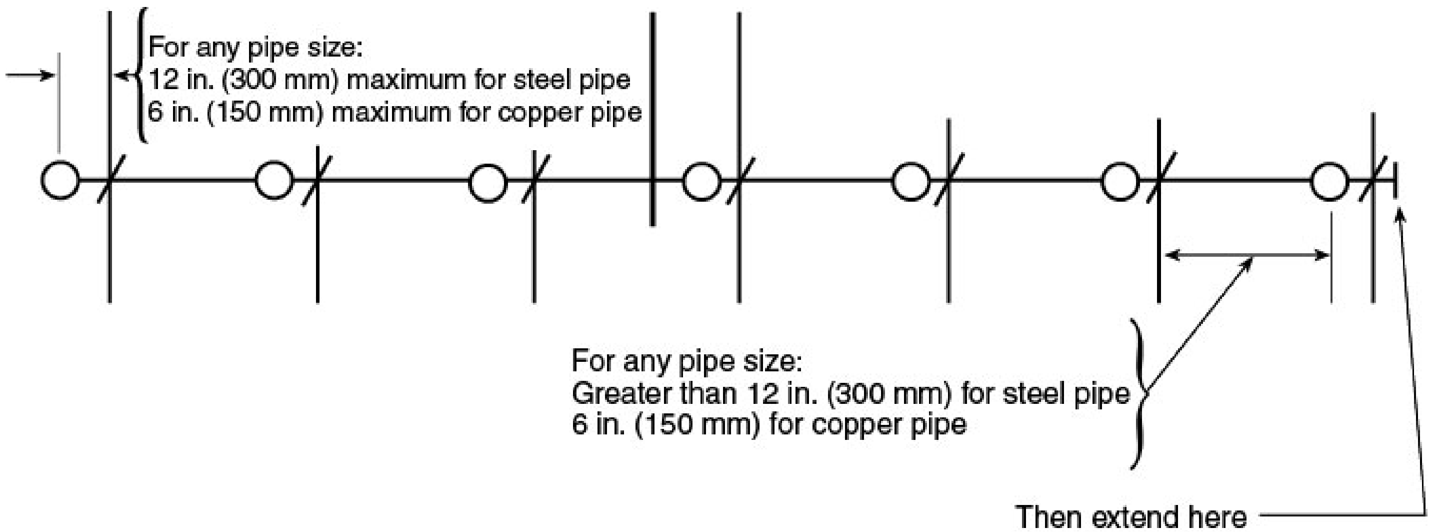
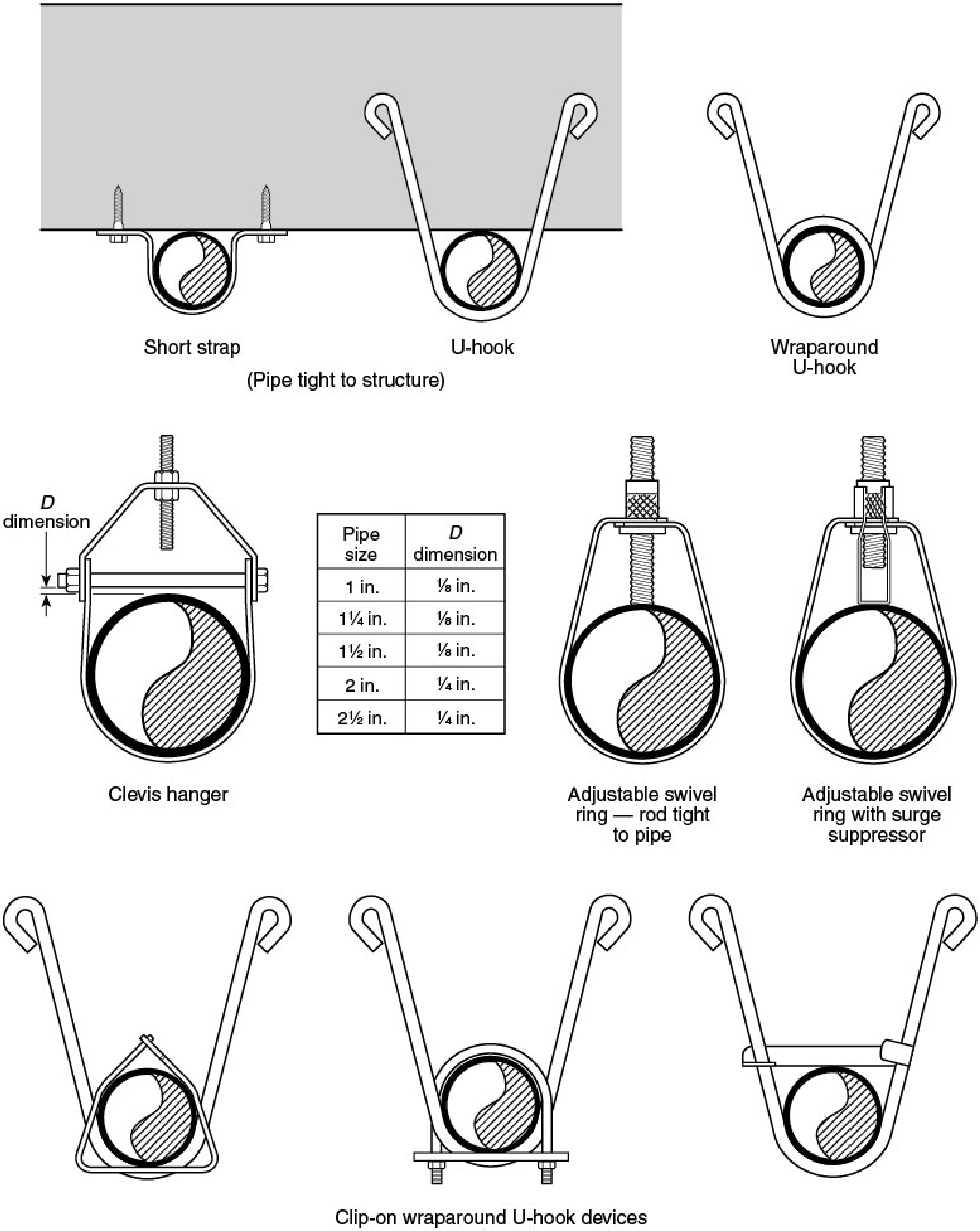


Figure A.17.4.3.4.4(b) Examples of Acceptable Hangers for End-of-Line (or Armover) Pendent Sprinklers.



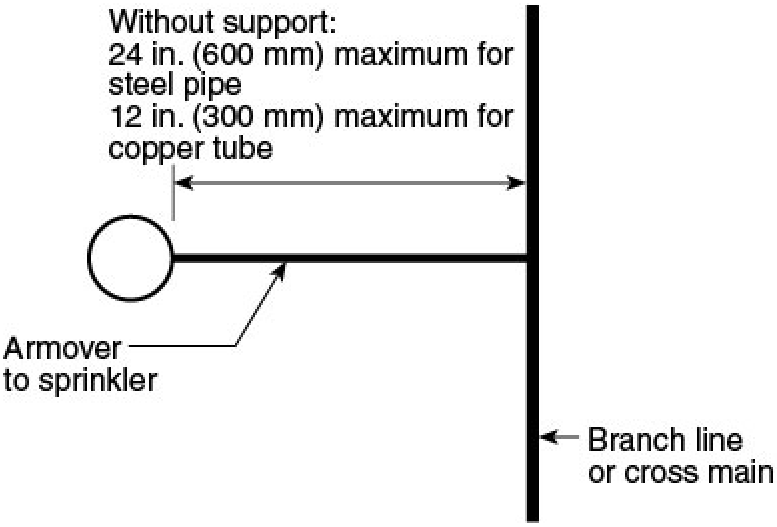
Pipe size	*D* dimension
1 in.	⅛ in.
1¼ in.	⅛ in.
1½ in.	⅛ in.
2 in.	¼ in.
2½ in.	¼ in.

For SI units, 1 in. = 25.4 mm.

A.17.4.3.5

See Figure A.17.4.3.5.

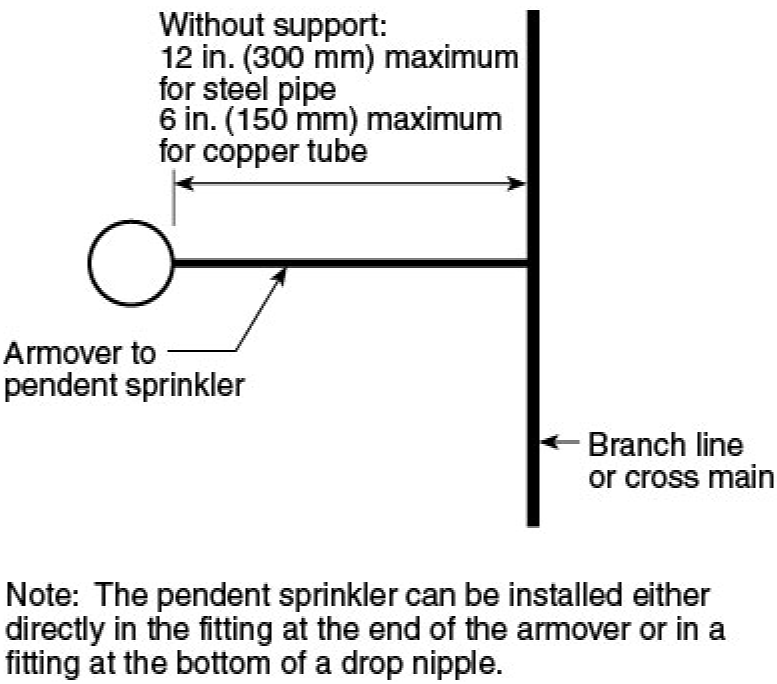
Figure A.17.4.3.5 Maximum Length for Unsupported Armover.



A.17.4.3.5.2

See Figure A.17.4.3.5.2.

Figure A.17.4.3.5.2 Maximum Length of Unsupported Armover Where Maximum Pressure Exceeds 100 psi (6.9 bar) and Branch Line Above Ceiling Supplies Pendent Sprinklers Below Ceiling.



A.17.4.3.6

The movement that is being restrained is to keep the sidewall sprinkler in its intended location during and post-operation. This should not be confused with the loads applicable to seismic restraints.

A.17.4.4.8

When a main contains offsets, sections of pipe are considered adequately supported by the hangers on the adjacent pipe sections when the overall distance between hangers does not exceed the requirements in Table 17.4.2.1(a) and Table 17.4.2.1(b). The cumulative distance includes changes in horizontal direction. Multiple consecutive sections of pipe should be permitted to omit hangers.

A.17.4.5.3

This arrangement is acceptable to establish and secure the riser's lateral position but not to support the riser's vertical load.

A.17.4.5.4.2

The restraint required by 17.4.5.4.2 is needed to prevent accumulated vertical movement when the riser is pressurized. Restraint is generally provided by use of a riser clamp at the underside of a floor slab.

A.17.5

Where applicable, the design of pipe stands should consider additional loading from other sources. Environmental impacts, including water accumulation at the base, corrosion, and wind, should also be taken into account as appropriate.

The performance of piping support systems should allow for expansion and contraction due to temperature change, expansion due to internal water pressure (thrust), restrained and/or unrestrained joints or pipe runs, heavy point loads (e.g., valves), and pipe deflection (span/support spacing). Manufacturer's installation instructions and engineering design guides should be consulted when available.

Examples of common applications include headers and horizontal runs of pipe that need support from the floor.

A.17.5.3.1

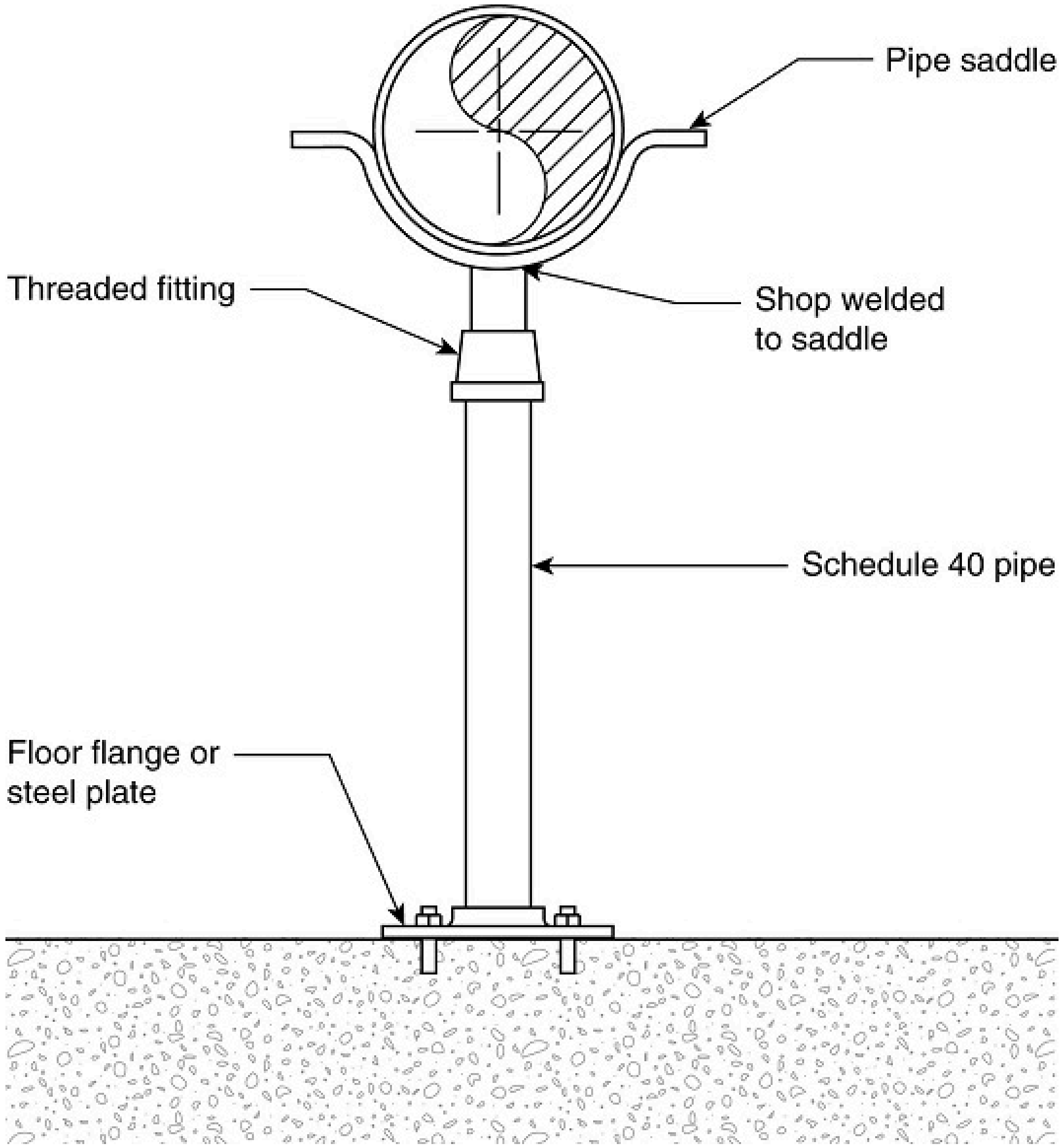
When a pipe stand does not resist lateral (e.g., earthquake or wind) forces, its maximum height and the weight of pipe it can support are based primarily on a limiting slenderness ratio (Kl/r), and on the axial and bending stresses caused by the vertical load applied at a specified eccentricity.

The pipe stand heights presented in Table 17.5.3.1(a) and Table 17.5.3.1(b) have been calculated using a "K" of 2.1 (i.e., assuming the pipe stand is an individual cantilever column) and a slenderness ratio limit of 300, except where combined axial and bending stresses caused by the vertical load at an eccentricity of 12 in. (300 mm) controls the design. In these cases, the pipe stand height is reduced such that the allowable axial stress (F_a) is sufficient to limit the combined axial stress ratio (f_a/F_a, i.e., actual axial stress divided by allowable axial stress) plus the bending stress ratio (f_b/F_b, i.e., actual bending stress divided by allowable bending stress) to 1.0. Two cases are considered: a vertical load at a 12 in. (300 mm) eccentricity equals a) 5 times the weight of the water-filled pipe plus 250 lb (115 kg) using a bending stress allowable of 28,000 psi (193 MPa), and b) the weight of the water-filled pipe plus 250 lb (115 kg) using a bending stress allowable of 15,000 psi (103 MPa). No drift limit was imposed.

When an engineering analysis is conducted, different pipe stand heights could be calculated if other assumptions are warranted based on actual conditions. For example, K=1.0 can be used if the pipe at the top of the pipe stand is braced in both horizontal directions, or a shorter cantilever column could be used to limit drift.

Pipe stands are intended to be a single piece of pipe. For lengths that require joining pipes, the pipes should be welded to ensure that strength is maintained. A single threaded fitting at the top of the pipe stand should be allowed for height adjustment in the field. *(See Figure A.17.5.3.1.)*

Figure A.17.5.3.1 Pipe Stand.



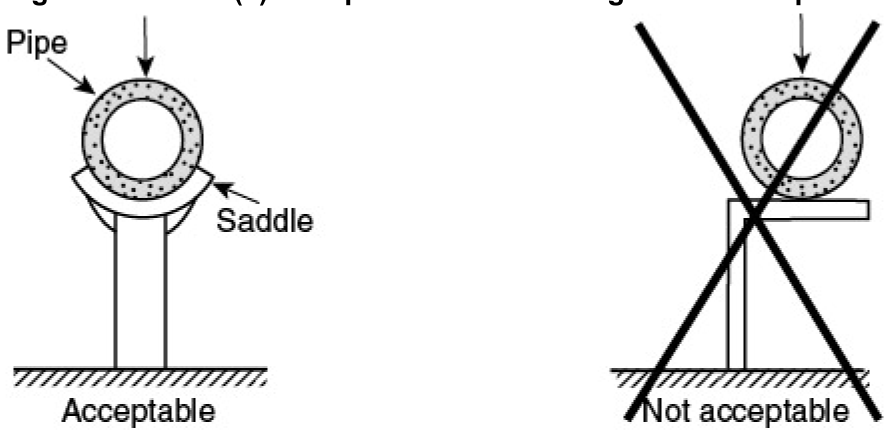
A.17.5.3.2

These short pipe stands commonly support items such as backflow preventers, header piping, and other appurtenances.

A.17.5.3.2(2)

The allowances for these short pipe stands do not account for eccentric loadings. See Figure A.17.5.3.2(2).

Figure A.17.5.3.2(2) Acceptable Axial Loading and Unacceptable Loading.



A.17.5.4.2

Where welded steel flanges are used for the base plate, the entire circumference of the flange should be welded.

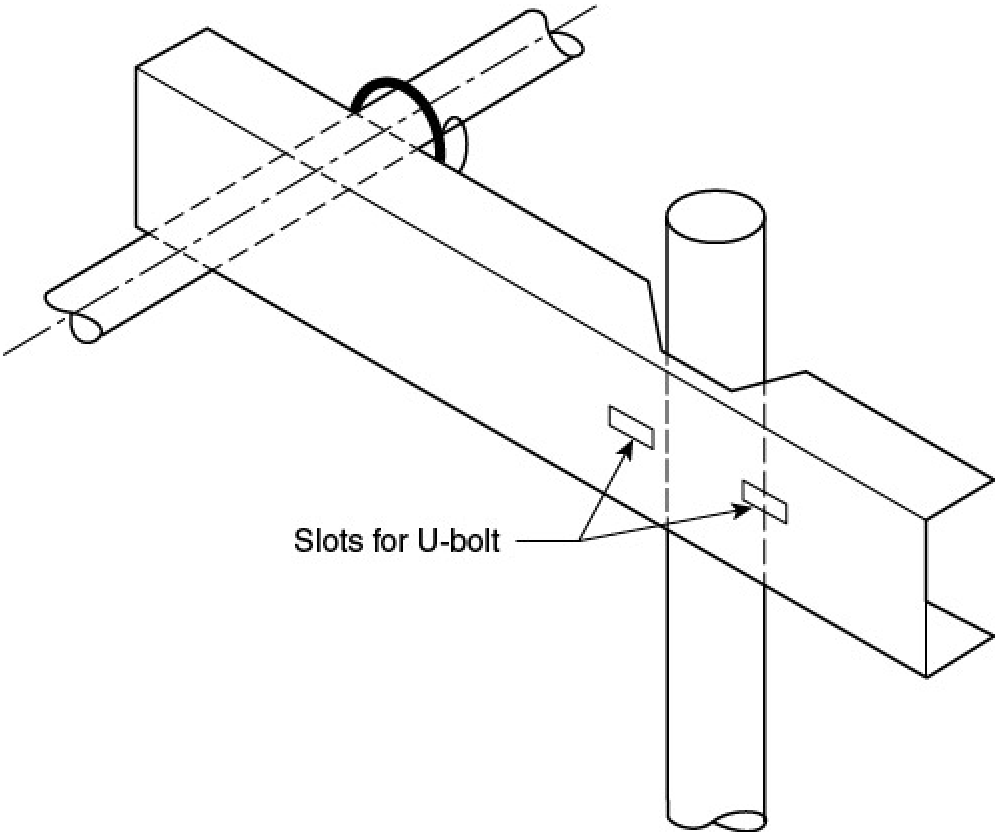
A.17.5.4.3

Examples of acceptable anchors can be listed inserts set in concrete, listed post-installed anchors, bolts for concrete, or cast-in-place J hooks.

A.17.5.5.3

See Figure A.17.5.5.3.

Figure A.17.5.5.3 Example of a Horizontal Bracket Attached to a Pipe Stand.



A.17.5.6.1

The support and restraint are needed in order to maintain system performance and integrity. Water surges could be from filling the system, from system operation, or water supply related.

A.17.5.6.2

Traditionally, pipe saddles have been used, which creates a “U” for the pipe to rest in. However, thrust forces in some applications can be large enough to move the pipe off the saddle. Therefore, a pipe ring or clamps should be around the system piping to keep it in place.

A.18.1

Sprinkler systems are protected against earthquake damage by means of the following:

(1) Stresses that would develop in the piping due to differential building movement are minimized using flexible joints or clearances.
(2) 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 earthquake potential have been identified in building codes and insurance maps. Based on the project location, local codes and requirements will be applied. For projects using metric units, it is likely that the enforced codes, standards, and guidelines will vary compared to those used to create the simplified approaches to seismic protection in Chapter 18. These variations could include strength design of components instead of the allowable stress design (ASD) of components, such as concrete anchors, tested by way of methods other than those listed in ACI 355.2, *Post-Installed Mechanical Anchors in Concrete — Qualification Requirements and Commentary*. Therefore, metric units have been included where practicable. In such situations, it is recommended to consult local requirements, authorities, and products to determine whether components are adequate for the seismic loads, including appropriate safety factors.

Displacement due to story drift is addressed in Sections 18.2 through 18.4.

Piping in racks needs to be treated like other sprinkler piping and protected in accordance with the proper rules. Piping to which in-rack sprinklers are directly attached should be treated as branch line piping. Piping that connects branch lines in the racks should be treated as mains. The bracing, restraint, flexibility, and requirements for flexible couplings are the same in the rack structures as at the ceiling.

Cloud ceilings can cause challenges for a sprinkler system in an earthquake where sprinklers are installed below the clouds to protect the floor below. Depending on the support structure of the cloud and the construction material of the cloud, differential movement could damage a sprinkler that is not installed in a fashion to accommodate the movement. Currently, there are no structural requirements in ASCE/SEI 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, for the clouds to be seismically braced. Unbraced cloud ceilings in higher seismic areas could easily displace during design earthquakes half the suspension length or more. One solution might be to use flexible sprinkler hose with the bracket connected to the cloud so that the sprinkler will move with the cloud during seismic motion, provided the ceiling system is constructed per ASTM C635/C635M, *Standard Specification for Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-In Panel Ceilings*, and ASTM C636/C636M, *Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels*. When a sprinkler is rigidly piped to the cloud, appropriate flexibility and clearances should be maintained to handle the anticipated movement.

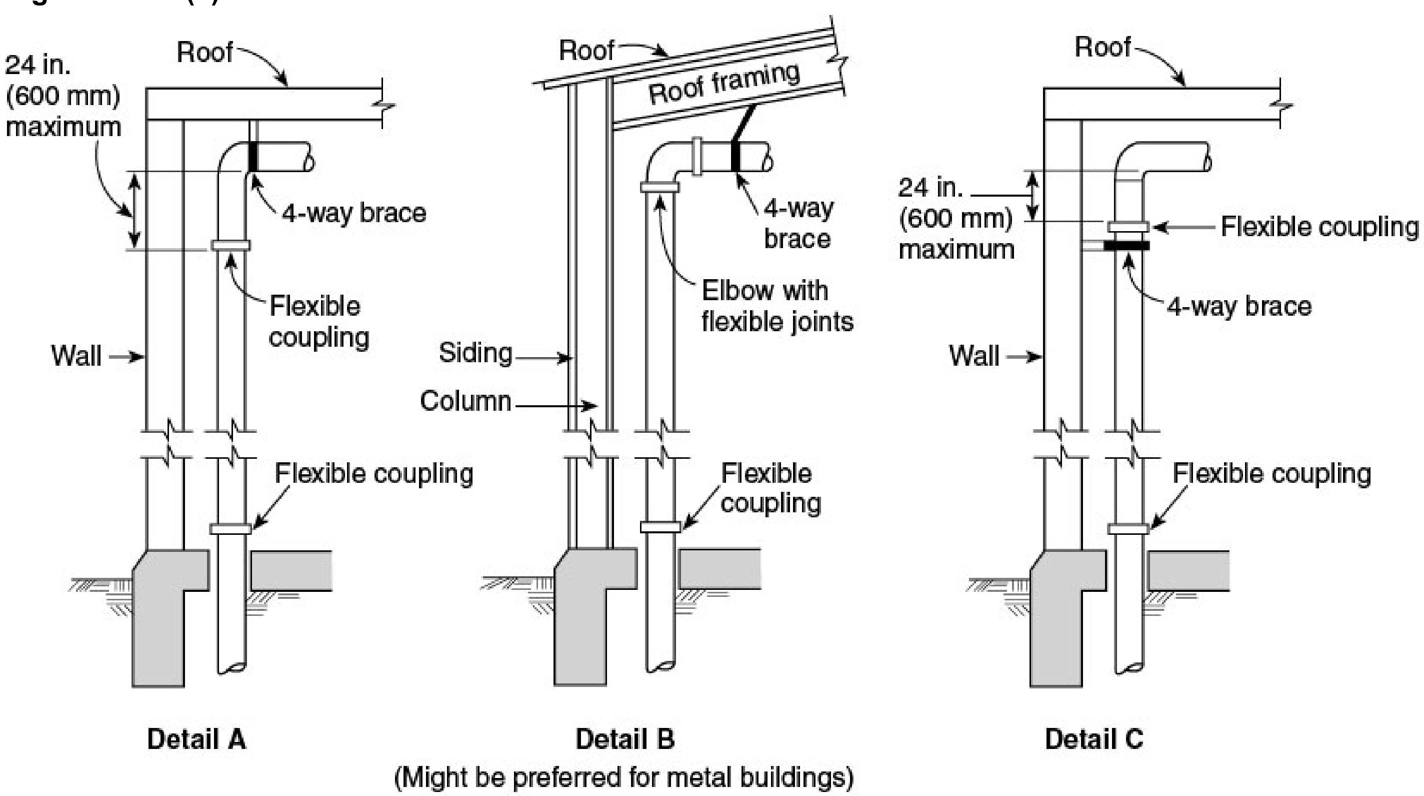
A.18.2

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.

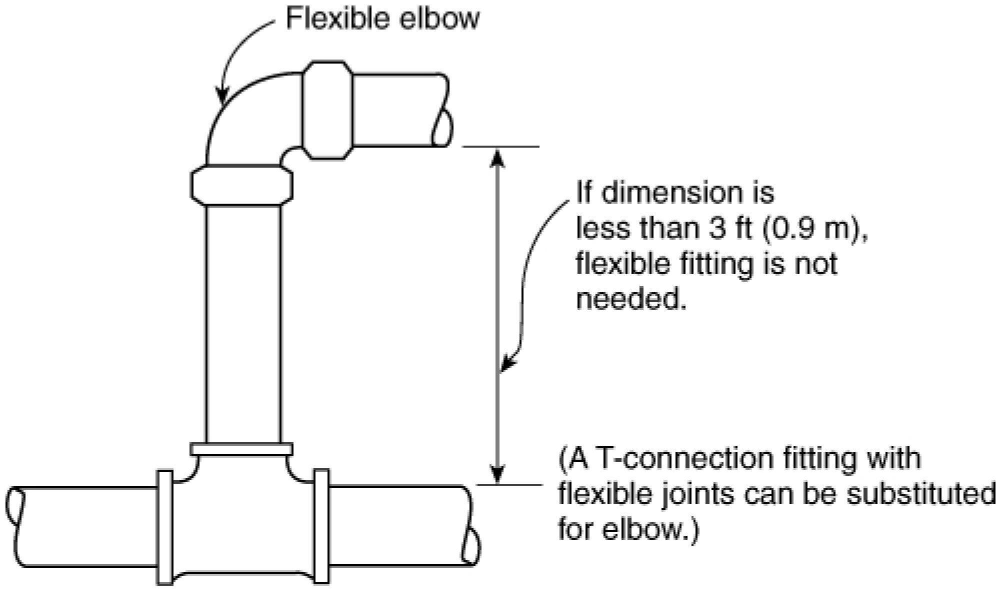
Piping 2 in. (50 mm) or smaller in size is pliable enough so that flexible couplings are not usually necessary. “Rigid-type” couplings that permit less than 1 degree of angular movement at the grooved connections are not considered to be flexible couplings. *[See Figure A.18.2(a) and Figure A.18.2(b).]*

Figure A.18.2(a) Riser Details.



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.18.2(b) Detail at Short Riser.



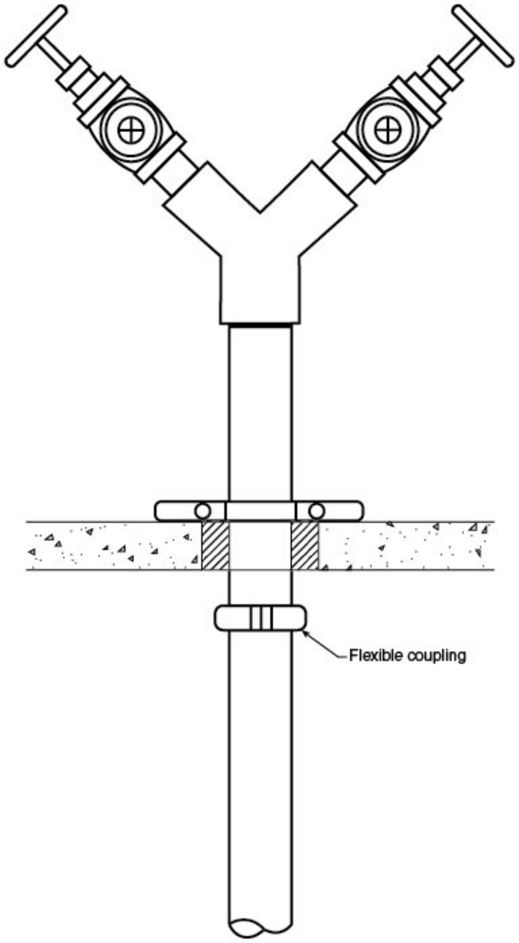
A.18.2.4.1(1)

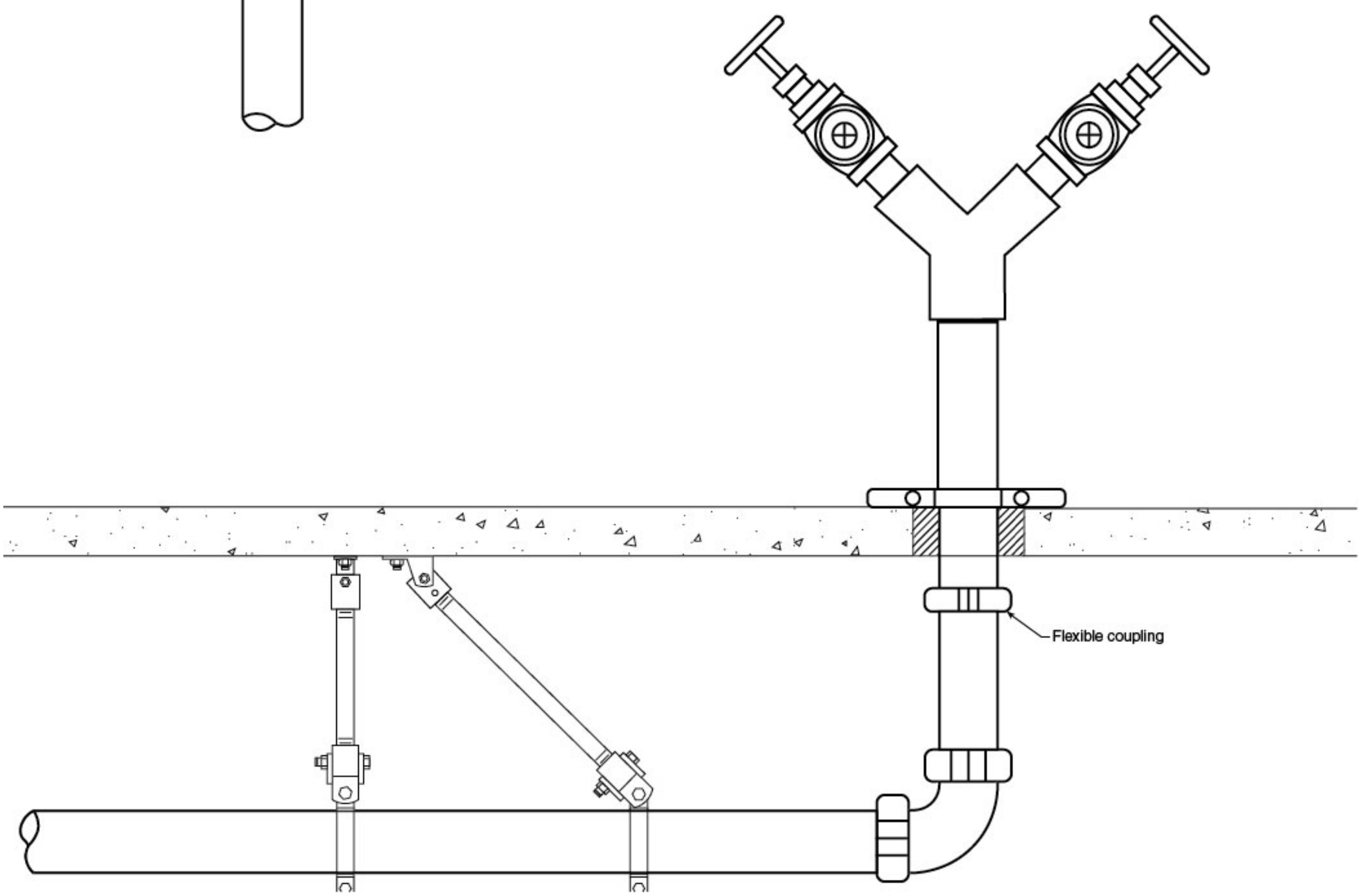
Risers do not include riser nipples as defined in 3.3.195.

A.18.2.4.1(3)

See Figure A.18.2.4.1(3).

Figure A.18.2.4.1(3) Flexible Coupling on Upper Landing or Roof Assembly.





A.18.2.4.1(5)

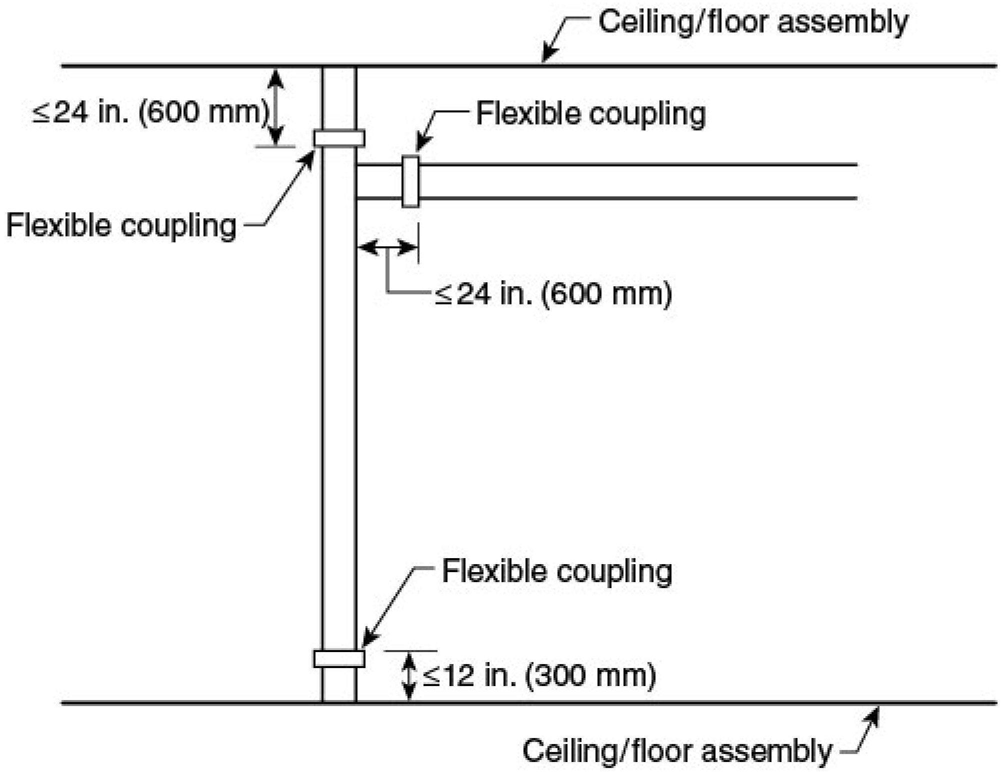
A building expansion joint is usually a bituminous fiber strip used to separate blocks or units of concrete to prevent cracking due to expansion as a result of temperature changes. Where building expansion joints are used, the flexible coupling is required on one side of the joint by 18.2.4.1(5).

For seismic separation joints, considerably more flexibility is needed, particularly for piping above the first floor. Figure A.18.3(a) shows a method of providing additional flexibility through the use of swing joints.

A.18.2.4.2(1)

See Figure A.18.2.4.2(1).

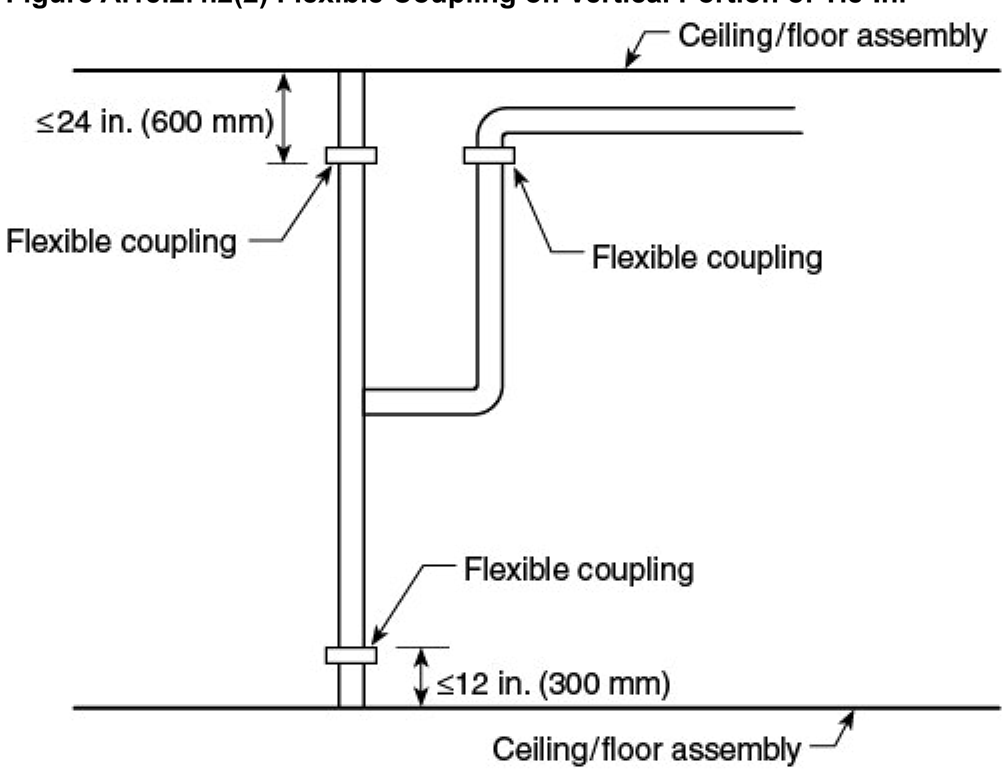
Figure A.18.2.4.2(1) Flexible Coupling on Horizontal Portion of Tie-In.



A.18.2.4.2(2)

The flexible coupling should be at the same elevation as the flexible coupling on the main riser. *[See Figure A.18.2.4.2(2).]*

Figure A.18.2.4.2(2) Flexible Coupling on Vertical Portion of Tie-In.



A.18.2.5

See Figure A.18.2.5. Drops that extend into freestanding storage racks or other similar structures should be designed to accommodate a horizontal relative displacement between the storage rack and the overhead supply piping. Free standing structures include but are not limited to freezers, coolers, spray booths, and offices.

The horizontal relative displacement should be determined using the least value from one of the following formulas and be taken as the height of the top point of attachment to the storage rack above its base or the highest point of potential contact between the rack structure and the piping above its base, whichever is higher. The design should account for the differential movement value as determined from one of the two formulas, not both, and the lesser of the two values is acceptable. It should be determined how to account for the differential movement using flexible couplings or other approved means.

$$D = H * 0.06 * S_1 * F_v$$
$$\text{or}$$
$$D = H * 0.05 \quad \text{[A.18.2.5]}$$

where:

D = differential movement between the rack and the roof [ft (m)]

H = height of the top point of attachment to the rack [ft (m)]

S_1 = one second period spectral acceleration per USGS 2010 Seismic Design Maps *(see ASCE/SEI 7)*

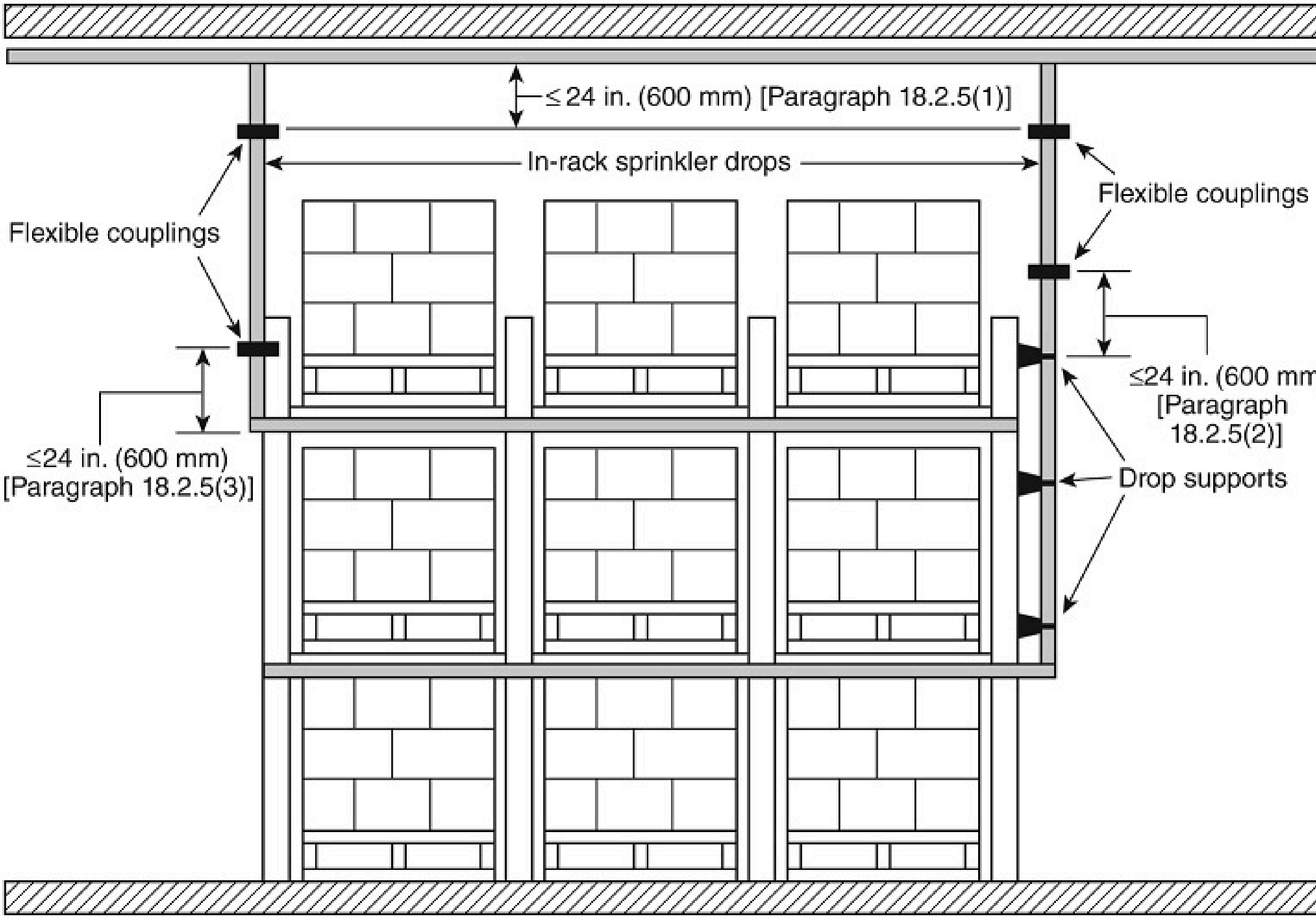
F_v = one second period site coefficient (Site Class D)

F_v is a function of S_1 and is determined as follows:

S_1	F_v
≤0.1	2.4
=0.2	2.0
=0.3	1.8
=0.4	1.6
≥0.5	1.5

Note: Use straight-line interpolation for intermediate values of S_1.

Figure A.18.2.5 Flexible Couplings for Drops.



A.18.3

Plan and elevation views of a seismic separation assembly configured with flexible elbows are shown in Figure A.18.3(a), Figure A.18.3(b), and Figure A.18.3(c).

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.

Figure A.18.3(a) Seismic Separation Assembly in which 8 in. (200 mm) Separation Crossed by Pipes Up to 4 in. (100 mm) in Nominal Diameter. (For other separation distances and pipe sizes, lengths and distances should be modified proportionally.)

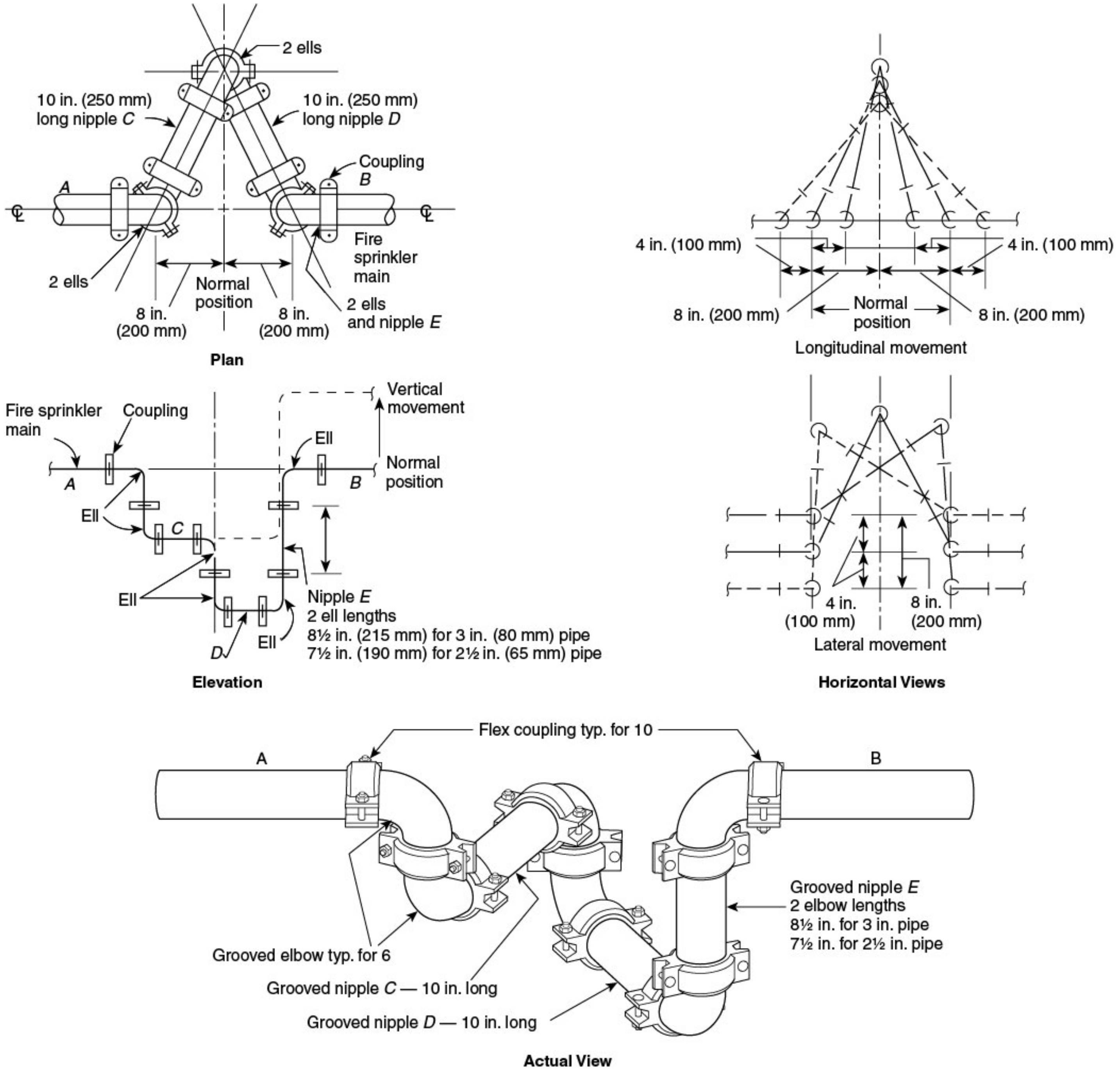


Figure A.18.3(b) Seismic Separation Assembly Incorporating Flexible Piping.

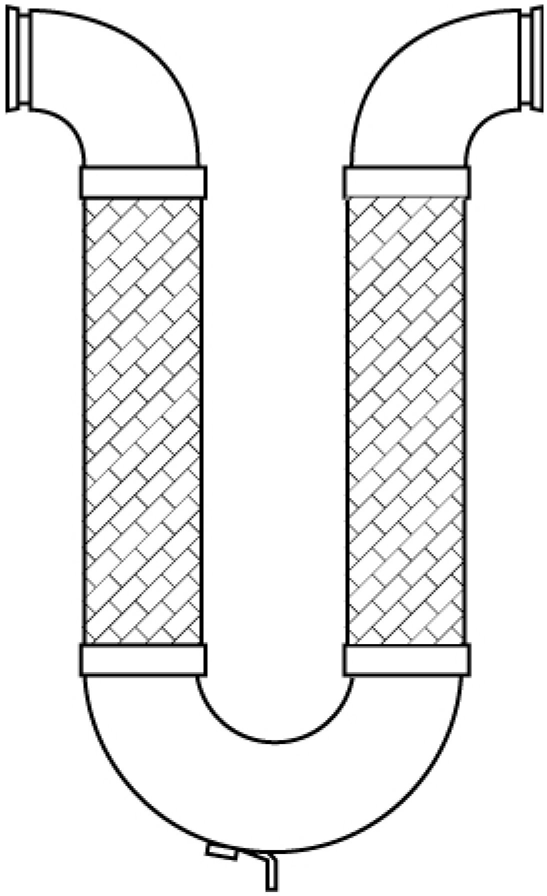
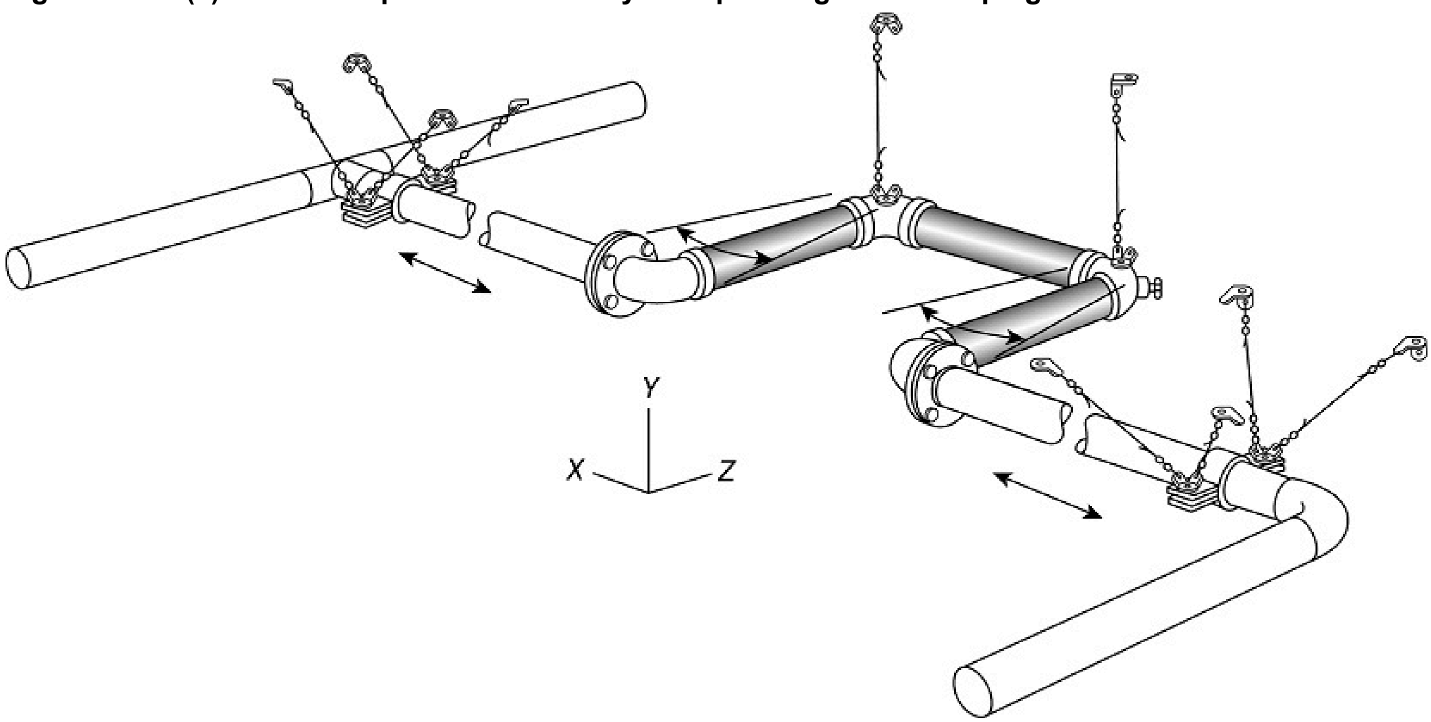


Figure A.18.3(c) Seismic Separation Assembly Incorporating Flexible Piping.



A.18.3.3

Each four-way brace should be attached to the building structure on opposite sides of the seismic separation joint.

A.18.4

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.

In areas that use suspended ceilings and are a seismic design category of D, E, or F, a larger clearance could be necessary around the sprinkler unless the suspended ceiling is rigidly braced or flexible sprinkler hose fitting are used as noted in ASTM E580/E580M, *Standard Practice for Installation of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Subject to Earthquake Ground Motions*.

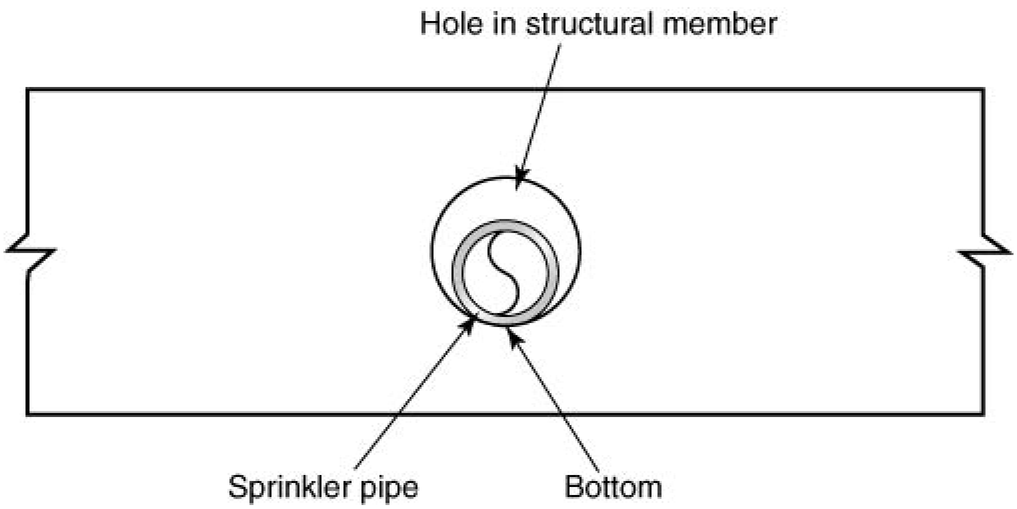
A.18.4.1

Penetrations with or without clearance for seismic protection also need to meet building code requirements for fire resistance ratings as applicable.

A.18.4.10

Figure A.18.4.10 is an example of piping supported by structure where there is no clearance required at the point of contact between the piping and structure.

Figure A.18.4.10 Pipe with Zero Clearance.



A.18.4.11

Structural elements include, but are not limited to, beams, girders, and trusses. Frangible ceilings should not be considered structural elements for this purpose.

A.18.5

Figure A.18.5(a) and Figure A.18.5(b) are examples of forms used to aid in the preparation of bracing calculations.

Figure A.18.5(a) Seismic Bracing Calculation Form.

Seismic Bracing Calculations

Sheet ________ of ________

Project: ______________________

Address: ______________________

____

Contractor: ______________________

Address: ______________________

____

Telephone: ______________________

Fax: ______________________

Brace Information

Length of brace: ____________

Diameter of brace: ____________

Type of brace: ____________

Angle of brace: ____________

Least radius of gyration:* ____________

l/*r* value:* ____________

Maximum horizontal load: ____________

Fastener Information

Orientation of connecting surface: ____________

Fastener:

Type: ____________

Diameter: ____________

Length (in wood): ____________

Maximum load: ____________

Seismic Brace Attachments

Structure attachment fitting or tension-only bracing system:

Make: ____________ Model: ____________

Transition attachment fitting (where applicable):

Make: ____________ Model: ____________

Listed load rating: ______ Adjusted load rating per 18.5.2.3: ______

Sway brace (pipe attachment) fitting:

Make: ____________ Model: ____________

Listed load rating: ______ Adjusted load rating per 18.5.2.3: ______

Seismic Brace Assembly Detail

(Provide detail on plans)

Brace identification no.
(to be used on plans) ____________

☐ Lateral brace ☐ Longitudinal brace ☐ 4-way brace

Sprinkler System Load Calculation ($F_{pw} = C_p W_p$)

C_p = ____________

Diameter	Type	Length (ft)	Total (ft)	Weight per ft	Weight
				lb/ft	lb
				lb/ft	lb
				lb/ft	lb
				lb/ft	lb
				lb/ft	lb
				Subtotal weight	lb
				W_p (incl. 15%)	lb
Main Size	Type\Sch.	Spacing (ft)		Total (F_{pw})	lb
				Maximum F_{pw} per 18.5.5.2 (if applicable)	

* Excludes tension-only bracing systems

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Figure A.18.5(b) Sample Seismic Bracing Calculation Form.

Seismic Bracing Calculations

Sheet ________ of ________

Project: Acme Warehouse
Address: 321 First Street
Any City, Any State

Contractor: Smith Sprinkler Company
Address: 123 Main Street
Any City, Any State
Telephone: (555) 555-1234
Fax: (555) 555-4321

Brace Information

Length of brace: 3 ft 6 in.
Diameter of brace: 1 in.
Type of brace: Schedule 40
Angle of brace: 45Υ to 59Υ
Least radius of gyration:* 0.421
l/r value:* 100
Maximum horizontal load: 4455 lb

Fastener Information

Orientation of connecting surface: "E"

Fastener:
- Type: Through bolt
- Diameter: 3/4 in.
- Length (in wood): 5 1/2 in.
- Maximum load: 620 lb

Seismic Brace Attachments

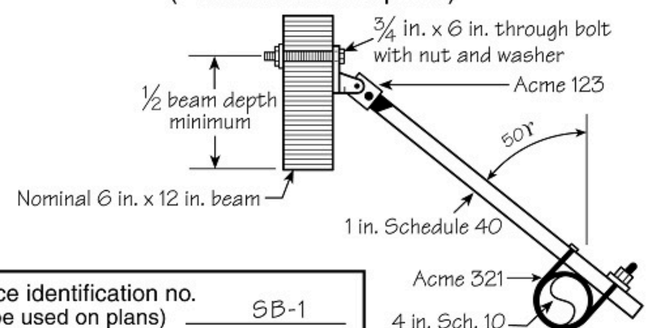
Structure attachment fitting or tension-only bracing system:
Make: Bolt Model: Bolt
Listed load rating: - - - Adjusted load rating per 18.5.2.3: - - -

Transition attachment fitting (where applicable):
Make: Acme Model: 123
Listed load rating: 1000 Adjusted load rating per 18.5.2.3: 707

Sway brace (pipe attachment) fitting:
Make: Acme Model: 321
Listed load rating: 1200 Adjusted load rating per 18.5.2.3: 849

Seismic Brace Assembly Detail

(Provide detail on plans)



Brace identification no. (to be used on plans) SB-1

☒ Lateral brace ☐ Longitudinal brace ☐ 4-way brace

Sprinkler System Load Calculation ($F_{pw} = C_p W_p$)

C_p = 0.40

Diameter	Type	Length (ft)	Total (ft)	Weight per ft	Weight
1 in.	Sch. 40	15 ft + 25 ft + 8 ft + 22 ft	70 ft	2.05 lb/ft	143.5 lb
1 1/4 in.	Sch. 40	25 ft + 33 ft + 18 ft	76 ft	2.93 lb/ft	222.7 lb
1 1/2 in.	Sch. 40	8 ft + 8 ft + 10 ft + 10 ft	36 ft	3.61 lb/ft	130.0 lb
2 in.	Sch. 40	20 ft	20 ft	5.13 lb/ft	102.6 lb
4 in.	Sch. 10	20 ft	20 ft	11.78 lb/ft	235.6 lb
				Subtotal weight	834.4 lb
				W_p (incl. 15%)	959.6 lb
Main Size	Type\Sch.	Spacing (ft)		Total (F_{pw})	383.8 lb
4 in.	Sch. 10	20 ft		Maximum F_{pw} per 18.5.5.2 (if applicable)	1634

* Excludes tension-only bracing systems

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A.18.5.1.3

All horizontal loads given in this document are at allowable stress design levels. When performing a more advanced analysis procedure, as described in 18.1.2, care should be taken to ensure that the correct load factors (strength design or allowable stress design) are used.

A.18.5.1.4

A shared support assembly can be used to provide both support as defined in 17.1.4.1 and provide resistance to seismic forces. When a shared support assembly is used for both support and seismic forces, the shared support assembly should be designed to resist the seismic force for all of the distribution system. The shared support assembly should be designed for a load in which the zone of influence includes the water-filled sprinkler pipe and all other distribution systems attached to the shared support assembly.

A.18.5.1.5

It is the intent of this section to avoid any incompatibility of displacements between the shared support assembly and the sprinkler seismic bracing, as might occur if the supports are located on separate adjacent structures.

A.18.5.2.3

The listed load rating should include a minimum safety factor of 2.2 against the ultimate break strength of the brace components and then be further reduced according to the brace angles.

A.18.5.2.3.1

Depending on the configuration of bracing fittings and connections, it is not always the case that the weakest component of a brace assembly tested at a brace angle of 90 degrees will be the same or will fail in the same way as the weakest component when tested at other brace angles. Therefore, determining an allowable horizontal load using the factors in Table 18.5.2.3 and a listed load rating established solely by testing along the brace assembly at 90 degrees might not be conservative. In most cases, a single listed load rating can be determined by testing the brace assembly at angles of 30, 45, 60, and 90 degrees, reducing the horizontal force at failure found for each of these angles by an appropriate safety factor and then resolving the resulting maximum allowable horizontal loads to a direction along the brace, and finally taking the minimum of these values along the brace assembly as the listed load rating. By taking the minimum value so determined as the listed load rating, allowable horizontal loads determined using Table 18.5.2.3 will be conservative. In some cases, and where justified by engineering judgment, fewer or additional tests might be needed to establish a listed load rating.

A.18.5.4.2

The investigation of tension-only bracing using materials, connection methods, or both, other than those described in Table 18.5.11.8(a) through Table 18.5.11.8(f), should involve consideration of the following:

(1) Corrosion resistance.
(2) Prestretching to eliminate permanent construction stretch and to obtain a verifiable modulus of elasticity.
(3) Color coding or other verifiable marking of each different size cable for field verification.
(4) The capacity of all components of the brace assemblies, including the field connections, to maintain the manufacturer’s minimum certified break strength.
(5) 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 Figure 18.5.12.1. The maximum allowable horizontal loads must not exceed the manufacturer’s minimum certified break strength of the brace assemblies, excluding fasteners, after taking a safety factor of 2.2 and then adjusting for the brace angle.
(6) Bracing product shipments accompanied by the manufacturer’s certification of the minimum break strength and prestretching and installation instructions.
(7) The manufacturer’s literature, including any special tools or precautions required to ensure proper installation.
(8) A means to prevent vertical motion due to seismic forces when required.

Table A.18.5.4.2 identifies standards for specially listed tension-only bracing systems.

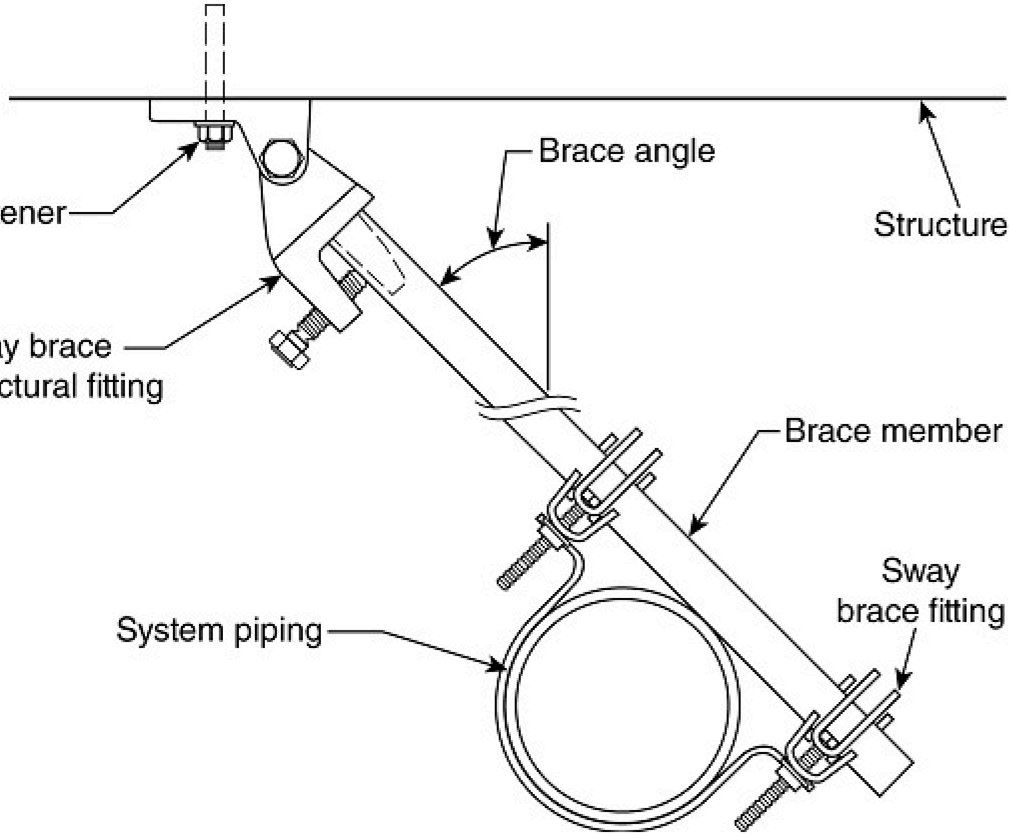
Table A.18.5.4.2 Specially Listed Tension-Only Seismic Bracing

Materials and Dimensions	Standard (or Document)
Structural application of steel cables	ASCE 19
Wire rope	*Wire Rope Users Manual*
Mechanical strength	ASTM A603
Small diameter steel cable for bracing	ASTM A1023/A1023M
Breaking strength failure test	ASTM E8/E8M

A.18.5.5

See Figure A.18.5.5.

Figure A.18.5.5 Generic Example of a Lateral Sway Brace.



A.18.5.5.1

A brace assembly includes the brace member, the attachment components to pipe and building, and their fasteners. There are primarily two considerations in determining the spacing of lateral earthquake braces in straight runs of pipe: (1) deflection and (2) stress. Both deflection and stress tend to increase with the spacing of the braces. The larger the midspan deflection, the greater the chance of impact with adjacent structural/nonstructural components. The higher the stress in the pipe, the greater the chance of rupture in the pipe or coupling. Braces are spaced to limit the stresses in the pipe and fittings to the levels permitted in modern building codes, with an upper limit of 40 ft (12.2 m). The braces also serve to control deflection of the pipe under earthquake loads. In the longitudinal direction, there is no deflection consideration, but the pipe must transfer the load to the longitudinal braces without inducing large axial stresses in the pipe and the couplings.

A.18.5.5.2

The maximum horizontal brace forces (F_{pw}) versus sway brace spacings in Table 18.5.5.2(a) through Table 18.5.5.2(n) were developed based on required horizontal seismic forces and allowable stresses appropriate for the pipe itself to allow designers to continue to use familiar concepts, such as zone of influence, to lay out and proportion braces while ensuring compatibility with modern seismic requirements. The spacing of braces was determined using the provisions of ASCE/SEI 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, assuming steel pipe with threaded or grooved connections for Table 18.5.5.2(a) through Table 18.5.5.2(f). The tabulated values are based on conservative simplifying assumptions. A detailed engineering analysis, taking into account the properties of the specific system, might provide greater spacing. However, in order to control deflections, in no case should the lateral sway brace spacing exceed 40 ft (12.2 m). See also A.18.5.9.1 and Annex E.

A.18.5.5.10

This does not apply to piping supported by or suspended from trapeze hangers.

The use of short hangers is an acceptable alternative to the lateral sway bracing requirements when following 18.5.5.10.1 and 18.5.5.10.2.

A.18.5.5.10.1(1)

Figure A.18.5.5.10.1(1)(a) and Figure A.18.5.5.10.1(1)(b) are examples of how to measure the distance between the top of pipe and the point of attachment.

Figure A.18.5.5.10.1(1)(a) Measurement for Distance Between Top of Pipe and Point of Attachment (Example 1).

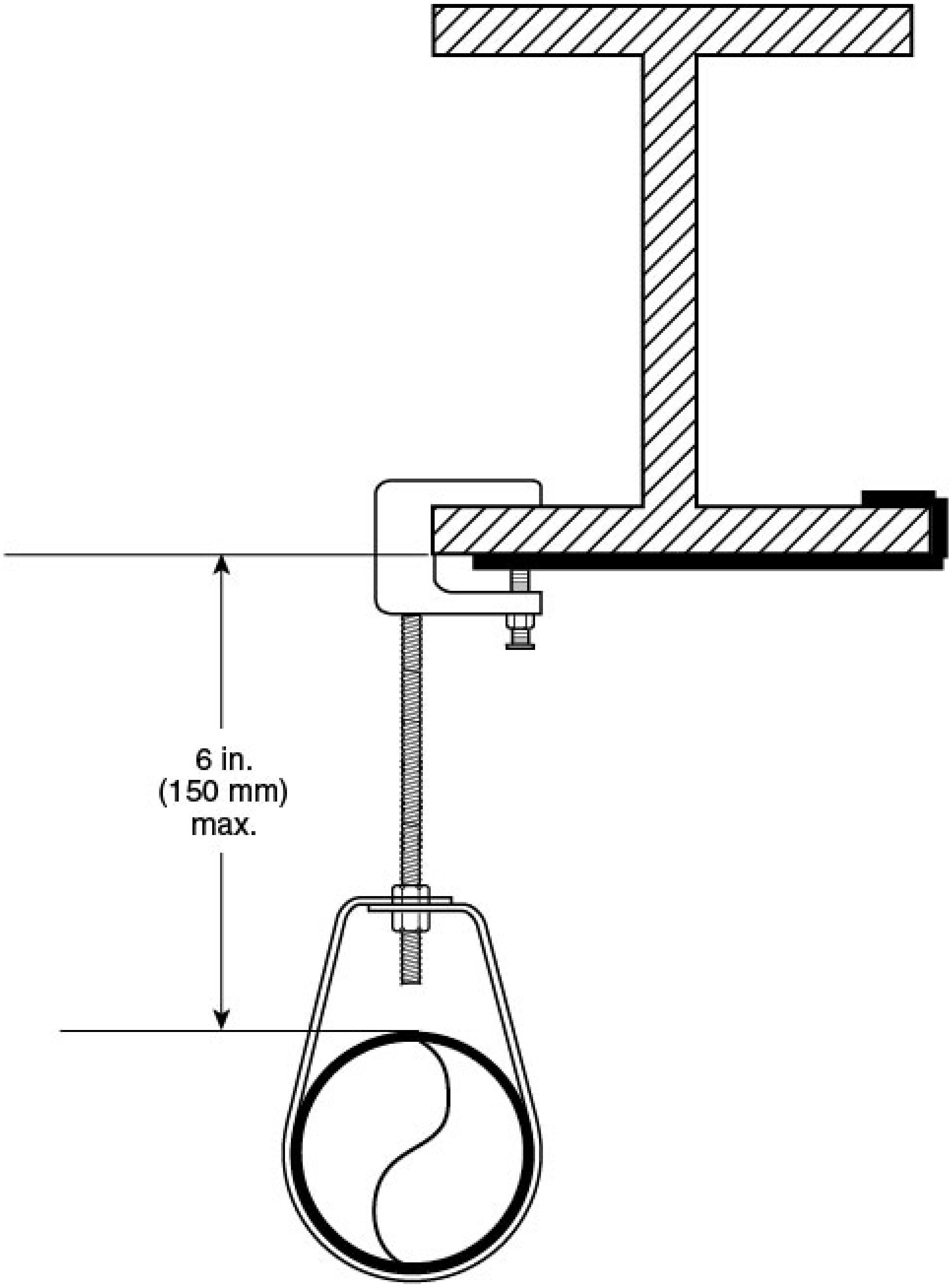
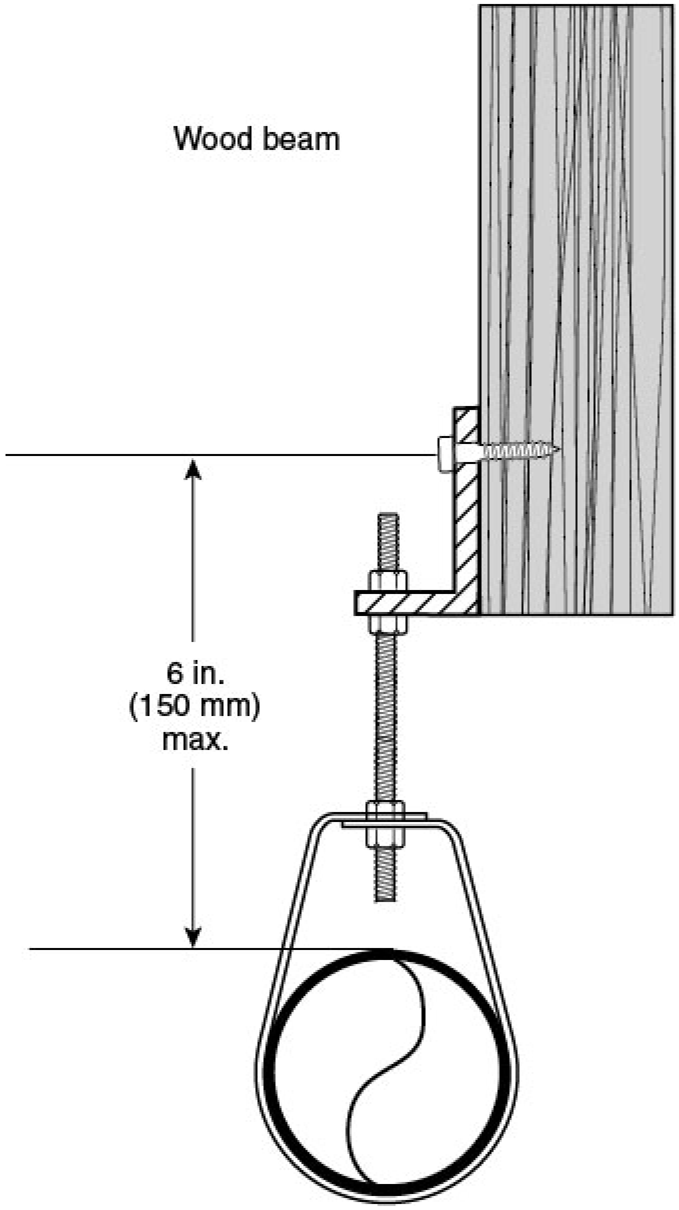


Figure A.18.5.5.10.1(1)(b) Measurement for Distance Between Top of Pipe and Point of Attachment (Example 2).



A.18.5.5.10.2(1)

See Figure A.18.5.5.10.1(1)(a) and Figure A.18.5.5.10.1(1)(b).

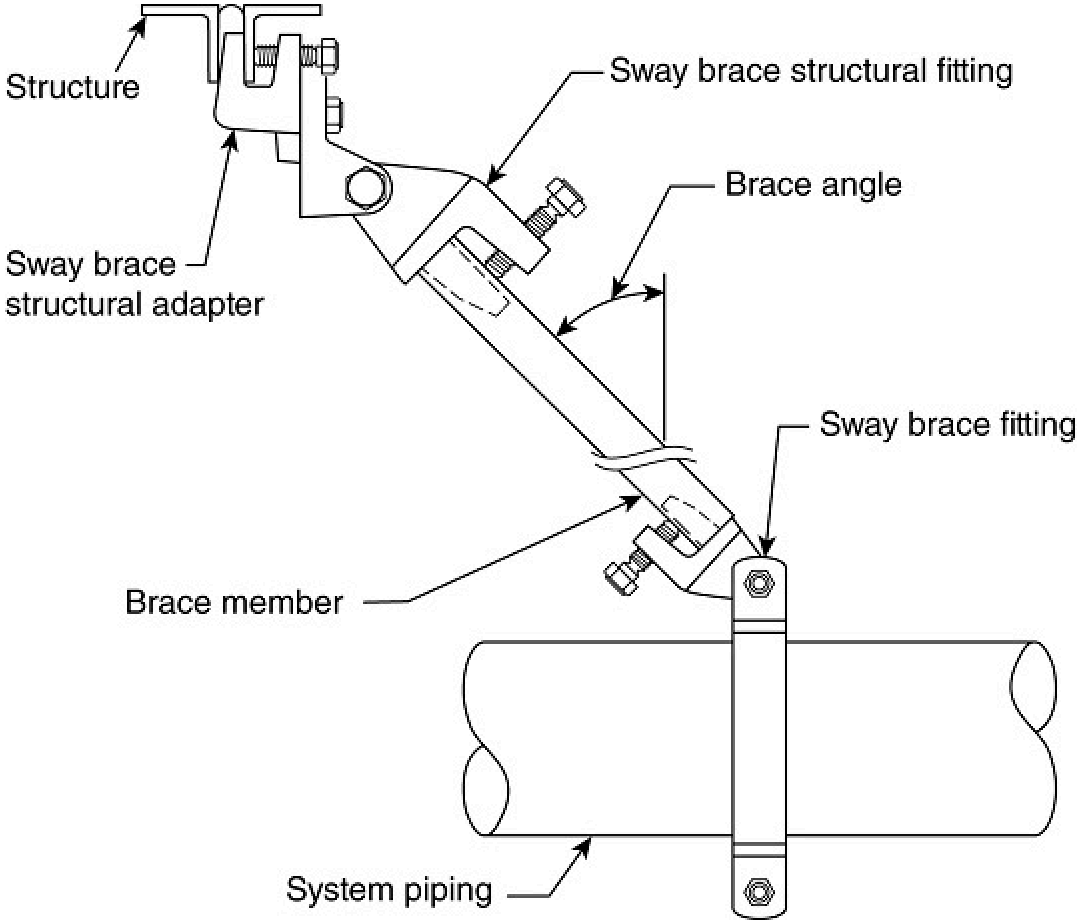
A.18.5.5.11

The use of U-hooks and wraparounds are an acceptable alternative to the lateral sway bracing requirements when following 18.5.5.11.1 and 18.5.5.11.2.

A.18.5.6

See Figure A.18.5.6.

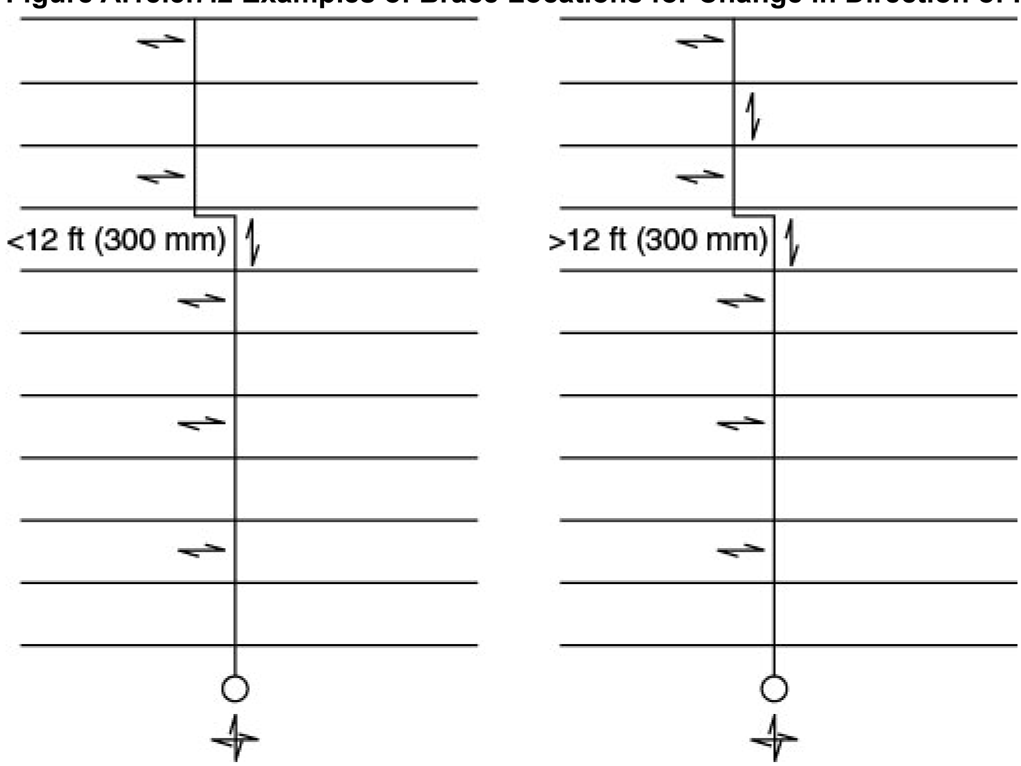
Figure A.18.5.6 Generic Example of a Longitudinal Sway Brace.



A.18.5.7.2

See Figure A.18.5.7.2.

Figure A.18.5.7.2 Examples of Brace Locations for Change in Direction of Pipe.



A.18.5.8.1

The four-way brace provided at the riser can also provide longitudinal and lateral bracing for adjacent mains. This section is not intended to require four-way bracing on a sprig or on a drop to a single sprinkler.

A.18.5.9

Location of Sway Bracing. Two-way braces are either longitudinal or lateral, depending on their orientation with the axis of the piping. *[See Figure A.18.5.9(a), Figure A.18.5.9(b), Figure A.18.5.9(c), and Figure A.18.5.9(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.18.5.9(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. In selecting brace locations, one must consider both the design load on the brace, as well as the ability of the pipe to span between brace locations.

Bracing should be on the main as indicated at Location B of Figure A.18.5.9(a). 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.

A four-way brace is indicated at Location A of Figure A.18.5.9(a). This keeps the riser and main lined up and also prevents the main from shifting.

In Building 1 of Figure A.18.5.9(a), 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.

Figure A.18.5.9(a) Typical Earthquake Protection for Sprinkler Main Piping.

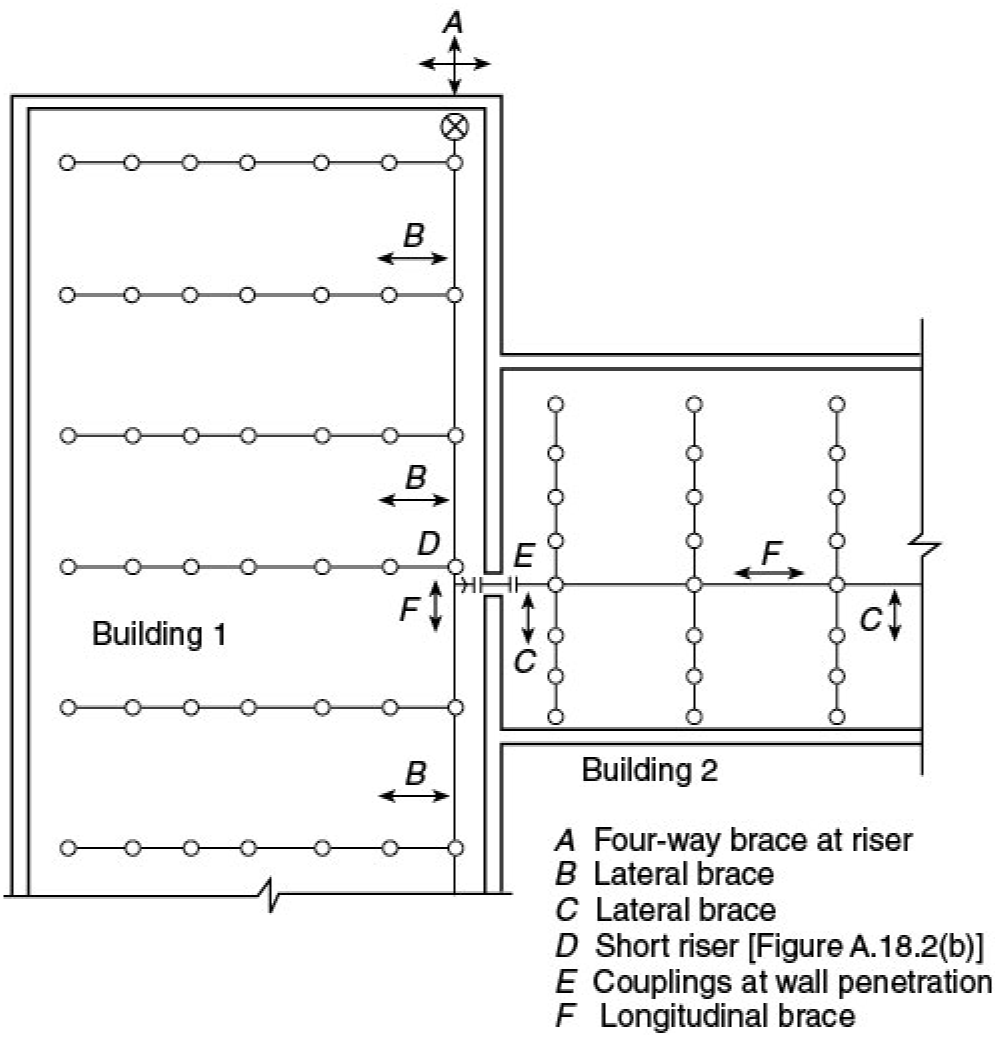


Figure A.18.5.9(b), Figure A.18.5.9(c), and Figure A.18.5.9(d) show typical locations of sway bracing.

Figure A.18.5.9(b) Typical Location of Bracing on Mains on Tree System.

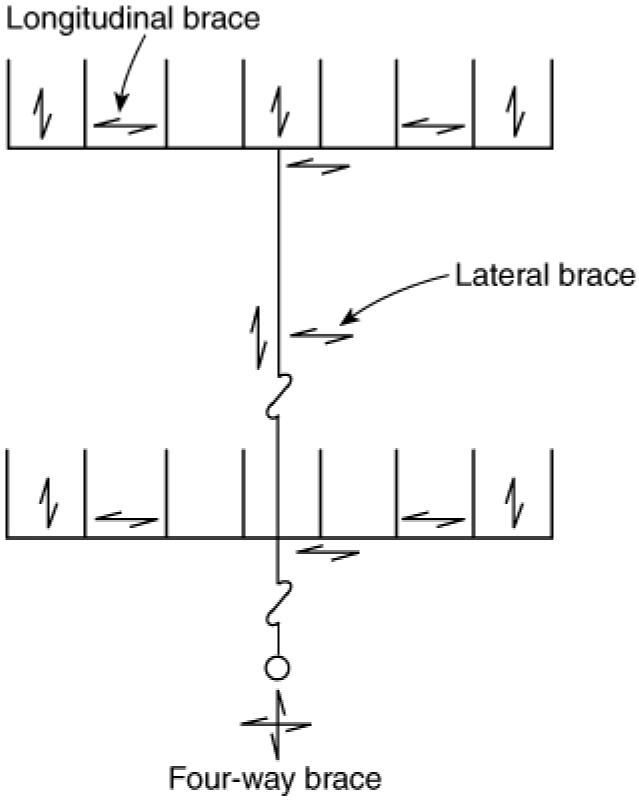


Figure A.18.5.9(c) Typical Location of Bracing on Mains on Gridded System.

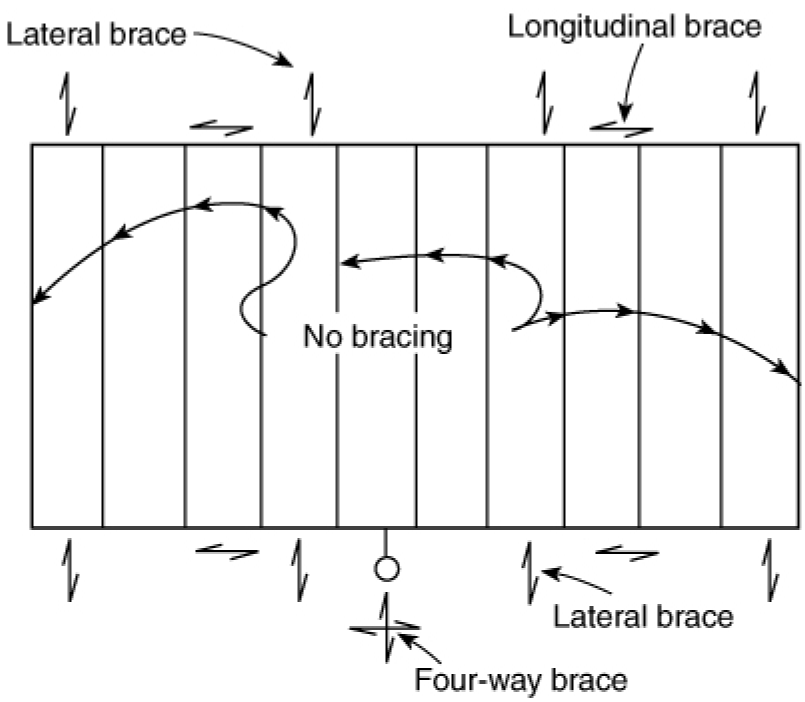
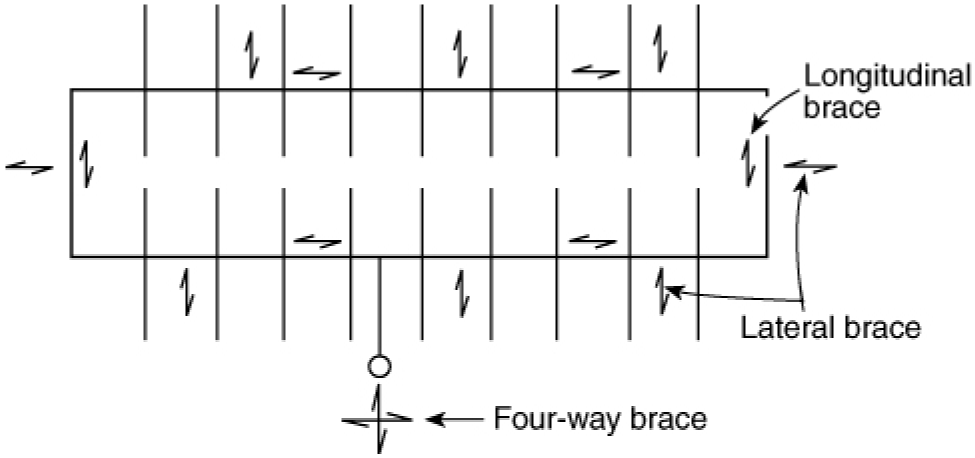


Figure A.18.5.9(d) Typical Location of Bracing on Mains on Looped System.



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:

(1) Determine the seismic coefficient, C_p, using the procedures in 18.5.9.3 or 18.5.9.4. This is needed by the designer to verify that the piping can span between brace points. For the purposes of this example, assume that C_p = 0.5.
(2) Based on the distance of system piping from the structural members that will support the braces, choose brace shapes and sizes from Table 18.5.11.8(a) through Table 18.5.11.8(f) 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.
(3) Tentatively space lateral braces at 40 ft (12 m) maximum distances along system piping, and tentatively space longitudinal braces at 80 ft (24 m) maximum distances along system piping. Lateral braces should meet the piping at right angles, and longitudinal braces should be aligned with the piping.
(4) Determine the total load tentatively applied to each brace in accordance with the examples shown in Figure A.18.5.9(e) and the following:
    (a) For the loads on lateral braces on cross mains, add C_p times the weight of the branch line to C_p times 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.18.5.9(e).]*
    (b) For the loads on longitudinal braces on cross mains, consider only C_p times 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 in Figure A.18.5.9(e).]*
    (c) 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.18.5.9(e)].* For the four-way bracing at the top of the riser, C_p times the weight of the riser should be assigned to both the lateral and longitudinal loads as they are separately considered.
    (d) When a single brace has a combined load from both lateral and longitudinal forces (such as a lateral brace at the end of a main that turns 90 degrees), only the lateral should be considered for comparison with the load tables in 18.5.5.2.
(5) If the total expected loads are less than the maximums permitted in Table 18.5.11.8(a) through Table 18.5.11.8(f) for the particular brace and orientation, and the maximum loads in the zone of influence of each lateral sway brace are less than the maximum values in Table 18.5.5.2(a) or Table 18.5.5.2(c), go on to A.18.5.9(6). If not, add additional braces to reduce the zones of influence of overloaded braces.
(6) Check that fasteners connecting the braces to structural supporting members are adequate to support the expected loads on the braces in accordance with Figure 18.5.12.1. If not, again add additional braces or additional means of support. Plates using multiple fasteners in seismic assemblies should follow the plate manufacturer guidelines regarding the applied loads.

Use the information on weights of water-filled piping contained within Table A.18.5.9. The factor of 1.15 is intended to approximate the additional weight of all the valves, fittings, and other devices attached to the system.

Figure A.18.5.9(e) Examples of Load Distribution to Bracing.

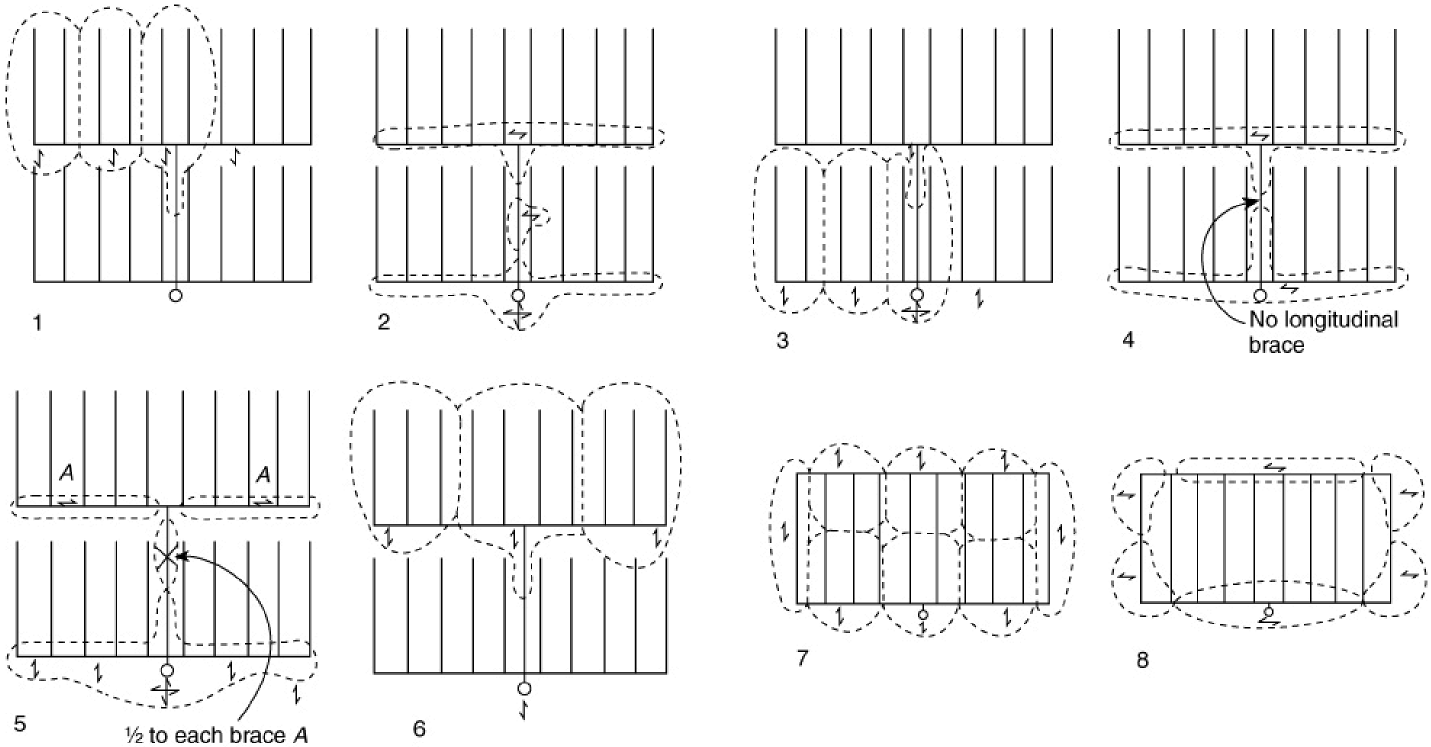


Table A.18.5.9 Piping Weights for Determining Horizontal Load

Nominal Dimensions		Weight of Water-Filled Pipe	
in.	**mm**	**lb/ft**	**kg/m**
Schedule 40 Pipe			
1	25	2.05	3.05
1¼	32	2.93	4.36
1½	40	3.61	5.37
2	50	5.13	7.63
2½	65	7.89	11.74
3	80	10.82	16.10
3½	90	13.48	20.06
4	100	16.40	24.40
5	125	23.47	34.92
6	150	31.69	47.15
8*	200	47.70	70.98
Schedule 10 Pipe			
1	25	1.81	2.69
1¼	32	2.52	3.75
1½	40	3.04	4.52
2	50	4.22	6.28
2½	65	5.89	8.76
3	80	7.94	11.81

Nominal Dimensions		Weight of Water-Filled Pipe	
in.	mm	lb/ft	kg/m
3½	90	9.78	14.55
4	100	11.78	17.53
5	125	17.30	25.74
6	150	23.03	34.27
8	200	40.08	59.64

*Schedule 30.

A.18.5.9.1

The factors used in the computation of the horizontal seismic load should be available from several sources, including the project architect or structural engineer or the authority having jurisdiction. In addition, the ground motion parameter S_{DS} is available using maps or software developed by the US Geological Survey and the American Society of Civil Engineers (ASCE). The approach presented in NFPA 13 is compatible with the requirements of ASCE/SEI 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, which provides the seismic requirements for model building codes. Sprinkler systems are emergency systems and as such should be designed for an importance factor (I_p) of 1.5. Seismic forces for sprinkler system bracing and piping depend on amplification factors that account for the height in the structure (H_f) and the component resonance ductility (C_{AR}), as well as reduction factors that account for the structure ductility (R_μ) and the component strength (R_{po}). For piping supported above grade in a building, H_f can be as large as 3.5 (for piping located at the roof) and R_μ can be as small as 1.3 when the lateral force-resisting system of the building is undetermined. For sway braces above grade in a building, C_{AR} is taken as 1.0 and R_{po} is taken as 1.5. However, horizontal seismic forces used to determine stresses in above-grade sprinkler pipe (i.e., due to bending between sway braces) require that C_{AR} be taken as 2.2 and R_{po} be taken as 2.0. Thus, the horizontal seismic forces used to determine bending stresses in the sprinkler pipe itself are 65 percent larger than the horizontal seismic forces used to design the braces. This difference accounts for the behavior of piping with joints made by threading, bonding, compressions couplings, and grooved couplings under seismic loading. The differences in seismic forces have been accounted for when determining the maximum F_{pw} values in Table 18.5.5.2(a) through Table 18.5.5.2(n) and the spacing of branch line restraints in Table 18.6.4(a) and Table 18.6.4(b), which are based on the allowable bending stress in the pipe.

A.18.5.9.3.1

See https://asce7hazardtool.online/.

A.18.5.9.3.2

The default site soil class is used when soil properties are not known in sufficient detail to determine the site class. The default site condition considers Site Class C (very dense sand or hard clay), Site Class CD (dense sand or very stiff clay) and Site Class D (medium dense sand or stiff clay) to determine the controlling value of S_{DS} based on which of these three site classes results in the largest amplification of bedrock ground motions.

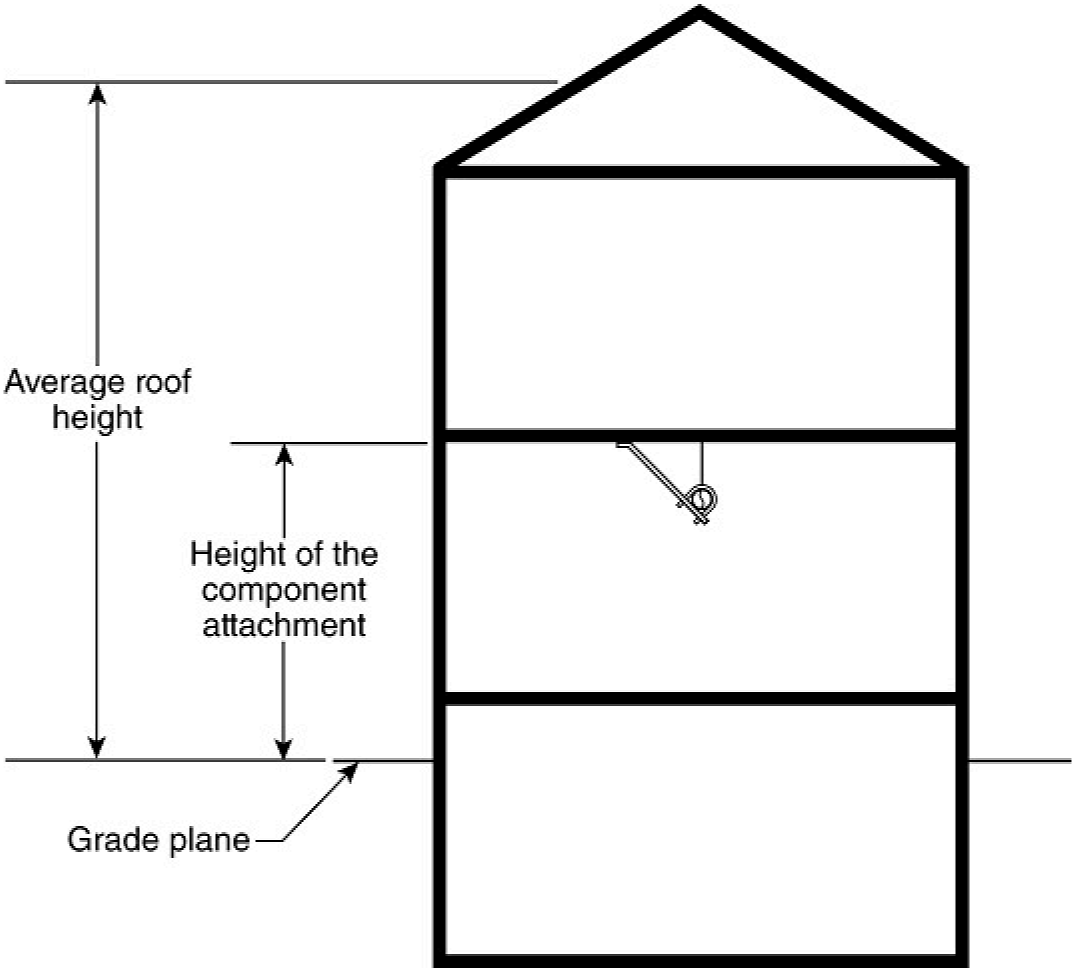
A.18.5.9.3.2.1

The authority having jurisdiction for the site class determination of the building can be someone other than the authority having jurisdiction for the sprinkler system.

A.18.5.9.3.3

See Figure A.18.5.9.3.3.

Figure A.18.5.9.3.3 Typical Example of the Component Attachment to the Structure Relative to the Average Roof Height and Ceiling Height.



A.18.5.9.4

NFPA 13 has traditionally used the allowable stress design (ASD) method for calculations. The building codes typically use an ultimate strength design. The 0.7 referred to in this section is a conversion value to accommodate the different calculation methods. *(See also Annex E.)*

A.18.5.9.5

S_{DS} is a measure of earthquake shaking intensity. S_{DS} shall be based on the maximum considered earthquake ground motion for 0.2-second spectral response acceleration (5 percent of critical damping) for the default site soil class when the soil properties are not known in sufficient detail to determine the site class *(see A.18.5.9.3.2)*. The data are available from the authority having jurisdiction or, in the United States, using maps developed by the US Geological Survey or the ASCE/SEI 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures,* Hazard Tool. All that is required to get S_{DS} is the latitude and longitude of the project site.

The horizontal force factor was given as F_p in earlier editions of NFPA 13. It has been changed to F_{pw} to clearly indicate that it is a working, not an ultimate, load. In model building codes, F_p is used to denote the strength design level load.

It is not the intent of this section to default to the C_p value of 0.5 before attempts to determine the value of S_{DS} and related coefficient value for C_p are made, such as on-line information provided by the ASCE/SEI 7 Hazard Tool website.

A.18.5.9.6

The zones of influence do not have to be symmetrically based on brace spacing. It is the intent of NFPA 13 that the chosen zone of influence be the worst-case load scenario.

A.18.5.9.6.1

Where the C_p is 0.6 or greater, the calculation should be done for any riser nipple length. The loads in this condition can rapidly exceed the yield strength. Where Schedule 10 and Schedule 40 steel pipe are used, the section modulus can be found in Table 17.3.1(c) or Table 17.3.1(d). Table A.18.5.9.6.1 illustrates when the required yield strength calculation based on riser nipple length is necessary. The riser nipple should be measured from the top of the cross main to the bottom of the branch line.

Table A.18.5.9.6.1 Required Yield Strength Calculation Based on Riser Nipple Length on C_p

Riser Nipple Length	Seismic Coefficient			
	$C_p \leq 0.3$	$C_p \leq 0.4$	$C_p < 0.6$	$C_p > 0.6$
>4 ft (>1.2 m)	X	X	X	X
≤4 ft (≤1.2 m)		X	X	X
≤3 ft (≤915 mm)			X	X
≤2 ft (≤610 mm)				X

Note: Conditions marked X are required to satisfy the equation provided in 18.5.9.6.2.

A.18.5.11

Sway brace members should be continuous. Where necessary, splices in sway bracing members should be designed and constructed to ensure that brace integrity is maintained.

A.18.5.11.1

Sway brace design and installation is critical to performance and requires attention to detail. Sway brace design parameters are dynamic and interdependent. Accordingly, seismic force is influenced by geography, brace location is impacted by system design, and brace geometry is relative to the building structure.

To enhance system durability and performance, sway brace installation should show evidence of good craftsmanship in conformance to approved drawings, correctly assembled and mounted at proper angles on a plane that corresponds to the parallel and perpendicular axis of the system pipe.

A.18.5.11.9

Maximum allowable horizontal loads for steel sway braces shown in Table 18.5.11.8(a) through Table 18.5.11.8(f) are applicable when the system is designed using allowable stress design methods. The maximum allowable loads have been derived for the controlling condition (braces in compression) using allowable stress design provisions of American Institute of Steel Construction (AISC) 360, *Specification for Structural Steel Buildings*.

In determining allowable horizontal loads in the tables, a modulus of elasticity (E) of 29,000 ksi, a yield stress (F_y) of 36 ksi, and an effective length factor (K) of 1.0 were assumed, since these are common. If these values are different in a specific situation, table values might need to be adjusted. Gross section properties are used for all shapes except for all-thread rods. For all-thread rods, area and radius of gyration are based on the minimum area of the threaded rod based on the radius at the root of the threads.

A.18.5.12

Concrete anchors can be cast-in-place [installed before the concrete is placed — see Figure A.18.5.12(a) and Figure A.18.5.12(b)] or post-installed [installed in hardened concrete — see Figure A.18.5.12(c)]. Examples of cast-in-place concrete anchors are embedded steel bolts or concrete inserts. There are several types of post-installed anchors, including expansion anchors, chemical or adhesive anchors, and undercut anchors. The criteria in Table 18.5.12.2(a) through Table 18.5.12.2(j) are based on the use of listed cast-in-place concrete inserts and listed post-installed wedge expansion anchors. The values for “effective embedment” for cast-in-place anchors and “nominal embedment” for post-installed anchors as shown in the tables represent the majority of commonly available anchors on the market at the time of publishing. Use of other anchors in concrete should be in accordance with the listing provisions of the anchor. Anchorage designs are usable under allowable stress design (ASD) methods.

Values in Table 18.5.12.2(a) through Table 18.5.12.2(j) are based on ultimate strength design values obtained using the procedures in Chapter 17 of ACI 318, *Building Code Requirements for Structural Concrete and Commentary*, which are then adjusted for ASD. Concrete inserts are installed into wood forms for concrete members using fasteners prior to the casting of concrete, inserted into wood forms for concrete members using fasteners prior to the casting of concrete, or inserted into a hole cut in steel deck that will be filled with concrete topping slab. A bolt or rod can be installed into the internally threaded concrete insert after the wood form is removed from the concrete or from the underside of the steel deck after it is filled with concrete topping slab. Wedge anchors are torque-controlled expansion anchors that are set by applying a torque to the anchor's nut, which causes the anchor to rise while the wedge stays in place. This causes the wedge to be pulled onto a coned section of the anchor and presses the wedge against the wall of the hole. Undercut anchors might or might not be torque-controlled. Typically, the main hole is drilled, a special second drill bit is inserted into the hole, and flare is drilled at the base of the main hole. Some anchors are self-drilling and do not require a second drill bit. The anchor is then inserted into the hole and, when torque is applied, the bottom of the anchor flares out into the flared hole and a mechanical lock is obtained. Consideration should be given with respect to the position near the edge of a slab and the spacing of anchors. For full capacity in Table 18.5.12.2(a) through Table 18.5.12.2(j), the edge distance spacing between anchors and the thickness of concrete should conform to the anchor manufacturer’s recommendations.

Calculation of ASD shear and tension values to be used in A.18.5.12.2 calculations should be performed in accordance with formulas in Chapter 17 of ACI 318 using the variables and recommendations obtained from the approved evaluation service reports (such as ICC-ES reports) for a particular anchor, which should then be adjusted to ASD values. All post-installed concrete anchors must be prequalified in accordance with ACI 355.2, *Post-Installed Mechanical Anchors in Concrete — Qualification Requirements and Commentary*, or other approved qualification procedures (Section 13.4.2.3 of ASCE/SEI 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*). This information is usually available from the anchor manufacturer.

The following variables are among those contained in the approved evaluation reports for use in calculations according to Chapter 17 of ACI 318. These variables do not include the allowable tension and shear capacities but do provide the information needed to calculate them. The strength design capacities must be calculated using the appropriate procedures in Chapter 17 of ACI 318 and then converted to allowable stress design capacities.

D_a = anchor diameter

L_{anch} = total anchor length

h_{nom}= nominal embedment

h_{ef} = effective embedment

h_{min} = minimum concrete thickness

C_{ac} = critical edge distance

N_{sa} = steel strength in tension

l_e = length of anchor in shear

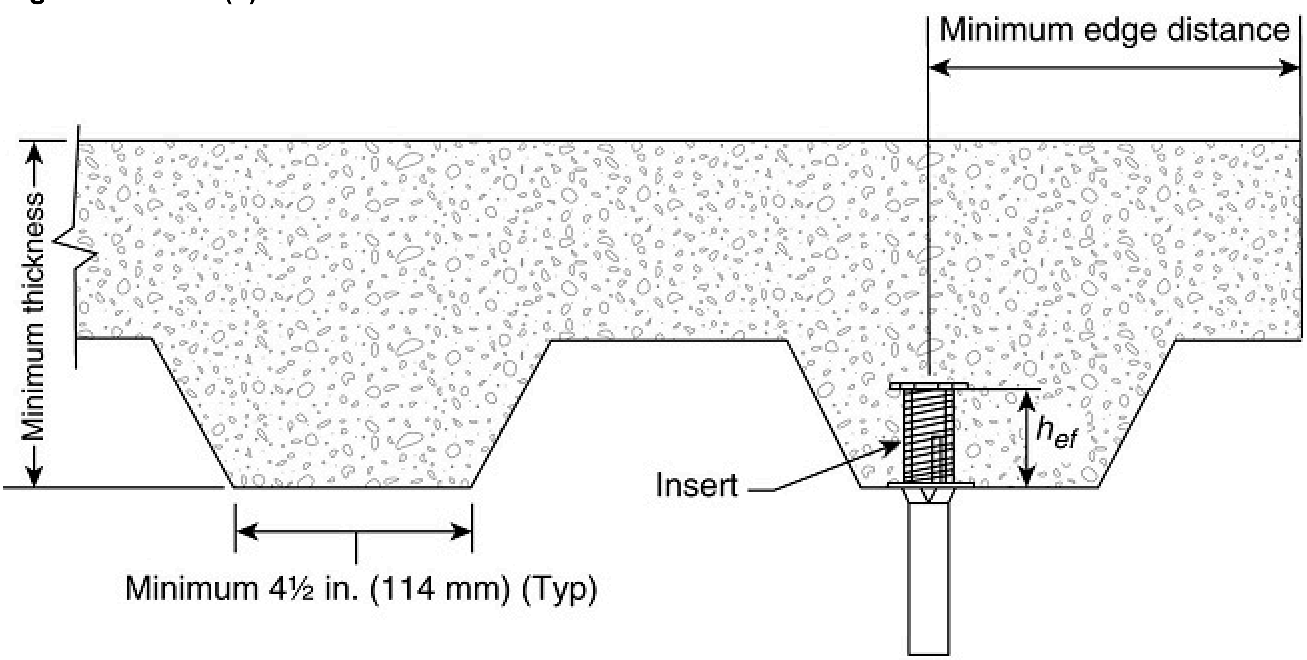
$N_{p,cr}$ = pull-out strength cracked concrete

K_{cp} = coefficient for pryout strength

$V_{sa,eq}$ = shear strength single anchor seismic loads

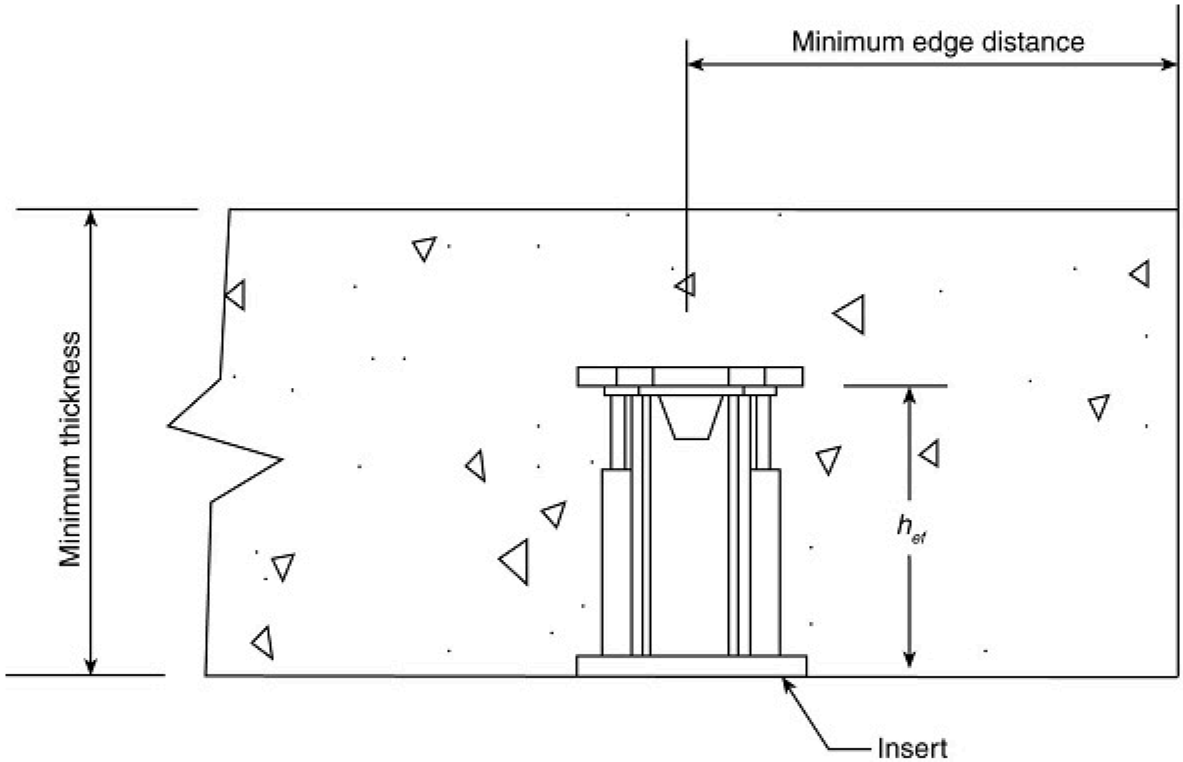
$V_{st.deck,eq}$ = shear strength single anchor seismic loads installed through the soffit of the metal deck

Figure A.18.5.12(a) Metal Deck Insert.



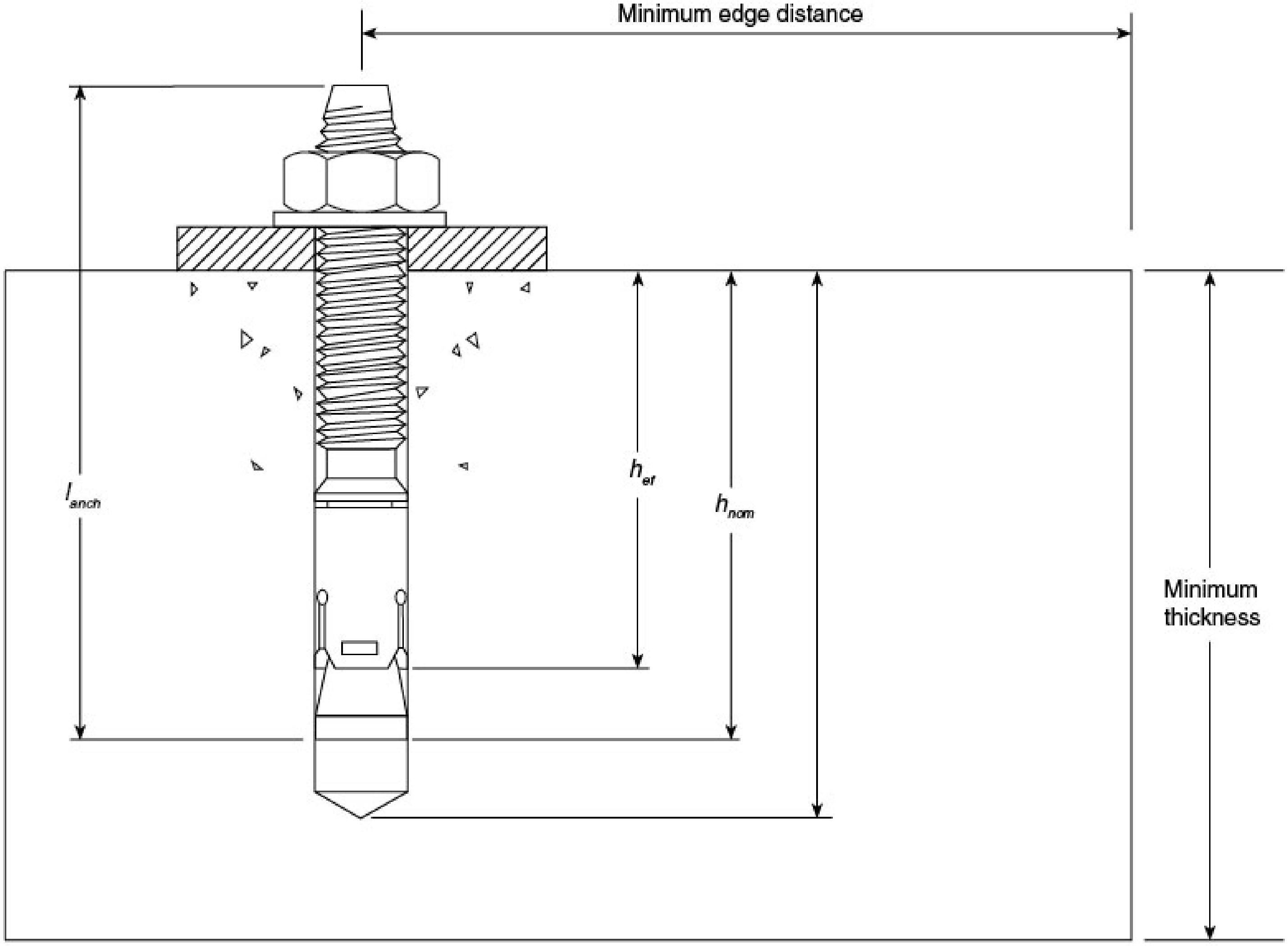
Note: h_{ef} is the effective embedment depth per Table 18.5.12.2(f).

Figure A.18.5.12(b) Wood Form Insert.



Note: h_{ef} is the effective embedment depth given in Tables 18.5.12.2(g) through (j).

Figure A.18.5.12(c) Wedge Anchor.



Note: h_{nom} is the nominal embedment depth given in Tables 18.5.12.2(a) through (e).

A.18.5.12.2

The values for the concrete insert and wedge anchor tables have been developed using the following formula:

$$\left(\frac{T}{T_{allow}}\right)+\left(\frac{T}{V_{allow}}\right)\leq 1.2 \qquad \text{[A.18.5.12.2a]}$$

where:

T = applied service tension load, including the effect of prying (F_{pw} × Pr)

F_{pw} = horizontal earthquake load

Pr = prying factor based on fitting geometry and brace angle from vertical

T_{allow} = allowable service tension load

V = applied service shear load

V_{allow} = allowable service shear load

T/T_{allow} = shall not be greater than 1.0.

V/V_{allow} = shall not be greater than 1.0.

The allowable tension and shear loads come from the anchor manufacturer’s published data. The design loads have been amplified by an overstrength factor of 2.0, and the allowable strength of the anchors has been increased by a factor of 1.2. The effect of prying on the tension applied to the anchor is considered when developing appropriate capacity values. The applied tension equation includes the prying effect, which varies with the orientation of the fastener in relationship to the brace necessary at various brace angles. The letters A through D in the following equations are dimensions of the attachment geometry as indicated in Figure A.18.5.12.2(a) through Figure A.18.5.12.2(c).

where:

Cr = critical angle at which prying flips to the toe or the heel of the structure attachment fitting

Pr = prying factor for service tension load effect of prying

*Tan*θ = tangent of brace angle from vertical

*Sin*θ = sine of brace angle from vertical

The greater *Pr* value calculated in tension or compression applies.

The *Pr* value cannot be less than 1.000/*Tan*θ for designated angle category A, B, and C; 1.000 for designated angle category D, E, and F; or 0.000 for designated angle category G, H, and I.

For designated angle category A, B, and C, the applied tension, including the effect of prying (*Pr*), is as follows:

$$Cr = Tan^{-1}\left(\frac{C}{D}\right) \qquad \text{[A.18.5.12.2b]}$$

For braces acting in **TENSION**

If *Cr* > brace angle from vertical:

$$Pr = \frac{\left(\dfrac{C+A}{Tan\theta}\right) - D}{A} \qquad \text{[A.18.5.12.2c]}$$

If *Cr* < brace angle from vertical:

$$Pr = \frac{D - \left(\dfrac{C-B}{Tan\theta}\right)}{B} \qquad \text{[A.18.5.12.2d]}$$

For braces acting in **COMPRESSION**

If *Cr* > brace angle from vertical:

$$Pr = \frac{\left(\dfrac{C-B}{Tan\theta}\right) - D}{B} \qquad \text{[A.18.5.12.2e]}$$

If *Cr* < brace angle from vertical:

$$Pr = \frac{D - \left(\dfrac{C+A}{Tan\theta}\right)}{A} \qquad \text{[A.18.5.12.2f]}$$

For designated angle category D, E, and F, the applied tension, including the effect of prying (*Pr*), is as follows:

$$Cr = Tan^{-1}\left(\frac{D}{C}\right) \qquad \text{[A.18.5.12.2g]}$$

For braces acting in **TENSION**

If *Cr* > brace angle from vertical:

$$Pr = \frac{\left(\frac{D}{Tan\theta}\right) - (C - B)}{B} \quad [A.18.5.12.2h]$$

If *Cr* < brace angle from vertical:

$$Pr = \frac{(C + A) - \left(\frac{D}{Tan\theta}\right)}{A} \quad [A.18.5.12.2i]$$

For braces acting in **COMPRESSION**

If *Cr* > brace angle from vertical:

$$Pr = \frac{\left(\frac{D}{Tan\theta}\right) - (C + A)}{A} \quad [A.18.5.12.2j]$$

If *Cr* < brace angle from vertical:

$$Pr = \frac{(C - B) - \left(\frac{D}{Tan\theta}\right)}{B} \quad [A.18.5.12.2k]$$

For designated angle category G, H, and I the applied tension, including the effect of prying (*Pr*), is as follows:

For braces acting in **TENSION**

$$Pr = \frac{\left(\frac{D}{B}\right)}{Sin\theta} \quad [A.18.5.12.2l]$$

For braces acting in **COMPRESSION**

$$Pr = \frac{\left(\frac{D}{A}\right)}{Sin\theta} \quad [A.18.5.12.2m]$$

The lightweight concrete anchor tables, Table 18.5.12.2(a) through Table 18.5.12.2(c) were based on sand lightweight concrete, which represents a conservative assumption for the strength of the material. For seismic applications, cracked concrete was assumed.

Figure A.18.5.12.2(a) Dimensions of Concrete Anchor for Orientations A, B, and C.

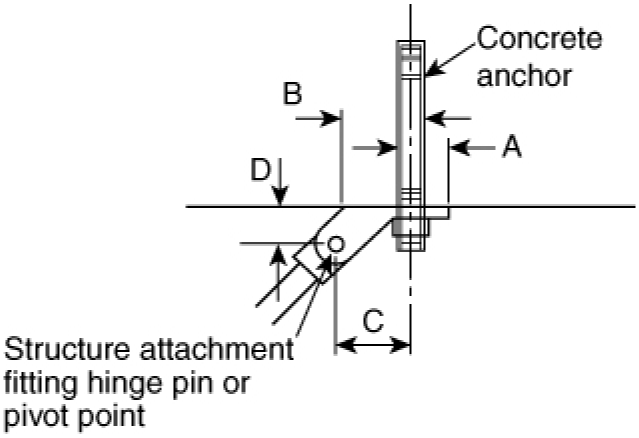


Figure A.18.5.12.2(b) Dimensions of Concrete Anchor for Orientations D, E, and F.

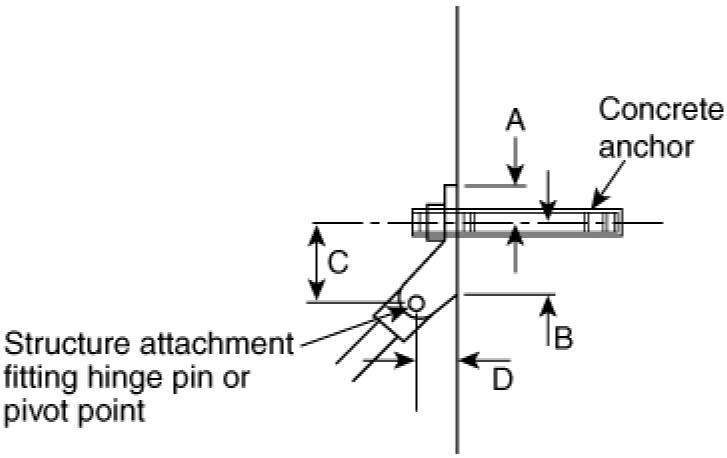
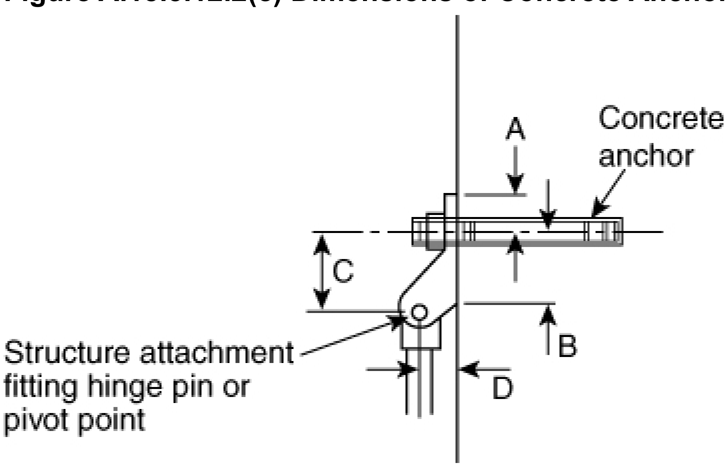


Figure A.18.5.12.2(c) Dimensions of Concrete Anchor for Orientations G, H, and I.



A.18.5.12.3

Listed devices might have accompanying software that performs the calculations to determine the allowable load.

A.18.5.12.4

Through-bolt as described in 18.5.12.4 is intended to describe a method of bolting and attachment. It is the intent of the committee that a “through-bolt” could consist of threaded rod with a flat washer and nut on each end.

A.18.5.12.7

The requirements for concrete anchor and concrete insert capacities in 18.5.12.7.1 through 18.5.12.7.5 are based on calculations performed in accordance with ACI 318, *Building Code Requirements for Structural Concrete and Commentary*, adjusted for allowable stress design (ASD), and using imperial units for anchors and inserts that have been seismically prequalified in accordance with ACI 355.2, *Post-Installed Mechanical Anchors in Concrete — Qualification Requirements and Commentary*. In jurisdictions that are working in metric units, it is likely that ASD is not the standardized method of calculation for these components. For example, in some areas of the world, it is commonly required that concrete anchor and insert calculations are determined in accordance with the procedures for load and resistance factor design (LRFD), and metric-sized anchors and inserts complying with standards other than those cited within this standard are used. In those instances, the calculation procedures, along with the required concrete anchors and inserts acceptable to the authority having jurisdiction, should be used.

A.18.5.12.7.1

Concrete anchors included in current evaluation service reports conforming to the requirements of acceptance criteria AC193, *Acceptance Criteria for Mechanical Anchors in Concrete Elements*, as issued by ICC Evaluation Service, Inc. should be considered to meet ACI 355.2, *Post-Installed Mechanical Anchors in Concrete — Qualification Requirements and Commentary*.

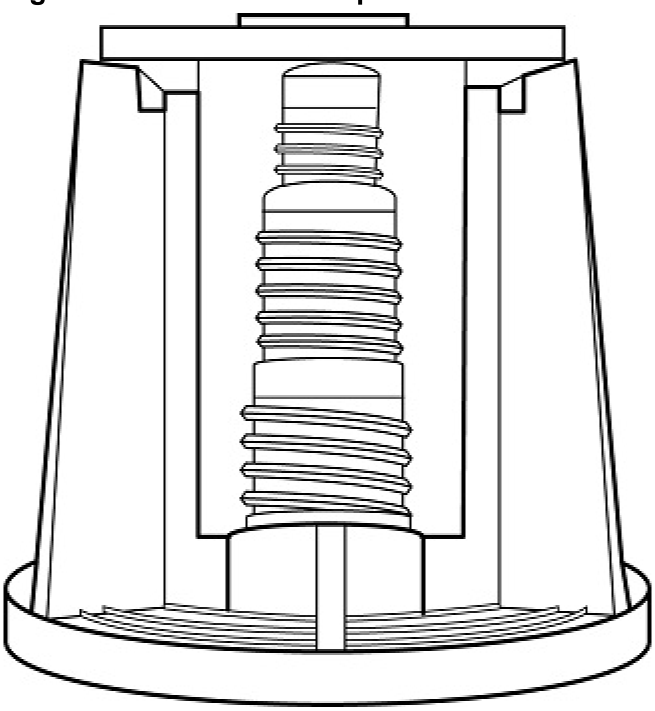
A.18.5.12.7.3.4

The values from Chapter 17 of ACI 318, *Building Code Requirements for Structural Concrete and Commentary*, are load and resistance factor design (LRFD) values that must be divided by 1.4 in order to convert them to allowable stress design (ASD) values. The factor of 0.43 was created to simplify the steps needed to account for the strength capacities and the ASD method of calculation. The 0.43 is a rounded value determined by 1.2 (allowable stress increase), divided by the quantity of 2.0 multiplied by 1.4 [i.e., 0.4286 = 1.2/(2.0 × 1.4)].

A.18.5.12.7.5

For any multithread anchor, special care must be taken when reviewing the manufacturer’s data sheet and report to validate which anchor diameter(s) can be used for seismic bracing. See Figure A.18.5.12.7.5 for an example of a multithread anchor.

Figure A.18.5.12.7.5 Example of a Multithread Anchor.



A.18.6.1

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. (38 mm) and should be attached to the structure in accordance with the details shown in Figure A.18.6.1(a) through Figure A.18.6.1(d) or other approved method.

Figure A.18.6.1(a) Wire Attachment to Cast-in-Place Concrete.

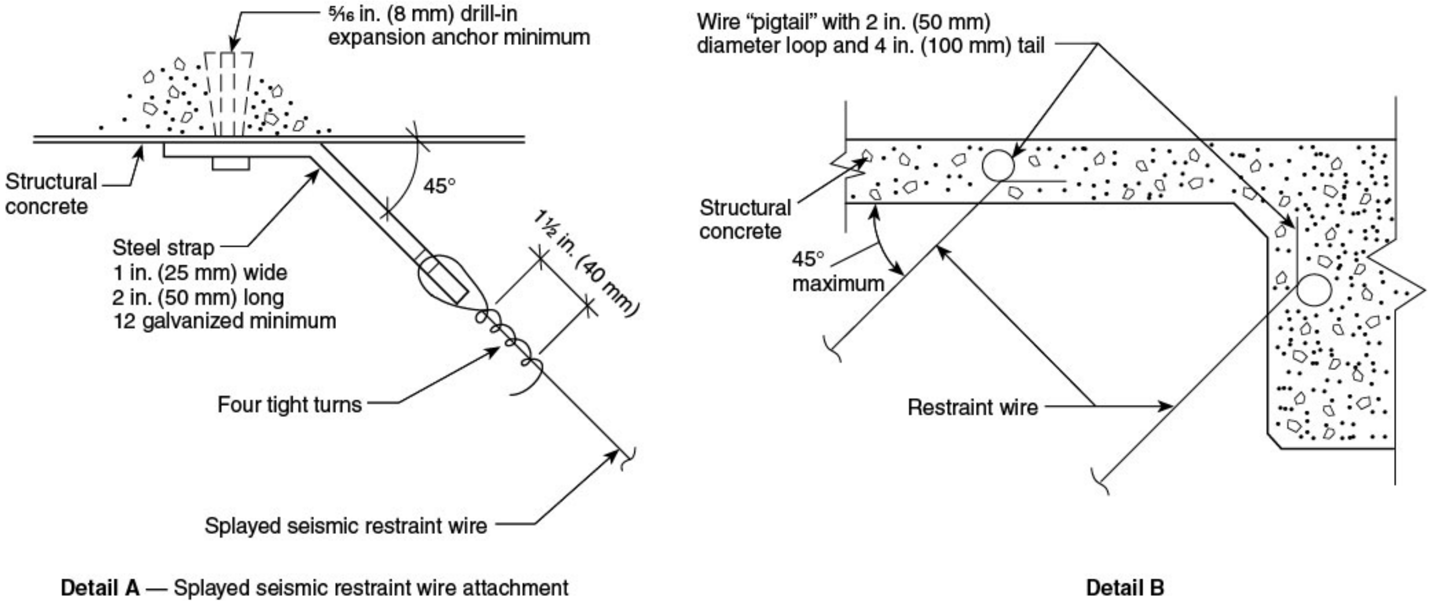


Figure A.18.6.1(b) Acceptable Details — Wire Connections to Steel Framing.

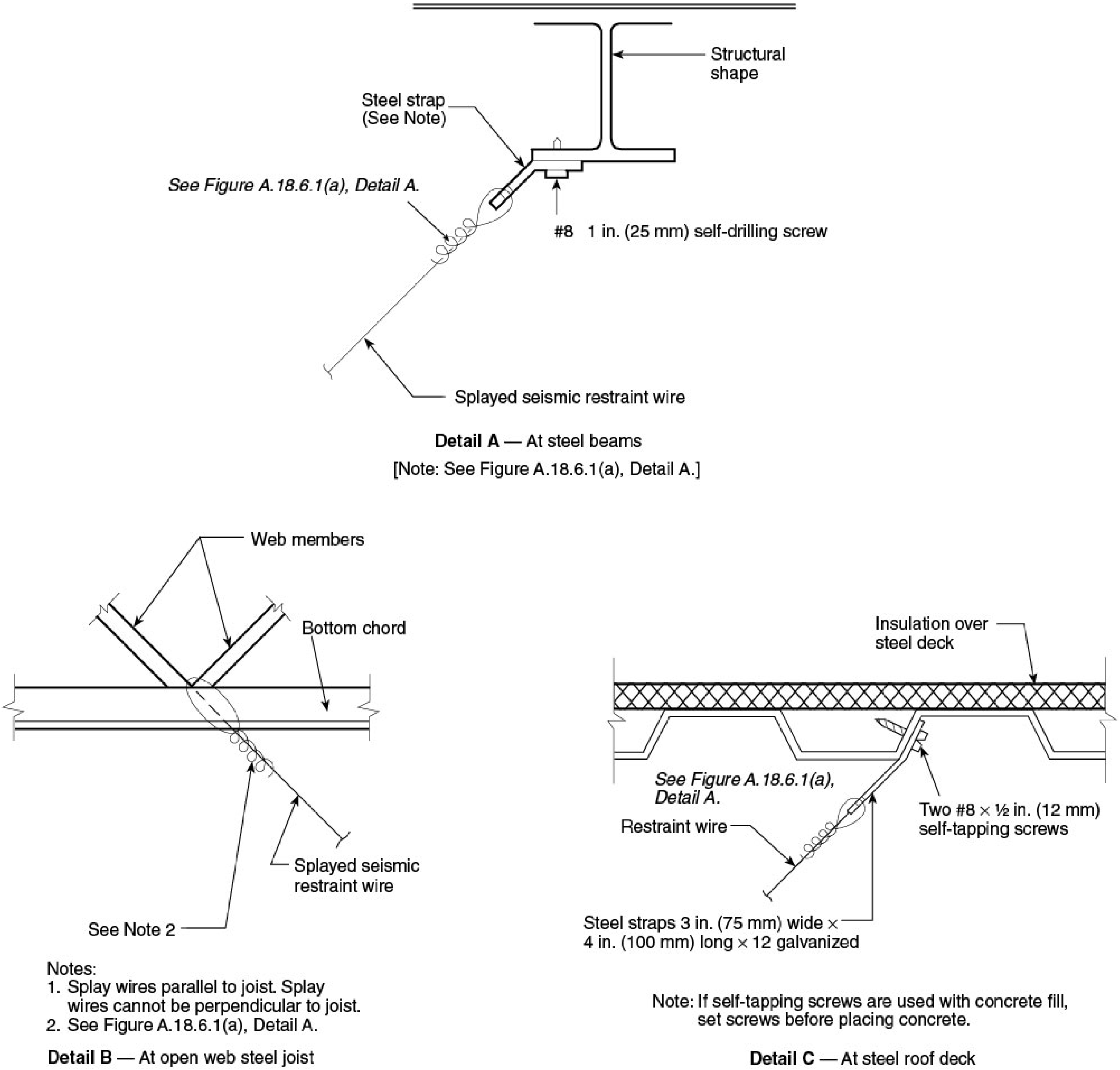
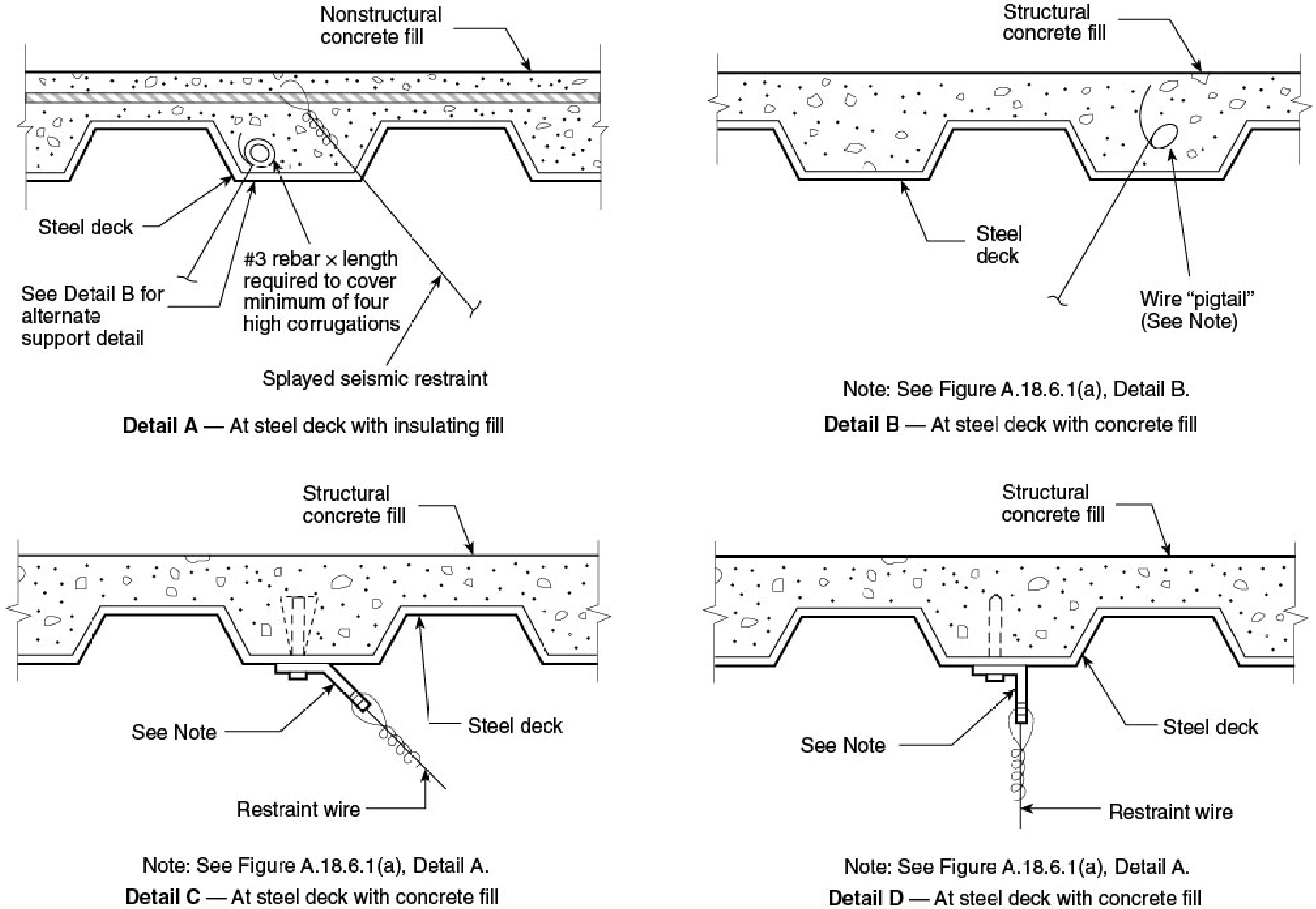
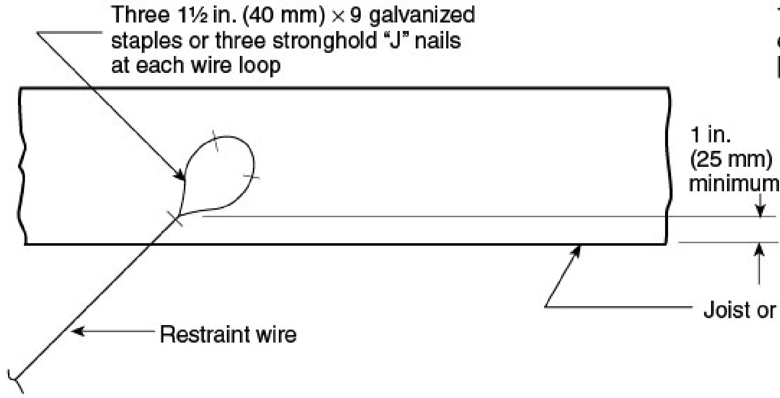


Figure A.18.6.1(c) Acceptable Details — Wire Connections to Steel Decking with Fill.

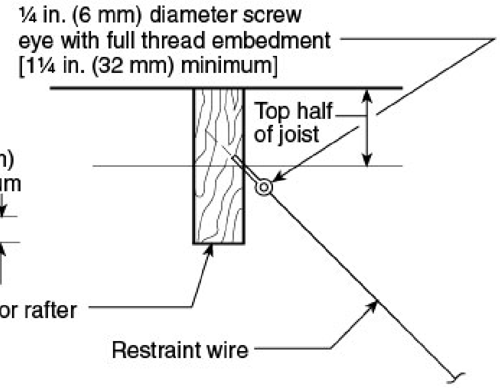


For SI units, 1 in. = 25.4 mm.
Note: If self-tapping screws are used with concrete fill, set screws before placing concrete.

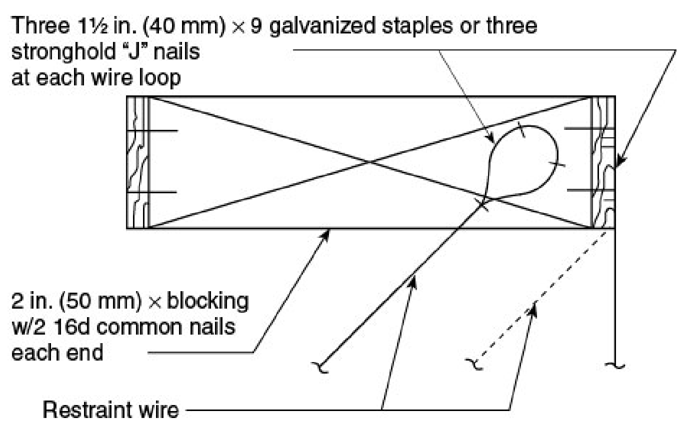
Figure A.18.6.1(d) Acceptable Details — Wire Connections to Wood Framing.



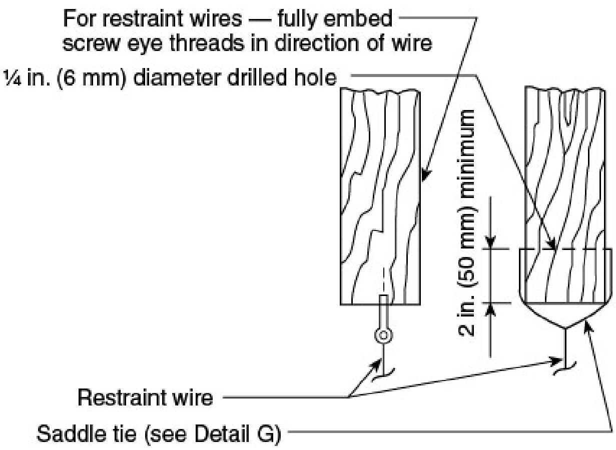
Detail A — Wood joist or rafter



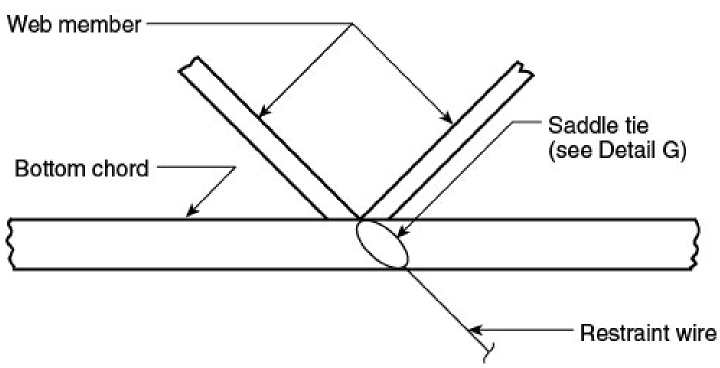
Detail B — At wood joist or rafter



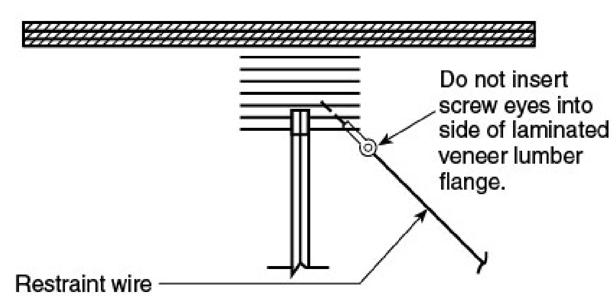
Detail C — At wood joist or block



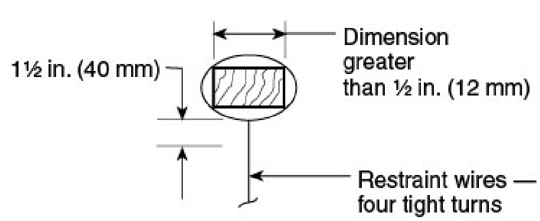
Detail D — To bottom of joist



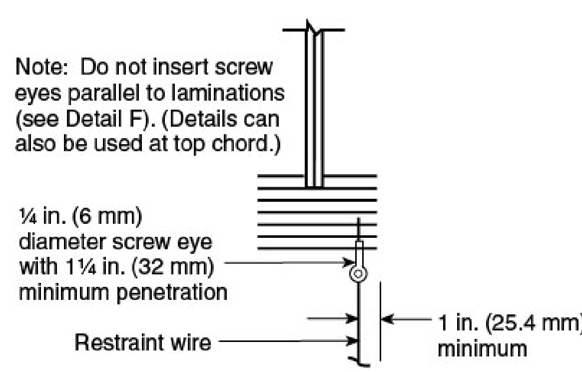
Detail E — Restraint wire parallel to wood truss



Detail F — Laminated veneer lumber upper flange



Detail G — Typical saddle tie



Detail H — Laminated veneer lumber lower flange

A.18.6.1(5)

See Figure A.18.6.1(5)(a) and Figure A.18.6.1(5)(b). When hangers are installed on both sides of the pipe, the *l/r* is not restricted.

Figure A.18.6.1(5)(a) Hangers, with Surge Clips, Used in Combination for Restraint of Branch Lines.

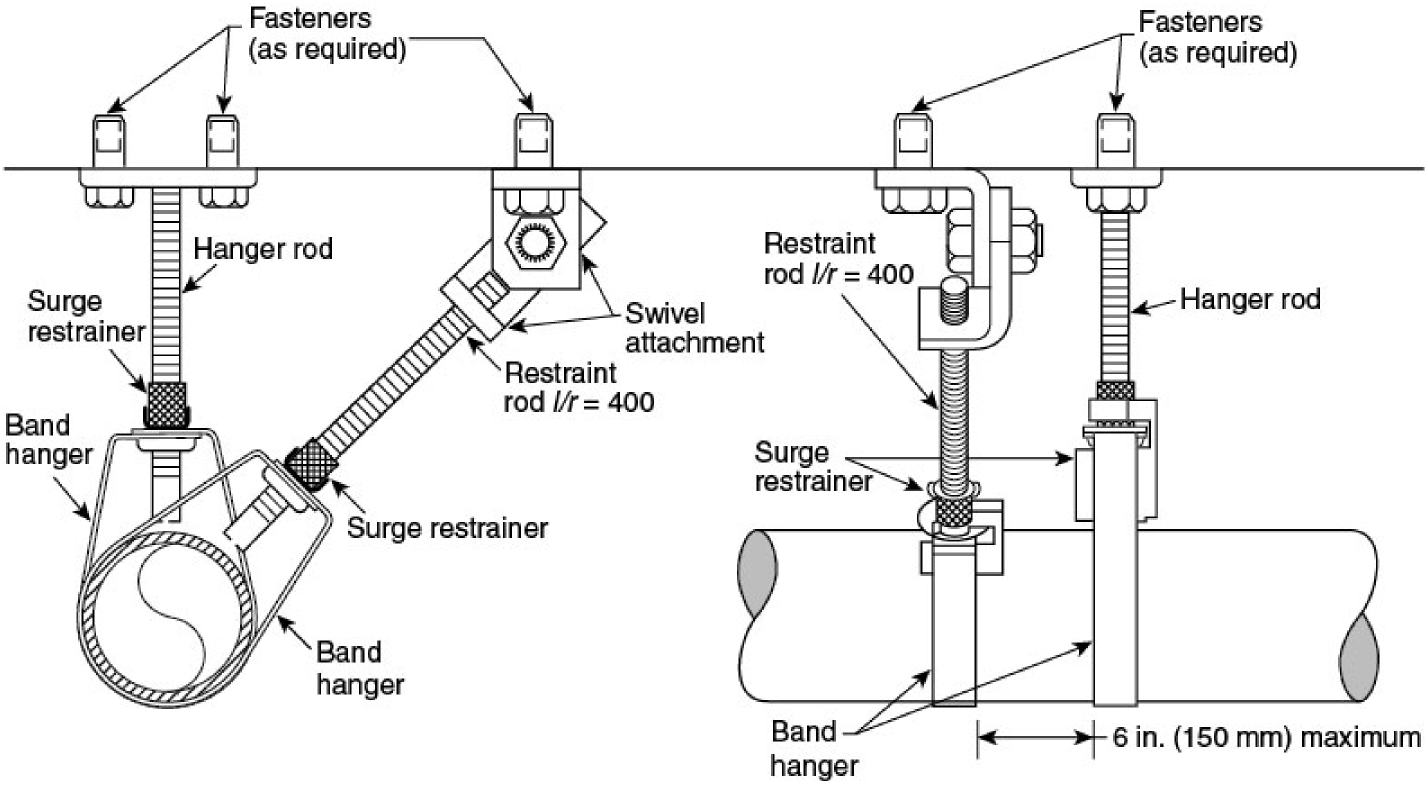
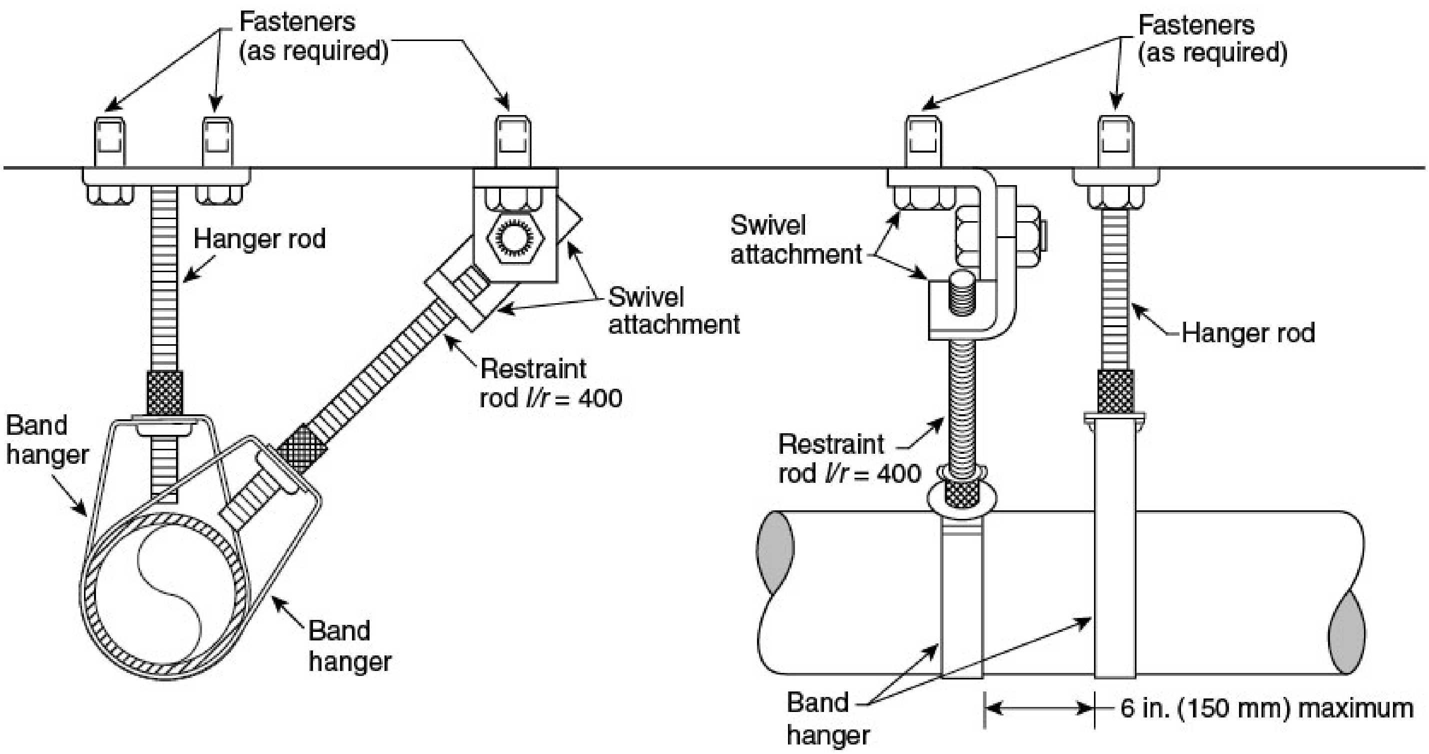


Figure A.18.6.1(5)(b) Hangers, with Threaded Rod Extended to Pipe, Used in Combination for Restraint of Branch Lines.



A.18.6.4

Modern seismic codes require branch lines to be restrained, both to limit interaction of the pipe with other portions of the structure and to limit stresses in the pipes to permissible limits. The maximum spacing between restraints is dependent on the seismic coefficient, C_p, as shown in Table 18.6.4(a). Table 18.6.4(a) has been limited to 2 in. (50 mm) lines and smaller, because branch lines $2\frac{1}{2}$ in. (65 mm) or larger are required to be seismically braced. See also 18.5.9.1.

It is not the intent of this section to require restraint of piping associated with valve trim, water motor gong piping, air or nitrogen supply piping, or other piping that is not essential to the operation of the sprinkler system. Essential piping such as fire pump sensing lines and diesel fuel lines are some examples of small piping that should be restrained.

A.18.6.6

Such restraint can be provided by using the restraining wire discussed in 18.6.1. For the purposes of determining the need for restraint, the length of the sprig is determined by measuring the length of the exposed pipe and does not include the fittings and sprinkler.

A.18.7.8

Concrete anchors included in current Evaluation Service Reports conforming to the requirements of acceptance criteria AC193 *Acceptance Criteria for Mechanical Anchors in Concrete Elements*, or AC308, *Post-installed Adhesive Anchors in Concrete Elements*, as issued by ICC Evaluation Service, Inc. should be considered to meet ACI 355.2, *Post-Installed Mechanical Anchors in Concrete — Qualification Requirements and Commentary*.

A.18.8

When using a pipestand to support the gravity load of a water-based fire protection system in an earthquake area, care should be taken in planning the seismic protection. This includes close attention to the differential movement between the system and the building or other components.

A.19.1.1

More than one design approach can be selected for a single building or system. It is the designer's discretion as to which design approaches or methods to utilize; prior approval by the authority having jurisdiction is not required.

A.19.1.2

The situation frequently arises where a small area of a higher hazard is surrounded by a lesser hazard. For example, consider a 600 ft^2 (56 m^2) area consisting of 10 ft (3 m) high on-floor storage of cartoned nonexpanded plastic commodities surrounded by a plastic extruding operation in a 15 ft (4.6 m) high building. In accordance with Chapter 20, the density required for the plastic storage must meet the requirements for extra hazard (Group 1) occupancies. The plastic extruding operation should be considered an ordinary hazard (Group 2) occupancy. In accordance with Chapter 19, the corresponding discharge densities should be 0.3 gpm/ft^2 (12.2 mm/min) over 2500 ft^2 (230 m^2) for the storage and 0.2 gpm/ft^2 (8.1 mm/min) over 1500 ft^2 (140 m^2) for the remainder of the area. *(Also see Chapter 19 for the required minimum areas of operation.)*

If the storage area is not separated from the surrounding area by a wall or partition *(see 19.1.2),* the size of the operating area is determined by the higher hazard storage.

For example, the operating area is 2500 ft^2 (230 m^2). The system must be able to provide the 0.3 gpm/ft^2 (12.2 mm/min) density over the storage area and 15 ft (4.6 m) beyond. If part of the remote area is outside the 600 ft^2 (56 m^2) plus the 15 ft (4.6 m) overlap, only 0.2 gpm/ft^2 (8.1 mm/min) is needed for that portion.

If the storage is separated from the surrounding area by a floor-to-ceiling/roof partition that is capable of preventing heat from a fire on one side from fusing sprinklers on the other side, the size of the operating area is determined by the occupancy of the surrounding area. In this example, the design area is 1500 ft^2 (140 m^2). A 0.3 gpm/ft^2 (12.2 mm/min) density is needed within the separated area with 0.2 gpm/ft^2 (8.1 mm/min) in the remainder of the remote area.

When the small higher hazard area is larger than the required minimum area dictated by the surrounding occupancy, even when separated by partitions capable of stopping heat, the size of the operating area is determined by the higher hazard storage.

A.19.1.4.2

Appropriate area/density, other design criteria, and water supply requirements should be based on scientifically based engineering analyses that can include submitted fire testing, calculations, or results from appropriate computational models.

Recommended water supplies anticipate successful sprinkler operation. Because of the small but still significant number of uncontrolled fires in sprinklered properties, which have various causes, there should be an adequate water supply available for fire department use.

The hose stream demand required by this standard is intended to provide the fire department with the extra flow they need to conduct mop-up operations and final extinguishment of a fire at a sprinklered property. This is not the fire department manual fire flow, which is determined by other codes or standards. However, it is not the intent of this standard to require that the sprinkler demand be added to the manual fire flow demand required by other codes and standards. While the other codes and standards can factor in the presence of a sprinkler system in the determination of the manual fire flow requirement, the sprinkler system water demand and manual fire flow demand are intended to be separate stand-alone calculations. NFPA 1 emphasizes this fact by the statement in A.18.4.1 that “It is not the intent to add the minimum fire protection water supplies, such as for a sprinkler system, to the minimum fire flow for manual fire suppression purposes required by this section.”

A.19.1.5.2

Where tanks serve sprinklers only, they can be sized to provide the duration required for the sprinkler system, ignoring any hose stream demands. Where tanks serve some combination of sprinklers, inside hose stations, outside hose stations, or domestic/process use, the tank needs to be capable of providing the duration for the equipment that is fed from the tank, but the demands of equipment not connected to the tank can be ignored. Where a tank is used for both domestic/process water and fire protection, the entire duration demand of the domestic/process water does not need to be included in the tank if provisions are made to segregate the tank so that adequate fire protection water is always present or if provisions are made to automatically cut off the simultaneous use in the event of fire.

A.19.1.5.3

Where pumps serve sprinklers only, they can be sized to provide the flow required for the sprinkler system, ignoring any hose stream demands. Where pumps serve some combination of sprinklers, inside hose stations, or outside hose stations, the pump needs to be capable of providing the flow for the equipment that is fed from the pump, but the demands of equipment not connected to the pump can be ignored except for evaluating their impact on the available water supply to the pump.

A.19.1.6.1(3)

When a light hazard occupancy, such as a school, contains separate ordinary hazard rooms no more than 400 ft^2 (37 m^2), the hose stream allowance and water supply duration would be that required for a light hazard occupancy.

A.19.1.6.2

When the hose demand is provided by a separate water supply, the sprinkler calculation does not include the outside hose demand.

A.19.1.6.4

For fully sprinklered buildings, if hose valves or stations are provided on a combination sprinkler riser and standpipe for fire department use in accordance with NFPA 14, the hydraulic calculation for the sprinkler system is not required to include the standpipe allowance.

A.19.1.7

A series of 10 full-scale fire tests and limited-scale testing were conducted to determine the impact of HVLS fan operation on the performance of sprinkler systems. The project, sponsored by the Property Insurance Research Group (PIRG) and other industry groups, was coordinated by the Fire Protection Research Foundation (FPRF). The complete test report, *High Volume/Low Speed Fan and Sprinkler Operation — Ph. 2 Final Report (2011)*, is available from the FPRF. Both control mode density area and early suppression fast response sprinklers were tested. Successful results were obtained when the HVLS fan was shut down upon the activation of the first sprinkler followed by a 90-second delay. Other methods of fan shutdown were also tested including shutdown by activation of air sampling–type detection and ionization-type smoke detectors. Earlier fan shutdown resulted in less commodity damage.

A.19.2.1.1

This approach is based on a general occupancy classification applied to the building or a portion of the building.

A.19.2.2.5

The additional pressure that is needed at the level of the water supply to account for sprinkler elevation is 0.433 psi/ft (0.098 bar/m) of elevation above the water supply.

A.19.2.3.1.4(1)

The area of sprinkler operation typically encompasses enough of the floor area to make-up the minimum allowed size of the remote area up to the entire area of a single floor of the building.

A.19.2.3.1.5.1

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.

In order for the minimum 3000 ft^2 (280 m^2) requirement for the size of the remote area to not be extended to the adjacent area, the qualifying concealed space must be separated by the entire fire-rated assembly. Such assemblies often have combustible structural members separating the exterior membranes that can create a concealed combustible space that can qualify for omitting sprinkler protection. If the fire-rated assembly is the qualifying concealed space, an interior fire would greatly reduce the assigned fire-rated duration.

A.19.2.3.1.5.2(4)

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. Application of this item is not affected by the depth of the joist channel except in determining the volume. The concealed space above the insulation can be an attic, roof space, or floor space within a floor assembly.

A.19.2.3.1.5.2(10)

The gypsum board (or equivalent material) used as the blocking material will compartment the concealed space and restrict the ability for fire to spread beyond 160 ft^3 (4.5 m^3) zones covering multiple joist channels.

A.19.2.3.2.5

Historically, prior to 2025, NFPA 13 has not limited ceiling heights for nonstorage occupancies, and for any ceiling height providing sprinklers has always been considered appropriate. Large-scale fire testing has demonstrated that the protection needed for Ordinary Hazard Group 1 and Group 2 occupancies is greater than the protection indicated in Table 19.2.3.1.1. See Table C.27 for fire test data specific to Ordinary Hazard Group 1 and Group 2 type occupancies where the ceiling heights exceed 30 ft (9.1 m).

A.19.2.3.2.5.1

The large-scale fire testing applicable to the requirements of this section did not include the use of sidewall sprinklers. As a result, sidewall sprinklers are not currently allowed for the protection of Ordinary Hazard Group 1 or greater occupancy hazards where the ceiling height exceeds 30 ft (9.1 m).

A.19.2.3.2.5.1(A)

The large-scale fire testing applicable to the requirements of this section demonstrated that sprinklers with a K-factor of K-8.0 (K-115) were not effective in providing fire control for a simulated Ordinary Hazard Group 2 occupancy with the ceiling height greater than 30 ft (9.1 m), whereas sprinklers with a minimum K-factor of K-11.2 (K-160) were effective at providing fire control. As a result, sprinklers with a K-factor less than K-11.2 (K-160) are not currently allowed for the protection of Ordinary Hazard Group 2 or greater occupancy hazards where the ceiling height exceeds 30 ft (9.1 m).

A.19.2.3.2.5.1(B)

The large-scale fire testing applicable to the requirements of this section did not include the use of extended-coverage sprinklers with a K-factor of less than K-25.2 (K-360). Testing at FM Global, however, has demonstrated that upright extended-coverage sprinklers with a K-factor of K-11.2 (K-160) and K-14.0 (K-200) can be effective for Ordinary Hazard Group 1 and 2 occupancies where the ceiling height is greater than 30 ft (9.1 m), whereas the testing at FM Global did not demonstrate this for the pendent version of these extended-coverage sprinklers. As a result, pendent extended-coverage sprinklers with K-factors of K-22.4 or less are not currently allowed for the protection of Ordinary Hazard Group 2 or greater occupancy hazards where the ceiling height exceeds 30 ft (9.1 m).

A.19.2.3.2.5.1(C)

The large-scale fire testing applicable to the requirements of this section demonstrated that for standard-coverage sprinklers, the use of quick-response sprinklers provided an acceptable level of fire control for simulated Ordinary Hazard Group 2 occupancy hazards. As a result, quick-response standard-coverage sprinklers with K-factors of K-11.2 (K-160) or greater are required for the protection of Ordinary Hazard Group 2 occupancy hazards where the ceiling height exceeds 30 ft (9.1 m).

A.19.2.3.2.5.2(A)

The results of Test Nos. 1 and 2 listed in Table C.27 demonstrate that standard-response K-5.6 (K-80) and K-8.0 (K-115) sprinklers can provide fire control for a simulated Ordinary Hazard Group 1 storage array under a 58 ft (17.7 m) high ceiling using a 0.15 gpm/ft^2 (6.1 mm/min) density. However, the number of sprinklers that operated resulted in a design area larger than that specified in Table 19.2.3.1.1 coupled with significant sprinkler skipping for both tests. As a result, the design areas in Table 19.2.3.1.1 are being increased, while maintaining the same design density, to account for the test results.

A.19.2.3.2.5.2(B)

The results of a test reported in the 2014 Suppression Detection conference proceedings (available from the NFPA Library) demonstrated that standard-response K-8.0 (K-115) sprinklers can provide fire control for a simulated Ordinary Hazard Group 2 storage array under a 40 ft (12.2 m) high ceiling using a 0.37 gpm/ft^2 (15 mm/min) density. However, with 12 sprinklers operating during this test, it demonstrated that a density of 0.37 gpm/ft^2 (15 mm/min) is more applicable than the density of 0.20 gpm/ft^2 (8.1 mm/min) that is provided in Table 19.2.3.1.1 and therefore has been given as the design density for this ceiling height. In addition, the results from Test Nos. 6 and 7 in Table C.27 along with a test reported in the 2014 Suppression Detection conference proceedings (available from the NFPA Library) suggest that the use of a K-11.2 (K-160) sprinkler will provide better fire control, as suggested by the requirements given in 21.1.4, even though this is not a storage occupancy.

A.19.2.3.2.5.2(C)

The results of Test Nos. 6 and 7 listed in Table C.27 demonstrated that quick-response K-11.2 (K-160) sprinklers can provide fire control for a simulated Ordinary Hazard Group 2 storage array under a 60 ft (18.3 m) high ceiling using a 0.45 gpm/ft^2 (18.3 mm/min) density. However, with 13 and 16 sprinklers operating during these two tests, it demonstrated that a density of 0.45 gpm/ft^2 (18.3 mm/min) is more applicable than the density of 0.20 gpm/ft^2 (8.1 mm/min) that is provided in Table 19.2.3.1.1 coupled with a design area greater than the 1500 ft^2 (140 m^2) given in Table 19.2.3.1.1. As a result, the original design density of 0.20 gpm/ft^2 (8.1 mm/min) has been increased to 0.45 gpm/ft^2 (18.3 mm/min), and the design area of 1500 ft^2 (140 m^2) has been increased by 30 percent. The 30 percent increase to the design area, however, was not applied to the K-25.2 (K-360) extended-coverage sprinkler due to the very positive results (only one sprinkler operated) obtained with it during Test 8 listed in Table C.27.

A.19.2.3.2.5.2(D)

The test data listed in Table C.27 does not include any tests representing simulated occupancy hazards for either Extra Hazard Group 1 or Extra Hazard Group 2. However, based on the results from the test data listed in Table C.27, the minimum design density requirements of 0.30 gpm/ft^2 (12.2 mm/min) for Extra Hazard Group 1 and 0.40 gpm/ft^2 (16.3 mm/min) for Extra Hazard Group 2 are both now less than the 0.45 gpm/ft^2 (18.3 mm/min) design density required for Ordinary Hazard Group 2. Therefore, the minimum design density for both Extra Hazard Group 1 and Extra Hazard Group 2 has been increased to 0.45 gpm/ft^2 (18.3 mm/min) while maintaining the same required design area.

A.19.2.3.2.6

Where extended coverage sprinklers are used and the design area (after appropriate increases) is satisfied by five sprinklers, no additional increase is required. With regard to preaction systems, the discharge criteria of Chapter 11 are written based upon the assumption that the release system will activate before the sprinkler system. It is generally accepted that smoke detectors and rate-of-rise detectors are more sensitive than sprinklers and that fixed-temperature release devices with RTIs lower than sprinklers will react faster than sprinklers at similar spacings and locations.

A.19.2.3.2.8

Example 1: A dry pipe sprinkler system (OH2) in a building with a ceiling slope exceeding 2 in 12 (16.7 percent). The initial area must be increased 30 percent for the dry pipe system and the resulting area an additional 30 percent for the roof slope if the ceiling construction does not comply with 19.2.3.2.4(3) or 19.2.3.2.4(4). Table 19.2.3.1.1 requires a density of 0.2 gpm/ft^2 (8.2 mm/min) over 1500 ft^2 (140 m^2) for situations where the design area is not required to be 3000 ft^2 per 19.2.3.1.5. The 1500 ft^2 (140 m^2) area is increased 450 ft^2 (42 m^2) to 1950 ft^2 (180 m^2), which is then further increased 585 ft^2 (54 m^2) to 2535 ft^2 (235 m^2). The final discharge criterion is then 0.2 gpm/ft^2 (8.2 mm/min) over 2535 ft^2 (235 m^2).

Example 2: A wet pipe sprinkler system (light hazard) in a building with a 16 ft 8 in. (5.1 m) ceiling and a slope exceeding 2 in 12 (16.7 percent) employs quick-response sprinklers qualifying for a 30 percent reduction as permitted by 19.2.3.2.3. The initial area must be increased 30 percent for the ceiling slope if the ceiling construction does not comply with 19.2.3.2.4(3) or 19.2.3.2.4(4), and the resulting area must be decreased 30 percent for quick-response sprinklers based on the reduction permitted by Figure 19.2.3.2.3.1. It does not matter whether the reduction or increase is applied first. Table 19.2.3.1.1 requires a density of 0.1 gpm/ft^2 (8.2 mm/min) over 1500 ft^2 (140 m^2) for situations where the design area is not required to be 3000 ft^2 per 19.2.3.1.5. The 1500 ft^2 (140 m^2) is increased 450 ft^2 (42 m^2), resulting in 1950 ft^2 (180 m^2), which is then decreased 585 ft^2 (54 m^2), resulting in 1365 ft^2 (125 m^2). The final design is 0.1 gpm/ft^2 (4.1 mm/min) over 1365 ft^2 (125 m^2).

A.19.2.3.3.1

This subsection 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 four sprinklers and a smaller room has two sprinklers but communicates through unprotected openings with three other rooms, each having two 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.19.2.3.4.2

This section is intended to apply to all types of systems including dry pipe and preaction systems.

A.19.3.1.1

In Figure A.19.3.1.1(a), calculate the area indicated by the heavy outline and X. The circle indicates sprinklers.

The protection area for residential sprinklers with extended coverage areas is defined in the listing of the sprinkler as a maximum square area for pendent sprinklers or a square or rectangular area. Listing information is presented in even 2 ft (600 mm) increments 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. (4.4 m) wide and 20 ft 8 in. (6.3 m) long, a sprinkler that is listed to protect an area of 16 ft × 22 ft (4.9 m × 6.7 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.19.3.1.1(b).]*

When a single compartment has a branch line with four or more sprinklers, the calculation should include all four sprinklers on the one branch line. When the remote area consists of eight sprinklers in compliance with 19.3.1.2.1, it is not necessary to include all eight sprinklers on the one branch line. One should include sprinklers that are adjacent when viewed as a group and not simply viewed as being next to one downstream sprinkler.

Figure A.19.3.1.1(a) Examples of Design Area for Dwelling Units.

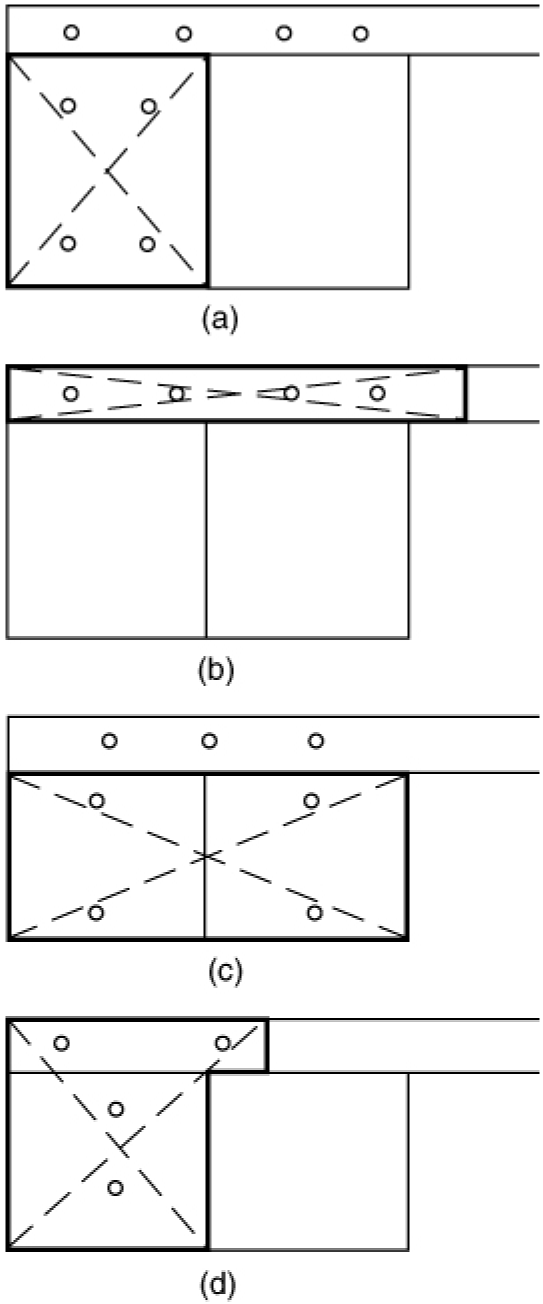
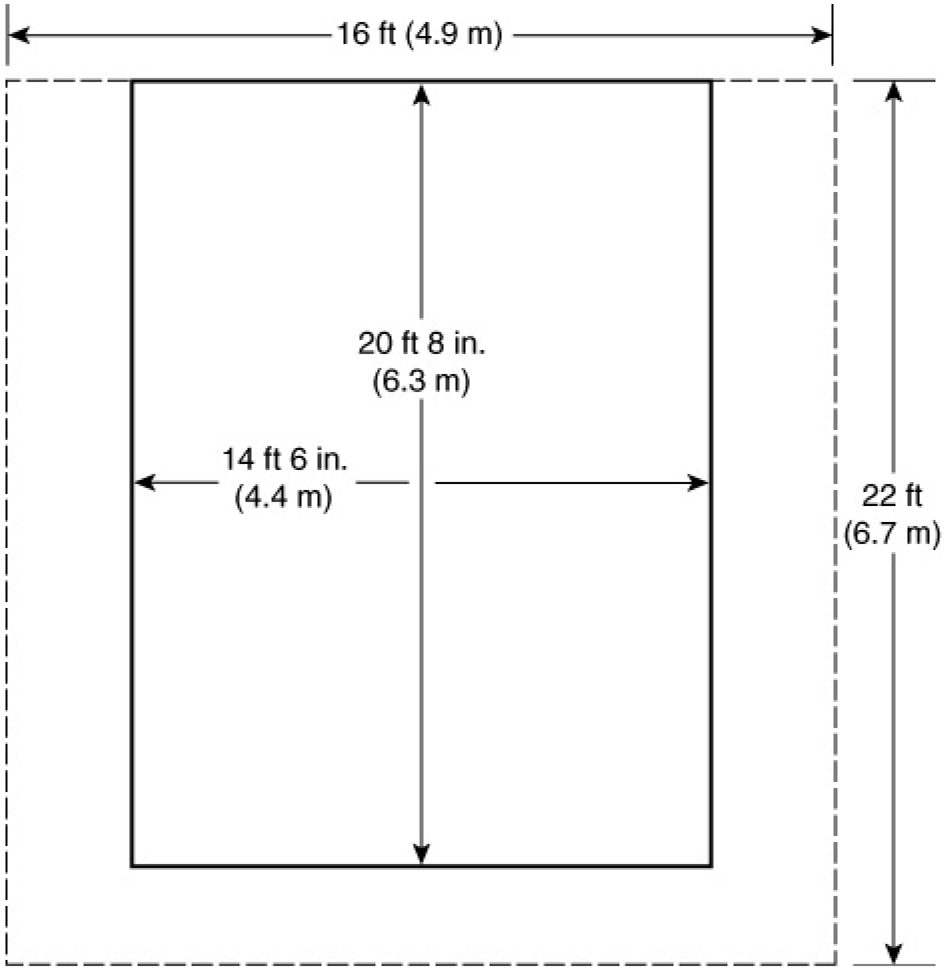


Figure A.19.3.1.1(b) Determination of Protection Area of Coverage for Residential Sprinklers.



A.19.3.1.2

It should be noted that the provisions of Section 19.2 do not normally apply to the residential sprinkler design approach. The reference to 19.2.3.1.5.2 is merely to provide a consistent approach between the occupancy hazard fire control approach and the residential sprinkler design approach with respect to unsprinklered combustible concealed spaces.

A.19.3.1.2.2

In order for the minimum eight sprinkler requirement for the size of the remote area to not be extended to the adjacent area, the qualifying concealed space must be separated by the entire fire-rated assembly. Such assemblies often have combustible structural members separating the exterior membranes that can create a concealed combustible space that can qualify for omitting sprinkler protection. If the fire-rated assembly is the qualifying concealed space, an interior fire would greatly reduce the assigned fire-rated duration.

A.19.3.2.1

If the system is a deluge type, all the sprinklers need to be calculated even if they are located on different building faces.

A.20.1

When sprinklers are being tested at a laboratory for the purposes of determining sprinkler discharge criteria for a specific hazard, the entity sponsoring the testing should request that the laboratory provide them with a report or test data that documents how the tests were conducted and what the results of the tests were, but not include proprietary product design information about the sprinkler. The following information should be included for each test in the report or data package:

(1) Material(s) being used as the fuel for the fire.
(2) Dimensional details of test commodity and storage arrangement.
(3) Nominal height of the stored commodity above the floor.
(4) Nominal clearance between the top of storage and the ceiling.
(5) Sprinkler identification number (SIN).
(6) K-factor of the sprinkler.
(7) Temperature rating and response characteristics of the sprinkler.
(8) Distance of the sprinkler deflector (or thermal element) below the ceiling.
(9) Orientation of the sprinkler (upright, pendent, horizontal).

(10) Obstructions to sprinklers (if any) including the branch line piping for upright sprinklers.
(11) Water pressure at sprinkler or flow from sprinkler during test.
(12) Sprinkler spacing.
(13) Fire location with respect to upright and pendent sprinkler(s). Typical test locations might include the following (note that tests are not required in all locations):
   (a) Under one sprinkler
   (b) Between two sprinklers on the same branch line
   (c) Between four sprinklers
   (d) At a dry spot in the sprinkler's spray pattern as identified in flow testing
(14) Fire location with respect to sidewall sprinkler(s). Test locations that should be considered include the following (note that tests are not required in all locations):
   (a) At the most remote location from a single sprinkler
   (b) Centered between two sprinklers at the far point of the coverage area
   (c) Centered between four sprinklers when sprinklers are on opposite walls spraying into a room or space
   (d) Directly underneath and behind a single sprinkler
   (e) On the same wall as the sprinklers, centered between two sprinklers
   (f) At a dry spot in the sprinkler's spray pattern as identified in flow testing
(15) Fire test results. The following are examples of successful criteria:
   (a) The fire does not show evidence of sustained combustion at the far ends of the main test array.
   (b) The fuel is not completely consumed.
   (c) The fire does not show evidence of sustained combustion at the outer edges of the target arrays.
   (d) The average one-minute temperature of a simulated steel structural member installed near the ceiling above ignition does not exceed 1000°F (538°C), or the ceiling temperatures are controlled so that they are below a predetermined limit.
   (e) Sprinklers do not operate at the edge of the protection array.
(16) Number of sprinklers that open during the test, where they were in relation to the fire, and what time they opened after ignition.
(17) Gas temperatures above ignition and near each installed sprinkler.
(18) Description of area or commodity damaged by fire.
(19) Other test conditions or parameters or observations that would help support a decision or limitation on the use of the sprinkler based on this test program.

The entity sponsoring the tests is responsible for proposing appropriate limits to the installation requirements and hazards that their sprinkler can protect based on the parameters of the fire tests and the results of those tests. This recommendation needs to include the following:

(1) The number of sprinklers that would be appropriate for the design area.
(2) The minimum discharge (pressure or flow) necessary from each sprinkler.
(3) The number of sprinklers that operated in the worst-case fire test with an appropriate safety factor applied (typically 1.5) to that number to account for variables not considered during the test program.
(4) An appropriate minimum number of sprinklers can be applied, depending on the hazard being protected.

A.20.2

Information for the protection of Classes I, II, III, and IV commodities was extrapolated from full-scale fire tests that were performed at different times than the tests that were used to develop the protection for plastic commodities. It is possible that, by selecting certain points from the tables (and after applying the appropriate modifications), the protection specified by 21.4.1.6 exceeds the requirements of Section 21.5. In such situations, the protection specified for plastics, although less than that required by the tables, can adequately protect Class I, II, III, and IV commodities.

This section also allows storage areas that are designed to protect plastics to store Class I, II, III, and IV commodities without a re-evaluation of fire protection systems.

A.20.2.3(3)

When a light hazard occupancy, such as a school, contains separate ordinary hazard rooms no more than 400 ft^2 (37 m^2), the hose stream allowance and water supply duration would be that required for a light hazard occupancy.

A.20.3

Commodity classification is governed by the types and amounts of materials (e.g., metal, paper, wood, plastics) that are a part of a product and its primary packaging. Consideration of all characteristics of the individual storage units, not just the product, is critical to identify the appropriate commodity classification. Refer to Table A.20.3 for general guidance for classifying commodities. For situations where it is difficult to determine the appropriate classification, testing should be considered to appropriately characterize the commodity.

Table A.20.3 General Guide to Identifying the Commodity Class for Solid Combustibles

Characteristics of Unit Load			
Material Used to Construct Product	**Packaging Material**	**Pallet Material**	**Commodity Class**
Noncombustible Product			
Entirely noncombustible	None or single-layer corrugated cartons	None, metal, or wood	Class I
Entirely noncombustible	None or single-layer corrugated cartons	Plastic	Class I, II, or III; see 20.3.2
Entirely noncombustible	Multiple-layered corrugated cartons, wooden crates, or wood boxes	None, metal, or wood	Class II
Entirely noncombustible	Multiple-layered corrugated cartons, wooden crates, or wood boxes	Plastic	Class II, III, or IV; see 20.3.2
Entirely noncombustible	Corrugated cartons, wooden crates, or wood boxes, with internal plastic packaging	None, metal, or wood	See Figure 20.4.3.3(a)
Entirely noncombustible	Corrugated cartons, wooden crates, or wooden boxes, with internal plastic packaging	Plastic	See 20.3.2 and Figure 20.4.3.3(a)
Wood, Paper, Natural Fibers, or Group C Plastics			
Entirely wood, paper, natural fibers, or Group C plastics, or a mix of these with noncombustible materials	None, corrugated cartons, wooden crates, or wood boxes	None, metal, or wood	Class III
Entirely wood, paper, natural fibers, or Group C plastics, or a mix of these with noncombustible materials	Corrugated cartons, wooden crates, or wood boxes, with internal plastic packaging	None, metal, or wood	See Figure 20.4.3.3(a)
Entirely wood, paper, natural fibers, or Group C plastics, or a mix of these with noncombustible materials	None, corrugated cartons, wooden crates, or wood boxes	Plastic	Class III or IV or cartoned nonexpanded Group A plastic; see 20.3.2
Entirely wood, paper, natural fibers, or Group C plastics, or a mix of these with noncombustible materials	Corrugated cartons, wooden crates, or wood boxes, with internal plastic packaging	Plastic	See 20.3.2 and Figure 20.4.3.3(a)
Group B Plastics			
Entirely Group B plastics, or a mix of these with noncombustible, wood, paper, natural fibers, or Group C plastics materials	None, corrugated cartons, wooden crates, or wood boxes	None, metal, or wood	Class IV
Entirely Group B plastics, or a mix of these with noncombustible, wood, paper, natural fibers, or Group C plastics materials	Corrugated cartons, wooden crates, or wood boxes	Plastic	Class IV or cartoned nonexpanded Group A plastic; see 20.3.2
Entirely Group B plastics, or a mix of these with noncombustible, wood, paper, natural fibers, or Group C plastics materials	None	Plastic	Class IV or cartoned nonexpanded Group A plastic; see 20.3.2
Entirely Group B plastics, or a mix of these with noncombustible, wood, paper, natural fibers, or Group C plastics materials	Corrugated cartons, wooden crates, or wood boxes, with plastic internal packaging	None, metal, or wood	See Figure 20.4.3.3(a)

Characteristics of Unit Load			
Material Used to Construct Product	**Packaging Material**	**Pallet Material**	**Commodity Class**
Entirely Group B plastics, or a mix of these with noncombustible, wood, paper, natural fibers, or Group C plastics materials	Corrugated cartons, wooden crates, or wood boxes, with plastic internal packaging	Plastic	See 20.3.2 and Figure 20.4.3.3(a)
Group A Plastics			
Free-flowing Group A plastic materials	Corrugated cartons, wooden crates, wood boxes, or bagged	None, metal, wood	Class IV
Free-flowing Group A plastic materials	Corrugated cartons, wooden crates, wood boxes, or bagged	Plastic	Class IV or cartoned nonexpanded Group A plastic; see 20.3.2
Entirely nonexpanded Group A plastic	Corrugated cartons, wooden crates, or wood boxes	None, metal, wood, or plastic	Cartoned nonexpanded Group A plastic
Entirely nonexpanded Group A plastic	None	None, metal, wood, or plastic	Exposed nonexpanded Group A plastic
Entirely nonexpanded Group A plastic	Corrugated cartons, wooden crates, or wood boxes, with internal plastic packaging	None, metal, wood, or plastic	See Figure 20.4.3.3(a)
Entirely expanded Group A plastic	Corrugated cartons, wooden crates, or wood boxes, with or without internal plastic packaging	None, metal, wood, or plastic	Cartoned expanded Group A plastic
Entirely expanded Group A plastic	None	None, metal, wood, or plastic	Exposed expanded Group A plastic
Mix of Group A plastics, noncombustible, wood, paper, natural fibers, Group B or C plastics materials	Corrugated cartons, wooden crates, or wood boxes, with or without internal plastic packaging	None, metal, or wood	See Figure 20.4.3.3(a)
Mix of Group A plastics, noncombustible, wood, paper, natural fibers, Group B or C plastics materials	Corrugated cartons, wooden crates, or wood boxes	Plastic	See 20.3.2 and Figure 20.4.3.3(a)
Mix of Group A plastics, noncombustible, wood, paper, natural fibers, Group B or C plastics materials	None	None, metal, or wood	See Figure 20.4.3.3(b)
Mix of Group A plastics, noncombustible, wood, paper, natural fibers, Group B or C plastics materials	None	Plastic	See 20.3.2 and Figure 20.4.3.3(b)

Note: This table provides guidance for the general characteristics to be considered in classifying a commodity. The additional commodity classification information included in this standard as well as any relevant test data that is available should be considered in identifying the appropriate classification.

A.20.3.1

Unit loads and pallet loads are examples of individual storage units.

A.20.3.2.2.1

For example, Class III will become Class IV, and Class IV will become a cartoned nonexpanded Group A plastic commodity.

A.20.3.2.2.2.1

For example, Class II will become Class IV, and Class III and Class IV will become a cartoned nonexpanded Group A plastic commodity.

A.20.4

Specification of the type, amount, and arrangement of combustibles for any commodity classification is essentially an attempt to define the potential fire severity, based on its burning characteristics, so the fire can be successfully controlled by the prescribed sprinkler protection for the commodity class. In actual storage situations, however, many storage arrays do not fit precisely into one of the fundamental classifications; therefore, the user needs to make judgments after comparing each classification to the existing storage conditions. Storage arrays consist of thousands of products, which makes it impossible to specify all the acceptable variations for any class. As an alternative, a variety of common products are classified in this annex based on judgment, loss experience, and fire test results.

Table A.20.4(a) provides examples of commodities not addressed by the classifications in Section 20.4. The commodities listed in Table A.20.4(a) are outside the scope of NFPA 13 protection.

Table A.20.4(a) includes lithium ion batteries. Lithium ion batteries have been a research project within the NFPA Research Foundation. As a result, the following reports have been published:

(1) *Lithium Ion Batteries Hazard and Use Assessment*, published July 2011 and available at the NFPA Research Foundation web site.
(2) *Flammability Characterization of Lithium-ion Batteries in Bulk Storage*, published March 2013 and available at www.fmglobal.com/researchreports.
(3) *Lithium Ion Batteries Hazard and Use Assessment Phase IIB, Flammability Characterization of Li-ion Batteries for Storage Protection*, published April 2013 and available at the NFPA Research Foundation web site.
(4) *Lithium Ion Batteries Hazard and Use Assessment — Phase III*, published November 2016 and available at the NFPA Research Foundation web site.

Table A.20.4(b) is an alphabetized list of commodities with corresponding classifications.

Table A.20.4.1, Table A.20.4.2, Table A.20.4.3, Table A.20.4.4, and Table A.20.4.5.1 provide examples of commodities within a specific class.

Table A.20.4(a) Examples of Commodities Not Addressed by Classifications in Section 20.4

Ammunition Components
- Bulk primers and powder
Batteries
- Lithium and other similar exotic metals
- Lithium-ion and other rechargeable batteries that contain combustible electrolyte
Boat Storage
- Stored on racks
Boxes, Crates
- Empty, wood slatted*
Carpet Rolls
Combustible Metals — unless specifically identified otherwise
Compressed or Liquefied Flammable Gases (i.e., filled propane cylinders) — unless specifically identified otherwise
Explosives
- Blasting primers and similar items
Fertilizers (nitrates)
Fireworks
- Consumer and display
Flammable and Combustible Liquids — unless specifically identified otherwise
- Liquids that contain greater than 20 percent alcohol
Hanging Garments, Bulk Storage
Lighters (butane)
- Loose in large containers (Level 3 aerosol)

Storage Container

- Large container storage of household goods

*Should be treated as idle pallets.

Table A.20.4(b) Alphabetical Listing of Commodity Classes

Product Heading	Product	NFPA 13
Batteries	Dry cells (excludes lithium, lithium-ion, and other similar exotic metals or combustible electrolyte); without blister packing (if blister packed refer to commodity classification definitions)	Class I
	Vehicle; any size (e.g., automobile or truck); empty plastic casing	Group A Nonexpanded
	Vehicle; large (e.g., truck or larger); dry or wet (excludes lithium-ion and other cells containing combustible electrolyte) cells	Group A Nonexpanded
	Vehicle; small (e.g., automobile); wet (excludes lithium-ion and other cells containing combustible electrolyte) cells	Class I
Empty Containers	Noncombustible	Class I
	PET, bottles or jars	Class IV
	Rigid plastic (not including PET), up to 32 oz. (1 L)	Group A Nonexpanded
	Rigid plastic (not including PET), greater than 32 oz. (1 L)	Group A Expanded
	Wood; solid sided (e.g., crates, boxes)	Class II
Film Rolls, Including Photographic	Film (polypropylene, polyester, polyethylene); rolled on any reel type	Group A Nonexpanded
	Film; 35 mm metal film cartridges in polyethylene cans; cartoned	Class III
	Film; motion picture or bulk rolls in polycarbonate, polyethylene or in metal cans; polyethylene bagged; cartoned	Class II
	Film; rolls in polycarbonate plastic cassettes; cartoned	Class IV
	Photographic paper; sheets; bagged in polyethylene; cartoned	Class III
Flammable/Combustible Liquids	Aerosol; Level 1	Class III
	Lighters; butane; blister-packed; cartoned	Group A Nonexpanded
	Liquids; up to 20 percent alcohol (e.g. alcoholic beverages, flavoring extracts); greater than 5 gal (20 L) plastic containers with wall thickness greater than $\frac{1}{4}$ in. (6 mm)	Group A Nonexpanded
	Liquids; up to 20 percent alcohol (e.g., alcoholic beverages, flavoring extracts); metal, glass or ceramic containers	Class I
	Liquids; up to 20 percent alcohol (e.g., alcoholic beverages, flavoring extracts); plastic containers greater than 5 gal (20 L) and wall thickness up to $\frac{1}{4}$ in. (6 mm)	Class II
	Liquids; up to 20 percent alcohol (e.g., alcoholic beverages, flavoring extracts); up to 5 gal (20 L) plastic bottles or jars	Class I
	Liquids; up to 20 percent alcohol (e.g., alcoholic beverages, flavoring extracts); wood containers	Class II
Food Products — Frozen	Frozen foods; nonwaxed or nonplastic packaging	Class I
	Frozen foods; plastic trays	Class III
	Frozen foods; waxed or plastic-coated paper packaging	Class II
Food Products — Non-Frozen	Butter (stick or whipped spread) or margarine (up to 50 percent oil)	Class III
	Dry foods (such as baked goods, candy, cereals, cheese, chocolate, cocoa, coffee, grains, granular sugar, nuts, etc.); bagged or cartoned	Class III

Product Heading	Product	NFPA 13
	Foods (e.g., coffee, fish products, fruit, meat products, nuts, poultry, etc.); metal cans	Class I
	Fruits and vegetables (noncombustible semi-liquids); crushed; plastic containers up to 5 gal (20 L)	Class I
	Fruits and vegetables; fresh; wood spacers, non-plastic trays or containers	Class I
	Margarine; over 50 and up to 80 percent oil	Group A Nonexpanded
	Meat; fresh; no plastic packaging; exposed	Class I
	Meat; fresh; no plastic packaging; cartoned	Class II
	Meat; fresh; plastic trays	Class III
	Milk; any container; stored in solid plastic crates	Group A Nonexpanded
	Milk; paper containers, or plastic bottles or jars up to 5 gal (20 L) plastic bottles or jars	Class I
	Salt; bagged	Class I
	Salt; cartoned	Class II
	Snack foods (e.g., potato chips); plasticized aluminum bags; cartoned	Group A Nonexpanded
	Syrup; wooden container	Class II
Furniture and Bedding	Furniture and bedding; with foam cushioning	Group A Expanded
	Furniture; metal (e.g., file cabinets or desks with plastic trim); cartoned	Class I
	Furniture; wood (e.g., doors, windows, cabinets, etc.); no plastic coverings or foam cushioning	Class III
	Furniture; wood; plastic coverings nonexpanded plastic trim	Class IV
	Box spring; standard (minimal plastic materials)	Class III
	Box spring; wrapped in plastic cover	Class IV
	Mattress; foam (in finished form)	Group A Expanded
Housing Materials/Appliances	Appliances; major (e.g., stoves, refrigerators); no appreciable plastic interior or exterior trim; cartoned	Class II
	Appliances; major (e.g., stoves, refrigerators); no appreciable plastic interior or exterior trim; exposed	Class I
	Appliances; no appreciable plastic exterior trim (interior of unit can have appreciable plastic)	Class III
	Carpet tiles; cartoned	Group A Nonexpanded
	Fiberglass insulation; paper-backed rolls; bagged or unbagged	Class IV
	Floor coverings; vinyl, stacked tiles	Class IV
	Floor coverings; vinyl; rolled	Group A Nonexpanded
	Gypsum board	Class I
	Housing materials (such as sinks, countertops, etc.); noncombustible, cartoned or crated	Class II
	Paint; oil-based; friction-top metal containers; cartoned	Class IV
	Paint; water-based (latex); friction-top metal containers; cartoned	Class I
	Roofing shingles; asphalt-coated fiberglass	Class III
	Roofing shingles; asphalt-impregnated felt	Class IV
Miscellaneous	Ammunition; small arms and shotgun; cartoned	Class IV

Product Heading	Product	NFPA 13
	Charcoal; mineral spirit impregnated; bagged	Group A Expanded
	Charcoal; standard (non-mineral spirit impregnated); bagged	Class III
	Leather hides; baled	Class II
	Leather; finished products (e.g., shoes, jackets, gloves, bags, luggage, belts)	Class III
	Motors; electric	Class I
	Shock absorbers; metal dust cover	Class II
	Shock absorbers; plastic dust cover	Class III
	Skis; composite materials (plastic, fiberglass, foam, etc.)	Class IV
	Tobacco products; cartoned	Class III
	Toys; stuffed; foam or synthetic	Group A Expanded
	Transformer; dry or empty (i.e., void of oil)-filled	Class I
Noncombustible Liquids	Liquids or semi-liquids; PET containers greater than 5 gal (20 L) having a nominal wall thickness greater than 0.25 in. (6 mm)	Class IV
	Liquids or semi-liquids; PET containers up to 5 gal (20 L) or greater than 5 gal (20 L) having a nominal wall thickness up to 0.25 in. (6 mm)	Class I
	Liquids or semi-liquids (e.g., crushed fruits and vegetables); plastic containers up to 5 gal (18.9 L) capacity	Class I
	Liquids or semi-liquids; plastic (except PET) containers greater than 5 gal (20 L) capacity having a nominal wall thickness greater than 0.25 in. (6 mm)	Group A Nonexpanded
	Liquids or semi-liquids; plastic (except PET) containers greater than 5 gal (20 L) capacity having a nominal wall thickness up to 0.25 in. (6 mm)	Class II
	Liquids; cardboard drink boxes, plastic-coated, wax-coated, and/or aluminum-lined; exposed or on corrugated carton trays with plastic sheeting.	Class I
	Liquids; cardboard drink boxes, plastic-coated, wax-coated, and/or aluminum-lined; stored in plastic containers	Group A Nonexpanded
	Liquids; glass bottles or jars; cartoned	Class I
	Liquids; pharmaceuticals (nonflammable); glass bottles or jars; cartoned	Class II
	Liquids; plastic bottles or jars; stored in open or solid plastic crates	Group A Nonexpanded
Paper Products	Book signatures (paper part of book without hard cover)	Class II
	Cartons (i.e., cardboard flats); corrugated; partially assembled	Class IV
	Cartons (i.e., cardboard flats); corrugated; unassembled in neat piles	Class III
	Cartons; wax-coated, single-walled corrugated	Group A Nonexpanded
	Cellulosic paper products; nonwax-coated (e.g., books, cardboard games, cartoned tissue products, magazines, newspapers, paper cups, paper plates, paper towels, plastic-coated paper food containers, stationery)	Class III
	Cellulosic paper products; wax-coated (e.g., paper plates, cups); loosely packed; cartoned	Group A Nonexpanded
	Cellulosic paper products; wax-coated (e.g., paper plates, cups.); nested; cartoned	Class IV
	Matches; paper-type; cartoned	Class IV
	Matches; wooden; cartoned	Group A Nonexpanded

Product Heading	Product	NFPA 13
	Rolled; lightweight; in storage racks	Class IV
	Rolled; medium or heavyweight; in storage racks or on-side	Class III
	Tissue products; plastic-wrapped; cartoned	Class III
	Tissue products; plastic-wrapped; exposed	Group A Nonexpanded
Plastic/Rubber	ABS (Acrylonitrile-butadiene-styrene copolymer)	Group A Nonexpanded
	Acetal (polyformaldehyde)	Group A Nonexpanded
	Acrylic (polymethyl methacrylate)	Group A Nonexpanded
	Automobile bumpers and dashboards	Group A Expanded
	Butyl rubber	Group A Nonexpanded
	Cellulose Acetate	Class IV
	Cellulose Acetate Butyrate	Group A Nonexpanded
	Chloroprene rubber	Class IV
	Containers; nonexpanded plastic gridded or solid; collapsed or nested with no air spaces	Group A Nonexpanded
	ECTFE (ethylene-chlorotrifluoro-ethylene copolymer)	Class IV
	EPDM (ethylene-propylene rubber)	Group A Nonexpanded
	ETFE (ethylene-tetrafluoroethylene copolymer)	Class IV
	Ethyl Cellulose	Group A Nonexpanded
	FEP (fluorinated ethylene-propylene copolymer)	Class IV
	FRP (fiberglass-reinforced polyester)	Group A Nonexpanded
	Melamine (melamine formaldehyde)	Class III
	Nitrile Rubber (acrylonitrile-butadiene rubber)	Group A Nonexpanded
	Nylon (nylon 6, nylon 6/6)	Group A Nonexpanded
	PCTFE (polychlorotrifluoroethylene)	Class III
	PET (Polyethylene Terephthalate — thermoplastic polyester)	Group A Nonexpanded
	Phenolic	Class III
	Plastics; stored in fully closed and solid (no openings), metal containers	Class I
	Polybutadiene	Group A Nonexpanded
	Polycarbonate	Group A Nonexpanded
	Polyester elastomer	Group A Nonexpanded
	Polyethylene	Group A Nonexpanded
	Polypropylene	Group A Nonexpanded
	Polystyrene; foam products (plates, cups, etc.)	Group A Expanded
	Polystyrene; rigid products	Group A Nonexpanded
	Polyurethane	Group A Expanded
	PTFE (polytetrafluoroethylene)	Class III
	PVC (polyvinyl chloride) products, up to 20 percent plasticizer	Class III
	PVC (polyvinyl chloride) products, greater than 20 percent plasticizer	Group A Nonexpanded
	PVC resins; bagged	Class III
	PVDC (polyvinylidene chloride)	Class III

Product Heading	Product	NFPA 13
	PVDF (polyvinylidene fluoride)	Class III
	PVF (polyvinyl fluoride)	Group A Nonexpanded
	Rubber; natural in blocks; cartoned	Group A Nonexpanded
	Rubber; natural; expanded	Group A Expanded
	Rubber; natural; nonexpanded	Group A Nonexpanded
	Rubber; synthetic (santoprene)	Group A Nonexpanded
	SAN (styrene acrylonitrile)	Group A Nonexpanded
	SBR (styrene-butadiene rubber)	Group A Nonexpanded
	Silicone rubber	Class IV
	Urea (urea formaldehyde)	Class III
Plastic Containers	Bottles or jars (except PET) greater than 1 gal (4 L) containing noncombustible solids	Group A Nonexpanded
	Bottles or jars (except PET) up to 1 gal (4 L) containing noncombustible solids	Group A, cartoned (treat as cartoned even if exposed) Nonexpanded
Powders/Pills	Pharmaceutical pills; glass bottles or jars; cartoned	Class II
	Pharmaceuticals pills; plastic bottles or jars; cartoned	Class IV
	Polyvinyl Alcohol (PVA) resins; bagged	Class IV
	Powders; combustible (ordinary such as sugar or flour); free-flowing; bagged	Class II
	Powders; noncombustible free-flowing powdered or granular materials (cement, calcium chloride, clay, iron oxide, sodium chloride, sodium silicate, etc.)	Class I
	Powders; noncombustible; glass bottles or jars; cartoned	Class I
	Powders; noncombustible; PET bottles or jars	Class II
	Powders; noncombustible; plastic (other than PET) bottles or jars; exposed	Group A Nonexpanded
	Powders; noncombustible; plastic bottles or jars greater than 1 gal (4 L) capacity	Group A Nonexpanded
	Powders; noncombustible; plastic bottles or jars up to 1 gal (4 L) capacity; cartoned	Class IV
Textile Materials/Products	Cloth; natural fibers; baled	Class III
	Cloth; synthetic cloth	Group A Nonexpanded
	Clothing; natural fibers (e.g., wool, cotton) and viscose	Class III
	Cotton; cartoned	Class III
	Diapers; cotton or linen	Class III
	Diapers; plastic or nonwoven fabric; cartoned	Class IV
	Diapers; plastic or nonwoven fabric; plastic-wrapped; exposed	Group A Nonexpanded
	Fabric; rayon and nylon	Group A Nonexpanded
	Fabric; synthetic (except rayon and nylon); greater than 50/50 blend	Group A Nonexpanded
	Fabric; synthetic (except rayon and nylon); up to 50/50 blend	Group A Nonexpanded
	Fabric; vinyl-coated (e.g., tablecloth); cartoned	Group A Nonexpanded
	Fibers; rayon and nylon; baled	Class IV

Product Heading	Product	NFPA 13
	Fibers; synthetic (except rayon and nylon); baled	Group A Nonexpanded
	Thread or yarn; rayon and nylon; wood or paper spools	Class IV
	Thread or yarn; rayon or nylon; plastic spools	Group A Nonexpanded
	Thread or yarn; synthetic (except rayon and nylon); greater than 50/50 blend; paper or wood spools	Group A Nonexpanded Plastic
	Thread or yarn; synthetic (except rayon and nylon); greater than 50/50 blend; plastic spools	Group A Nonexpanded
	Thread or yarn; synthetic (except rayon and nylon); up to 50/50 blend; plastic spools	Group A Nonexpanded
	Thread or yarn; synthetic (except rayon and nylon); up to 50/50 blend; wood or paper spools	Group A Nonexpanded Plastic
Wax Products	Candles	Group A Expanded
	Paraffin or petroleum wax; blocks	Group A Expanded
Wire/Cable/Spools	Spools; plastic; empty	Group A Nonexpanded
	Spools; wood; empty	Class III
	Wire or cable; PVC insulated; metal or wood spools	Class II
	Wire or cable; PVC insulated; plastic spools	Class IV
	Wire; bare; metal spools, exposed	Class I
	Wire; bare; metal spools; cartoned	Class II
	Wire; bare; plastic spools; cartoned	Class IV
	Wire; bare; plastic spools; exposed	Group A Nonexpanded
	Wire; bare; wood or cardboard spools	Class II
Wood Products	Wood patterns	Class IV
	Wood products (e.g., fiberboard, lumber, particle board, plywood, pressboard with smooth ends and edges); bundled solid blocks	Class II
	Wood products (e.g., fiberboard, lumber, particle board, plywood, pressboard with smooth ends and edges); unbundled or non-solid blocks	Class III
	Wood products (e.g., toothpicks, clothespins and hangers)	Class III

A.20.4.1

See Table A.20.4.1.

Table A.20.4.1 Examples of Class I Commodities

Product Heading	Product
Batteries	Dry cells (excludes lithium, lithium-ion, and other similar exotic metals or combustible electrolyte); without blister packing (if blister packed refer to commodity classification definitions)
	Vehicle; small (e.g., automobile); wet (excludes lithium-ion and other cells containing combustible electrolyte) cells
Empty Containers	Noncombustible
Flammable/Combustible Liquids	Liquids; up to 20 percent alcohol (e.g., alcoholic beverages, flavoring extracts); metal, glass or ceramic containers
	Liquids; up to 20 percent alcohol (e.g., alcoholic beverages, flavoring extracts); up to 5 gal (20 L) plastic bottles or jars
Food Products — Frozen	Frozen foods; nonwaxed or nonplastic packaging

Product Heading	Product
Food Products — Non-Frozen	Foods (coffee, fish products, fruit, meat products, nuts, poultry, etc.); metal cans
	Fruits and vegetables (noncombustible semi-liquids); crushed; plastic containers up to 5 gal (20 L)
	Fruits and vegetables; fresh; wood spacers, non-plastic trays or containers
	Meat; fresh; no plastic packaging; exposed
	Milk; paper containers, or plastic bottles or jars up to 5 gal (20 L) plastic bottles or jars
	Salt; bagged
Furniture and Bedding	Furniture; metal (e.g., file cabinets or desks with plastic trim); cartoned
Housing Materials/Appliances	Appliances; major (e.g., stoves, refrigerators); no appreciable plastic interior or exterior trim; exposed
	Gypsum board
	Paint; water-based (latex); friction-top metal containers; cartoned
Miscellaneous	Motors; electric
	Transformer; dry or empty (i.e., void of oil)
Noncombustible Liquids	Liquids or semi liquids; PET containers greater than 5 gal (20 L) having a nominal wall thickness greater than 0.25 in. (6 mm)
	Liquids or semi-liquids (e.g., crushed fruits and vegetables); plastic containers up to 5 gal (20 L) capacity
	Liquids; cardboard drink boxes, plastic-coated, wax-coated, and/or aluminum-lined; exposed or on corrugated carton trays with plastic sheeting
	Liquids; glass bottles or jars; cartoned
Plastic/Rubber	Plastics; stored in fully closed and solid (no openings), metal containers
Powders/Pills	Powders; noncombustible free-flowing powdered or granular materials (cement, calcium chloride, clay, iron oxide, sodium chloride, sodium silicate, etc.); bagged
	Powders; noncombustible; glass bottles or jars; cartoned
Wire/Cable/Spools	Wire; bare; metal spools, exposed

A.20.4.2

See Table A.20.4.2.

Table A.20.4.2 Examples of Class II Commodities

Product Heading	Product
Empty Containers	Wood; solid sided (e.g., crates, boxes)
Film Rolls, Including Photographic	Film; motion picture or bulk rolls in polycarbonate, polyethylene or in metal cans; polyethylene bagged; cartoned
Flammable/Combustible Liquids	Liquids; up to 20 percent alcohol (e.g., alcoholic beverages, flavoring extracts); plastic containers greater than 5 gal (20 L) and wall thickness up to $^1/_4$ in. (6 mm)
	Liquids; up to 20 percent alcohol (e.g., alcoholic beverages, flavoring extracts); wood containers
Food Products — Frozen	Frozen foods; waxed or plastic-coated paper packaging
Food Products — Non-Frozen	Meat; fresh; no plastic packaging; cartoned
	Salt; cartoned
	Syrup; wooden container

Product Heading	Product
Housing Materials/Appliances	Appliances; major (e.g., stoves, refrigerators); no appreciable plastic interior or exterior trim; cartoned
	Housing materials (such as sinks, countertops, etc.); noncombustible, cartoned or crated
Miscellaneous	Leather hides; baled
	Shock absorbers; metal dust cover
Noncombustible Liquids	Liquids or semi-liquids; plastic (except PET) containers greater than 5 gal (20 L) capacity having a nominal wall thickness up to 0.25 in. (6 mm)
	Liquids; pharmaceuticals (nonflammable); glass bottles or jars; cartoned
Paper Products	Book signatures (paper part of book without hard cover)
Powders/Pills	Pharmaceutical pills; glass bottles or jars; cartoned
	Powders; combustible (ordinary such as sugar or flour); free-flowing; bagged
	Powders; noncombustible; PET bottles or jars
Wire/Cable/Spools	Wire or cable; PVC insulated; metal or wood spools
	Wire; bare; metal spools; cartoned
	Wire; bare; wood or cardboard spools
Wood Products	Wood products (e.g., fiberboard, lumber, particle board, plywood, pressboard with smooth ends and edges); bundled solid blocks

A.20.4.3

See Table A.20.4.3.

Table A.20.4.3 Examples of Class III Commodities

Product Heading	Product
Film Rolls, Including Photographic	Film; 35 mm metal film cartridges in polyethylene cans; cartoned
	Photographic paper; sheets; bagged in polyethylene; cartoned
Flammable/Combustible Liquids	Aerosol; Level 1
Food Products — Frozen	Frozen foods; plastic trays
Food Products — Non-Frozen	Butter (stick or whipped spread) or margarine (up to 50 percent oil)
	Dry foods (such as baked goods, candy, cereals, cheese, chocolate, cocoa, coffee, grains, granular sugar, nuts, etc.); bagged or cartoned
	Meat; fresh; plastic trays
Furniture and Bedding	Furniture; wood (doors, windows, cabinets, etc.); no plastic coverings or foam cushioning
	Box spring; standard (minimal plastic materials)
Housing Materials/Appliances	Appliances; no appreciable plastic exterior trim (interior of unit can have appreciable plastic)
	Roofing shingles; asphalt-coated fiberglass
Miscellaneous	Charcoal; standard (non-mineral spirit impregnated); bagged
	Leather; finished products (e.g., shoes, jackets, gloves, bags, luggage, belts)
	Shock absorbers; plastic dust cover
	Tobacco products; cartoned
Paper Products	Cartons (i.e., cardboard flats); corrugated; unassembled in neat piles

Product Heading	Product
	Cellulosic paper products; nonwax-coated (e.g., books, cardboard games, cartoned tissue products, magazines, newspapers, paper cups, paper plates, paper towels, plastic-coated paper food containers, stationery)
	Rolled; medium or heavyweight; in storage racks or on-side
	Tissue products; plastic-wrapped; cartoned
Plastic/Rubber	Melamine (melamine formaldehyde)
	PCTFE (polychlorotrifluoroethylene)
	Phenolic
	PTFE (polytetrafluoroethylene)
	PVC (polyvinyl chloride) products, up to 20 percent plasticizer
	PVC resins; bagged
	PVDC (polyvinylidene chloride)
	PVDF (polyvinylidene fluoride)
	Urea (urea formaldehyde)
Textile Materials/Products	Cloth; natural fibers; baled
	Clothing; natural fibers (e.g., wool, cotton) and viscose
	Cotton; cartoned
	Diapers; cotton or linen
Wire/Cable/Spools	Spools; wood; empty
Wood Products	Wood products (e.g., fiberboard, lumber, particle board, plywood, pressboard with smooth ends and edges); unbundled or non-solid blocks
	Wood products (e.g., toothpicks, clothespins and hangers)

A.20.4.4

Cartons containing Group A plastic materials can be treated as Class IV commodities when the plastic materials are surrounded by noncombustible material or a sufficient layer(s) of cardboard to significantly delay fire involvement. For more information on the total range of materials that can be treated as Class IV commodity, see Table A.20.4.4.

Table A.20.4.4 Examples of Class IV Commodities

Product Heading	Product
Empty containers	PET, bottles or jars
Film rolls, including photographic	Film; rolls in polycarbonate plastic cassettes; cartoned
Furniture and bedding	Furniture; wood; plastic coverings; nonexpanded plastic trim
	Box spring; wrapped in plastic cover
Housing materials/appliances	Fiberglass insulation; paper-backed rolls; bagged or unbagged
	Floor coverings; vinyl, stacked tiles
	Paint; oil-based; friction-top metal containers; cartoned
	Roofing shingles; asphalt-impregnated felt
Miscellaneous	Ammunition; small arms and shotgun; cartoned
	Skis; composite materials (e.g., plastic, fiberglass, foam)
Noncombustible liquids	Liquids or semi-liquids; PET containers greater than 5 gal (20 L) having a nominal wall thickness greater than 0.25 in. (6 mm)

Product Heading	Product
Paper products	Cartons (i.e., cardboard flats); corrugated; partially assembled
	Cellulosic paper products; wax-coated (e.g., paper plates, paper cups); nested; cartoned
	Matches; paper-type; cartoned
	Rolled; lightweight; in storage racks
Plastic/rubber	Cellulose acetate
	Chloroprene rubber
	Ethylene-chlorotrifluoro-ethylene copolymer (ECTFE)
	Ethylene-tetrafluoroethylene copolymer (ETFE)
	Fluorinated ethylene-propylene copolymer (FEP)
	Silicone rubber
Powders/pills	Pharmaceuticals pills; plastic bottles or jars; cartoned
	Polyvinyl alcohol (PVA) resins; bagged
	Powders; noncombustible; plastic bottles or jars up to 1 gal (4 L) capacity; cartoned
Textile materials/products	Cloth; synthetic cloth
	Diapers; plastic or nonwoven fabric; cartoned
	Fabric; rayon and nylon
	Fibers; rayon and nylon; baled
	Thread or yarn; rayon and nylon; wood or paper spools
	Thread or yarn; synthetic (except rayon and nylon); greater than 50/50 blend; paper or wood spools
Wire/cable/spools	Wire or cable; PVC insulated; plastic spools
	Wire; bare; plastic spools; cartoned
Wood products	Wood patterns

A.20.4.5

The categories listed in 20.4.5.1, 20.4.6, and 20.4.7 are based on unmodified plastic materials. The use of fire- or flame-retarding modifiers or the physical form of the material could change the classification.

The addition of fire retardants to plastic should not be relied upon as the sole basis for a reduction in classification given the unknown performance of the fire retardant under a storage scenario. It is expected that full-scale or commodity classification type testing would be necessary to justify any such reduction in classification. No reduction in classification should be given for plastics simply because they contain a fire retardant.

Plastic materials not specifically classified in 20.4.5 should be protected as Group A plastics unless full-scale or commodity classification type testing demonstrates otherwise. It is not possible to classify full-scale fire performance of plastics by looking solely at heat of combustion. Plastic materials should not be categorized into a Group (A, B, or C) based upon comparing heat of combustion with values for plastics already classified in NFPA 13.

A.20.4.5.1

See Table A.20.4.5.1.

Table A.20.4.5.1 Examples of Group A Plastic Commodities

Product Heading	Product	Expanded/Nonexpanded
Batteries	Vehicle; any size (e.g., automobile or truck); empty plastic casing	Nonexpanded
	Vehicle; large (e.g., truck or larger); dry or wet (excludes lithium-ion and other cells containing combustible electrolyte) cells	Nonexpanded
Empty Containers	Rigid plastic (not including PET), up to 32 oz (1 L)	Nonexpanded

Product Heading	Product	Expanded/Nonexpanded
	Rigid plastic (not including PET), greater than 32 oz (1 L)	Expanded
Film Rolls, Including Photographic	Film (polypropylene, polyester, polyethylene); rolled on any reel type	Nonexpanded
Flammable/Combustible Liquids	Lighters; butane; blister-packed; cartoned	Nonexpanded
	Liquids; up to 20 percent alcohol (e.g. alcoholic beverages, flavoring extracts); greater than 5 gal (20 L) plastic containers with wall thickness greater than $\frac{1}{4}$ in. (6 mm)	Nonexpanded
Food Products — Non-Frozen	Margarine; over 50 and up to 80 percent oil	Nonexpanded
	Milk; any container; stored in solid plastic crates	Nonexpanded
	Snack foods (e.g., potato chips); plasticized aluminum bags; cartoned	Nonexpanded
Furniture and Bedding	Furniture and bedding; with foam cushioning	Expanded
	Mattress; foam (in finished form)	Expanded
Housing Materials/Appliances	Carpet tiles; cartoned	Nonexpanded
	Floor coverings; vinyl; rolled	Nonexpanded
Miscellaneous	Charcoal; mineral spirit impregnated; bagged	Expanded
	Toys; stuffed; foam or synthetic	Expanded
Noncombustible Liquids	Liquids or semi-liquids; plastic (except PET) containers greater than 5 gal (20 L) capacity having a nominal wall thickness greater than $\frac{1}{4}$ in. (6 mm)	Nonexpanded
	Liquids; cardboard drink boxes, plastic-coated, wax-coated, and/or aluminum-lined; stored in plastic containers	Nonexpanded
	Liquids; plastic bottles or jars; stored in open or solid plastic crates	Nonexpanded
Paper Products	Cartons; wax-coated, single-walled corrugated	Nonexpanded
	Cellulosic paper products; wax-coated (paper plates, cups, etc.); loosely packed; cartoned	Nonexpanded
	Matches; wooden; cartoned	Nonexpanded
	Tissue products; plastic-wrapped; exposed	Nonexpanded
Plastic/Rubber	ABS (Acrylonitrile-butadiene-styrene copolymer)	Nonexpanded
	Acetal (polyformaldehyde)	Nonexpanded
	Acrylic (polymethyl methacrylate)	Nonexpanded
	Automobile bumpers and dashboards	Expanded
	Butyl rubber	Nonexpanded
	Cellulose Acetate Butyrate	Nonexpanded
	Containers; nonexpanded plastic gridded or solid; collapsed or nested with no air spaces	Nonexpanded
	EPDM (ethylene-propylene rubber)	Nonexpanded
	Ethyl Cellulose	Nonexpanded
	FRP (fiberglass-reinforced polyester)	Nonexpanded
	Nitrile Rubber (acrylonitrile-butadiene rubber)	Nonexpanded
	Nylon (nylon 6, nylon 6/6)	Nonexpanded
	PET (Polyethylene Terephthalate - thermoplastic polyester)	Nonexpanded
	Polybutadiene	Nonexpanded

Product Heading	Product	Expanded/Nonexpanded
	Polycarbonate	Nonexpanded
	Polyester elastomer	Nonexpanded
	Polyethylene	Nonexpanded
	Polypropylene	Nonexpanded
	Polystyrene; foam products (e.g., plates, cups, etc.)	Expanded
	Polystyrene; rigid products	Nonexpanded
	Polyurethane	Expanded
	PVC (polyvinyl chloride) products, greater than 20 percent plasticizer	Nonexpanded
	PVF (polyvinyl fluoride)	Nonexpanded
	Rubber; natural in blocks; cartoned	Nonexpanded
	Rubber; natural; expanded	Expanded
	Rubber; natural; nonexpanded	Nonexpanded
	Rubber; synthetic (santoprene)	Nonexpanded
	SAN (styrene acrylonitrile)	Nonexpanded
	SBR (styrene-butadiene rubber)	Nonexpanded
Plastic Containers	Bottles or jars (except PET) greater than 1 gal (4 L) containing noncombustible solids	Nonexpanded
	Bottles or jars (except PET) up to 1 gal (4 L) containing noncombustible solids (Group A, cartoned (treat as cartoned even if exposed)	Nonexpanded
Powders/Pills	Powders; noncombustible; plastic (other than PET) bottles or jars; exposed	Nonexpanded
	Powders; noncombustible; plastic bottles or jars greater than 1 gal (4 L) capacity	Nonexpanded
Textile Materials/Products	Diapers; plastic or nonwoven fabric; plastic-wrapped; exposed	Nonexpanded
	Fabric; vinyl-coated (e.g., tablecloth); cartoned	Nonexpanded
	Fabric; synthetic (except rayon and nylon; greater than 50/50 blend	Nonexpanded
	Fibers; synthetic (except rayon and nylon); baled	Nonexpanded
	Thread or yarn; rayon or nylon; plastic spools	Nonexpanded
	Thread or yarn; synthetic (except rayon and nylon); greater than 50/50 blend; plastic spools	Nonexpanded
	Thread or yarn; synthetic (except rayon and nylon); up to 50/50 blend; plastic spools	Nonexpanded
Wax Products	Candles	Expanded
	Paraffin or petroleum wax; blocks	Expanded
Wire/Cable/Spools	Spools; plastic; empty	Nonexpanded
	Wire; bare; plastic spools; exposed	Nonexpanded

A.20.4.5.2

Generally, expanded plastics are low-density materials and commonly referred to as “foam plastics.”

A.20.4.8

All arrangements of exposed plastics cannot be protected with all types of sprinklers. Only certain combinations of ceiling sprinklers and in-rack sprinklers have been found to provide acceptable protection. No full-scale fire testing has been performed that has determined acceptable criteria for exposed expanded plastics. Factory Mutual has published criteria in its data sheets to protect exposed expanded plastics based on a risk analysis and small/intermediate-scale test data. Some authorities having jurisdiction accept that criteria as an alternative to the intent of NFPA 13.

A.20.4.10

Paper Classification. These classifications were derived from a series of large-scale and laboratory-type small-scale fire tests. It is recognized that not all paper in a class burns with exactly the same characteristics.

Paper can be soft or hard, thick or thin, or heavy or light and can also be coated with various materials. The broad range of papers can be classified according to various properties. One important property is basis weight, which is defined as the weight of a sheet of paper of a specified area. Two broad categories are recognized by industry — paper and paperboard. Paperboard normally has a basis weight of 20 lb (100 g/m^2) or greater measured on a 1000 ft^2 (93 m^2) sheet. Stock with a basis weight less than 20 lb/1000 ft^2 (100 g/m^2) is normally categorized as paper. The basis weight of paper is usually measured on a 3000 ft^2 (280 m^2) sheet. The basis weight of paper can also be measured on the total area of a ream of paper, which is normally the case for the following types of printing and writing papers:

(1) *Bond paper* — 500 sheets, 17 in. × 22 in. (425 mm × 550 mm) = 1300 ft^2 (120 m^2) per ream
(2) *Book paper* — 500 sheets, 25 in. × 38 in. (625 mm × 950 mm) = 3300 ft^2 (305 m^2) per ream
(3) *Index paper* — 500 sheets, 25½ in. × 30½ in. (640 mm × 765 mm) = 2700 ft^2 (250 m^2) per ream
(4) *Bristol paper* — 500 sheets, 22½ in. × 35 in. (565 mm × 890 mm) = 2734 ft^2 (255 m^2) per ream
(5) *Tag paper* — 500 sheets, 24 in. × 36 in. (600 mm × 900 mm) = 3000 ft^2 (280 m^2) per ream

For the purposes of this standard, all basis weights are expressed in lb/1000 ft^2 (kg/93 m^2) of paper. To determine the basis weight per 1000 ft^2 (93 m^2) for papers measured on a sheet of different area, the following formula should be applied:

$$\frac{\text{Base weight}}{1000\ \text{ft}^2} = \text{basis weight} \times 1000\ \text{measured area} \qquad \text{[A.20.4.10a]}$$

Example: To determine the basis weight per 1000 ft^2 (93 m^2) of 16 lb (7.3 kg) bond paper:

$$\left(\frac{16\ \text{lb}}{1300\ \text{ft}^2}\right)1000 = \frac{12.3\ \text{lb}}{1000\ \text{ft}^2} \qquad \text{[A.20.4.10b]}$$

Large- and small-scale fire tests indicate that the burning rate of paper varies with the basis weight. Heavyweight paper burns more slowly than lightweight paper. Full-scale roll paper fire tests were conducted with the following types of paper:

(1) *Linerboard* — 42 lb/1000 ft^2 (0.2 kg/m^2) nominal basis weight
(2) *Newsprint* — 10 lb/1000 ft^2 (50 g/m^2) nominal basis weight
(3) *Tissue* — 5 lb/1000 ft^2 (20 g/m^2) nominal basis weight

The rate of firespread over the surface of the tissue rolls was extremely rapid in the full-scale fire tests. The rate of firespread over the surface of the linerboard rolls was slower. Based on the overall results of these full-scale tests, along with additional data from small-scale testing of various paper grades, the broad range of papers has been classified into three major categories as follows:

(1) *Heavyweight* — Basis weight of 20 lb/1000 ft^2 (100 g/m^2) or greater
(2) *Mediumweight* — Basis weight of 10 lb to 20 lb/1000 ft^2 (100 g/m^2)
(3) *Lightweight* — Basis weight of less than 10 lb/1000 ft^2 (50 g/m^2) and tissues regardless of basis weight

The following SI units were used for conversion of US customary units:

1 lb = 0.45 kg

1 in. = 25 mm

1 ft = 0.3 m

1 ft^2 = 0.09 m^2

The various types of papers normally found in each of the four major categories are provided in Table A.20.4.10.

Table A.20.4.10 Paper Classification

Heavyweight	Mediumweight	Lightweight	Tissue
Linerboards	Bond and reproduction	Carbonizing tissue	Toilet tissue
Medium	Vellum	Cigarette	Towel tissue
Kraft roll wrappers	Offset	Fruit wrap	
Milk carton board	Tablet	Onion skin	
Folding carton board	Computer		
Bristol board	Envelope		
Tag	Book		
Vellum bristol board	Label		
Index	Magazine		
Cupstock	Butcher		
Pulp board	Bag		
	Newsprint (unwrapped)		

A.20.4.13

Exposed, expanded Group A plastic dunnage, instrument panels, and plastic bumper facia where the automotive components with their related packaging that were utilized in the fire tests. This test commodity used in the large-scale sprinklered fire test proved to be the worst challenge per the large-scale calorimeter tests of available components. See *Technical Report of Fire Testing of Automotive Parts in Portable Storage Racking*, prepared by Underwriters Laboratories, Project 99NK29106, NC4004, January 5, 2001, and *Commodity Hazard Comparison of Expanded Plastic in Portable Bins and Racking*, Project 99NK29106, NC4004, September 8, 2000.

A.20.5.3

Many factors affect the protection of rack storage. Section 20.5.3 defined the variables that limit or change the available protection criteria found in Chapters 21 through 25. Subsections 20.5.3.1 through 20.6.2 identify the general terms of rack storage that identify which type of rack and shelving criteria is to be used in Chapters 21 through 25.

A.20.5.3.2

Slatting of decks or walkways or the use of open grating as a substitute for automatic sprinkler thereunder is not acceptable.

In addition, where shelving of any type is employed, it is for the basic purpose of providing an intermediate support between the structural members of the rack. As a result, it becomes almost impossible to define and maintain transverse flue spaces across the rack as required.

A.20.8

A series of 10 full-scale fire tests and limited-scale testing were conducted to determine the impact of HVLS fan operation on the performance of sprinkler systems. The project, sponsored by the Property Insurance Research Group (PIRG) and other industry groups, was coordinated by the Fire Protection Research Foundation (FPRF). The complete test report, *High Volume/Low Speed Fan and Sprinkler Operation — Ph. 2 Final Report* (2011), is available from the FPRF. Both control mode density area and early suppression fast response sprinklers were tested. Successful results were obtained when the HVLS fan was shut down upon the activation of the first sprinkler followed by a 90-second delay. Other methods of fan shutdown were also tested including shutdown by activation of air sampling–type detection and ionization-type smoke detectors. Earlier fan shutdown resulted in less commodity damage.

A.20.9.1.1

The intent is to have a structural member that prevents the passage of heat. The member can have holes for penetrations with reasonable clearance and penetration sealant is not expected.

A.20.9.2

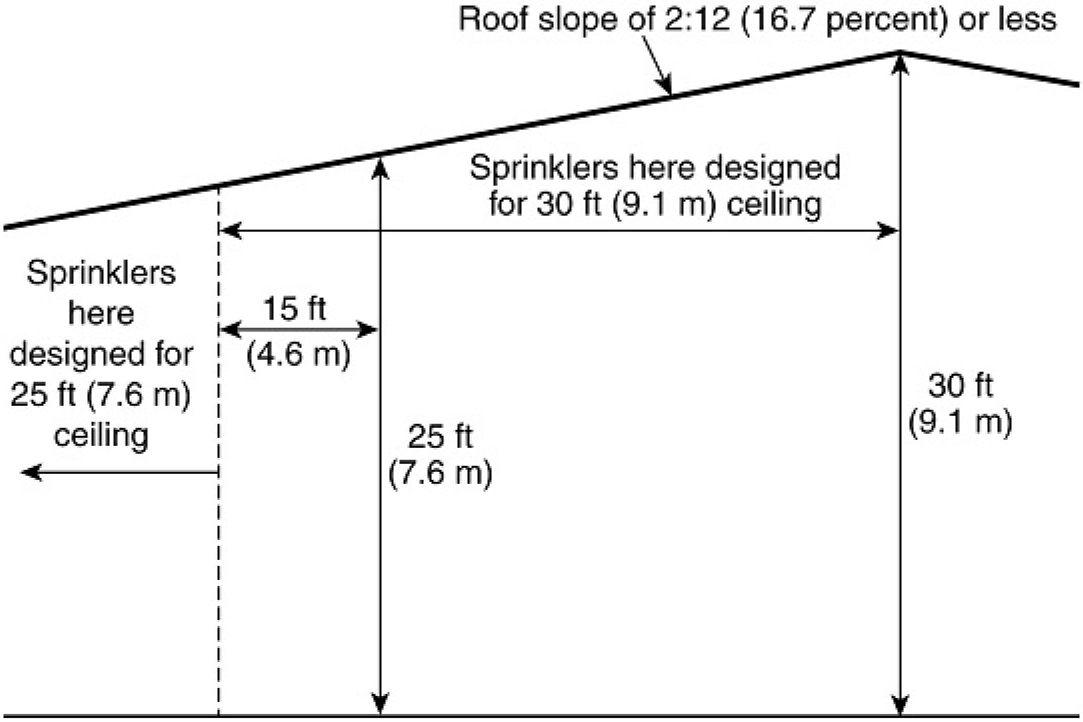
The fire protection system design should consider the maximum storage height. For new sprinkler installations, maximum storage height is the usable height at which commodities can be stored above the floor while the minimum required unobstructed space below sprinklers is maintained. Where evaluating existing situations, maximum storage height is the maximum existing storage height if space between the sprinklers and storage is equal to or greater than that required.

Building heights where baled cotton is stored should allow for proper clearance between the pile height and sprinkler deflectors. Fire tests of high-piled storage have shown that sprinklers are generally more effective if located $1\frac{1}{2}$ ft to $4\frac{1}{2}$ ft (450 mm to 1.4 m) above the storage height.

A.20.9.2.5

In the example shown in Figure A.20.9.2.5, the maximum ceiling height shown is 30 ft (9.1 m). Sprinkler protection under the highest part of the ceiling must be designed for that height to a point at least 15 ft (4.6 m) beyond where the ceiling height drops to 25 ft (7.6 m). Sprinkler protection beyond that point can be designed for a 25 ft (7.6 m) ceiling.

Figure A.20.9.2.5 Extended Sprinkler Coverage Under Sloped Ceilings.



A.20.9.4.1

Batt insulation creates an effective thermal barrier and can be considered the ceiling/roof deck when determining the clearance to ceiling. The insulation needs to be installed in each pocket (not just above the sprinkler) and attached to the ceiling/roof in such a manner that it will not fall out during a fire prior to sprinkler activation.

A.20.9.5.1

Sprinkler protection criteria are based on the assumption that roof vents and draft curtains are not being used and could be detrimental to the performance of the sprinkler system. If manual roof vents are provided, care should be taken to not open the manual roof vents before the fire has been controlled or suppressed. *(See Section C.6.)*

A.20.9.5.3

Draft curtains have been shown to have a negative effect on sprinkler effectiveness. If they are mandated, extreme care needs to be taken to minimize any potential impacts.

A.20.10.1

In order for the minimum 3000 ft^2 (280 m^2) requirement for the size of the remote area to not be extended to the adjacent area, the qualifying concealed space must be separated by the entire fire-rated assembly. Such assemblies often have combustible structural members separating the exterior membranes that can create a concealed combustible space that can qualify for omitting sprinkler protection. If the fire-rated assembly is the qualifying concealed space, an interior fire would greatly reduce the assigned fire-rated duration.

A.20.11.1

This subsection 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 four sprinklers and a smaller room has two sprinklers but communicates through unprotected openings with three other rooms, each having two 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.20.11.3

This section is not intended to limit the use of the room design method to density/area sprinkler design. The room design method can be used with any type of ceiling sprinklers if the room enclosure requirements are met.

A.20.12

Detection systems, concentrate pumps, generators, and other system components that are essential to the operation of the system should have an approved standby power source.

Where high-expansion foam is contemplated as the protection media, consideration should be given to possible damage to the commodity from soaking and corrosion. Consideration also should be given to the problems associated with the removal of the foam after discharge.

A.20.13

The situation frequently arises where a small area of a higher hazard is surrounded by a lesser hazard. For example, consider a 600 ft^2 (56 m^2) area consisting of 10 ft (3 m) high on-floor storage of cartoned nonexpanded plastic commodities surrounded by a plastic extruding operation in a 15 ft (4.6 m) high building. In accordance with Chapter 12, the density required for the plastic storage must meet the requirements for extra hazard (Group 1) occupancies. The plastic extruding operation should be considered an ordinary hazard (Group 2) occupancy. In accordance with Chapter 11, the corresponding discharge densities should be 0.3 gpm/ft^2 (12.2 mm/min) over 2500 ft^2 (230 m^2) for the storage and 0.2 gpm/ft^2 (8.1 mm/min) over 1500 ft^2 (140 m^2) for the remainder of the area. *(Also see Chapter 11 for the required minimum areas of operation.)*

If the storage area is not separated from the surrounding area by a wall or partition *(see 19.1.2),* the size of the operating area is determined by the higher hazard storage.

For example, the operating area is 2500 ft^2 (230 m^2). The system must be able to provide the 0.3 gpm/ft^2 (12.2 mm/min) density over the storage area and 15 ft (4.6 m) beyond. If part of the remote area is outside the 600 ft^2 (56 m^2) plus the 15 ft (4.6 m) overlap, only 0.2 gpm/ft^2 (8.1 mm/min) is needed for that portion.

If the storage is separated from the surrounding area by a floor-to-ceiling/roof partition that is capable of delaying heat from a fire on one side from fusing sprinklers on the other side, the size of the operating area is determined by the occupancy of the surrounding area. In this example, the design area is 1500 ft^2 (140 m^2). A 0.3 gpm/ft^2 (12.2 mm/min) density is needed within the separated area with 0.2 gpm/ft^2 (8.1 mm/min) in the remainder of the remote area.

Where high temperature–rated sprinklers are installed at the ceiling, high temperature–rated sprinklers also should extend beyond storage in accordance with Table A.20.13.

When the small higher hazard area is larger than the required minimum area dictated by the surrounding occupancy, even when separated by draft curtains, barriers, or partitions capable of delaying heat, the size of the operating area is determined by the higher hazard storage.

Table A.20.13 Extension of Installation of High-Temperature Sprinklers over Storage

Design Area for High Temperature–Rated Sprinklers		Distance Beyond Perimeter of High Hazard Occupancy for High Temperature–Rated Sprinklers	
ft^2	m^2	ft	m
2000	185	30	9.1
3000	280	40	12
4000	370	45	14
5000	465	50	15
6000	555	55	17

A.20.14

Authorities having jurisdiction have varying requirements for plant first-aid and firefighting operations. Examples include no hose stations, hose stations with hose line and nozzles, and hose stations with no hose line or nozzles.

A.20.15.2.1

Where tanks serve sprinklers only, they can be sized to provide the duration required for the sprinkler system, ignoring any hose stream demands. Where tanks serve some combination of sprinklers, inside hose stations, outside hose stations, or domestic/process use, the tank needs to be capable of providing the duration for the equipment that is fed from the tank, but the demands of equipment not connected to the tank can be ignored. Where a tank is used for both domestic/process water and fire protection, the entire duration demand of the domestic/process water does not need to be included in the tank if provisions are made to segregate the tank so that adequate fire protection water is always present or if provisions are made to automatically cut off the simultaneous use in the event of fire.

A.20.15.2.2

Where pumps serve sprinklers only, they can be sized to provide the flow required for the sprinkler system, ignoring any hose stream demands. Where pumps serve some combination of sprinklers, inside hose stations, or outside hose stations, the pump needs to be capable of providing the flow for the equipment that is fed from the pump, but the demands of equipment not connected to the pump can be ignored.

A.20.16.2

Wet systems are recommended for storage occupancies. Dry pipe systems should be permitted only where it is impractical to provide heat.

A.20.16.2.2

Wet systems are recommended for rack storage occupancies. Dry systems are permitted only where it is impractical to provide heat. Preaction systems should be considered for rack storage occupancies that are unheated, particularly where in-rack sprinklers are installed or for those occupancies that are highly susceptible to water damage.

A.20.17

Idle pallet storage introduces a severe fire condition. Stacking idle pallets in piles is the best arrangement of combustibles to promote rapid spread of fire, heat release, and complete combustion. After pallets are used for a short time in warehouses, they dry out and edges become frayed and splintered. In this condition, they are subject to easy ignition from a small ignition source. Again, high piling increases considerably both the challenge to sprinklers and the probability of involving a large number of pallets when fire occurs. Therefore, it is preferable to store pallets outdoors where possible.

A fire in stacks of idle plastic or wood pallets is one of the greatest challenges to sprinklers. The undersides of the pallets create a shadow area on which a fire can grow and expand to other dry or partially wet areas. This process of jumping to other dry, closely located, parallel, combustible surfaces continues until the fire bursts through the top of the stack. Once this happens, very little water is able to reach the base of the fire. The only practical method of stopping a fire in a large concentration of pallets with ceiling sprinklers is by means of prewetting. In high stacks, this cannot be done without abnormally high water supplies. The storage of empty wood pallets should not be permitted in an unsprinklered warehouse containing other storage.

A series of seven large-scale fire tests involving idle wood pallets stored on the floor was conducted at Underwriters Laboratories in 2009 and 2010. This testing was conducted to investigate the performance of an upright sprinkler having a nominal K-factor of 11.2 (160) when installed to protect a 8 ft (2.4 m) high array of new 4-way entry, softwood pallets under a 30 ft (9.1 m) ceiling. The pallets used for this test series were supplied by CHEP USA. The impact of the sprinkler temperature rating on fire control performance was the key variable investigated during this test series. Except for the temperature rating of the sprinkler's heat responsive element, the same sprinkler design was used for all seven tests. Three tests were conducted using 286°F (141°C) temperature-rated sprinklers, two tests were conducted using 200°F (93°C) temperature-rated sprinklers, and two tests conducted using 155°F (68°C) temperature-rated sprinklers. The ignition location for all tests was centered between four sprinklers. To enhance test repeatability, the four sprinklers nearest the ignition location were arranged to discharge water when the first sprinkler operated. The results of this test series are summarized in Table A.20.17.

The results of this large-scale fire test series indicated that sprinklers in the 155°F (68°C) and 200°F (93°C) temperature ratings performed significantly better than the 286°F (141°C) temperature-rated sprinklers as evidenced by a reduced number of operated sprinklers and lower steel temperatures.

Table A.20.17 Summary of Fire Test Data for Idle Pallets (4-Way Entry Softwood) Stored on Floor

Test Date	Test Array	Nominal Storage Height ft (m)	Ceiling Height ft (m)	Sprinkler Information	Number of Operated Sprinklers	Time of First Sprinkler Operation (min:sec)	Time of Last Sprinkler Operation (min:sec)	Max. 1 Min. Ave. Steel Temp. ºF (ºC)

Test Date	Test Array	Nominal Storage Height ft (m)	Ceiling Height ft (m)	Sprinkler Information	Number of Operated Sprinklers	Time of First Sprinkler Operation (min:sec)	Time of Last Sprinkler Operation (min:sec)	Max. 1 Min. Ave. Steel Temp. ºF (ºC)
9/1/2009	2 × 3 with 6 in. (150 mm) longitudinal flue main array 2 × 1 target pallets on each end with 6 in. (150 mm) longitudinal and transverse flues	8 (2.4)	30 (9.1)	286ºF, K-11.2, 0.45 gpm/ft^2 (141ºC, K-160, 18.3 mm/min)	12	5:00	23:03	220 (104)
9/10/2009	2 × 3 with 6 in. (150 mm) longitudinal flue main array 2 × 1 target pallets on each end with 6 in. (150 mm) longitudinal and transverse flues	8 (2.4)	30 (9.1)	286ºF, K-11.2, 0.45 gpm/ft^2 (141ºC, K-160, 18.3 mm/min)	13	5:05	19:10	208 (98)
9/11/2009	2 × 3 with 6 in. (150 mm) longitudinal flue main array 2 × 1 target pallets on each end with 6 in. (150 mm) longitudinal and transverse flues	8 (2.4)	30 (9.1)	286ºF, K-11.2, 0.45 gpm/ft^2 (141ºC, K-160, 18.3 mm/min)	16	5:48	19:04	228 (109)
6/21/2010	2 × 3 with 6 in. (150 mm) longitudinal flue main array 2 × 1 target pallets on each end with 6 in. (150 mm) longitudinal and transverse flues	8 (2.4)	30 (9.1)	200ºF, K-11.2, 0.45 gpm/ft^2 (93ºC, K-160, 18.3 mm/min)	4	4:10	4:10	134 (57)
6/22/2010	2 × 3 with 6 in. (150 mm) longitudinal flue main array 2 × 1 target pallets on each end with 6 in. (150 mm) longitudinal and transverse flues	8 (2.4)	30 (9.1)	200ºF, K-11.2, 0.45 gpm/ft^2 (93ºC, K-160, 18.3 mm/min)	4	3:34	3:34	135 (57)

Test Date	Test Array	Nominal Storage Height ft (m)	Ceiling Height ft (m)	Sprinkler Information	Number of Operated Sprinklers	Time of First Sprinkler Operation (min:sec)	Time of Last Sprinkler Operation (min:sec)	Max. 1 Min. Ave. Steel Temp. ºF (ºC)
6/23/2010	2 × 3 with 6 in. (150 mm) longitudinal flue main array 2 × 1 target pallets on each end with 6 in. (150 mm) longitudinal and transverse flues	8 (2.4)	30 (9.1)	155ºF, K-11.2, 0.45 gpm/ft^2 (68ºC, K-160, 18.3 mm/min)	4	3:46	3:46	115 (46)
6/23/2010	2 × 3 with 6 in. (150 mm) longitudinal flue main array 2 × 1 target pallets on each end with 6 in. (150 mm) longitudinal and transverse flues	8 (2.4)	30 (9.1)	155ºF, K-11.2, 0.45 gpm/ft^2 (68ºC, K-160, 18.3 mm/min)	4	3:09	3:09	113 (45)

A.20.17.1.1

Table A.20.17.1.1(a) gives recommended clearances between outside idle wood pallet storage and a building. If plastic pallets are stored outdoors, consideration should be given to the anticipated radiated heat produced by the materials used to construct the pallet to establish the appropriate separation distance. *[See Table A.20.17.1.1(b).]*

Table A.20.17.1.1(a) Control Mode Density/Area Sprinkler Protection for Indoor Storage of Idle Wood Pall

Type of Sprinkler	Location of Storage	Nominal K-Factor	Maximum Storage Height		Maximum Ceiling/Roof Height		Sprinkler Density		Area of Operation		Hose Stream Allowance		Wate Supp Durati (hour
			ft	m	ft	m	gpm/ft^2	mm/min	ft^2	m^2	gpm	L/min	
Control mode density/area	On floor	8 (115) or larger	Up to 6	Up to 1.8	20	6.1	0.2	8.2	3000*	280*	500	1900	1½
	On floor	11.2 (160) or larger	Up to 8	Up to 2.4	30	9.1	0.45	18.3	2500	230	500	1900	1½
	On floor or rack without solid shelves	11.2 (160) or larger	>8 to 12	>2.4 to 3.7	30	9.1	0.6	24.5	3500	325	500	1900	1½
			>12 to 20	>3.7 to 6.1	30	9.1	0.6	24.5	4500	420	500	1900	1½
	On floor	16.8 (240) or larger	Up to 20	Up to 6.1	30	9.1	0.6	24.5	2000	185	500	1900	1½

*The area of sprinkler operation can be permitted to be reduced to 2000 ft^2 (185 m^2) when sprinklers having a nominal K-factor of 11.2 (160) or larger are used, or if high temperature–rated sprinklers having a nominal K-factor of 8.0 (115) are used.

Table A.20.17.1.1(b) Recommended Clearance Between Outside Idle Wood Pallet Storage and Building

Wall Construction		Minimum Distance Between Wall and Storage					
		Under 50 Pallets		50 to 200 Pallets		Over 200 Pallets	
Wall Type	**Openings**	**ft**	**m**	**ft**	**m**	**ft**	**m**
Masonry	None	0	0	0	0	0	0
	Wired glass with outside sprinklers and 1-hour doors	0	0	10	3.0	20	6.1
	Wired or plain glass with outside sprinklers and $^{3}/_{4}$-hour doors	10	3.0	20	6.1	30	9.1
Wood or metal with outside sprinklers		10	3.0	20	6.1	30	9.1
Wood, metal, or other		20	6.1	30	9.1	50	15

Notes:

(1) Fire-resistive protection comparable to that of the wall also should be provided for combustible eaves lines, vent openings, and so forth.

(2) Where pallets are stored close to a building, the height of storage should be restricted to prevent burning pallets from falling on the building.

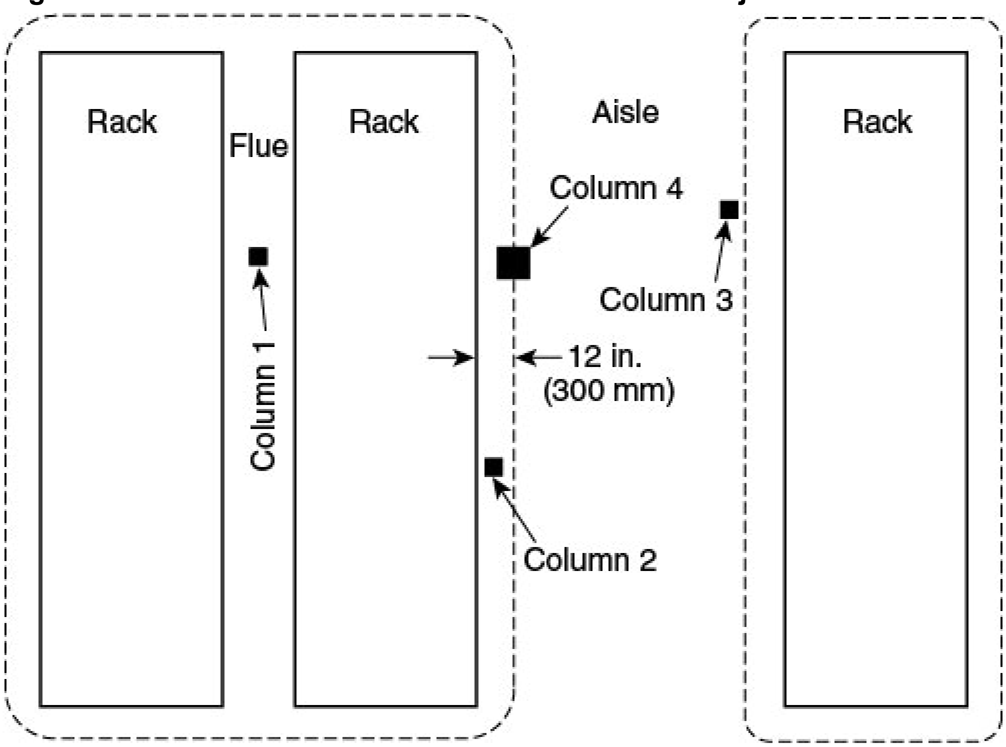
(3) Manual outside open sprinklers generally are not a reliable means of protection unless property is attended to at all times by plant emergency personnel.

(4) Open sprinklers controlled by a deluge valve are preferred.

A.20.18.1

Columns at the ends of racks or in the aisles need to be protected from the heat of a fire in the racks if they are near the racks. Columns within the flue spaces are already within the footprint of the racks and need protection. In Figure A.20.18.1, Column 1 is within the flue space and needs protection. Column 2 is within 12 in. (300 m) of the rack and needs protection. Column 3 is more than 12 in. (300 m) away from the rack and does not need protection even though it is in an aisle. A portion of Column 4 is within 12 in. (300 m) of the rack and therefore requires sprinkler protection.

Figure A.20.18.1 Protection of Columns Within and Adjacent to Rack Structure.



A.21.1.2

The reasons for using larger orifice sprinklers in storage situations are based on a number of fire tests in recent years that continue to show an advantage of the larger orifice [K-11.2 (K-160) and K-16.8 (K-240)] sprinklers over the K-5.6 (K-80) and even the K-8.0 (K-115) orifice sprinklers. Following are four sets of fire test comparisons using constant densities *[see Table A.21.1.2(a) and Table A.21.1.2(b)]*:

Table A.21.1.2(a) Ceiling Type

Fire Type	Ceiling Type	Sprinkler Distance Below Ceiling [in. (mm)]	Time to Activation (seconds)	Size of Fire at Activation [Btu/s (kW)]
Fast- growing fire	Insulated deck	1 (25)	76	450 (475)
	Steel	1 (25)	97	580 (612)
	Wood	1 (25)	71	420 (443)
	Insulated deck	12 (300)	173	1880 (1985)
	Steel	12 (300)	176	1930 (2035)
	Wood	12 (300)	172	1900 (475)
Slow- growing fire	Insulated deck	1 (25)	281	220 (232)
	Steel	1 (25)	375	390 (411)
	Wood	1 (25)	268	200 (211)
	Insulated deck	12 (300)	476	630 (665)
	Steel	12 (300)	492	675 (712)
	Wood	12 (300)	473	620 (654)

Table A.21.1.2(b) Ceiling Arrangement

Situation	Fire	Time to Activate Sprinkler (seconds)	Fire Size at Time of Activation [Btu/s (kW)]
Ceiling with pocket	Fast	86 to 113	585 (617)
Sprinkler 12 in. below ceiling	Fast	172 to 176	1880 to 1900 (1985 to 2005)
Ceiling with pocket	Slow	288 to 395	490 (517)
Sprinkler 12 in. below ceiling	Slow	473 to 492	620 to 675 (654 to 712)

(1) K-5.6 (K-80) vs. K-11.2 (K-160)
   (a) Commodity — idle wood two-way pallets
   (b) 2 stacks × 3 stacks × 8 ft (2.4 m) high
   (c) Ceiling height — 30 ft (9.1 m)
   (d) Density — constant 0.30 gpm/ft^2 (12.2 mm/min)
   (e) Test #1 — 165°F (74°C) rated, K-11.2 (K-160) sprinklers
   (f) Test #2 — 165°F (74°C) rated, K-5.6 (K-80) sprinklers
   (g) Test #1 results — 4 A.S. operated
   (h) Test #2 results — 29 A.S. operated, less fire control and greater temperatures
(2) K-8.0 (K-115) vs. K-11.2 (K-160) vs. K-16.8 (K-240)
   (a) Commodity — idle wood four-way pallets
   (b) Two stacks × three stacks × 12 ft high (3.7 m)
   (c) Ceiling height — 30 ft (9.1 m)

   (d) Density — constant 0.6 gpm/ft^2 (24.5 mm/min)
   (e) Test #1 — 286°F (141°C) rated, K-8.0 (K-115) sprinklers
   (f) Test #2 — 165°F (74°C) rated, K-11.2 (K-160) sprinklers
   (g) Test #3 — 165°F (74°C) rated, K-16.8 (K-240) sprinklers
   (h) Test #1 results — 10 A.S. operated, 1215°F (658°C) maximum steel temperature, fire spread to all sides
   (i) Test #2 results — 13 A.S. operated, 200°F (94°C) maximum steel temperature, fire spread to three sides
   (j) Test #3 results — 6 A.S. operated, 129°F (54°C) maximum steel temperature, fire spread (just reached) one side

(3) K-5.6 (K-80) vs. K-16.8 (K-240)
   (a) Commodity — FMRC standard plastic commodity rack style 9 ft (2.7 m) high
   (b) Ceiling height — 30 ft (9.1 m)
   (c) Density — 0.45 gpm/ft^2 (18.3 mm/min)
   (d) Test #1 — K-5.6 (K-80) orifice sprinklers
   (e) Test #2 — K-16.8 (K-240) orifice sprinklers
   (f) Test #1 results — 29 A.S. operated, 14 pallet loads consumed
   (g) Test #2 results — 5 A.S. operated, 2 pallet loads consumed

(4) K-8.0 (K-115) vs. K-16.8 (K-240)
   (a) Commodity — FMRC standard plastic commodity rack stage 14 ft (4.3 m) high
   (b) Ceiling height — 25 ft (7.6 m)
   (c) Density — 0.60 gpm/ft^2 (24.5 mm/min)
   (d) Test #1 — K-8.0 (K-115) sprinklers
   (e) Test #2 — K-16.8 (K-240) sprinklers
   (f) Test #1 results — 29 A.S. operated, 25 pallet loads consumed
   (g) Test #2 results — 7 A.S. operated, 4 pallet loads consumed

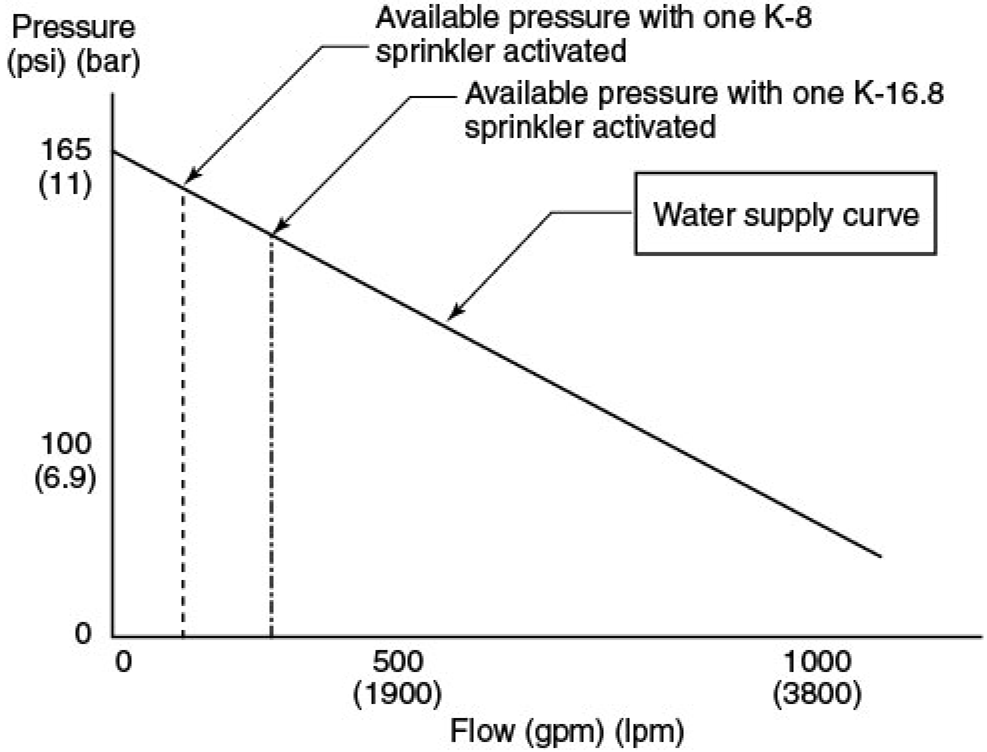
On an equal density basis, the fire test comparisons show the advantage of the larger orifices. A possibly even bigger advantage can be seen when investigating the performance of larger orifice sprinklers in the real world condition of high initial operating pressures.

The volume of water discharged through the larger K-factor for the initial sprinklers has three significant effects:

(1) First, the increase in sheer volume flowing through the larger orifice enhances performance. For example, a 165 psi (11 bar) initial operating pressure would provide 102.8 gpm (390 L/min) from a K-8.0 (K-115), while the K-16.8 (K-240) will discharge 215.8 gpm (815 L/min).
(2) Second, fire testing at high pressures [100+ psi (6.9 bar)] with K-5.6 (K-80) and K-8.0(K-115) (when high fire updrafts occur) has shown less water penetration and more sprinkler skipping. When fire testing the K-11.2(K-160) and K-16.8 (K-240) sprinklers at 100+ psi (6.9 bar), more water penetration is evident and little or no sprinkler skipping has occurred.
(3) Third, with such high initial discharge rates among K-16.8 (K-240) sprinklers, the friction loss in the supply pipes would be greater. This would result in lower initial pressures than a K-8.0(K-115) as well as being farther down the water supply curve with greater flows resulting in lower initial operating pressures.

Figure A.21.1.2 highlights the differences between the K-8.0(K-115) and K-16.8 (K-240) initial operating pressures.

Figure A.21.1.2 Available Pressure Comparison.



The higher flow rate of the K-16.8 (K-240) sprinkler results in greater friction losses in the initial operating heads as compared to the K-8.0(K-115) sprinkler. Combined with the lower pressure available on the water supply curve, the end result is a self-regulating K-factor allowing greater initial pressures without a negative impact.

Table A.21.1.2(c) summarizes the paper product testing.

Table A.21.1.2(c) Paper Product Testing Results

Test Parameters	Test Date			
	3/25/98	3/18/98*	4/4/98	6/4/98†
Sprinklers	K-8.0 (K-115)	K-8.0 (K-115)	K-11.2 (K-160)	K-16.8 (K-240)
Temperature	286°F (141°C)	286°F (141°C)	165°F (74°C)	155°F (68°C)
Storage Type	4 tier pyramid	5 tier pyramid	4 tier pyramid	5 tier pyramid
Storage Height	16 ft (4.9 m)	22 ft (6.7 m)	16 ft (4.9 m)	22 ft (6.7 m)
Ceiling Height	30 ft (9.1 m)	31 ft (9.1 m)	30 ft (9.1 m)	31 ft (9.1 m)
Sprinkler Flow Pressure	22.6 psi (1.6 bar)	175 psi (12.1 bar)	11.9 psi (0.82 bar)	130 psi (9.0 bar)
Number of Operated Sprinklers	15	2	10	2
Peak Gas Temperature	—	868°F (464°C)	—	424°F (217°C)
Peak Steel Temperature	—	421°F (216°C)	—	113°F (45°C)
Fire Spread Across Aisle (30 in.)	N/A	Yes	N/A	No

*This test was run with a fire brigade response of 20:00 minutes.

†This test was run with a fire brigade response of 7:00 minutes.

The results. The tests indicated that even at a high temperature of 286°F (141°C), the K-8.0 (K-115) sprinklers operating at higher pressures were not effective in controlling the fire. Conversely, the K-16.8 (K-240) sprinkler was able to control the fire at the lower temperature [155°F (68°C)], by operating sooner, and at lower, self-regulating flowing pressures.

Conclusions. The larger K-factor of the K-16.8 (K-240) sprinkler is not affected by high initial operating pressures. In fact, the protection is enhanced, providing better fire protection.

The ability to use lower-rated temperatures, such as 155°F (68°C) in lieu of 286°F (141°C), shows that the performance of the initial operating sprinklers is effective in controlling the fire. Therefore, using high-temperature sprinklers to reduce the number of surrounding rings of sprinklers to open is not necessary when using the K-16.8 (K-240) technology.

In short, the K-16.8 (K-240) sprinkler proved highly effective when subjected to high initial operating pressures.

A.21.2

The following procedure should be followed in determining the proper density and area as specified in Chapter 12:

(1) Determine the commodity class
(2) Select the density and area of application
(3) Adjust the required density for storage height
(4) Increase the operating area by 30 percent where a dry pipe system is used
(5) Satisfy the minimum densities and areas *Example:* Storage — greeting cards in boxes in cartons on pallets Height — 22 ft (6.7 m) Clearance to ceiling — 6 ft (1.8 m) Sprinklers — ordinary temperature System type — dry
    (a) Classification — Class III
    (b) Selection of density/area — 0.225 gpm/ft^2 (9.2 mm/min) over 3000 ft^2 (280 m^2)
    (c) Adjustment for height of storage — 1.15 × 0.225 gpm/ft^2 (9.2 mm/min) = 0.259 gpm/ft^2 (10.553 mm/min), rounded up to 0.26 gpm/ft^2 (10.6 mm/min)
    (d) Adjustment of area of operation for dry system — 1.3 × 3000 ft^2 (280 m^2) = 3900 ft^2 (360 m^2)
    (e) Confirmation that minimum densities and areas have been achieved

The minimum design density for a dry sprinkler system is 0.15 gpm/ft^2 over 2600 ft^2 (6.1 mm/min over 240 m^2) for Class III.

The corresponding minimum density at 3000 ft^2 (280 m^2) is 0.17 gpm/ft^2 (7 mm/min) (satisfied); 1.3 × 3000 ft^2 (280 m^2) = 3900 ft^2 (363 m^2), 0.17 gpm/ft^2 over 3900 ft^2 (7 mm/min over 360 m^2).

The design density and area of application equals 0.26 gpm/ft^2 over 3900 ft^2 (10.6 mm/min over 360 m^2).

A.21.2.1(3)

Full-scale tests show no appreciable difference in the number of sprinklers that open for either nonencapsulated or encapsulated products up to 15 ft (4.6 m) high. Test data are not available for encapsulated products stored higher than 15 ft (4.6 m). However, in rack storage tests involving encapsulated storage 20 ft (6.1 m) high, increased protection was needed over that for nonencapsulated storage.

The protection specified contemplates a maximum of 10 ft (3.0 m) clearances from top of storage to sprinkler deflectors for storage heights of 15 ft (4.6 m) and higher.

A.21.3.2

There are few storage facilities in which the commodity mix or storage arrangement remains constant, and a designer should be aware that the introduction of different materials can change protection requirements considerably. Design should be based on higher densities and areas of application, and the various reductions allowed should be applied cautiously. For evaluation of existing situations, however, the allowances can be quite helpful.

A.21.3.3

Test data are not available for all combinations of commodities, storage heights, and clearances to ceiling. Some of the protection criteria in this standard are based on extrapolations of test data for other commodities and storage configurations, as well as available loss data.

For example, there are very limited test data for storage of expanded plastics higher than 20 ft (6.1 m). The protection criteria in this standard for expanded plastics higher than 20 ft (6.1 m) are extrapolated from test data for expanded plastics storage 20 ft (6.1 m) and less in height and test data for nonexpanded plastics above 20 ft (6.1 m).

Further examples can be found in the protection criteria for clearance to ceiling up to 15 ft (4.6 m). Test data are limited for clearance to ceiling greater than 10 ft (3.0 m). It should be assumed that, if protection is adequate for a given storage height in a building of a given height, the same protection will protect storage of any lesser height in the same building. For example, protection adequate for 20 ft (6.1 m) storage in a 30 ft (9.1 m) building [10 ft (3.0 m) clearance to ceiling] would also protect 15 ft (4.6 m) storage in a 30 ft (9.1 m) building [15 ft (4.6 m) clearance to ceiling]. Therefore, the protection criteria in Table 21.3.3(a) for 15 ft (4.6 m) clearance to ceiling are based on the protection criteria for storage 5 ft (1.5 m) higher than the indicated height with 10 ft (3.0 m) clearance to ceiling.

Table 21.3.3(a) is based on tests that were conducted primarily with high temperature–rated, K-8 orifice sprinklers. Other tests have demonstrated that, where sprinklers are used with orifices greater than K-8, ordinary-temperature sprinklers are acceptable.

A.21.3.3.1

Two direct comparisons between ordinary temperature– and high temperature–rated sprinklers are possible, as follows:

(1) With nonexpanded polyethylene 1 gal (3.8 L) bottles in corrugated cartons, a 3 ft (0.9 m) clearance, and the same density, approximately the same number of sprinklers operated (nine at high temperature versus seven at ordinary temperature)
(2) With exposed, expanded polystyrene meat trays, a 9.5 ft (1.9 m) clearance, and the same density, three times as many ordinary temperature–rated sprinklers operated as did high temperature–rated sprinklers (11 at high temperature versus 33 at ordinary temperature)

A.21.3.3.2

The “up to” in Table 21.3.3(a) and Table 21.3.3(b) is intended to aid in the interpolation of densities between storage heights.

A.21.4.1.1

Bulkheads are not a substitute for sprinklers in racks. Their installation does not justify reduction in sprinkler densities or design operating areas as specified in the design curves.

A.21.4.1.2.4

The aisle width and the depth of racks are determined by material-handling methods. The widths of aisles should be considered in the design of the protection system. Storage in aisles can render protection ineffective and should be discouraged.

A.21.4.2.1

Water demand for storage height over 25 ft (7.6 m) on racks separated by aisles at least 4 ft (1.2 m) wide and with more than 10 ft (3.0 m) between the top of storage and the sprinklers should be based on sprinklers in a 2000 ft^2 (185 m^2) operating area for double-row racks and a 3000 ft^2 (280 m^2) operating area for multiple-row racks discharging a minimum of 0.18 gpm/ft^2 (7.3 mm/min) for Class I commodities, 0.21 gpm/ft^2 (8.5 mm/min) for Class II and Class III commodities, and 0.25 gpm/ft^2 (10.2 mm/min) for Class IV commodities for ordinary temperature–rated sprinklers or a minimum of 0.25 gpm/ft^2 (10.2 mm/min) for Class I commodities, 0.28 gpm/ft^2 (11.4 mm/min) for Class II and Class III commodities, and 0.32 gpm/ft^2 (13 mm/min) for Class IV commodities for high temperature–rated sprinklers. (*See 25.4.3.1.1.1 through 25.4.3.1.1.3 and 25.4.3.2.1.1 through 25.4.3.2.1.3.*)

Where such storage is encapsulated, ceiling sprinkler density should be 25 percent greater than for nonencapsulated storage.

Data indicate that the sprinkler protection criteria in 21.4.2.1 are ineffective, by themselves, for rack storage with solid shelves if the required flue spaces are not maintained. Use of 21.4.2.1, along with the additional provisions that are required by this standard, can provide acceptable protection.

A.21.7

The protection criteria in Table 21.7.1(a) and Table 21.7.1(b) have been developed from fire test data. Protection requirements for other storage methods are beyond the scope of this standard at the present time. From fire testing with densities of 0.45 gpm/ft^2 (18.3 mm/min) and higher, there have been indications that large orifice sprinklers at greater than 50 ft^2 (4.6 m^2) spacing produce better results than the $\frac{1}{2}$ in. (15 mm) orifice sprinklers at 50 ft^2 (4.6 m^2) spacing.

Table 21.7.1(a) is based on operation of standard sprinklers. Use of quick-response or other special sprinklers should be based on appropriate tests as approved by the authority having jurisdiction.

The current changes to Table 21.7.1(a) and Table 21.7.1(b) represent test results from rubber tire fire tests performed at the Factory Mutual Research Center.

Storage heights and configurations, or both [e.g., automated material-handling systems above 30 ft (9.1 m)], beyond those indicated in the table have not had sufficient test data developed to establish recommended criteria. Detailed engineering reviews of the protection should be conducted and approved by the authority having jurisdiction.

A.21.8.4

Generally, more sprinklers open in fires involving roll paper storage protected by sprinklers rated below the high-temperature range. An increase of 67 percent in the design area should be considered.

A.22.1.5.4

An evaluation for each field situation should be made to determine the worst applicable height–clearance to ceiling relationship that can be expected to appear in a particular case. Fire tests have shown that considerably greater demands occur where the clearance to ceiling is 10 ft (3.0 m) as compared to 3 ft (900 mm) and where a pile is stable as compared to an unstable pile. Since a system is designed for a particular clearance to ceiling, the system could be inadequate when significant areas do not have piling to the design height and larger clearances to ceiling. This can also be true where the packaging or arrangement is changed so that stable piling is created where unstable piling existed. Recognition of these conditions is essential to avoid installation of protection that is inadequate or becomes inadequate because of changes.

No tests were conducted simulating a peaked roof configuration. However, it is expected that the principles of Chapter 20 still apply. The worst applicable height–clearance to ceiling relationship that can be expected to occur should be found, and protection should be designed for it. If storage is all at the same height, the worst height–clearance to ceiling relationship creating the greatest water demand would occur under the peak. If commodities are stored higher under the peak, the various height–clearance to ceiling relationships should be tried and the one creating the greatest water demand used for designing protection.

A.22.1.6

Solid shelf racks as defined in 3.3.216 or obstructions resulting in solid shelf requirements could require additional in-rack sprinklers that could affect the ceiling design requirements.

A.23.4

The Fire Protection Research Foundation conducted a series of full-scale fire tests at Underwriters Laboratories to develop protection criteria for the rack storage of exposed expanded Group A plastic commodities. The tests are documented in the report, *Protection of Rack Stored Exposed Expanded Group A Plastics with ESFR Sprinklers and Vertical Barriers*. The criteria for exposed expanded plastics are based on Tests 2, 3, 7, and 8 of the series, which investigated a 40 ft (12.2 m) ceiling with a range of storage heights. The tests used K-25.2 intermediate-temperature ESFR sprinklers with vertical barriers attached to the rack uprights at nominal 16 ft (4.9 m) apart. Vertical barriers of sheet metal and $^3/_8$ in. plywood were both investigated. In Tests 1 through 6, transverse flue spaces between commodities were blocked. Comparing the results of Test 6, with blocked transverse flue spaces, and Test 7, with no blocking of transverse flue spaces, revealed the number of operated sprinklers decreased from 11 to 7 and improved suppression of the fire. The criteria for exposed expanded plastics are based on Tests 9 and 10 of the series, which investigated a 30 ft (9.1 m) ceiling with a range of storage heights. The tests used K-25.2 intermediate-temperature ESFR sprinklers with vertical barriers attached to the rack uprights at 16 ft (4.9 m) (nominal) apart. Vertical barriers of $^3/_8$ in. plywood was investigated.

The area limitation between the vertical barriers and aisles indicated in 23.4.7.2 will limit the depth of a multiple-row rack arrangement. The hose stream allowance and water supply duration requirements considered the burning characteristics of the exposed expanded plastic commodity, which generates a high rate of heat release very quickly. However, the commodity involved in the combustion process is quickly consumed after fire suppression or control is achieved.

A.24.1

The intent of this chapter is to provide protection options for the commodity hazards and storage arrangements outlined in Chapters 20 through 25 based on the characteristics of the sprinkler, such as K-factor, orientation, RTI rating, sprinkler spacing type and temperature rating, and using a design format of number of sprinklers at a minimum operating pressure. The protection options offered in this chapter will be based on the results of full-scale fire testing, as outlined in A.24.2 or A.24.3, while incorporating a minimum 50 percent safety factor into the number of sprinklers provided in the design. The intent of this chapter is to offer protection options using sprinklers having a nominal K-factor of 11.2 (160) or higher.

Nothing in this chapter is intended to limit the development and use of equivalency or new technology applications under the provisions of Section 1.5 or Section 1.7.

A.24.2

The protection options offered in Section 24.2 are intended to be based on the results of full-scale fire tests conducted at a recognized testing laboratory using the standardized testing methods established by the testing laboratory and supplemented within this chapter.

Protection options for this chapter can be based on storage arrangements other than palletized, solid piled, bin box, shelf storage, or back-to-back shelf storage, provided that the tested storage arrangement (such as rack storage) is deemed more hazardous than the storage arrangements outlined for this chapter.

Ceiling-level sprinkler system designs for this chapter should include a series of tests to evaluate the ability of the sprinkler to control or suppress a fire under a range of test variables for the commodity to be protected when maintained in a storage arrangement applicable to Section 24.2. The sprinkler standards referenced in Table A.7.1.1 provide detailed information regarding representative test commodities, measurement of steel temperatures, and the construction of igniters used to initiate the fire.

Test parameters to be held constant during the test series should include at least the following:

(1) Minimum operating pressure of the sprinklers
(2) Highest commodity hazard that will apply to the protection option
(3) Storage arrangement type

Test parameters that can vary during the test series should include at least the following:

(1) Ignition locations relative to the overhead sprinklers including the following:
   (a) Under one sprinkler
   (b) Between two sprinklers on the same branch line
   (c) Between four sprinklers
   (d) ADD analysis can be used to choose either A.24.2(1)(b) or A.24.2(1)(c)
(2) Maximum ceiling height *(see Table A.24.2 for ceiling height variance)*; representative tests at each ceiling height limitation that has a discrete minimum operating pressure or number of sprinklers required to be included in the hydraulic calculation
(3) Storage heights that are based on the following clearances between the deflector of the ceiling-level sprinkler and the top of storage:
   (a) Minimum clearance, which is typically 3 ft (900 mm)
   (b) Nominal 10 ft (3.0 m) clearance
   (c) Nominal 20 ft (6.1 m) clearance for maximum ceiling heights of 40 ft (12.2 m) or higher
(4) Minimum and maximum temperature ratings
(5) Minimum and maximum sprinkler spacing
(6) Maximum sprinkler distance below the ceiling when greater than 12 in. (300 mm).

See Figure A.24.2 for an example of a nominal 25 ft (7.6 m) high palletized storage fire test arrangement. See Table A.24.2 for a typical large-scale fire test series to investigate the performance of a sprinkler covered by this chapter having a standard coverage area and a discrete minimum operating pressure for a 30 ft (9.1 m) ceiling height.

In addition to determining the number of operated sprinklers, the maximum 1 minute average steel temperature measured above the fire should not exceed 1000°F (538°C), and there should be no sustained combustion at the far end of the main test array and at the outer edges of the target arrays during each test. In addition, no sprinklers should operate at the outer edges of the installed sprinkler system.

The number of sprinklers to be used in the sprinkler system design will be based on the worst-case result obtained from the full-scale fire test series increased by a minimum 50 percent. Regardless of the number of sprinklers that operated during the worst-case full-scale fire test, the number in the sprinkler system demand will be no less than 12 sprinklers for standard coverage sprinklers or six sprinklers for extended coverage sprinklers.

Figure A.24.2 Typical Example of 15 ft (4.6 m) Palletized Storage Full-Scale Fire Test Arrangement.

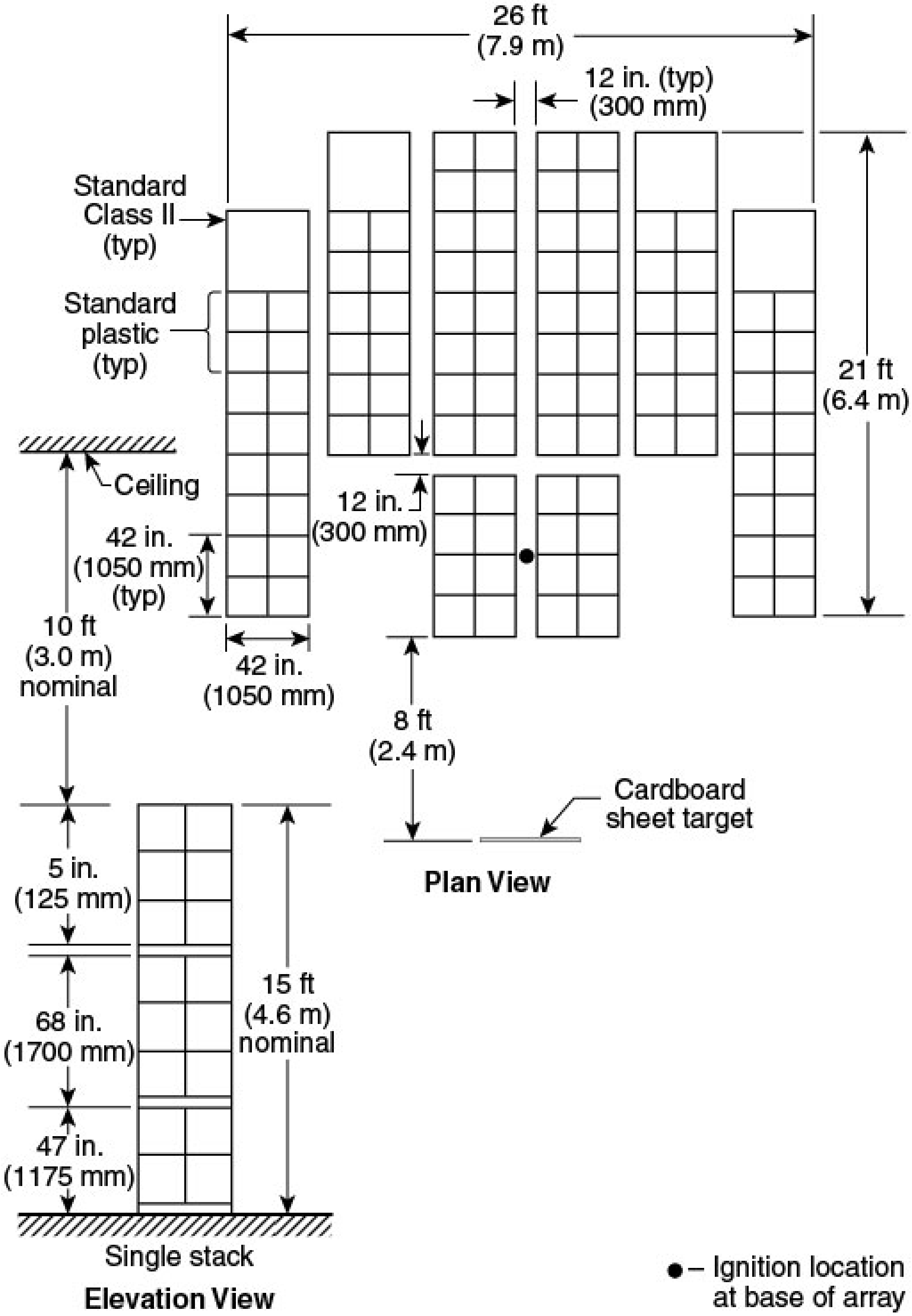


Table A.24.2 Typical Example of 25 ft (7.6 m) Palletized Storage Under 30 ft (9.1 m) Ceiling Full-Scale Fire Test Series on Simulated Wet-Type Sprinkler System (considers ADD results)

Parameter	Test 1	Test 2	Test 3	Test 4
Storage type	Palletized	Palletized	Palletized	Palletized
Nominal storage height, ft (m)	20 (6.1)	25 (7.6)	20 (6.1)	20 (6.1)
Nominal ceiling height, ft (m)	30 (9.1)	Adjusted to achieve minimum sprinkler deflector to commodity clearance	30 (9.1)	30 (9.1)

Parameter	Test 1	Test 2	Test 3	Test 4
Sprinkler temperature rating	Minimum temperature rating	Maximum temperature rating	Minimum temperature rating	Minimum temperature rating
Nominal deflector to ceiling distance, in. (cm)	Maximum specified by manufacturer	Maximum specified by manufacturer	Maximum specified by manufacturer	Maximum specified by manufacturer
Sprinkler spacing	Maximum permitted by NFPA 13	Maximum permitted by NFPA 13	Minimum permitted by NFPA 13	Maximum permitted by NFPA 13
Nominal discharge pressure, psig (kPa)	Minimum operating	Minimum operating	Minimum operating	Minimum operating
Ignition location	Under one	Between two on same branch line or between four	Under one	Between two on same branch line or between four
Test duration, minutes	30	30	30	30

A.24.3

The protection options offered in Section 24.3 are intended to be based on the results of full-scale fire tests conducted at a recognized testing laboratory using the standardized testing methods established by the testing laboratory and supplemented within this chapter.

Ceiling-level sprinkler system designs for this chapter should include a series of tests to evaluate the ability of the sprinkler to control or suppress a fire under a range of test variables for the commodity to be protected when maintained in a storage arrangement applicable to Section 24.3. The sprinkler standards referenced in Table A.7.1.1 provide detailed information regarding representative test commodities, measurement of steel temperatures, and the construction of igniters used to initiate the fire.

Test parameters to be held constant during the test series should include at least the following:

(1) Minimum operating pressure of the ceiling-level sprinklers
(2) Highest commodity hazard that will apply to the protection option
(3) Storage arrangement type
(4) Minimum aisle width

Test parameters that can vary during the test series should include at least the following:

(1) Ignition locations relative to the overhead sprinklers including the following:
    (a) Under one sprinkler
    (b) Between two sprinklers on the same branch line
    (c) Between four sprinklers
    (d) ADD analysis can be used to choose either A.24.3(1)(b) or A.24.3(1)(c)
(2) Maximum ceiling height *(see Table A.24.2 for ceiling height variance)*; representative tests at each ceiling height limitation that has a discrete minimum operating pressure or number of sprinklers required to be included in the hydraulic calculation
(3) Storage heights that are based on the following clearances between the deflector of the ceiling-level sprinkler and the top of storage:
    (a) Minimum clearance, which is typically 3 ft (900 mm)
    (b) Nominal 10 ft (3.0 m) clearance
    (c) Nominal 20 ft (6.1 m) clearance for maximum ceiling heights of 40 ft (12.2 m) or higher
(4) Minimum and maximum temperature ratings
(5) Minimum and maximum sprinkler spacing
(6) Maximum sprinkler distance below the ceiling when greater than 12 in. (300 mm)

Historical testing has indicated that a double-row rack storage arrangement is considered representative of single- and multiple-row rack storage. The ignition location relative to the sprinkler has been demonstrated to be a key variable associated with full-scale fire tests. The critical ignition scenarios include locating (1) one of the sprinklers directly above the center of the main storage array, (2) two of the sprinklers on the same branch line such that the midpoint between the two sprinklers is directly above the center of the storage array, and (3) four sprinklers (two each on adjacent branch lines) such that the geometric center point between the four sprinklers is located directly above the center of the main storage array. The igniters for this testing should be placed at the base of the storage array and offset from the center of the main array in the transverse flue space as illustrated in Figure A.24.3. Previous testing has demonstrated that an offset ignition location represents a challenging test scenario.

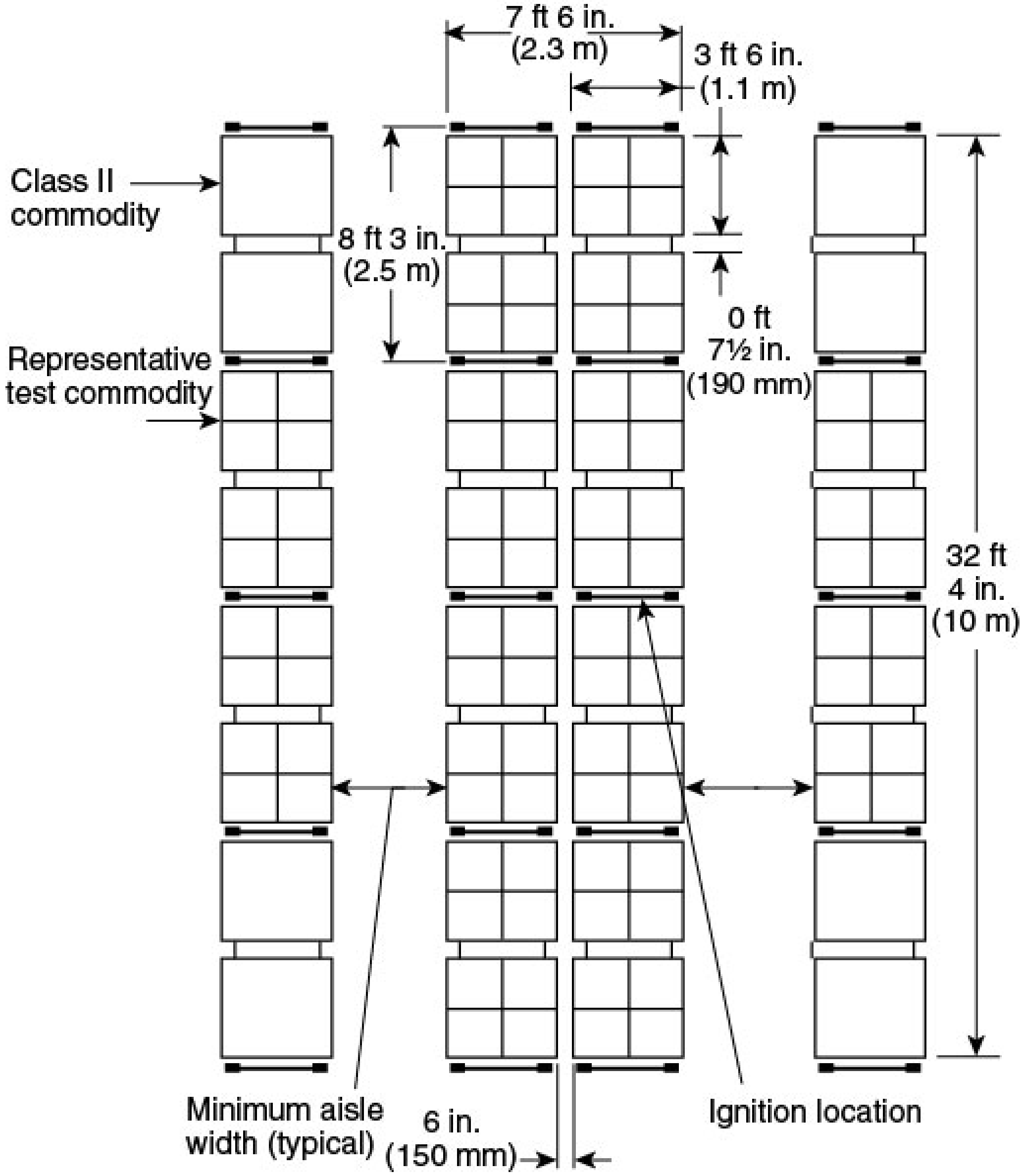
A double-rack storage array should be a nominal 32 ft (9.8 m) long with single-row target arrays located on each side of the main array. The sprinkler branch lines should be installed in a direction that is perpendicular to the longitudinal flue spacing of the storage arrangement, and the branch lines over the test array should be sized such that they represent the largest obstruction for upright-style sprinklers. See Figure A.24.3 for an example of a nominal 30 ft (9.1 m) high double-row rack storage fire test arrangement. See Table A.24.3(a) and Table A.24.3(b) for a typical full-scale fire test series to investigate the performance of a sprinkler covered by this chapter having a standard coverage area and a discrete minimum operating pressure for a 40 ft (12.2 m) ceiling height.

In addition to determining the number of operated sprinklers, the maximum 1 minute average steel temperature measured above the fire should not exceed 1000°F (538°C), and there should be no sustained combustion at the far end of the main test array and at the outer edges of the target arrays during each test. In addition, no sprinklers should operate at the outer edges of the installed sprinkler system.

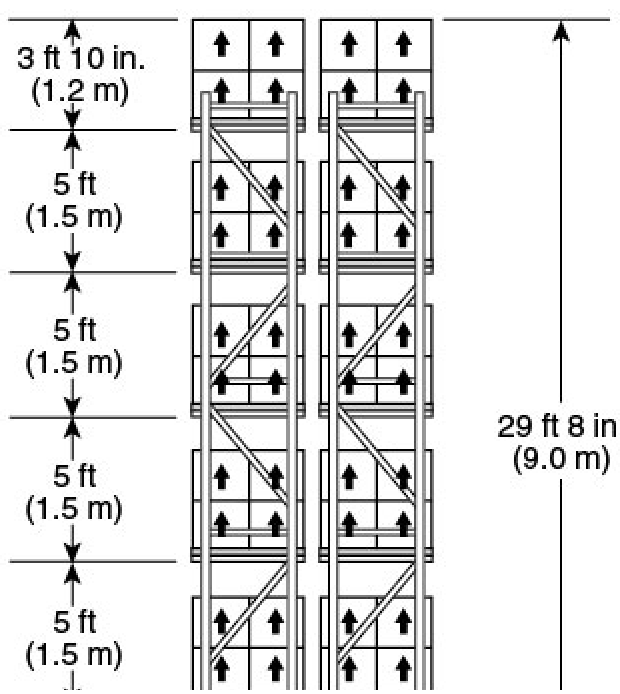
The number of sprinklers to be used in the sprinkler system design will be based on the worst-case result obtained from the full-scale fire test series increased by a minimum 50 percent. Regardless of the number of sprinklers that operated during the worst-case full-scale fire test, the number in the sprinkler system demand will be no less than 12 sprinklers for standard coverage sprinklers or six sprinklers for extended coverage sprinklers.

Once the number of sprinklers for a demand area has been established, the minimum operating area, based on the proposed sprinkler spacing, cannot be less than 768 ft^2 (71 m^2).

Figure A.24.3 Typical Example of 30 ft (9.1 m) Double-Row Rack Storage Fire Test Arrangement.


7 ft 6 in.
(2.3 m)
3 ft 6 in.
(1.1 m)
Class II
commodity
8 ft 3 in.
(2.5 m)
0 ft
7½ in.
(190 mm)
Representative
test commodity
32 ft
4 in.
(10 m)
Minimum aisle
width (typical)
6 in.
(150 mm)
Ignition location

Plan View


3 ft 10 in.
(1.2 m)
5 ft
(1.5 m)
5 ft
(1.5 m)
5 ft
(1.5 m)
5 ft
(1.5 m)
29 ft 8 in.
(9.0 m)

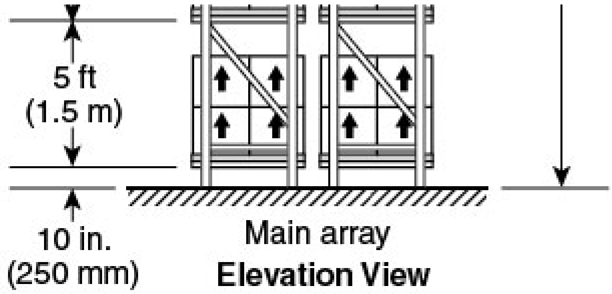


Table A.24.3(a) Typical Example of a 35 ft (10.7 m) Rack Storage Under a 40 ft (12.2 m) Ceiling Full-Scale Fire Test Series on a Simulated Wet-Type Sprinkler System (considers ADD results)

Parameter	Test 1	Test 2	Test 3	Test 4
Storage type	Double-row rack	Double-row rack	Double-row rack	Double-row rack
Nominal storage height, ft (m)	30 (9.1)	35 (10.7)	30 (9.1)	20 (6.1)
Nominal ceiling height, ft (m)	40 (12.2)	Adjusted to achieve minimum sprinkler deflector to commodity clearance	40 (12.2)	40 (12.2)
Sprinkler temperature rating	Minimum temperature rating	Maximum temperature rating	Minimum temperature rating	Minimum temperature rating
Nominal deflector to ceiling distance, in. (mm)	Maximum specified by manufacturer	Maximum specified by manufacturer	Maximum specified by manufacturer	Maximum specified by manufacturer
Sprinkler spacing	Maximum permitted by NFPA 13	Maximum permitted by NFPA 13	Minimum permitted by NFPA 13	Maximum permitted by NFPA 13
Nominal discharge pressure, psig (kPa)	Minimum operating	Minimum operating	Minimum operating	Minimum operating
Ignition location	Under one	Between two on same branch line or between four	Under one	Between two on same branch line or between four
Test duration, minutes	30	30	30	30

Table A.24.3(b) Typical Example of 35 ft (10.7 m) Rack Storage Under 40 ft (12.2 m) Ceiling Full-Scale Fire Test Series on a Simulated Wet-Type Sprinkler System

Parameter	Test 1	Test 2	Test 3	Test 4
Storage type	Double-row rack	Double-row rack	Double-row rack	Double-row rack
Nominal storage height, ft (m)	30 (9.1)	35 (10.7)	30 (9.1)	20 (6.1)
Nominal ceiling height, ft (m)	40 (12.2)	Adjusted to achieve minimum sprinkler deflector to commodity clearance	40 (12.2)	40 (12.2)
Sprinkler temperature rating	Minimum temperature rating	Maximum temperature rating	Minimum temperature rating	Minimum temperature rating
Nominal deflector to ceiling distance, in. (mm)	Within 12 (300)	Maximum specified by manufacturer	Maximum specified by manufacturer	Maximum specified by manufacturer
Sprinkler spacing	10 × 10 (3.0 × 3.0)	10 × 10 (3.0 × 3.0)	10 × 10 (3.0 × 3.0)	10 × 10 (3.0 × 3.0)
Nominal discharge pressure, psig (kPa)	Minimum operating	Minimum operating	Minimum operating	Minimum operating
Ignition location	Under one	Between four	Between two on same branch line	Between two on same branch line

Parameter	Test 1	Test 2	Test 3	Test 4
Test duration, minutes	30	30	30	30

A.25.1.1.1

The following information should be obtained prior to using Chapter 25 to assist in determining the proper protection options provided in the chapter:

(1) Commodity classification of the storage, using Chapter 20
(2) If Class I through Class IV, whether the commodity is exposed and nonencapsulated, exposed and encapsulated, or cartoned
(3) The maximum storage height and ceiling height for the storage area
(4) Rack type (i.e., fixed-in-place, portable, or moveable) in which the storage will be maintained
(5) Aisle width between storage racks
(6) Depth of the storage racks
(7) Rack arrangements (i.e., single-, double-, or multiple-row racks) in which the storage will be maintained
(8) Whether solid shelves will be present and, if applicable, shelf size

Fire testing of in-rack sprinkler protection schemes described in Chapter 25 have generally demonstrated improved fire protection compared to the ceiling-only sprinkler protection schemes described in Chapters 21 through 24. Lower ceiling temperatures and a reduced amount of smoke/combustion products developed during the fire control or suppression process has typically been observed during fire testing of these in-rack sprinkler systems. A reduction in the amount of smoke/combustion product generation provides greater visibility for the fire service while achieving final extinguishment.

A.25.1.4.2

In-rack sprinklers and ceiling sprinklers selected for protection should be controlled by at least two separate indicating valves and drains. In higher rack arrangements, consideration should be given to providing more than one in-rack control valve in order to limit the extent of any single impairment.

A.25.1.5

Solid shelf racks as defined in 3.3.216 or obstructions resulting in solid shelf requirements could require additional in-rack sprinklers that could affect the ceiling design requirements.

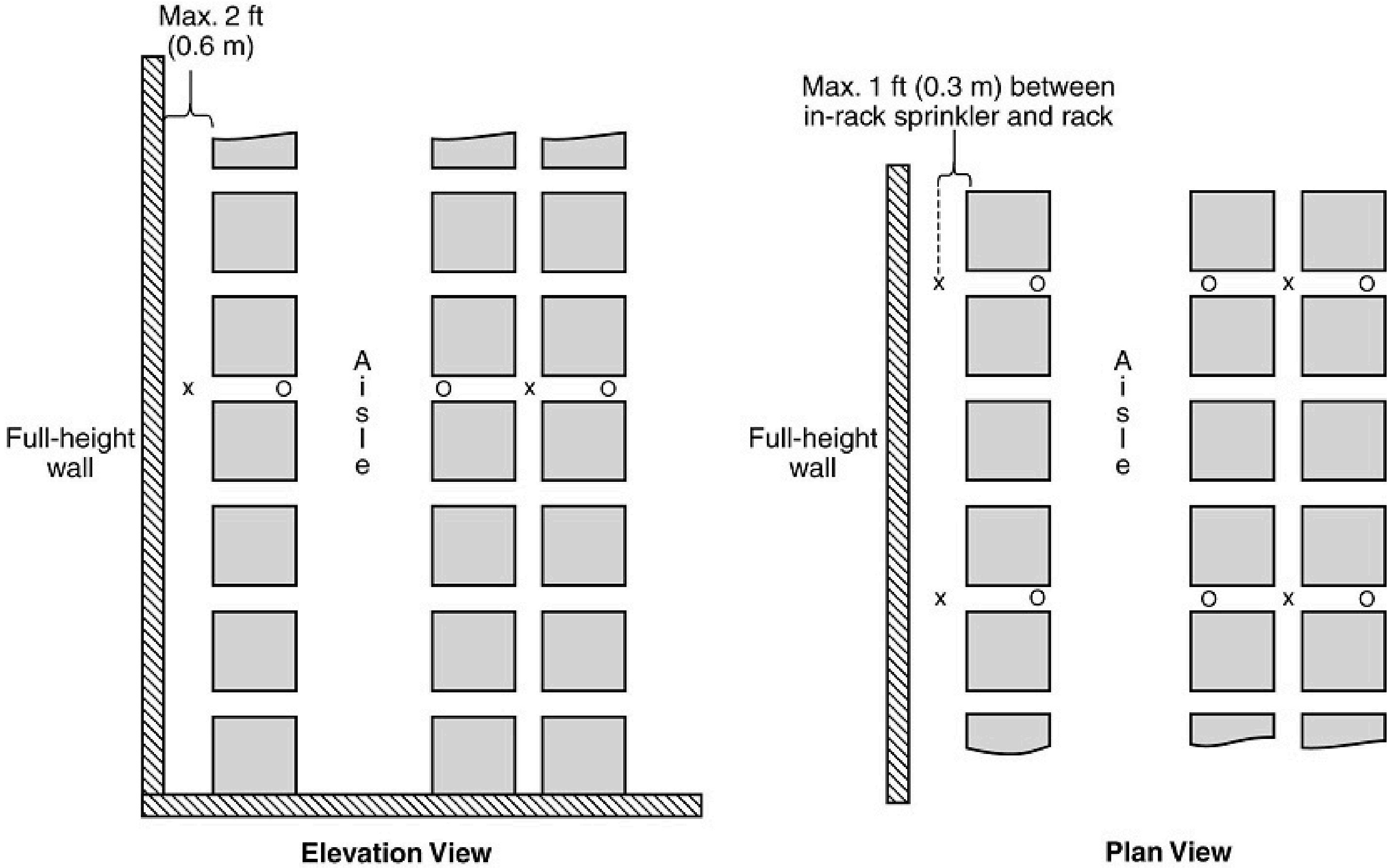
A.25.1.7.3

In-rack sprinklers have proven to be the most effective way to fight fires in rack storage. To accomplish this, however, in-rack sprinklers must be located where they will operate early in a fire and direct water where it will do the most good. Simply maintaining a minimum horizontal spacing between sprinklers does not achieve this goal because fires in rack storage develop and grow in transverse and longitudinal flues, and in-rack sprinklers do not operate until flames actually impinge on them. To ensure early operation and effective discharge, in-rack sprinklers in the longitudinal flue of open-frame racks need to be located at transverse flue intersections.

A.25.1.7.9.2

See Figure A.25.1.7.9.2 for an example of in-rack sprinklers being installed between a single-row rack and an adjacent full-height wall.

Figure A.25.1.7.9.2 Example of In-Rack Sprinklers Installed Between a Single-Row Rack and an Adjacent Full-Height Wall.



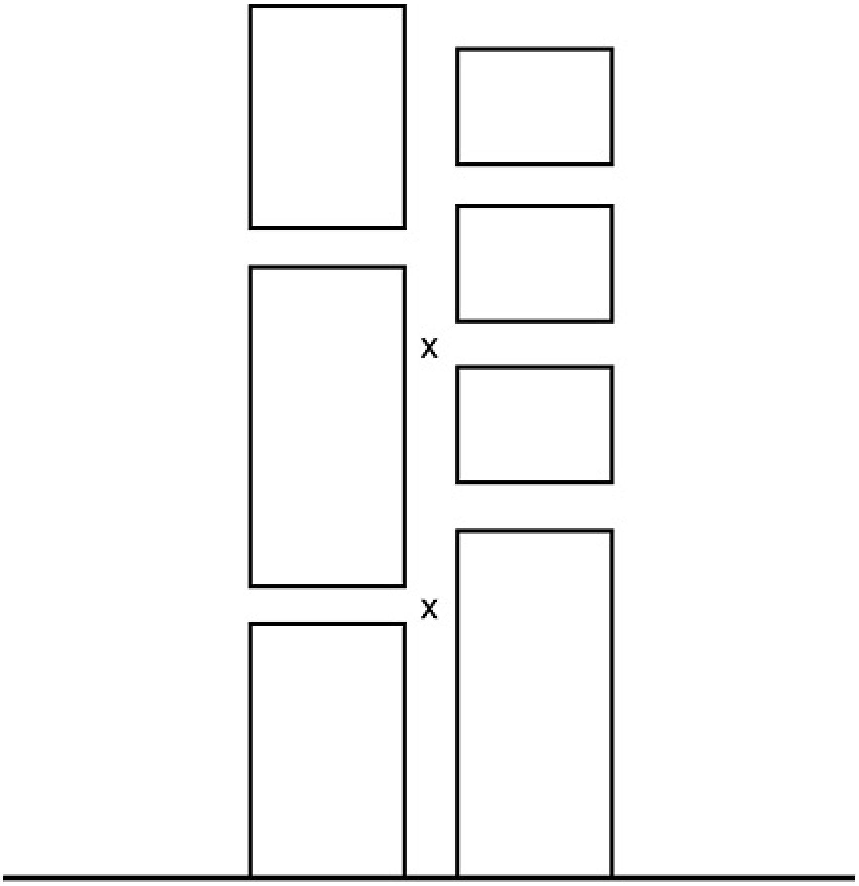
A.25.1.8.1

Where one level of in-rack sprinklers is required by the guidelines in Chapter 25, in-rack sprinklers for multiple-row rack storage up to and including 25 ft (7.6 m) of Class I through Class IV commodities should be installed at the first tier level nearest one-half to two-thirds of the highest expected storage height.

A.25.1.8.3.1

Where storage tiers in a double-row rack are not the same size on each side of the longitudinal flue, one side of the flue should be protected with sprinklers at the proper elevation above the load. The next level of sprinklers should protect the other side of the flue with the sprinklers at the proper elevation above that load as indicated in Figure A.25.1.8.3.1. The vertical spacing requirements for in-rack sprinklers, as specified in the appropriate section for the commodity and storage height, should be followed.

Figure A.25.1.8.3.1 Placement of In-Rack Sprinklers Where Rack Levels Have Varying Heights.



Elevation View

A.25.1.8.3.2

Where possible, it is recommended that in-rack sprinkler deflectors be located at least 6 in. (150 mm) vertically above the top of storage located below them.

A.25.1.9.1

Barriers should be of sufficient strength to avoid sagging that interferes with loading and unloading operations.

A.25.1.12

Information for the protection of Class I through Class IV commodities was extrapolated from full-scale fire tests that were performed at different times than the tests that were used to develop the protection for Group A plastic commodities. It is possible that, by selecting certain points from the tables, and after applying the appropriate modifications, the protection specified by 25.4.2.1 or 25.4.2.2 for Class I through Class IV commodities exceeds the requirements for Group A plastic commodities. In such situations, the protection specified for Group A plastic commodities, although less than that required by the tables, can adequately protect Class I through Class IV commodities. This section also allows storage areas that are designed to protect Group A plastic commodities to store Class I through Class IV commodities without a re-evaluation of the fire protection systems.

A.25.2.2.1(2)

All rack fire tests of Group A plastic commodities were run with an approximate 10 ft (3.0 m) maximum clearance to ceiling.

A.25.4.2.1.1

Spacing of sprinklers on branch lines in racks in the various tests demonstrates that maximum spacing as specified is proper.

A.25.4.2.1.2.1

Bulkheads are not a substitute for sprinklers in racks. Their installation does not justify reduction in sprinkler densities or design operating areas as specified in the design curves. Data indicate that the sprinkler protection criteria in Table 25.4.2.1.2.1(A)(a) through Table 25.4.2.1.2.1(A)(d) are ineffective, by themselves, for rack storage with solid shelves if the required flue spaces are not maintained. Use of Table 25.4.2.1.2.1(A)(a) through Table 25.4.2.1.2.1(A)(d), along with the additional provisions that are required by this standard, can provide acceptable protection. It is not the intent that an in-rack sprinkler be installed above the top-tier of storage when utilizing in-rack sprinklers at each tier level.

A.25.4.2.1.2.1(B)

The aisle width and the depth of racks are determined by material-handling methods. The widths of aisles should be considered in the design of the protection system. Storage in aisles can render protection ineffective and should be discouraged.

A.25.4.2.2.1

Spacing of sprinklers on branch lines in racks in the various tests demonstrates that maximum spacing as specified is proper.

A.25.4.2.2.2.1

Bulkheads are not a substitute for sprinklers in racks. Their installation does not justify reduction in sprinkler densities or design operating areas as specified in the design curves. Data indicate that the sprinkler protection criteria in Table 25.4.2.2.2.1(A)(a) through Table 25.4.2.2.2.1(A)(d) are ineffective, by themselves, for rack storage with solid shelves if the required flue spaces are not maintained. Use of Table 25.4.2.2.2.1(A)(a) through Table 25.4.2.2.2.1(A)(d), along with the additional provisions that are required by this standard, can provide acceptable protection. It is not the intent that an in-rack sprinkler be installed above the top-tier of storage when utilizing in-rack sprinklers at each tier level.

A.25.4.2.2.2.1(B)

Bulkheads are not a substitute for sprinklers in racks. Their installation does not justify reduction in sprinkler densities or design operating areas as specified in the design curves. Data indicate that the sprinkler protection criteria in Table 25.4.2.1.2.1(A)(a) through Table 25.4.2.1.2.1(A)(d) are ineffective, by themselves, for rack storage with solid shelves if the required flue spaces are not maintained. Use of Table 25.4.2.1.2.1(A)(a) through Table 25.4.2.1.2.1(A)(d), along with the additional provisions that are required by this standard, can provide acceptable protection. It is not the intent that an in-rack sprinkler be installed above the top-tier of storage when utilizing in-rack sprinklers at each tier level.

A.25.4.2.3.1.2

In most of the figures listed in 25.4.2.3.1.1, the designer is presented with multiple options from which to choose. The single column of boxes in the elevation view represents single-row rack storage, the double column of boxes in the elevation view represents double-row rack storage, and the options with three or four columns of boxes represent different arrangements of multiple-row rack storage. The symbols *X* and *O* in the elevation and plan views represent different rows of in-rack sprinklers: the symbols in the elevation view show the vertical spacing of the in-rack sprinklers, while the symbols in the plan view show the horizontal spacing of in-rack sprinklers. Different symbols are used so that the upper and lower levels of in-rack sprinklers can be determined when looking at the plan view.

A.25.4.2.4.1

Each of the figures listed in 25.4.2.4.1 shows a variety of different potential rack arrangements. The first single-row rack (SRR) to the left in each figure shows a single-row rack with aisles on each side. The double-row rack (DRR) is in the center of the figure. The multiple-row rack (MRR) on the right shows rack structures where the in-rack sprinkler pattern can be repeated.

A.25.4.3.1.1.6(A)

Where the clearance to ceiling exceeds 10 ft (3.0 m) with CMDA ceiling-level sprinklers protecting exposed nonencapsulated Class I, Class II, Class III, or Class IV commodities, a horizontal barrier should be installed above storage with one level of in-rack sprinklers under the barrier.

A.25.4.3.1.2

Data indicate that the sprinkler protection criteria in 25.4.3.1.2 are ineffective, by themselves, for rack storage with solid shelves if the required flue spaces are not maintained. Use of 25.4.3.1.2, along with the additional provisions that are required by this standard, can provide acceptable protection.

A.25.4.3.2.1.6(A)

Where the clearance to ceiling exceeds 10 ft (3.0 m) with CMDA ceiling-level sprinklers protecting exposed encapsulated, or cartoned (nonencapsulated or encapsulated) Class I, Class II, Class III, or Class IV commodities, a horizontal barrier should be installed above storage with one level of in-rack sprinklers under the barrier.

A.25.4.3.2.2

Data indicate that the sprinkler protection criteria in 25.4.3.2.2 are ineffective, by themselves, for rack storage with solid shelves if the required flue spaces are not maintained. Use of 25.4.3.2.2, along with the additional provisions that are required by this standard, can provide acceptable protection.

A.25.4.3.3.2

Ordinary-, intermediate-, or high-temperature ceiling-level sprinklers can be used in this application. There are no data to support temperature rating restrictions for this section.

A.25.4.3.4.2

Ordinary-, intermediate-, or high-temperature ceiling-level sprinklers can be used in this application. There are no data to support temperature rating restrictions for this section.

A.25.5.2.1

There are currently no situations where in-rack sprinklers are required to be used to protect Group A plastic commodities stored over 25 ft (7.6 m) in height where CMSA sprinklers are used at the ceiling.

A.25.7.2.5.5.2

An example of equipment that might create an opening is a pipe drop.

A.25.7.3.2.1

The design for the ceiling sprinkler system can treat the top level of in-rack sprinklers as a floor, thus allowing for storage heights above the top in-rack sprinkler level that exceed 10 ft (3.0 m). For example, if open rack storage of cartoned Group A plastics was stored to 70 ft (21.3 m) high under an 80 ft (24.4 m) ceiling and one level of in-rack sprinklers was installed in accordance with Option 2 of Table 25.7.2.2 at the 40 ft (12.2 m) level, then the ceiling level sprinkler system could be designed based on 30 ft (9.1 m) high storage being maintained under a 40 ft (12.2 m) high ceiling.

A.25.7.3.3.3

Hydraulic balancing with the ceiling sprinkler system is not required.

A.26.1

Compliance with these provisions requires the storage arrangements and the sprinkler system design to comply with all limitations in the option that is selected. The use of a designation associated with a specific industry usage, such as retail, automotive, or records storage, is not intended to mandate the use of such protection criteria to only that applicable to such industries, nor is it intended to limit the use of the specified criteria to only such industries, provided the storage arrangement and protected commodities fall within the bounds of permitted protection.

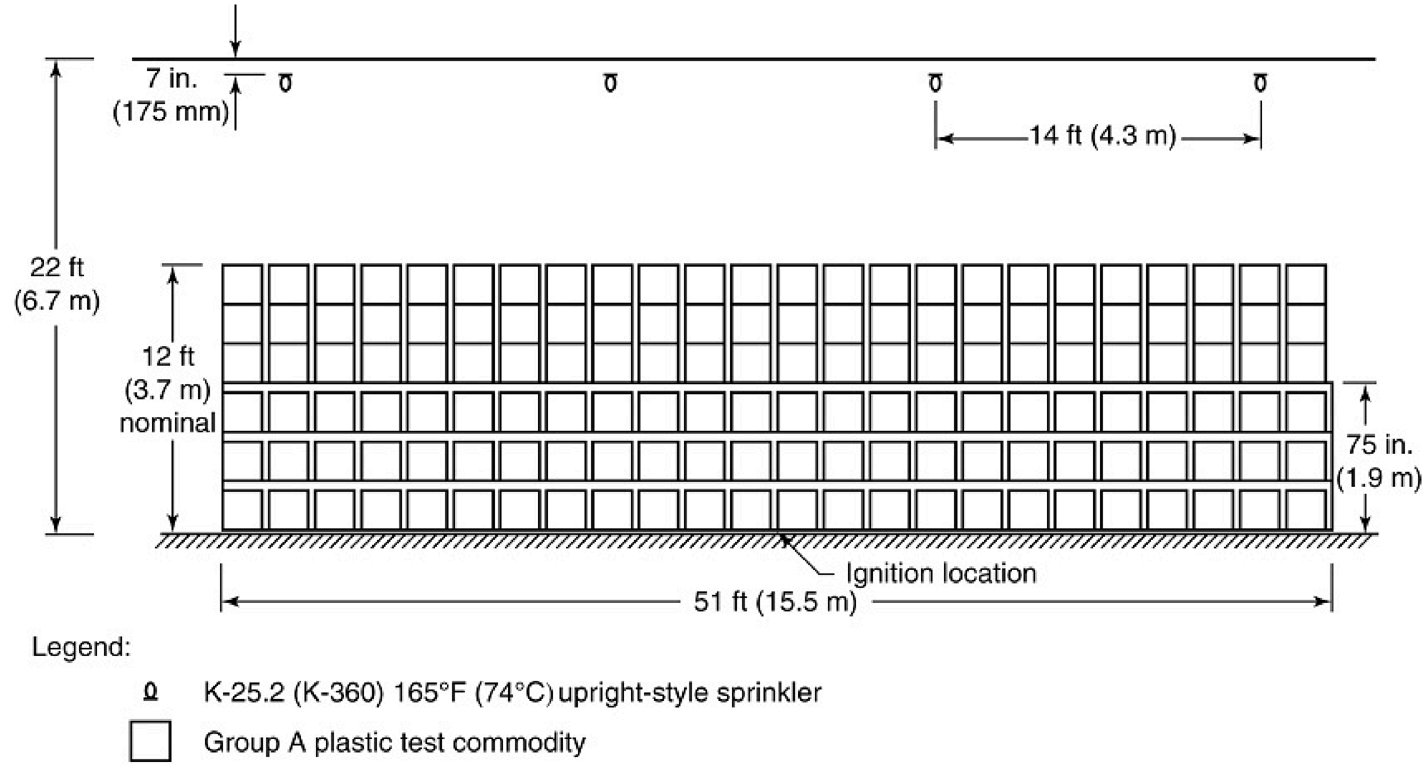
A.26.1.1

These storage configurations do not conform precisely with the storage arrangements detailed in Chapters 20 through 25. The designs are the result of specific research and test data that have been provided to support the specific protection requirements for the unique storage arrangements. The special sprinkler system designs for storage protection of Chapter 26 are options to general storage requirements.

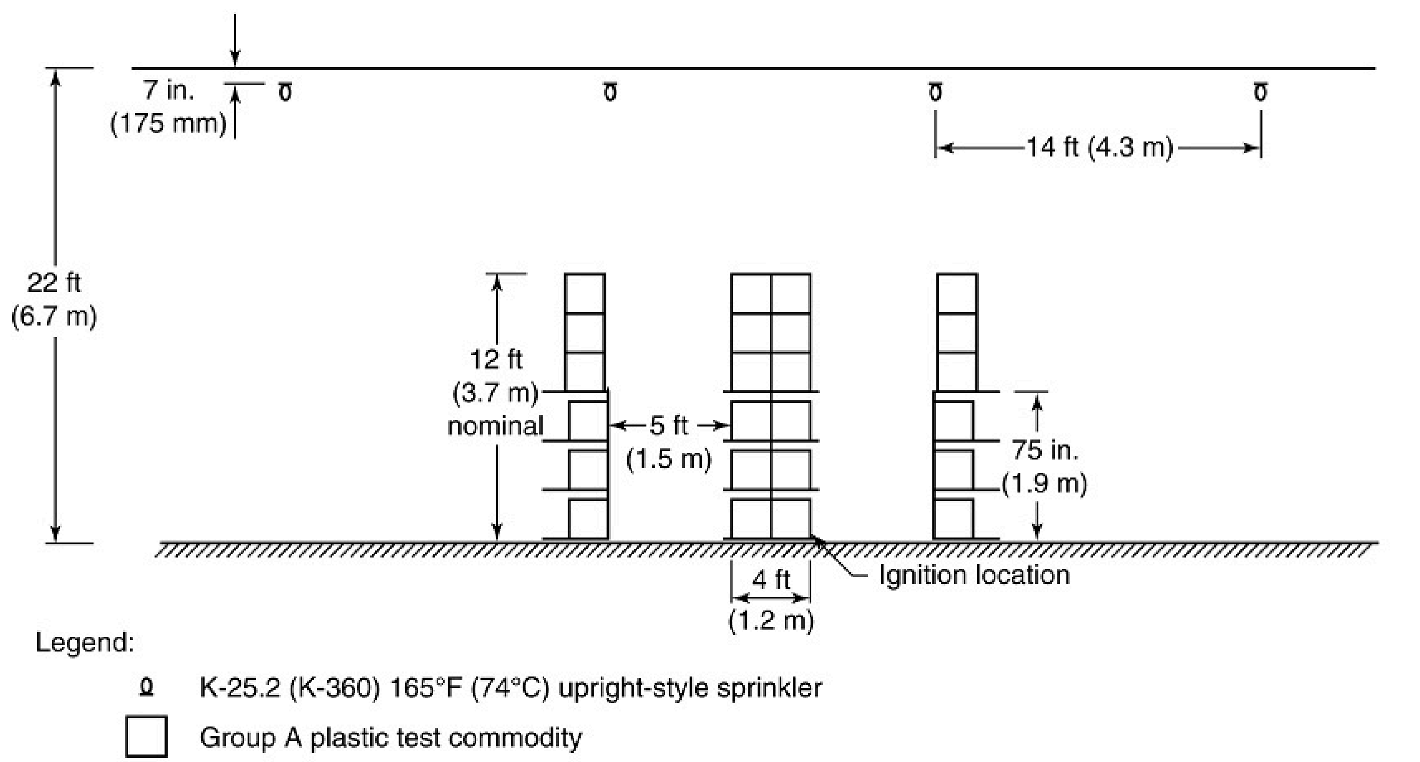
A.26.3

These special designs are based on fire heat release calorimeter tests and 11 full-scale tests conducted by the Retail Fire Research Coalition at Underwriters Laboratories in 2000 and 2007. *[See Figure A.26.3(a) through Figure A.26.3(f).]*

Figure A.26.3(a) Fire Test A1.

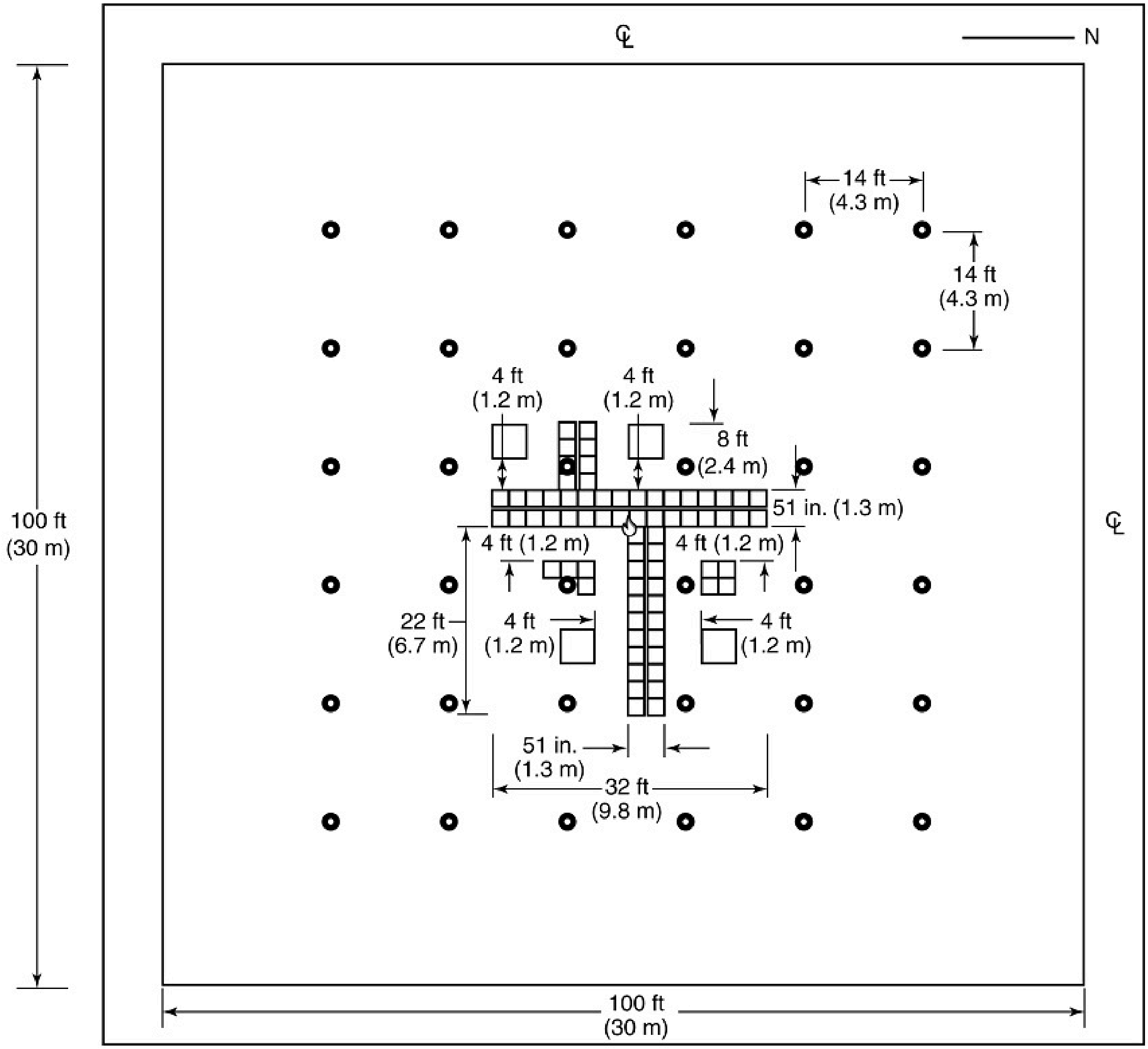


Side Elevation View of Main Array



Front Elevation View

Figure A.26.3(b) Fire Test A2.



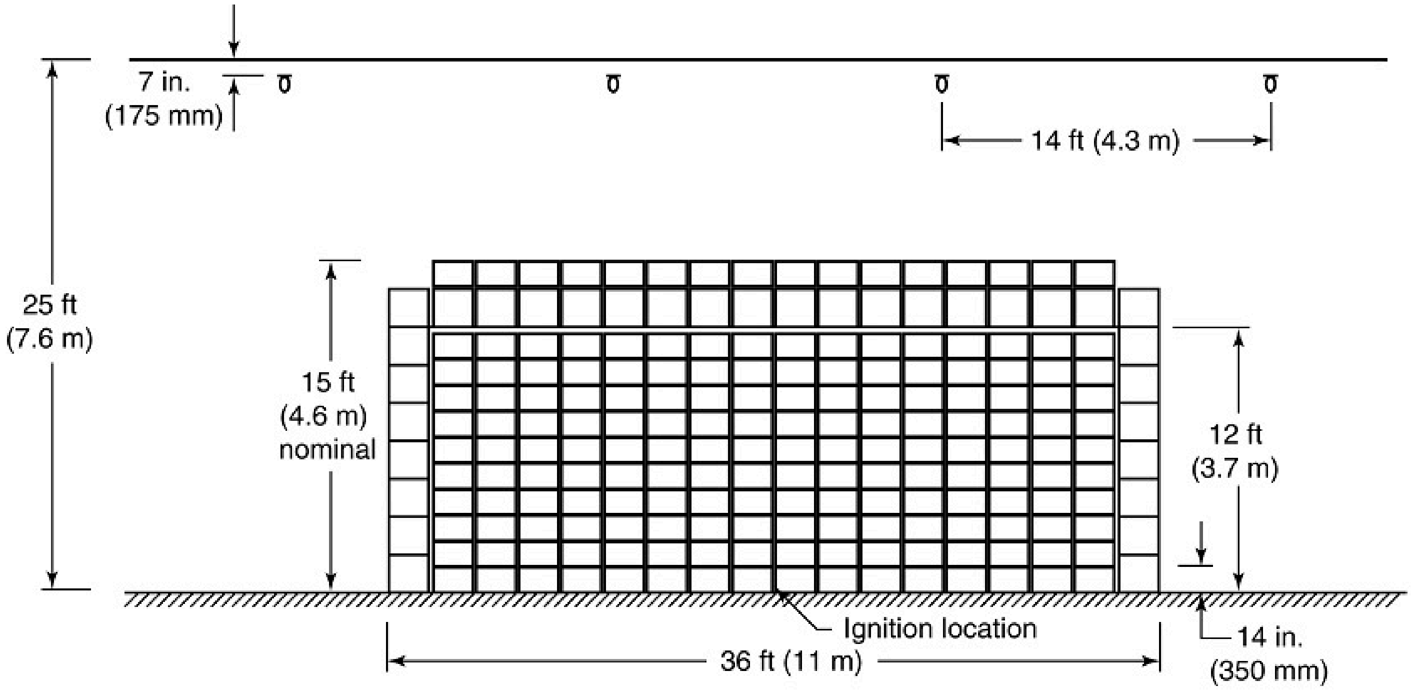
Shelving suspended on wire uprights at 24 in. (600 mm), 48 in. (1200 mm), 72 in. (1800 mm), 96 in. (2400 mm), and 120 in. (3000 mm) with a wire shelf at 148 in. (3.7 m)

Legend:

- K-25.2 (K-360) upright-style sprinkler 165°F (74°C) QR, 0.55 gpm/ft^2 (22.4 mm/min/m^2) water density for first four sprinkler operations, then 0.49 gpm/ft^2 (20 mm/min/m^2) for all additional operations
- Group A plastic test commodity
- Class II target commodity
- Ignition location

Plan View

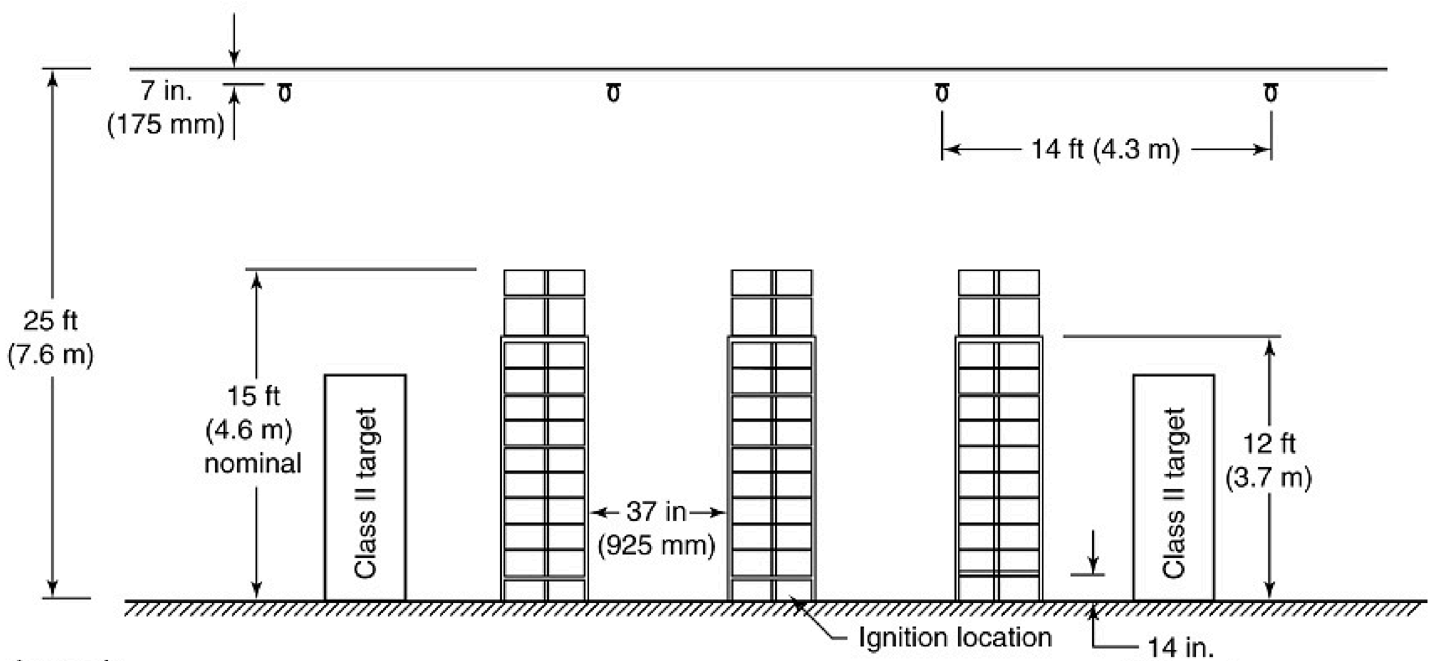
Figure A.26.3(c) Fire Test A3.



Legend:

- K-25.2 (K-360) 165°F (74°C) upright-style sprinkler
- Group A plastic test commodity nominal 12.25 in. (305 mm) tall
- Group A plastic test commodity nominal 21 in. (525 mm) tall

Side Elevation View of Main Array

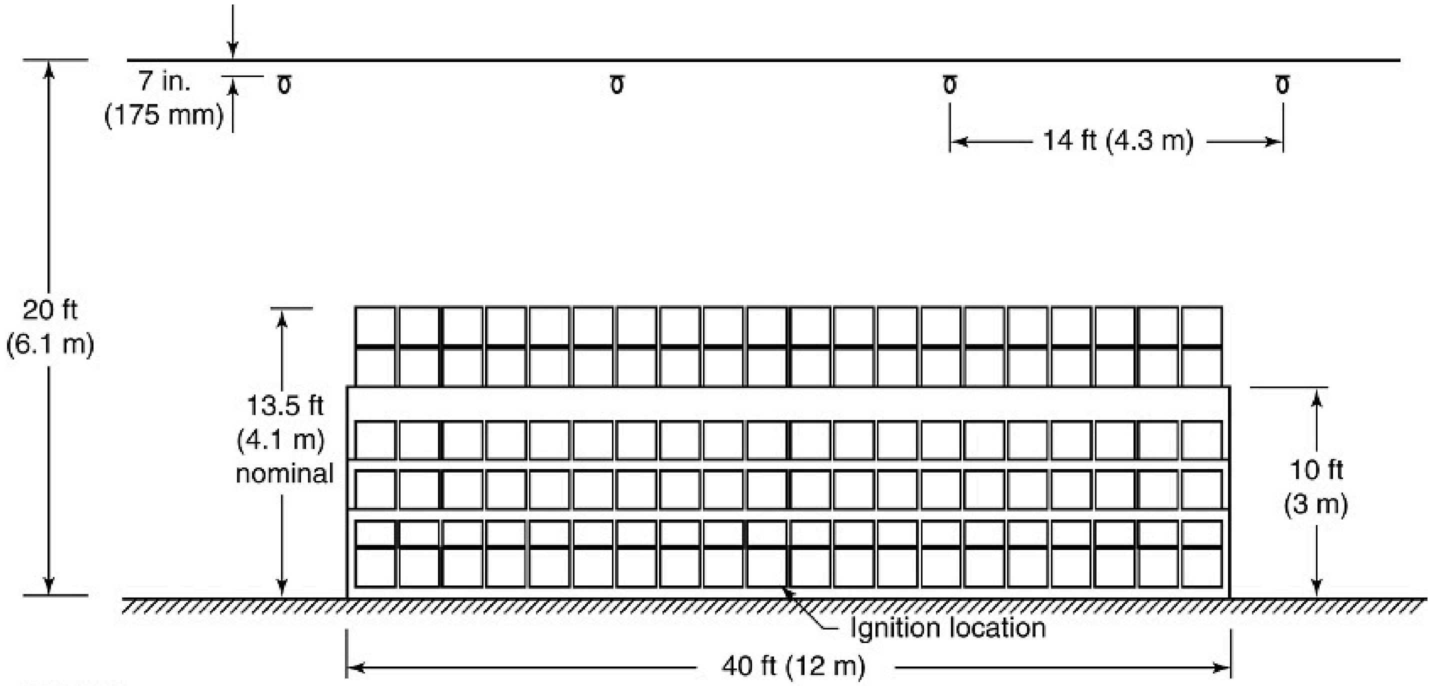


Legend:

- K-25.2 (K-360) 165°F (74°C) QR upright-style sprinkler
- Group A plastic test commodity nominal 12.25 in. (305 mm) tall
- Group A plastic test commodity nominal 21 in. (525 mm) tall

Front Elevation View

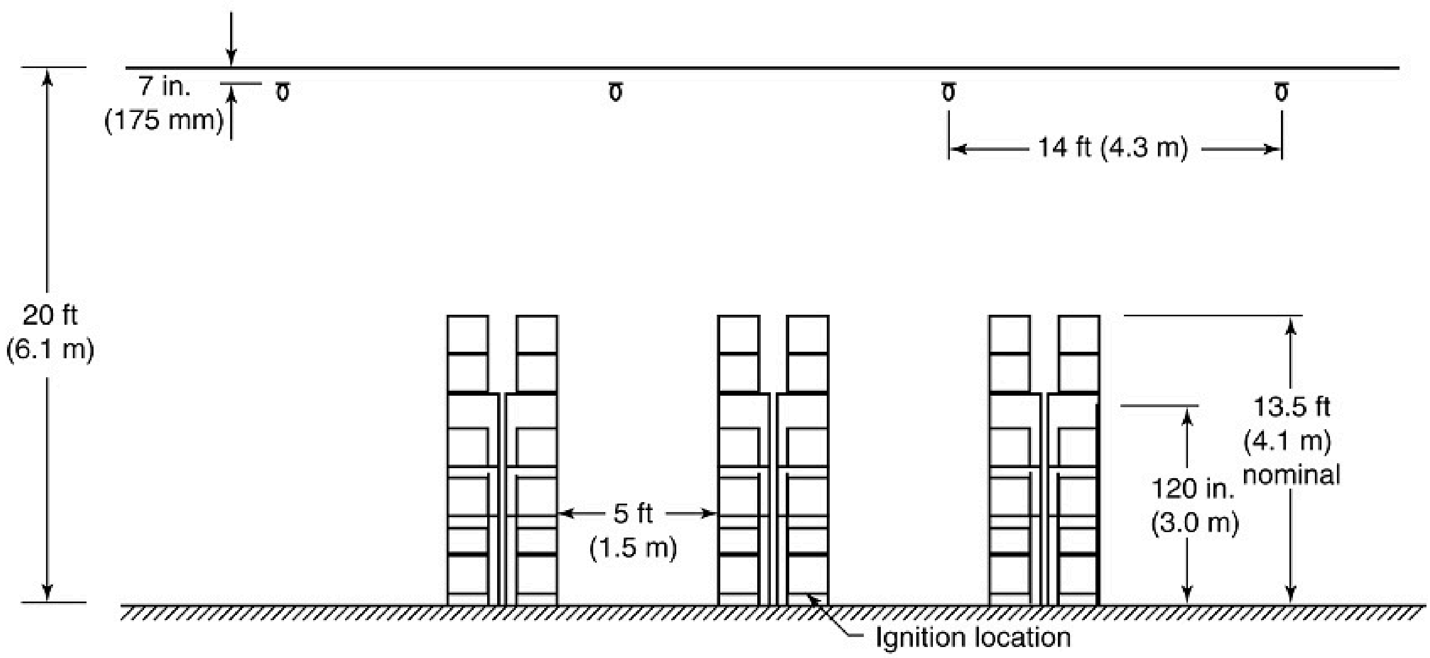
Figure A.26.3(d) Fire Test A4.



Legend:

- K-25.2 (K-360) 165°F (74°C) upright-style sprinkler
- Group A plastic test commodity nominal 12.25 in. (305 mm) tall
- Group A plastic test commodity nominal 21 in. (525 mm) tall

Side Elevation View of Main Array

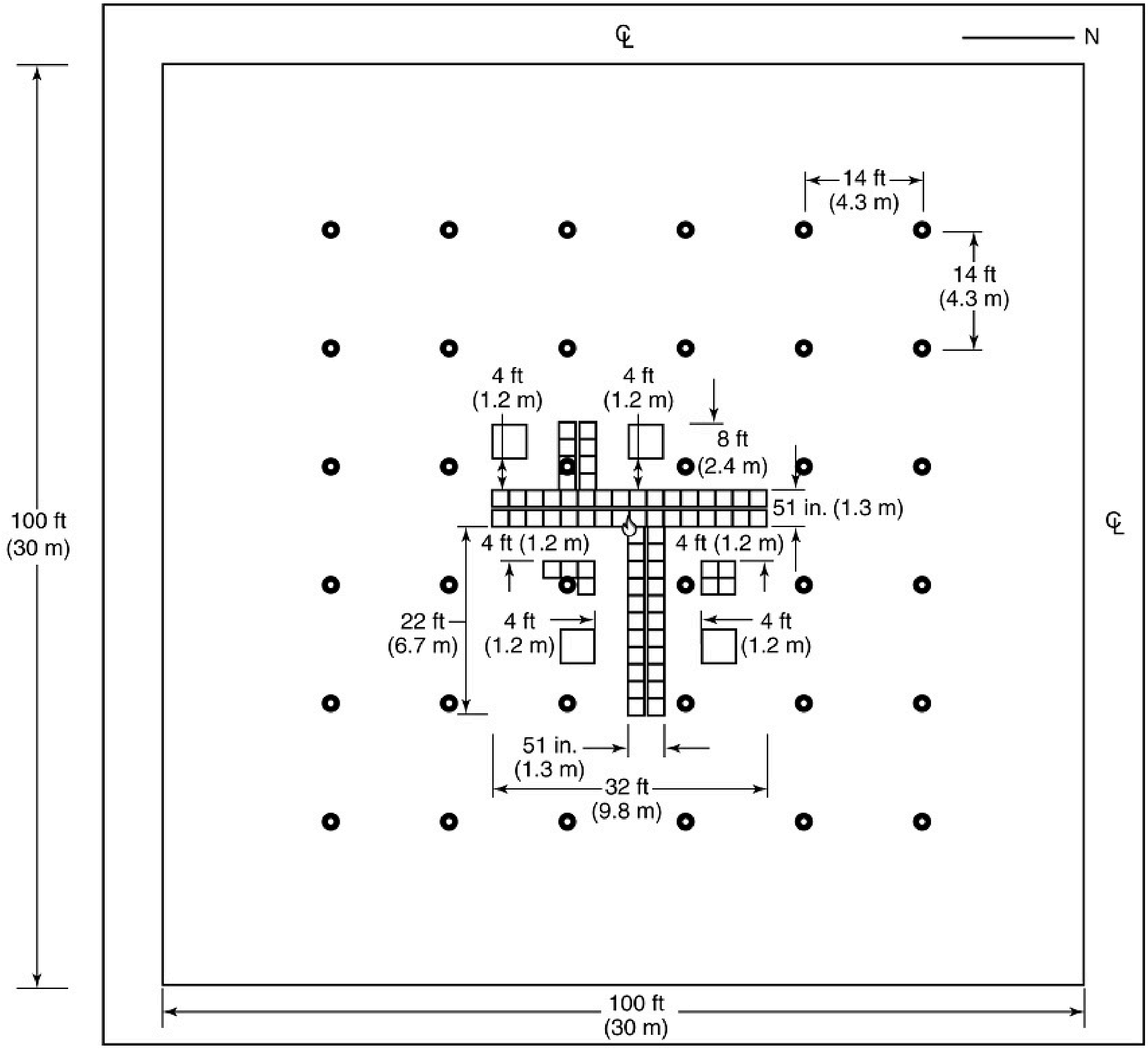


Legend:

- K-25.2 (K-360) 165°F (74°C) upright-style sprinkler
- Group A plastic test commodity nominal 12.25 in. (305 mm) tall
- Group A plastic test commodity nominal 21 in. (525 mm) tall

Front Elevation View

Figure A.26.3(e) Fire Test A6 — Plan View.



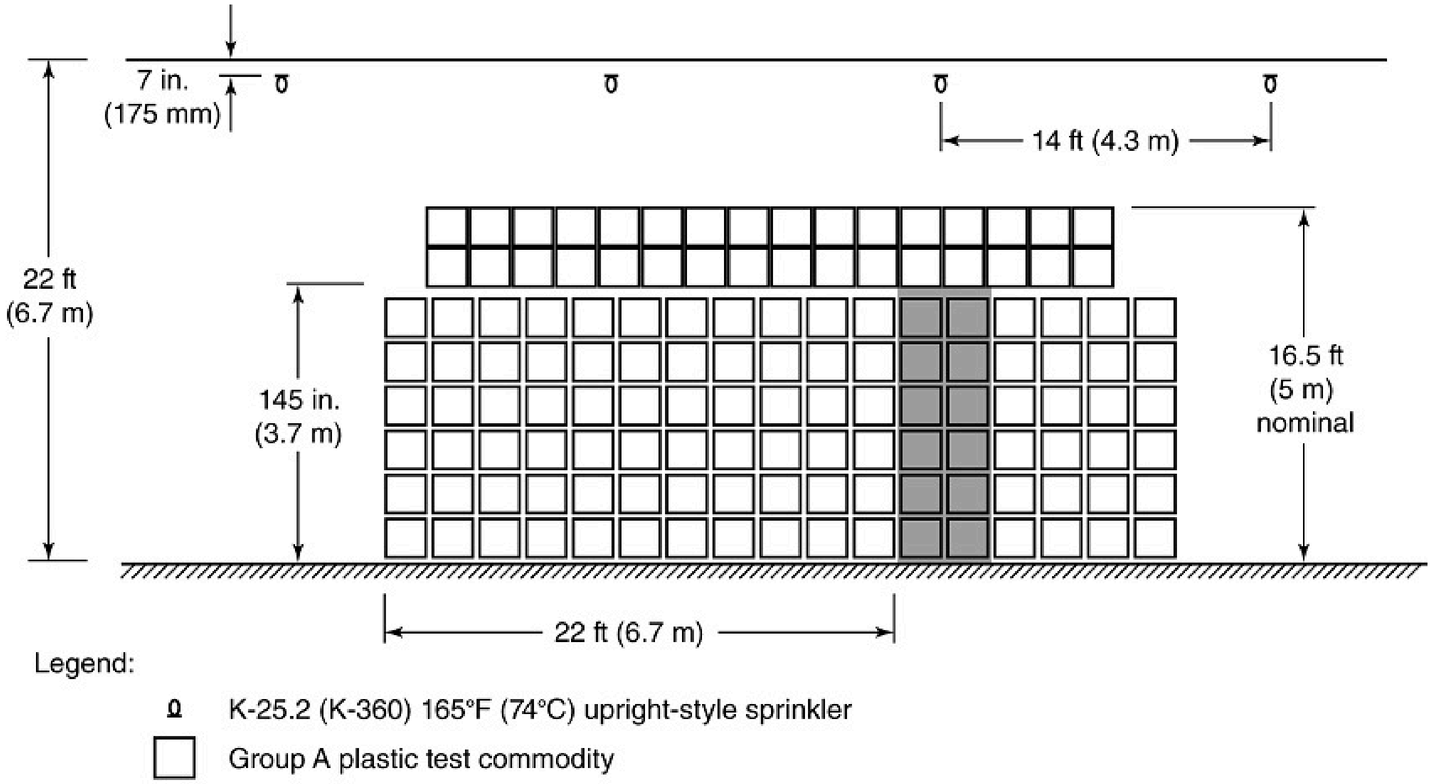
Shelving suspended on wire uprights at 24 in. (600 mm), 48 in. (1200 mm), 72 in. (1800 mm), 96 in. (2400 mm), and 120 in. (3000 mm) with a wire shelf at 148 in. (3700 mm)

Legend:

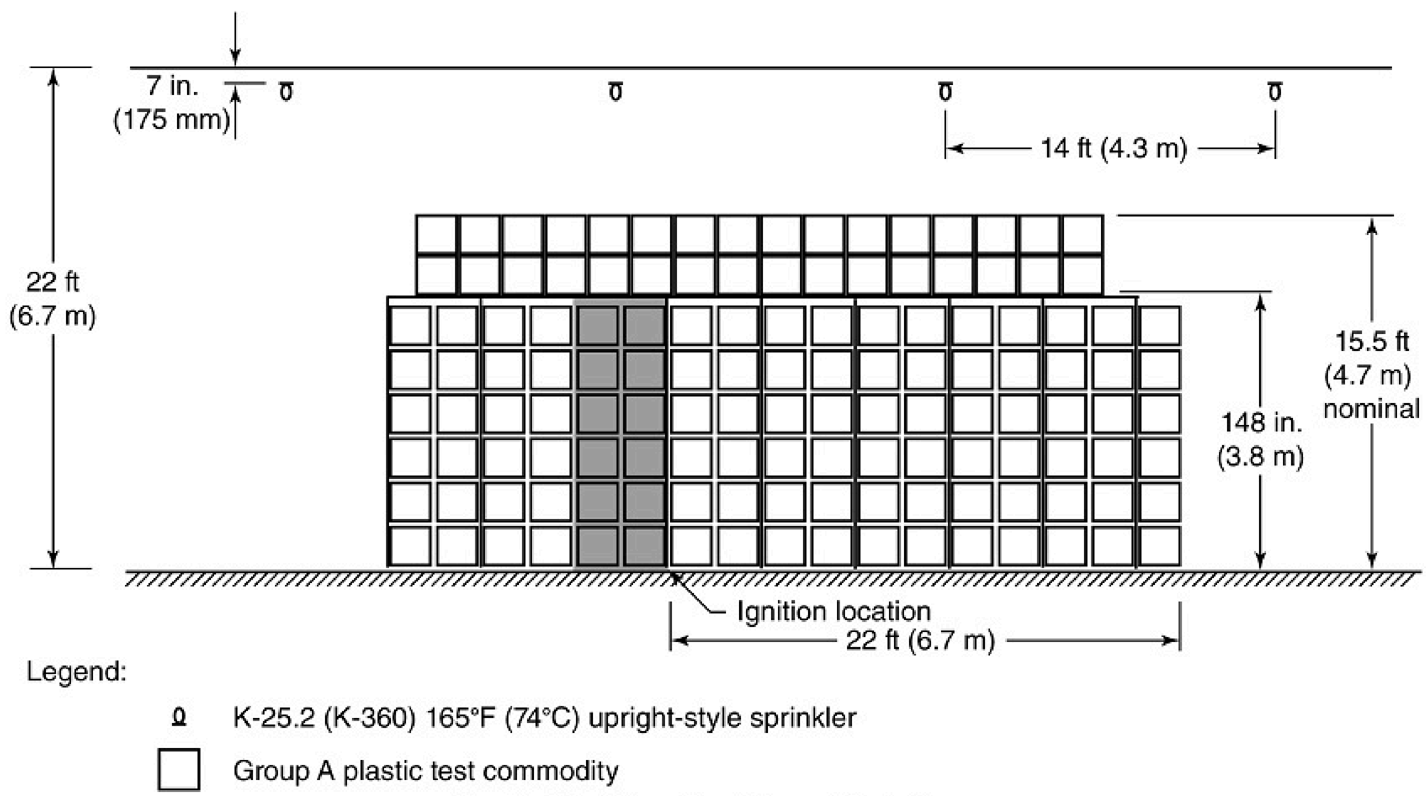
- K-25.2 (K-360) upright-style sprinkler 165°F (74°C) QR, 0.55 gpm/ft^2 (22.4 mm/min/m^2) water density for first four sprinkler operations, then 0.49 gpm/ft^2 (20 mm/min/m^2) for all additional operations
- Group A plastic test commodity
- Class II target commodity
- Ignition location

Plan View

Figure A.26.3(f) Fire Test A6 — Main Array (North/South).



North Side Elevation View of Main Array



South Side Elevation View of Main Array

A.26.5

For the protection of baled cotton, fire tests and actual fire experience indicate an initial low heat release; thus, sprinklers in the ordinary-temperature range should offer some advantage by opening faster than those of intermediate- or high-temperature classifications under similar conditions.

A.26.6.6.3.5

Figure A.26.6.6.3.5(a) through Figure A.26.6.6.3.5(c) illustrate a typical rack layout for cartoned record storage showing the design and installation of in-rack sprinklers underneath the catwalks and in the transverse flues.

Figure A.26.6.6.3.5(a) Typical Cartoned Record Storage Sprinkler Installation.

Figure A.26.6.6.3.5(b) Plan View of Sprinkler Locations in Cartoned Record Storage.

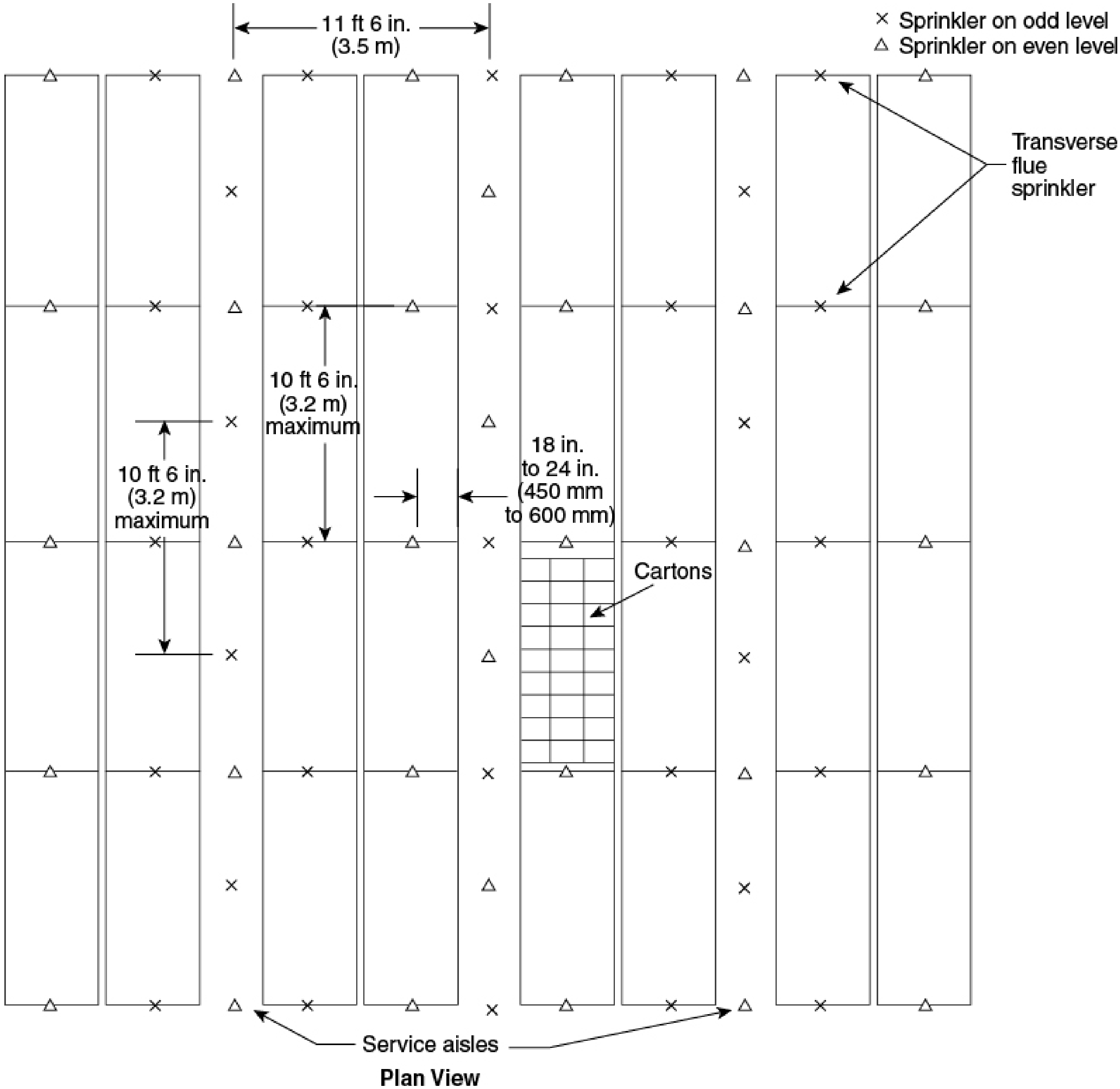
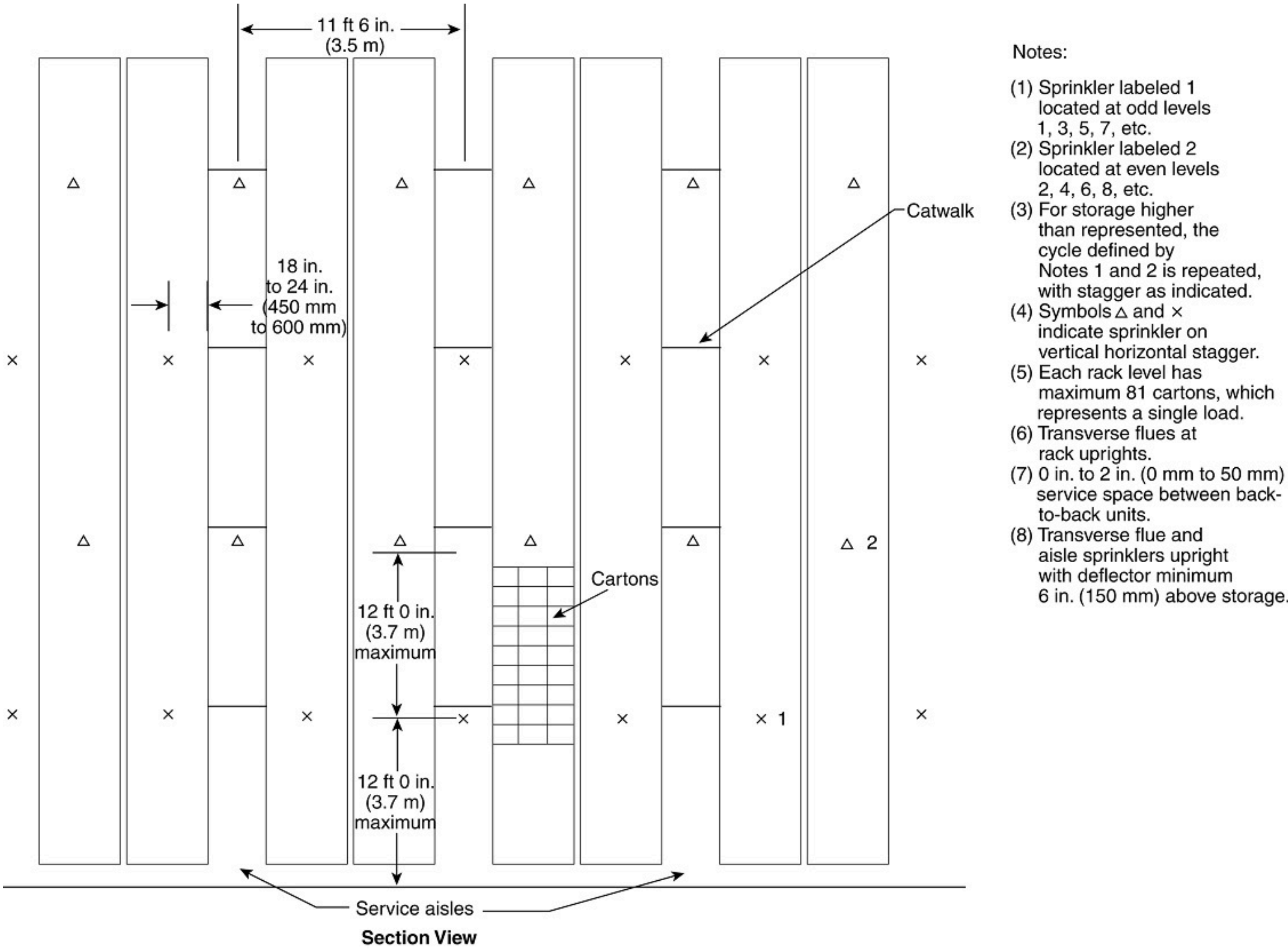


Figure A.26.6.6.3.5(c) Section View of Sprinkler Locations in Cartoned Record Storage.



A.26.7.1

NFPA 13 contains protection criteria for limited configurations of compact mobile storage units and materials stored. Storage arrangements not specifically addressed in NFPA 13 are outside the scope of the standard (i.e., protection for commodities other than paper files, magazines, or books in compact mobile storage units does not simply follow high-piled storage protection criteria for shelves or racks). Where compact mobile storage configurations outside the scope of NFPA 13 are to be utilized, they must be addressed on a case-by-case basis with consideration given to the fact that no known sprinkler protection criteria is currently available. Additional protection features, such as rated construction, barriers within the storage, consideration for safe locating away from vulnerable areas, and methods for control or exhausting of the smoke, should be considered.

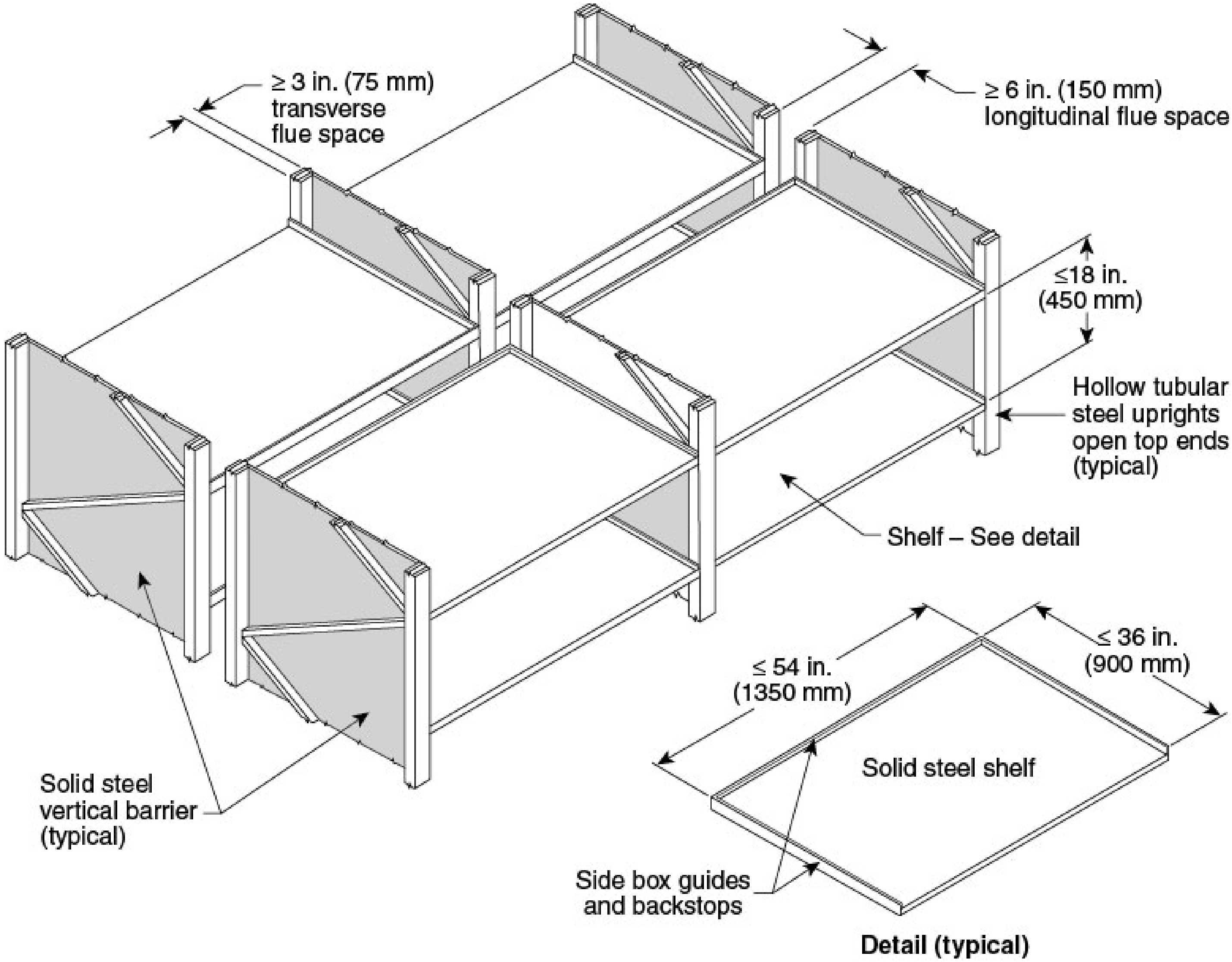
A.26.7.5

Steel barriers that are shown to have equivalent resistance to passage of flames and heat transfer in fire tests as solid 24 gauge (0.6 mm) steel barriers are permitted.

A.26.8.1

See Figure A.26.8.1.

Figure A.26.8.1 Typical Fixed High Bay Record Storage Structure.



A.28.1

Preliminary plans should be submitted for review to the authority having jurisdiction prior to the development of working plans *[see Figure A.28.1(a)]*. The preliminary plans can be part of the construction documents submitted in order to obtain a building permit. However, working drawings in accordance with Section 28.1 should be submitted and approved prior to the installation of system equipment. Preliminary plans should include as much information as is required to provide a clear representation of the hazard to be protected, the system design concept, the proposed water supply configuration, and the building construction information pertinent to the system layout and detailing.

The owner's information certificate, shown in Figure A.28.1(b), should be used to obtain a declaration of the intended use of the occupancy to be protected.

Drawings that accompany the certificate should include the following:

(1) Name of owner and occupant
(2) Location, including street address
(3) Point of compass
(4) Construction and occupancy of each building
(5) Building height in feet
(6) Waterflow test information and, if a waterflow test of the city main is available, indicate the following:
    (a) Date and time of the test
    (b) Name of party that conducted the test
    (c) Location of the hydrants where the flow was taken and where static and residual pressure readings were recorded *(see A.5.2.2)*
    (d) Size and configuration of mains supplying the hydrants
    (e) Size and number of open hydrant butts that were flowed
    (f) Results of the test

(g) Any required adjustments to water flow test information

(7) Building features such as combustible concealed spaces, floor openings, areas subject to freezing, and areas from which it is intended to omit sprinkler protection

(8) Proposed location and approximate size, if a water supply employing pumps or tanks is contemplated

(9) Name and address of party submitting the preliminary plans

(10) Tentative location of major piping, including mains underground, risers, overhead mains, and fire department connections

(11) The need for seismic protection and the applicable design spectral response acceleration at short periods (S_{DS})

Figure A.28.1(a) Typical Preliminary Plan.

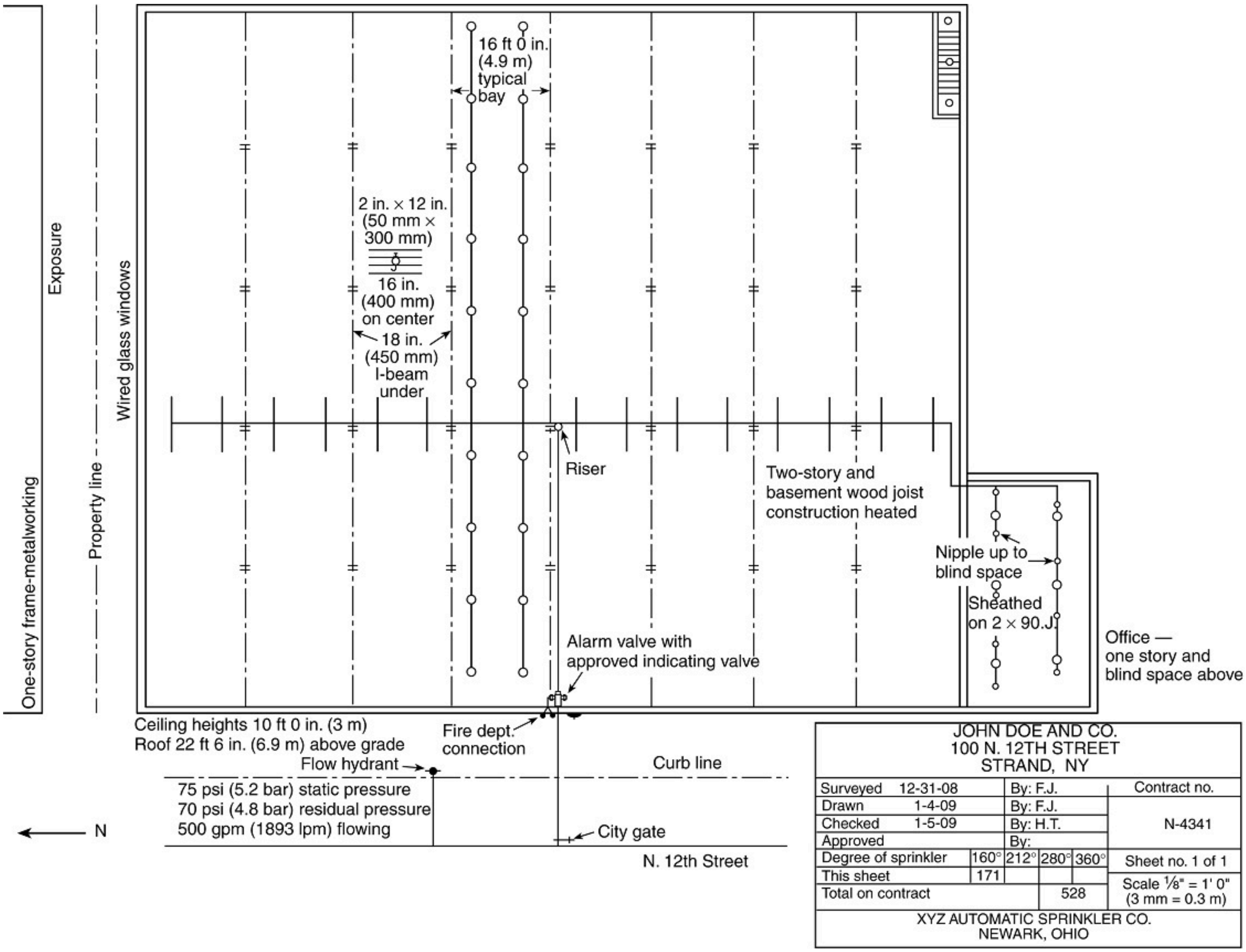


Figure A.28.1(b) Owner's Information Certificate.

OWNER'S INFORMATION CERTIFICATE

Name/address of property to be protected with sprinkler protection:

____

____

Name of owner: ______________________________

Existing or planned construction is:

- ❑ Fire resistive or noncombustible
- ❑ Wood frame or ordinary (masonry walls with wood beams)
- ❑ Unknown

Describe the intended use of the building: ______________________________

____

____

Note regarding speculative buildings: The design and installation of the fire sprinkler system is dependent on an accurate description of the likely use of the building. Without specific information, assumptions will need to be made that will limit the actual use of the building. Make sure that you communicate any and all use considerations to the fire sprinkler contractor in this form and that you abide by all limitations regarding the use of the building based on the limitations of the fire sprinkler system that is eventually designed and installed.

Is the system installation intended for one of the following special occupancies:

Aircraft hangar	❑ Yes	❑ No
Fixed guideway transit system	❑ Yes	❑ No
Race track stable	❑ Yes	❑ No
Marine terminal, pier, or wharf	❑ Yes	❑ No
Airport terminal	❑ Yes	❑ No
Aircraft engine test facility	❑ Yes	❑ No
Power plant	❑ Yes	❑ No
Water-cooling tower	❑ Yes	❑ No

If the answer to any of the above is "yes," the appropriate NFPA standard should be referenced for sprinkler density/area criteria.

Indicate whether any of the following special materials are intended to be present:

Flammable or combustible liquids	❑ Yes	❑ No
Aerosol products	❑ Yes	❑ No
Nitrate film	❑ Yes	❑ No
Pyroxylin plastic	❑ Yes	❑ No
Compressed or liquefied gas cylinders	❑ Yes	❑ No
Liquid or solid oxidizers	❑ Yes	❑ No
Organic peroxide formulations	❑ Yes	❑ No
Idle pallets	❑ Yes	❑ No

If the answer to any of the above is "yes," describe type, location, arrangement, and intended maximum quantities.

____

____

Indicate whether the protection is intended for one of the following specialized occupancies or areas:

Spray area or mixing room	❏ Yes	❏ No
Solvent extraction	❏ Yes	❏ No
Laboratory using chemicals	❏ Yes	❏ No
Oxygen-fuel gas system for welding or cutting	❏ Yes	❏ No
Acetylene cylinder charging	❏ Yes	❏ No
Production or use of compressed or liquefied gases	❏ Yes	❏ No
Commercial cooking operation	❏ Yes	❏ No
Class A hyperbaric chamber	❏ Yes	❏ No
Cleanroom	❏ Yes	❏ No
Incinerator or waste handling system	❏ Yes	❏ No
Linen handling system	❏ Yes	❏ No
Industrial furnace	❏ Yes	❏ No
Water-cooling tower	❏ Yes	❏ No

If the answer to any of the above is "yes," describe type, location, arrangement, and intended maximum quantities.

____

____

Will there be any storage of products over 12 ft (3.7 m) in height? ❏ Yes ❏ No

If the answer is "yes," describe product, intended storage arrangement, and height.

____

____

Will there be any storage of plastic, rubber, or similar products over 5 ft (1.5 m) high except as described above?
❏ Yes ❏ No

If the answer is "yes," describe product, intended storage arrangement, and height.

____

____

Is there any special information concerning the water supply? ❏ Yes ❏ No

If the answer is "yes," provide the information, including known environmental conditions that might be responsible for corrosion, including microbiologically influenced corrosion (MIC).

Determine and confirm the water supply including any necessary adjustments: ______________________

____

____

Is seismic protection required? ❏ Yes ❏ No
Provide design spectral response acceleration at short periods (S_{DS}): ______________________

____

I certify that I have knowledge of the intended use of the property and that the above information is correct.

Signature of owner's representative or agent: ______________________ Date: ____________

Name of owner's representative or agent completing certificate (print): ______________________

Relationship and firm of agent (print): ______________________

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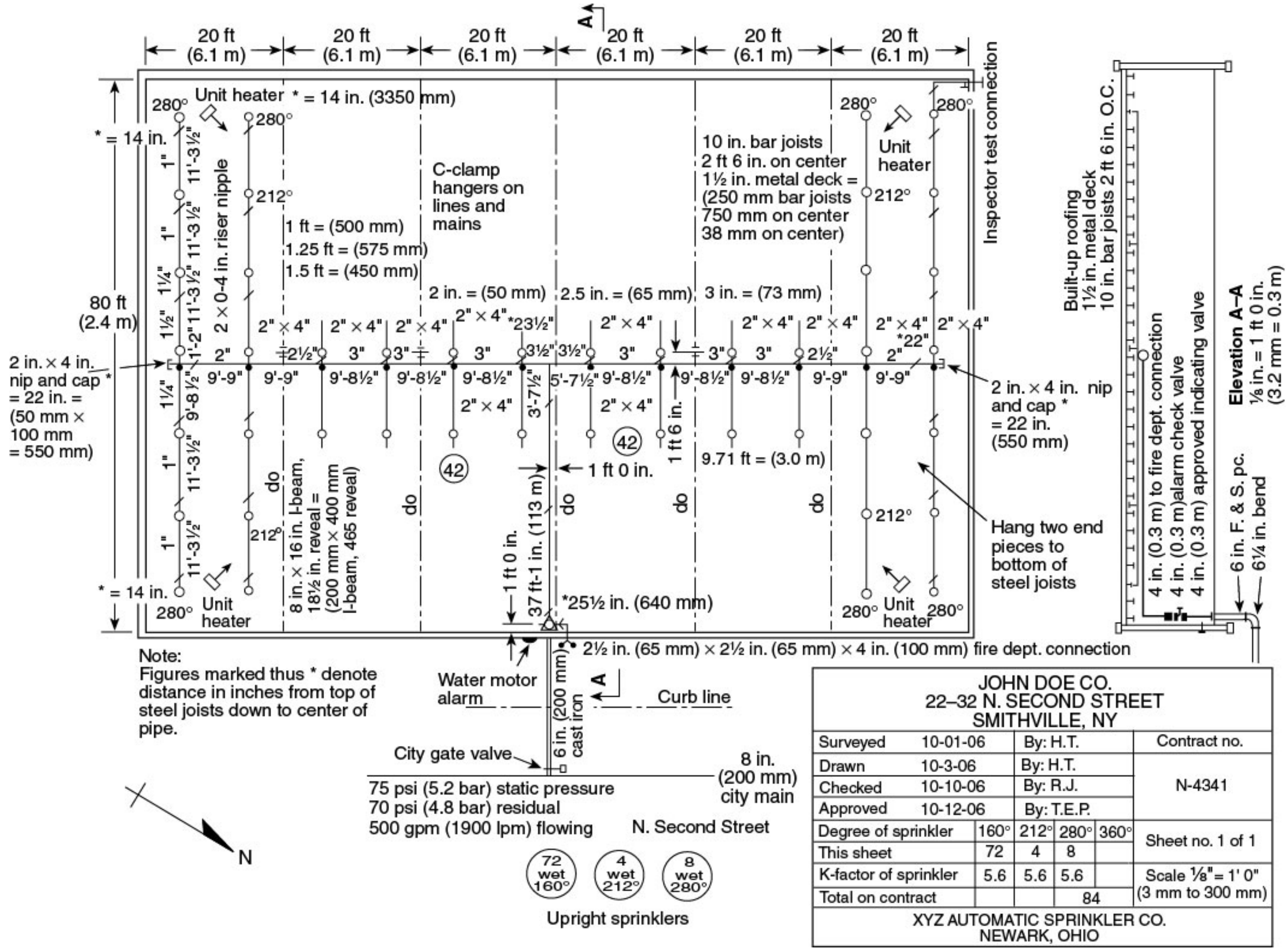
A.28.1.1

See Figure A.28.1.1.

Figure A.28.1.1 Typical Working Plans.



A.28.1.1.1(4)

It is the intent to provide the owner's certificate for all new systems and where there is a change of occupancy and/or building use.

A.28.1.3(4)

It might not be necessary to show details of the structural member(s) in every cross section or schematic. However, it is important to show details of the structural members when they have an impact on sprinkler performance such as with ESFR sprinklers or when the structural member creates an obstruction to the spray patterns of sprinklers.

A.28.1.3(11)

Examples of such major mechanical, plumbing, and electrical equipment include, but are not limited to, ducts, piping, cable trays, and air handling and heating units.

A.28.1.3(12)

Examples of such major structural members include, but are not limited to, beams, joists, and ceiling and roof deck types.

A.28.1.3(13)

Examples of such major structural members include, but are not limited to, walls, floors, ceilings, and roof systems.

A.28.1.3(16)(b)ii.

Examples of such configurations include, but are not limited to, solid piled, rack, shelf, and palletized.

A.28.2.1

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 that can be required to carry water to the new work.

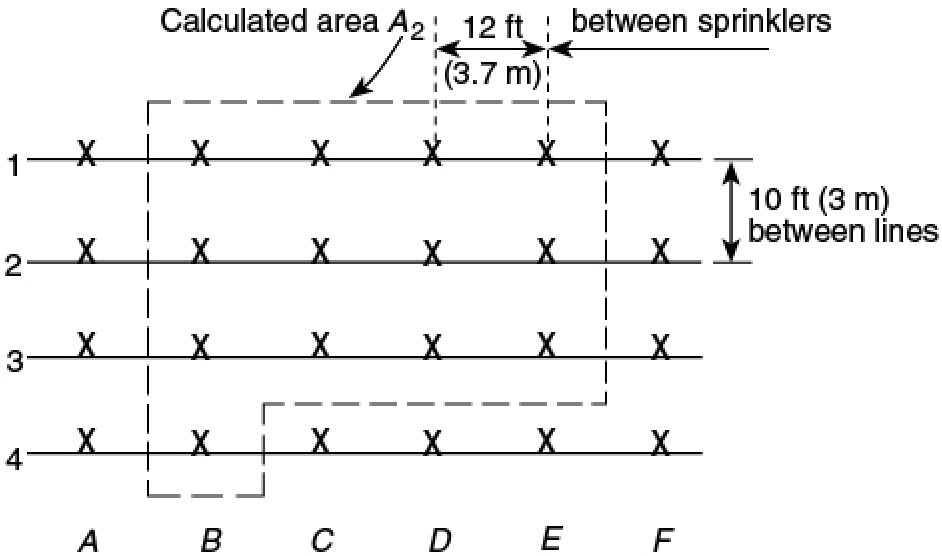
A.28.2.1.4

NFPA 13 does not provide a specific velocity limitation for the use of the Hazen-Williams formula. This is, in part, due to an expectation that excessive friction loss values will result in increasing pipe sizes, thereby serving as an inherent limit on velocity. However, the fact that NFPA 13 does not provide a specific limit should not be taken as an endorsement that the formula can be used for any velocity of water flow. The formula was empirically determined using "normal" conditions. When the velocity in the pipe exceeds that which was used to determine the formula, the formula might no longer be valid. There has been some research performed (Huggins 1996) in which results using the Hazen-Williams formula and the Darcy-Weisbach formula were compared, and the conclusion was that a specific velocity limit applied to all pipe sizes is not appropriate.

A.28.2.4

See Figure A.28.2.4.

Figure A.28.2.4 Example of Determining the Number of Sprinklers to Be Calculated.



Notes:

1. For gridded systems, the extra sprinkler (or sprinklers) on branch line 4 can be placed in any adjacent location from *B* to *E* at the designer's option.
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 ft² (139 m²) with sprinkler coverage of 120 ft² (11.1 m²)

$$\text{Total sprinklers to calculate} = \frac{\text{Design area}}{\text{Area per sprinkler}}$$

$$= \frac{1500\ (139\ \text{m}^2)}{120\ (11.1\ \text{m}^2)} = 12.5\text{, calculate } 13$$

$$\text{Number of sprinklers on branch line} = \frac{1.2\sqrt{A}}{S}$$

Where:
A = design area
S = distance between sprinklers on branch line

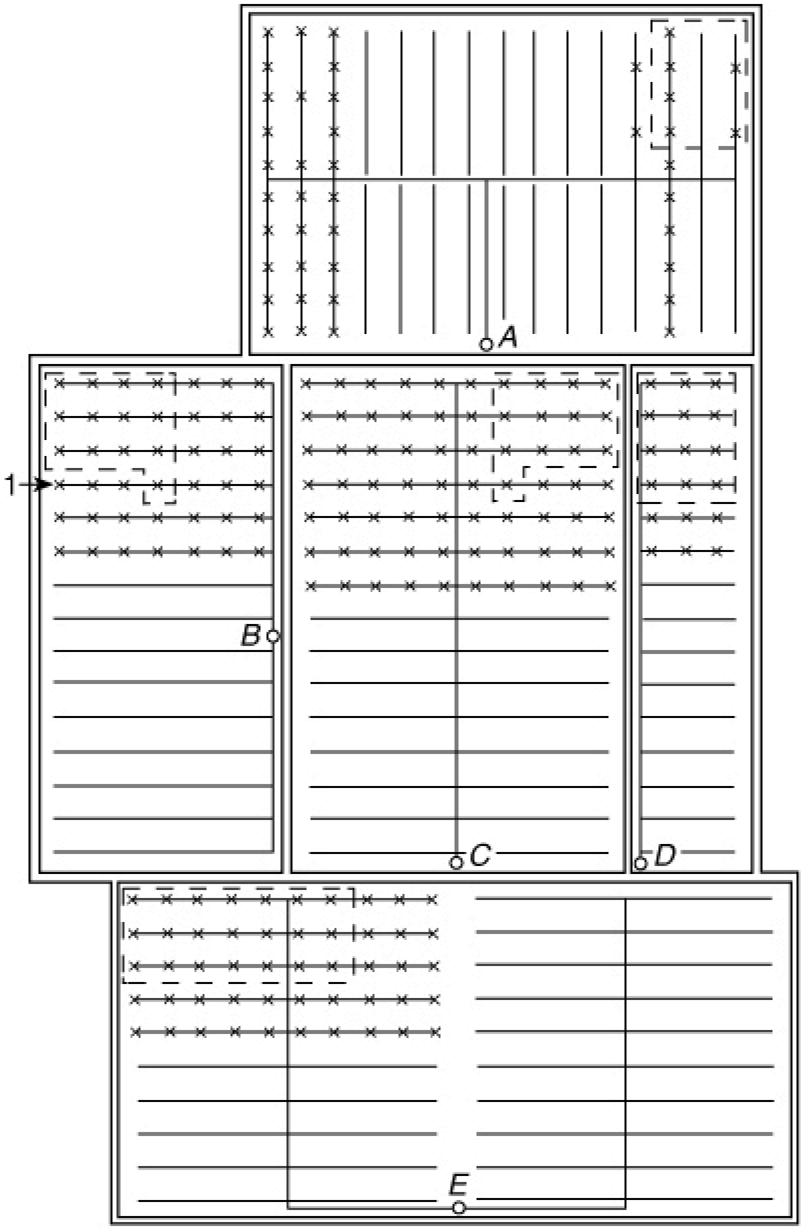
$$\text{Number of sprinklers on branch line} = \frac{1.2\sqrt{1500}}{12} = 3.87$$

For SI units, 1 ft = 0.3048 m; 1 ft² = 0.0929 m².

A.28.2.4.1

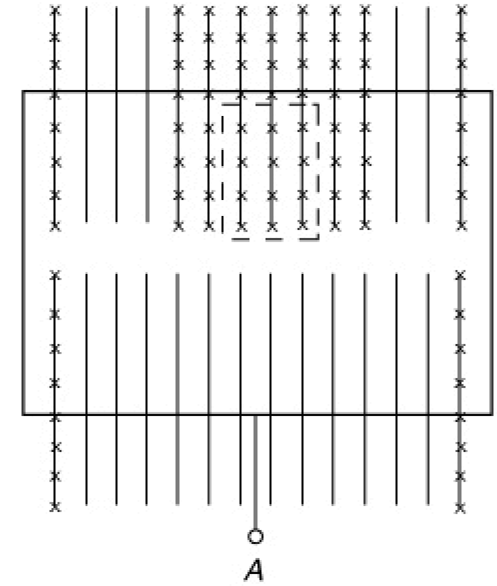
See Figure A.28.2.4.1(a), Figure A.28.2.4.1(b), and Figure A.28.2.4.1(c).

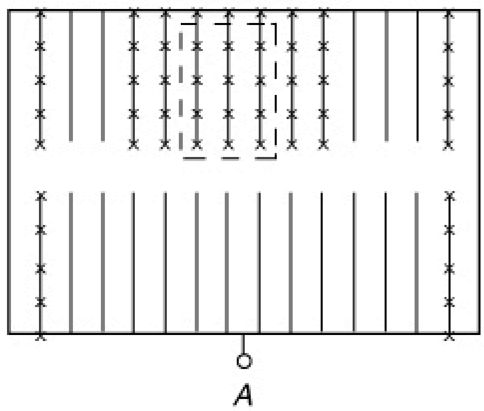
Figure A.28.2.4.1(a) Example of Hydraulically Most Demanding Area.

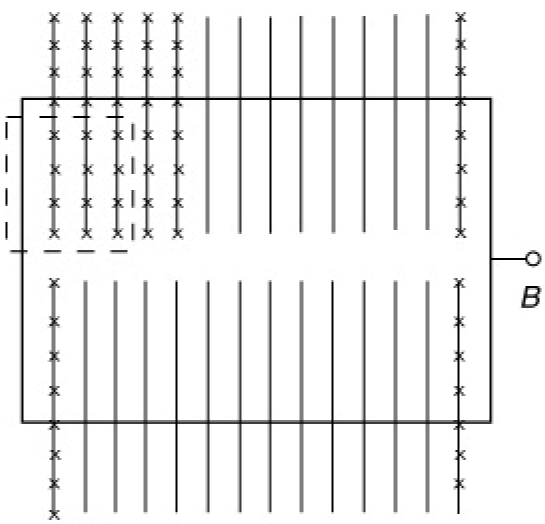


1 This sprinkler is not in the selected area of operation.

Figure A.28.2.4.1(b) Example of Hydraulically Most Demanding Area for Various Piping Arrangements.


A


A


B

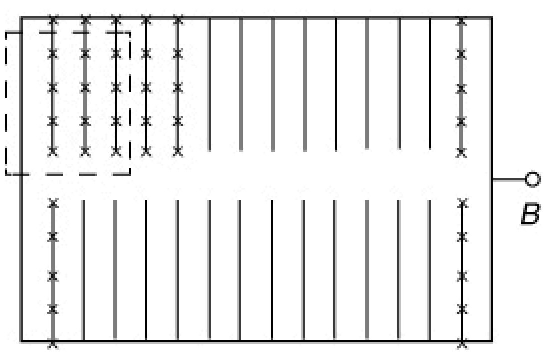
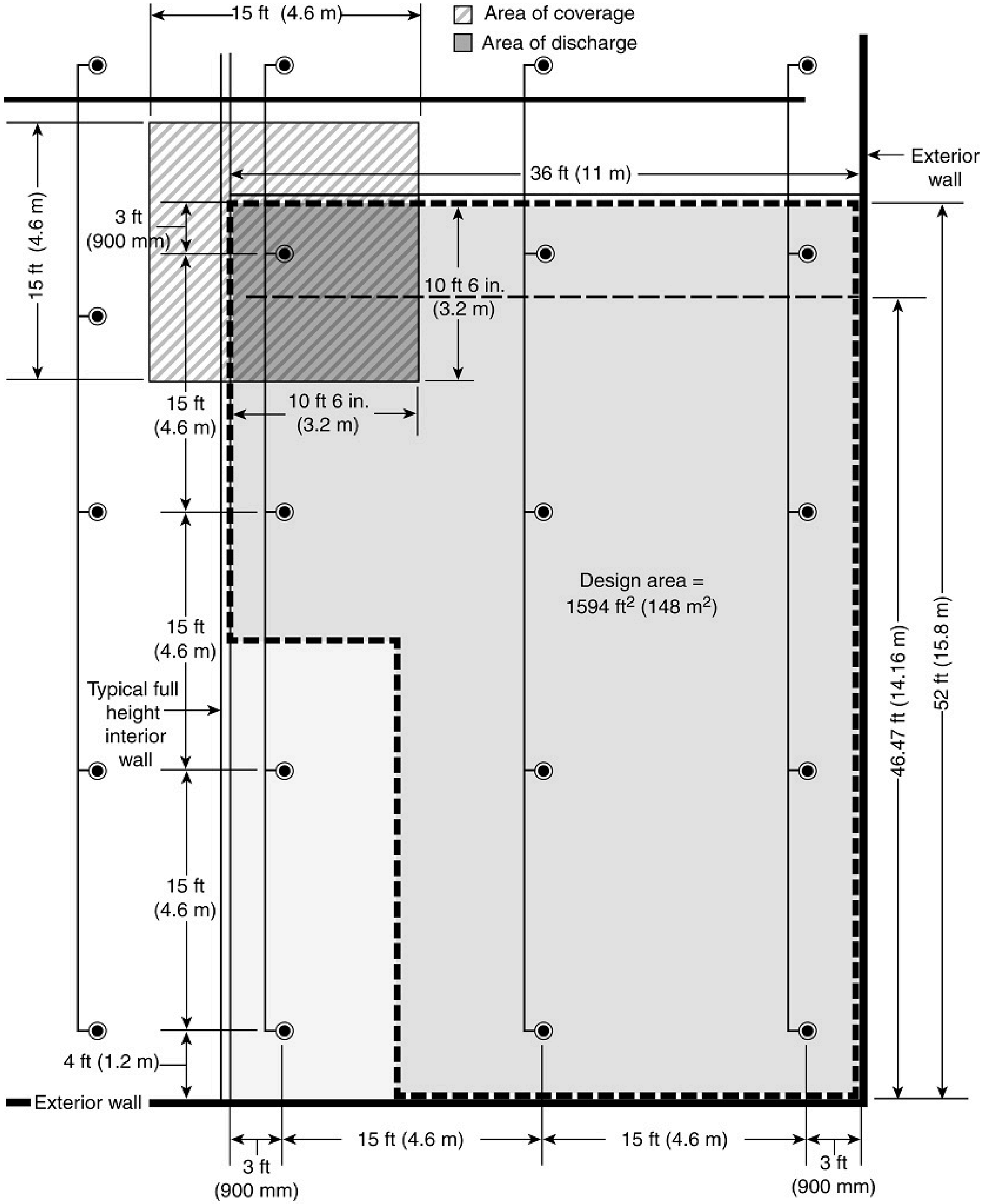

B

Figure A.28.2.4.1(c) Example of Hydraulically Most Demanding Area Boundary When Interior Walls are Present.

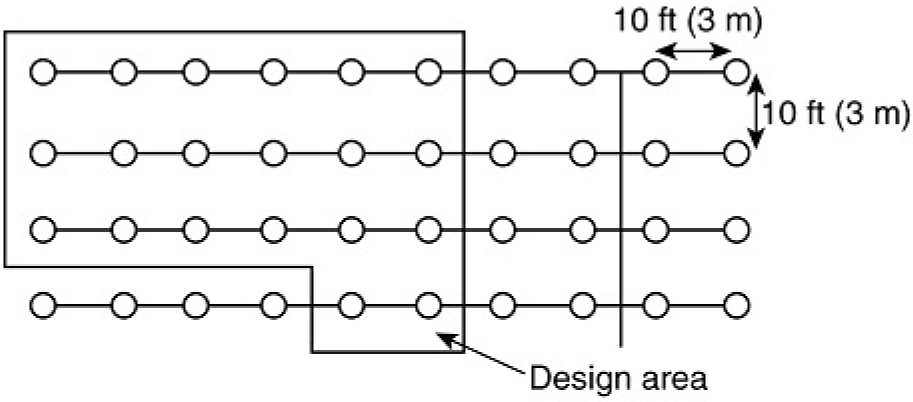


Notes:
(1) Full height walls impact the design area boundaries.
(2) Sprinkler spacing: 15 ft × 15 ft (4.6 m × 4.6 m)
Mimimum area of operations: 1500 ft^2 (140 m^2)
(3) Number of sprinklers on a branch line: $(1.2\sqrt{1500})/15 = 3.09$ (calculate 4)
Mimimum length of design area (parallel to branch lines): $1.2\sqrt{1500} = 46.47$ ft (14.16 m)

A.28.2.4.2.1

The word “rectangular” in this section is not meant to imply that the design area always has to be a rectangle. Instead, the intent is to require a design area with sides that meet at right angles and the longer side parallel to the branch lines. In many cases, this will be a perfect rectangle with four sides. However, in some cases with multiple sprinklers on multiple branch lines within the design area, the design area can be satisfied with fewer sprinklers on the last branch line than on the first, resulting in a design area that is a rectangle with the corner cut out as shown in Figure A.28.2.4.2.1.

Figure A.28.2.4.2.1 Example of Nonsymmetrical Hydraulically Most Demanding Area.



Discharge criteria: 0.45 gpm^2/2000 ft^2 (18.3 mm/min/m^2)/185 m^2
20 sprinklers in design area 1.2(2000)0.5/10 (185 m^2) = 5.3 rounded
up to 6 sprinklers per branch line.
Note that the design area is not a perfect rectangle.
The 2000 ft^2 (185 m^2) requirement can be met with fewer sprinklers on the fourth branch line back, so there is no need to include the additional four sprinklers on the fourth branch line.

A.28.2.4.2.3.1

For most tree and loop systems, the hydraulically most demanding sprinklers will be those closest to the cross main. For gridded systems, the hydraulically most remote sprinklers could end up being any of those along the adjacent branch line, grouped together within the 1.2 length.

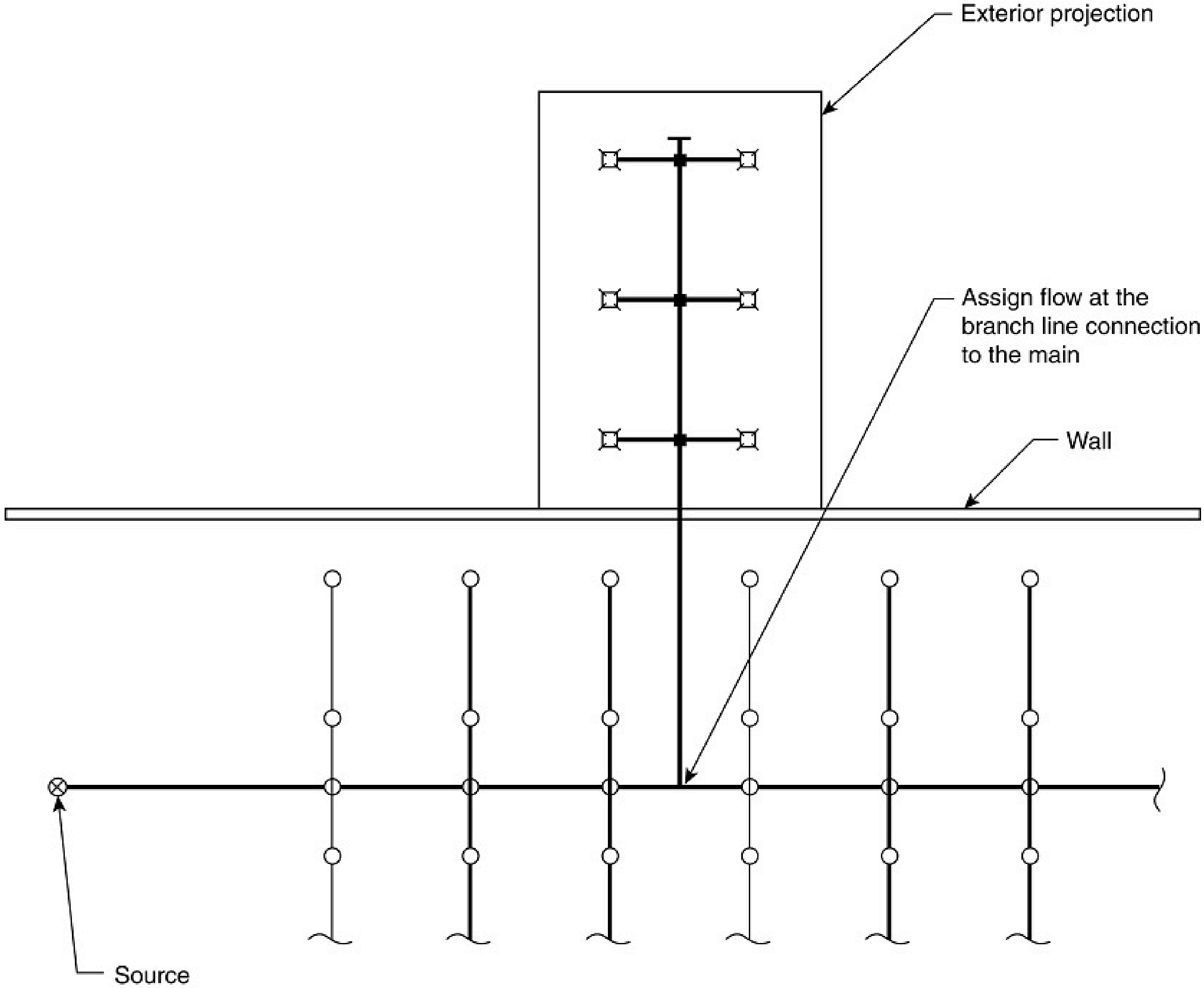
A.28.2.4.2.5

The following steps outline the procedure for calculation in accordance with 28.2.4.2.4:

(1) Calculate the hydraulic design discharge including those sprinklers within the available floor area.
(2) Calculate the minimum required discharge by multiplying the required design density times the required minimum design area.
(3) Subtract the discharge calculated in Step 1 from the discharge calculate in Step 2.
(4) Where the discharge calculated in Step 3 is greater than 0, the hydraulic design discharge is recalculated including an additional flow equal to that calculated in Step 3. The additional flow is added at the point of connection of the branch line to the cross main furthest from the source.
(5) Where the discharge calculated in Step 3 is less than or equal to 0, the hydraulic design discharge is as calculated in Step 1.

See Figure A.28.2.4.2.5 for an example of the point of connection for additional flow.

Figure A.28.2.4.2.5 Point of Connection for Additional Flow.



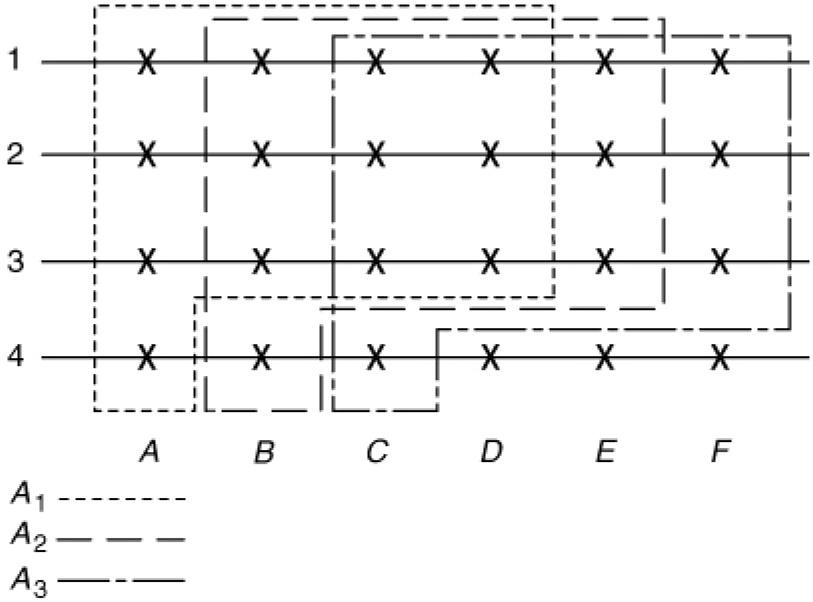
A.28.2.4.2.6

When determining the hydraulic design area, walls and physical barriers that can impact water distribution, as well as fire load, and growth of radiant heat need to be considered. Extending the hydraulic design area beyond a wall should not be done and spacing directly between sprinklers should not be used for hydraulic advantage. All areas of operation should represent the most demanding area of operation based on the actual piping configuration and consideration for the use of the building.

A.28.2.4.5

See Figure A.28.2.4.5.

Figure A.28.2.4.5 Example of Determining the Most Remote Area for Gridded System.



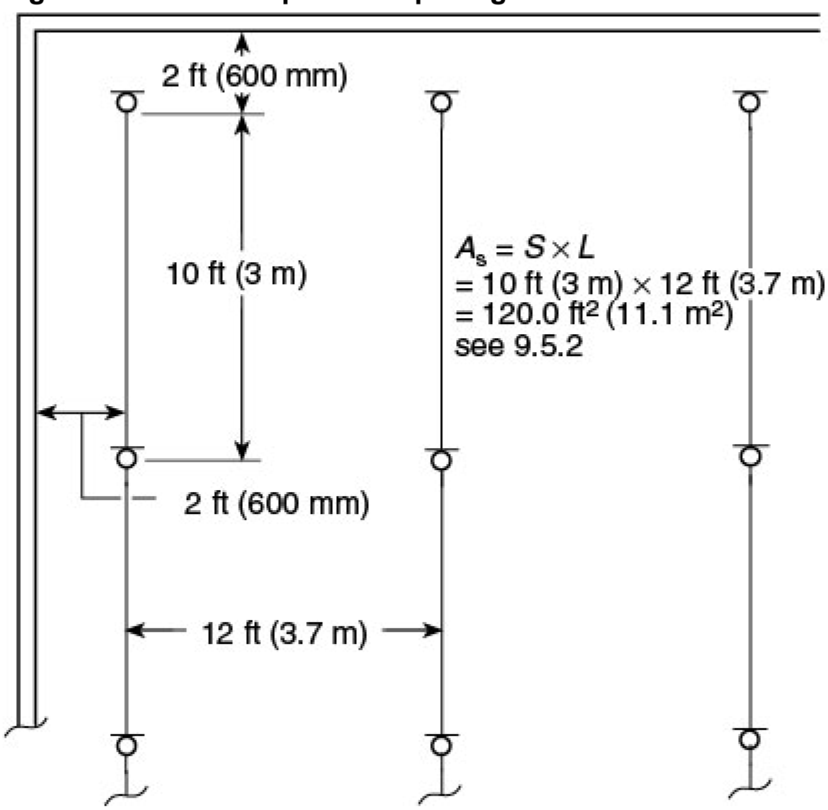
A.28.2.4.6.1

When listed with antifreeze solution, sprinklers should be hydraulically calculated in accordance with the listing and manufacturer's instructions.

A.28.2.4.6.2

See Figure A.28.2.4.6.2.

Figure A.28.2.4.6.2 Sprinkler Spacing.



A.28.2.4.6.5

Where the slope is parallel with the branch lines, the area per sprinkler for hydraulic calculation purposes would be found as

$$A_s = S' \times L \qquad \text{[A.28.2.4.6.5]}$$

where:

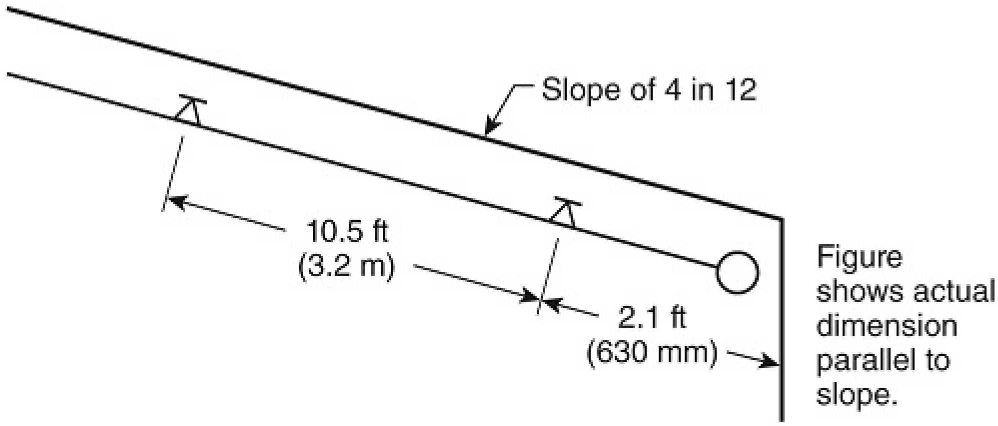
$S' = (\cos \theta)S$

θ = angle of slope

S = distance between sprinklers on branch line per 9.5.2.1.2

See Figure A.28.2.4.6.5.

Figure A.28.2.4.6.5 Determination of Floor Area Under Sloped Ceiling/Roof.



Calculation floor area = 10 ft × 12 ft (3.0 m × 3.7 m) (*see Figure A.28.2.4.6.2*)

A.28.2.4.7

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.28.2.4.7.2

The intent of this section is not to allow the omission of discharge from sprinklers in small compartments where the design area has been reduced below the values in Table 28.2.4.7.2 for situations such as quick-response sprinklers. Where quick-response sprinklers are used, the discharge from sprinklers in small compartments in the design area can be omitted as long as the design area meets the size required by Table 28.2.4.7.2.

A.28.2.4.7.3

Examples of obstructions are wide ducts or tables.

A.28.2.4.7.4.3(A)

If there is a single line of sprinklers installed under the obstruction, then four sprinklers on the same branch line should be included in the hydraulic calculations. If, however, there is more than one line of sprinklers installed under the obstruction, then the hydraulic calculations should account for two sprinklers on two lines.

A.28.2.4.8.2

See Figure A.28.2.4.8.2 for a Moody diagram and Table A.28.2.4.8.2 for ε-factors that correspond to Hazen–Williams *C* factors. The corresponding Hazen-Williams *C* factor should be used for the calculation of equivalent pipe length in accordance with 28.2.3.

Figure A.28.2.4.8.2 Moody Diagram.

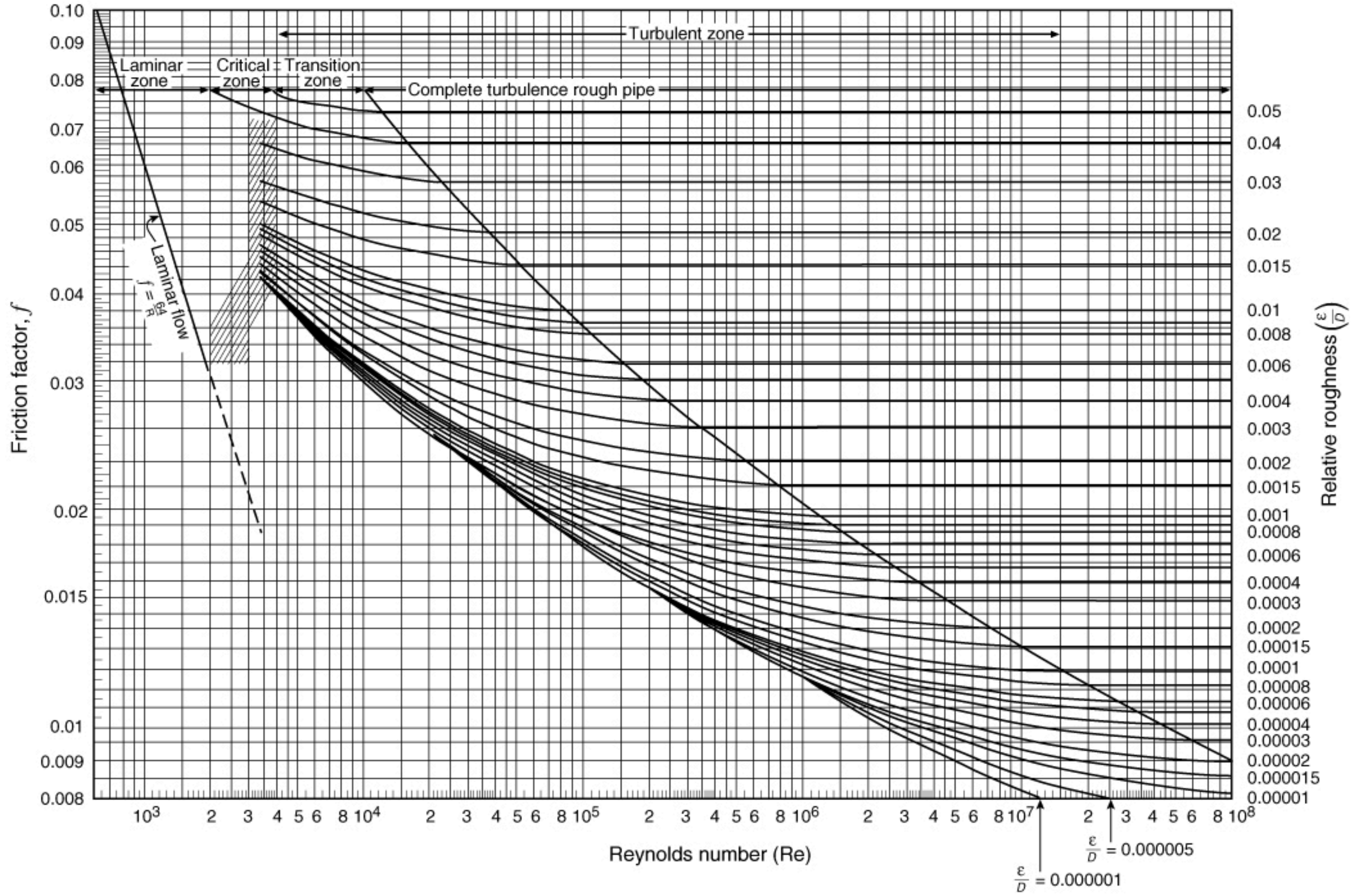


Table A.28.2.4.8.2 Suggested ε-Factor for Aged Pipe

Pipe	Hazen–Williams *C* Factor	ε-Factor in.	ε-Factor mm
Steel (new)	143	0.0018	0.045
Steel	120	0.004	0.100
Steel	100	0.015	0.375
Copper	150	0.000084	0.0021
Plastic	150	0.000084	0.0021

A.28.2.4.9.3

The use of sprinklers with differing K-factors 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 K-factors in closets, foyers, 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.28.2.4.10

Where the normal pressure (P_n) is used to calculate the flow from an orifice, the following assumptions should be used:

(1) 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:
   - (a) The last flowing sprinkler on a dead-end branch line
   - (b) The last flowing branch line on a dead-end cross main
   - (c) Any sprinkler where a flow split occurs on a gridded branch line
   - (d) Any branch line where a flow split occurs on a looped system

(2) 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.

(3) 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 should be repeated.

A.28.4.1.2

See Figure A.28.4.1.2(a) through Figure A.28.4.1.2(d).

Figure A.28.4.1.2(a) Summary Sheet.

Hydraulic Calculations

for

ABC Company, employee garage

7499 Franklin Road

Charleston, SC

Contract No. 4001

Date 1-7-08

Design data:

Occupancy classification ORD. GR. 1

Density 0.15 gpm/ft^2 (6.1 mm/min/m^2)

Area of application 1500 ft^2 (139 m^2)

Coverage per sprinkler 130 ft^2 (12.1 m^2)

Special sprinklers ____

No. of sprinklers calculated 12

In-rack demand ____

Hose streams 250 gpm (950 lpm)

Total water required 510.4 gpm (1930 lpm) including hose streams

Name of contractor ____

Name of designer ____

Address ____

Authority having jurisdiction ____

Figure A.28.4.1.2(b) Hydraulic Calculation Example (Plan View and Elevation View).

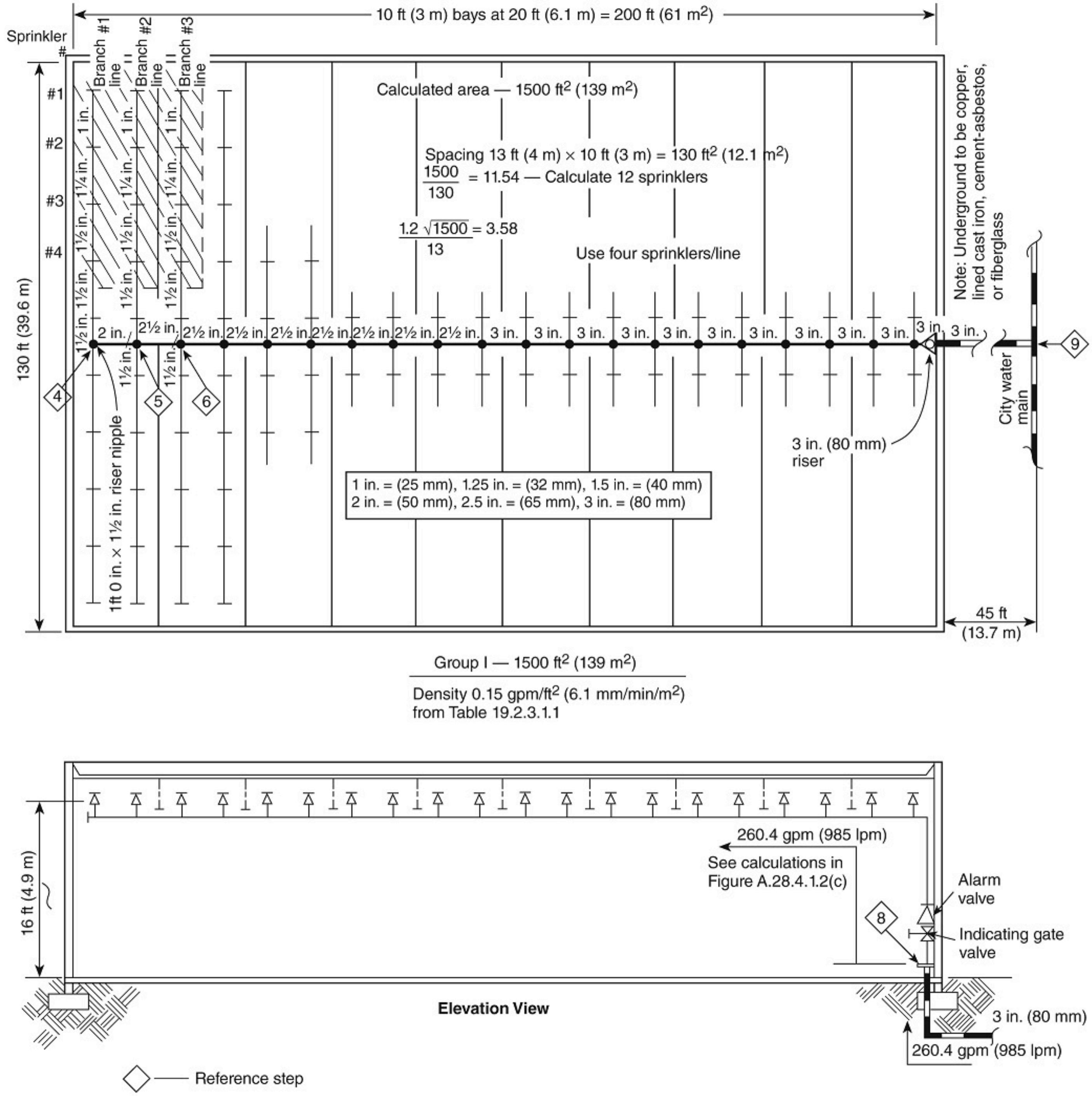
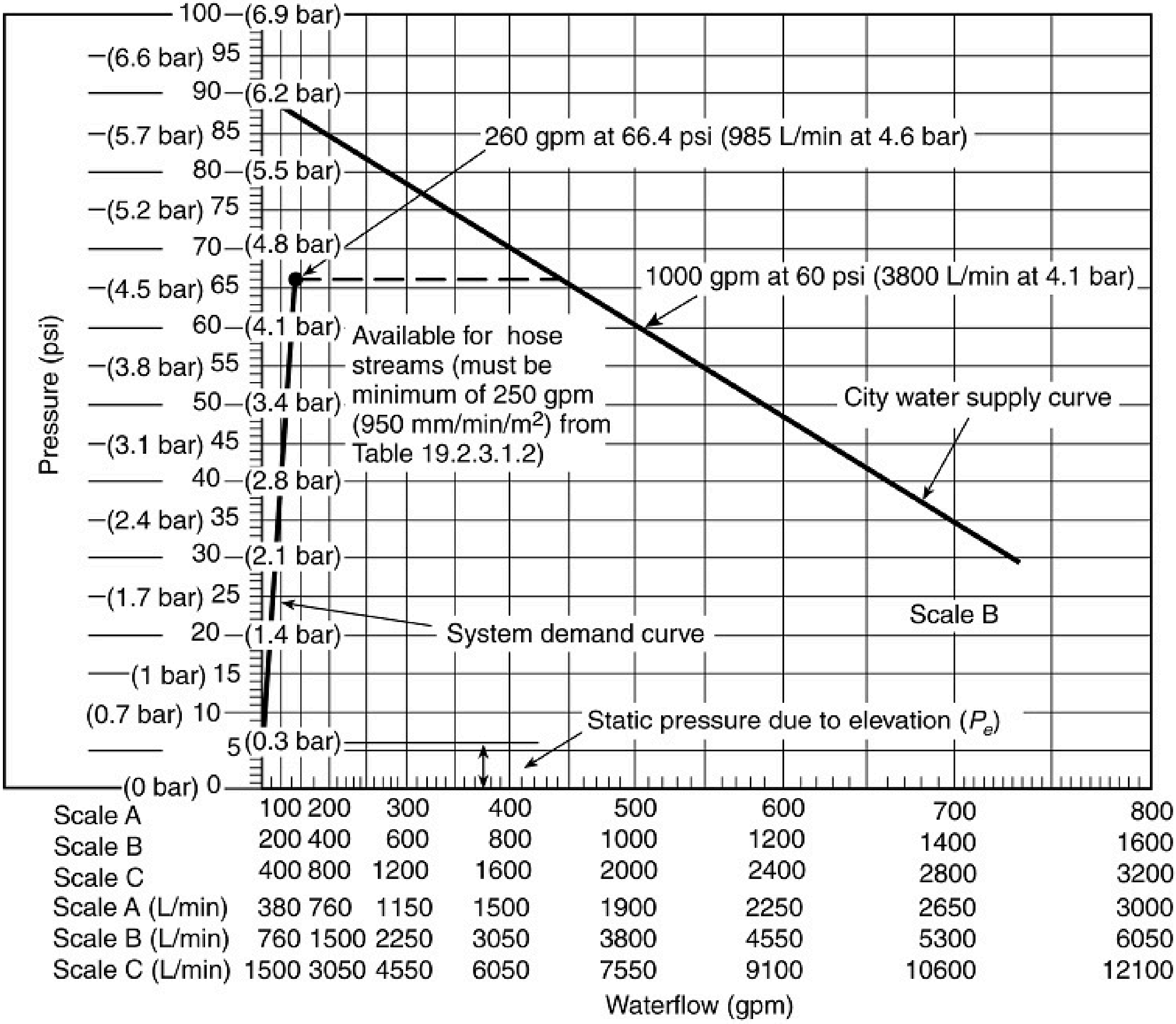


Figure A.28.4.1.2(c) Hydraulic Calculations.

Contract Name GROUP I 1500 ft² (139 m²) Sheet 2 Of 3

Step No.	Nozzle Ident. and Location		Flow in gpm (lpm)	(mm) Pipe Size	Pipe Fittings and Devices	Equiv. Pipe Length (m)	Friction Loss psi Foot	(bar) Pressure Summary	Normal Pressure	D = 0.15 gpm/ft² Notes K = 5.6	Ref. Step
1	1	BL-1	q	1 in. (25 mm)		L 13 ft (4 m)	C=120	P_t 12.1	P_t		
						F		P_e	P_v	Q = 130 x 0.15 = 19.5 (74 bar)	
			Q 19.5 (74)			T 13 ft (4 m)	0.124	P_f 1.6	P_n	$P = (19.5/5.6)^2 = 12.1$ psi (0.83 bar)	
2	2		q 20.7 (78.4)	1¼ in. (32 mm)		L 13 ft (4 m)		P_t 13.7	P_t		
						F		P_e	P_v	$q = 5.6\ \sqrt{13.7}$	
			Q 40.2 (152.2)			T 13 ft (4 m)	0.125	P_f 1.6	P_n		
3	3		q 21.9 (83)	1½ in. (40 mm)		L 13 ft (4 m)		P_t 15.3	P_t		
						F		P_e	P_v	$q = 5.6\ \sqrt{15.3}$	4
			Q 62.1 (235.1)			T 13 ft (4 m)	0.131	P_f 1.7	P_n		
4	4	DN RN	q 23.1 (87.4)	1½ in. (40 mm)	2T-16	L 20.5 ft (6.2 m)		P_t 17.0	P_t		
						F 16 ft (4.8 m)		P_e 0.4	P_v	$q = 5.6\ \sqrt{17}$	5
			Q 85.2 (322.5)			T 36.5 ft (11 m)	0.236	P_f 8.6	P_n	$P_e = 1 \times 0.433$	
5		CM TO BL-2	q	2 in. (50 mm)		L 10 ft (3 m)		P_t 26.0	P_t	$K = \frac{85.2}{\sqrt{26}}$	
						F		P_e	P_v		
			Q 85.2 (322.5)			T 10 ft (3 m)	0.07	P_f 0.7	P_n	K = 16.71	
6		BL-2 CM TO BL-3	q 86.3 (326.7)	2½ in. (65 mm)		L 10 ft (3 m)		P_t 26.7	P_t		
						F		P_e	P_v	$q = 16.71\ \sqrt{26.7}$	6
			Q 171.5 (549.2)			T 10 ft (3 m)	0.107	P_f 1.1	P_n		
7		BL-3 CM	q 88.1 (333.5)	2½ in. (65 mm)		L 70 ft (21 m)		P_t 27.8	P_t		
						F		P_e	P_v	$q = 16.7\ \sqrt{27.8}$	
			Q 259.6 (982.7)			T 70 ft (21 m)	0.231	P_f 16.2	P_n		
8		CM TO FIS	q	3 in. (80 mm)	E5	L 119 ft (36 m)		P_t 44.0	P_t		
					AV15	F 21 ft (6.4 m)		P_e 6.5	P_v	$P_e = 15 \times 0.433$	8
			Q 259.6 (982.7)		GV1	T 140 ft (43 m)	0.081	P_f 11.2	P_n		
9		THROUGH UNDER-GROUND TO CITY MAIN	q	3 in. (80 mm)	E5	L 50 ft (15 m)	C=150	P_t 61.7	P_t	$F = F_{40} \times 1.51 \times F_c$	
					GV1	F 27.6 ft (8.4 m)	TYPE'M'	P_e	P_v	$F_c = [2.981/3.068]^{4.87} = 0.869$ $F = 21 \times 1.51 \times 0.869$	9
			Q 259.6 (982.7)		T15	T 77.6 ft (24 m)	0.061	P_f 4.7	P_n	F = 27.6	
			q			L		P_t 66.4	P_t		
						F		P_e	P_v		
			Q			T		P_f	P_n		
			q			L		P_t	P_t		
						F		P_e	P_v		
			Q			T		P_f	P_n		
								P_t			

Figure A.28.4.1.2(d) Hydraulic Graph.



A.28.4.1.3

See Figure A.28.4.1.3.

Figure A.28.4.1.3 Sample Worksheet.

Contract no. ____________________ Sheet no. ________ of ________

Name and location ____

Reference	Nozzle type and location	Flow in gpm (L/min)	Pipe size (in.)	Fitting and devices	Pipe equivalent length	Friction loss psi/ft (bar/m)	Required psi (bar)	Normal Pressure	Notes
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	

P_t: total pressure. P_f: friction loss pressure. P_v: velocity pressure. P_e: elevation pressure.

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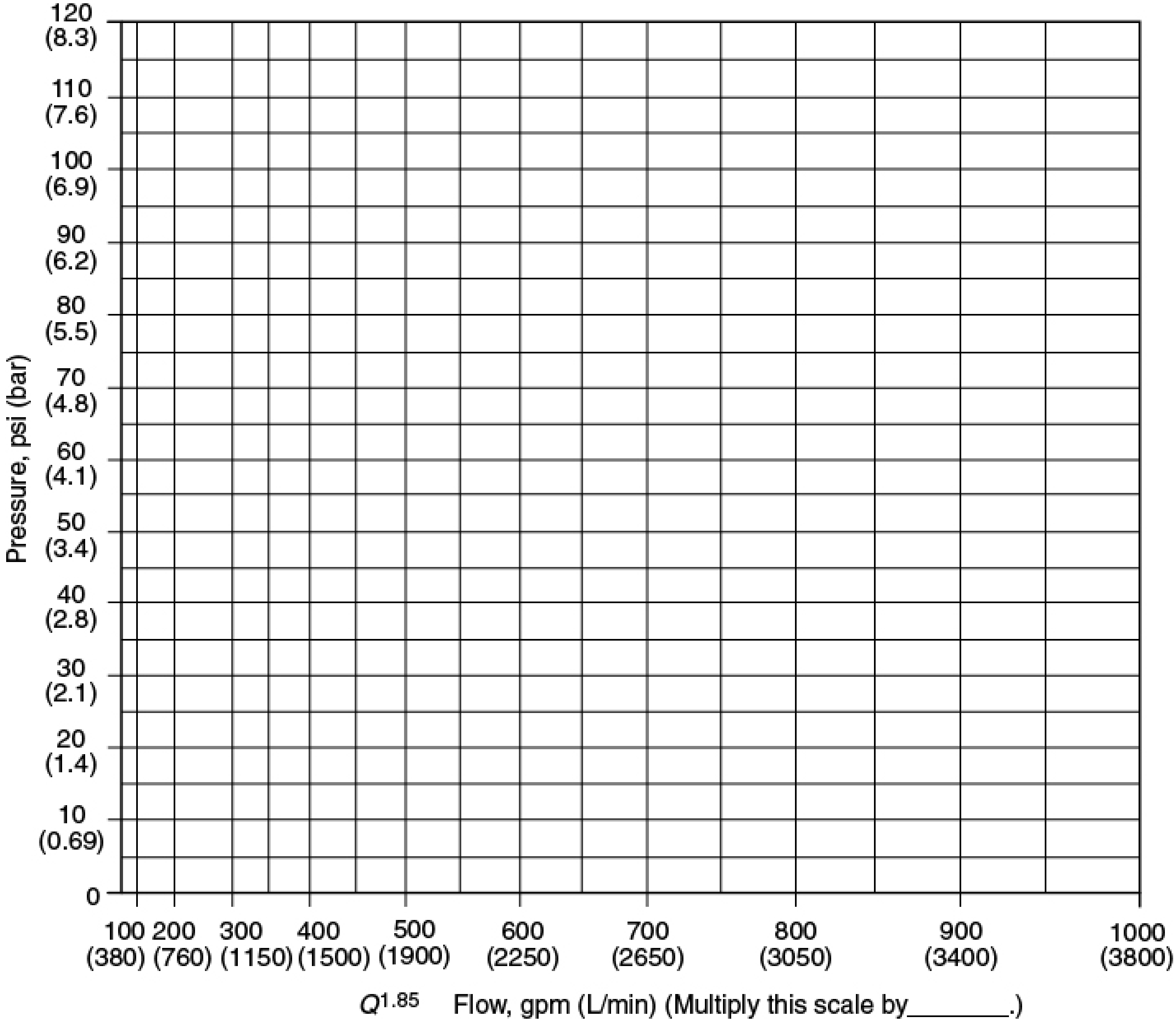
A.28.4.1.4

See Figure A.28.4.1.4.

Figure A.28.4.1.4 Sample Graph Sheet.



A.28.4.2.1

Additional data can be added to any of the forms, provided that the format and order of the original information shown in Figure 28.4.2.1.2(a), Figure 28.4.2.1.2(b), Figure 28.4.2.1.2(c), and Figure 28.4.2.1.2(d) is followed.

A.28.5.1

The demonstrated effectiveness of pipe schedule systems is limited to their use with $\frac{1}{2}$ in. (15 mm) orifice sprinklers. The use of other size orifices can require hydraulic calculations to prove their ability to deliver the required amount of water within the available water supply.

A.28.5.1.4

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 can be required to compensate for increased friction losses.

A.28.5.2.6

For example, a $2\frac{1}{2}$ in. (65 mm) steel pipe, which is permitted to supply 30 sprinklers, can supply a total of 50 sprinklers where not more than 30 sprinklers are above or below a ceiling.

A.28.5.3.9

For example, a 3 in. (80 mm) steel pipe, which is permitted to supply 40 sprinklers in an ordinary hazard area, can supply a total of 60 sprinklers where not more than 40 sprinklers protect the occupied space below the ceiling.

A.28.5.4

The piping schedule shown in Table A.28.5.4 is reprinted only as a guide for existing systems. New systems for extra hazard occupancies should be hydraulically calculated as required in 28.5.4.

Table A.28.5.4 Extra Hazard Pipe Schedule

Steel			Copper		
Size			Size		
in.	mm	Number of Sprinklers	in.	mm	Number of Sprinklers
1	25	1	1	25	1
1¼	32	2	1¼	32	2
1½	40	5	1½	40	5
2	50	8	2	50	8
2½	65	15	2½	65	20
3	80	27	3	80	30
3½	90	40	3½	90	45
4	100	55	4	100	65
5	125	90	5	125	100
6	150	150	6	150	170

A.29.1

See Figure A.29.1.

Figure A.29.1 Contractor's Material and Test Certificate for Aboveground Piping.

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 the property owner or their authorized agent. 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

New installation? ❑ Yes ❑ No

Modification? If yes, complete applicable portions of the form. ❑ Yes ❑ No

Provide a description of the scope of work on page 3.

Plans	Accepted by approving authorities (names)		
	Address		
	Installation conforms to accepted plans	❑ Yes	❑ No
	Equipment used is approved If no, explain 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 the following been left on the premises?	❑ Yes	❑ No
	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	SIN	K-factor	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	Minutes	Seconds

Dry pipe and double-interlock preaction operating test

Dry valve			Q. O. D.		
Make	Model	Serial no.	Make	Model	Serial no.

	Time to trip through test connection[a,b]		Water pressure	Air pressure	Trip point air pressure	Time water reached test outlet[a,b]		Alarm operated properly		System temperature	System fill time
	Minutes	Seconds	psi	psi	psi	Minutes	Seconds	Yes	No		
Without Q.O.D.											
With Q.O.D.											

If no, explain

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[a] Measured from time inspector's test connection is opened.

[b] NFPA 13 only requires the 60-second limitation in specific sections.

Deluge and preaction valves	Operation ☐ Pneumatic ☐ Electric ☐ Hydraulics							
	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?		Does each circuit operate valve release?		Maximum time to operate release	
			Yes	No	Yes	No	Minutes	Seconds

Pressure-reducing valve test	Location and floor	Make and model	Setting	Static pressure		Residual pressure (flowing)		Flow rate
				Inlet (psi)	Outlet (psi)	Inlet (psi)	Outlet (psi)	Flow (gpm)

Backflow device forward flow test	Indicate means used for forward flow test of backflow device: ____ When means to test device was opened, was system flow demand created? ☐ Yes ☐ No ☐ N/A
Test description	Hydrostatic: Hydrostatic tests shall be made at not less than 200 psi (13.8 bar) for 2 hours or 50 psi (3.4 bar) above static pressure in excess of 150 psi (10.3 bar) 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 bar) air pressure and measure drop, which shall not exceed 1½ psi (0.1 bar) 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 bar) in 24 hours.

Tests	All piping hydrostatically tested at ____ psi (____ bar) for ____ hours Dry piping pneumatically tested at ____ psi (____ bar) for ____ hours ☐ N/A		
	All control valves fully closed and opened under system water pressure ☐ Yes ☐ No Equipment operates properly ☐ Yes ☐ No If no, state reason ____		
	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 (____ bar)	Residual pressure with valve in test connection open wide: ____ psi (____ bar)
	Underground mains and lead-in connections to system risers flushed before connection made to sprinkler piping Verified by copy of the Contractor's Material and Test Certificate for Underground Piping. ☐ Yes ☐ No Flushed by installer of underground sprinkler piping ☐ Yes ☐ No		Other Explain
	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	Welding piping ☐ Yes ☐ No
	If yes . . .
	Do you certify as the sprinkler contractor that welding procedures used complied with the minimum requirements of AWS B2.1, ASME Section IX *Welding, Brazing, and Fusing Qualifications,* or other applicable qualification standard as required by the AHJ? ☐ Yes ☐ No Do you certify that all welding was performed by welders or welding operators qualified in accordance with the minimum requirements of AWS B2.1, ASME Section IX *Welding, Brazing, and Fusing Qualifications,* or other applicable qualification standard as required by the AHJ? ☐ Yes ☐ No Do you certify that the welding was conducted in compliance with a documented quality control procedure to ensure that (1) all discs are retrieved; (2) that openings in piping are smooth, that slag and other welding residue are removed; (3) the internal diameters of piping are not penetrated; (4) completed welds are free from cracks, incomplete fusion, surface porosity greater than 1⁄16 in. (1.6 mm) diameter, undercut deeper than the lesser of 25% of the wall thickness or 1⁄32 in. (0.8 mm); and (5) completed circumferential butt weld reinforcement does not exceed 3⁄32 in. (2.4 mm)? ☐ Yes ☐ No

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Coupons (discs)	Do you certify that you have a control feature to ensure that all coupons (discs) are retrieved? ❑ Yes ❑ No	
Hydraulic data nameplate	Nameplate provided ❑ Yes ❑ No	If no, explain
Sprinkler contractor removed all caps and straps? ❑ Yes ❑ No		
Remarks	Date left in service with all control valves open	
Signatures	Name of sprinkler contractor	
	Tests witnessed by	
	The property owner or their authorized agent (signed)	Title / Date
	For sprinkler contractor (signed)	Title / Date

Additional explanations and notes

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A.29.2.1

The use of noncombustible compressed gas to increase the pressure in a water-filled system is an acceptable test procedure.

A.29.2.1.6

As an example, in a system that had piping at an elevation that was 25 ft (7.6 m) higher than the test gauge, an acceptable pressure during the hydrostatic test is 189 psi (13 bar) at the top of the system due to the loss of 11 psi (0.8 bar) in elevation pressure [25 ft × 0.433 psi/ft = 11 psi (0.8 bar)].

A.29.2.1.7

Bacterial inhibitors and other chemicals that are approved and used for the prevention and mitigation of MIC and that do not adversely affect the firefighting properties of the water or the performance of the fire sprinkler system components are not prohibited.

A.29.2.1.12

Valves isolating the section to be tested might not be “drop-tight.” When such leakage is suspected, test blanks of the type required in 29.2.1.12 should be used in a manner that includes the valve in the section being tested.

A.29.2.3.2

When the acceptance test is being performed during freezing conditions, a partial flow trip test should be conducted at that time and the full flow trip test specified should be conducted as soon as conditions permit.

A.29.2.3.2.3

The test criteria are based on the first evidence of waterflow to the inspector's test. Air can be mixed with the water for several minutes until the air is completely flushed from the system.

A.29.2.3.2.3.2

Although the time criteria for calculated systems is not required to be verified, a test is still required to document the initial water delivery for comparison to future inspection test requirements. If the time of a single sprinkler test outlet exceeds 70 seconds, evaluation of the calculations and the system installation might be necessary.

A.29.2.3.4.2

Measuring the flow during a main drain test is not required.

A.29.3(2)

A copy of NFPA 25 is not required for system alterations or additions.

A.29.4

See Figure A.29.4.

Figure A.29.4 Sample Hydraulic Design Information Sign.

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 (bar) 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 . . . .

A.29.6

While the information on this sign is useful during an inspection, such use should not be considered a hazard assessment based on the requirements of this standard. *(See Figure A.29.6.)*

Figure A.29.6 Sprinkler System General Information.

SPRINKLER SYSTEM — GENERAL INFORMATION
for

____

____

____

Pipe schedule system ❏ Yes ❏ No
High-piled storage ❏ Yes ❏ No
Rack storage: ❏ Yes ❏ No
Commodity class: ________________
Max. storage height __________ ft m
Aisle width (min.) __________ ft m
Encapsulation ❏ Yes ❏ No
Solid shelving: ❏ Yes ❏ No
Flammable/ combustible liquids: ❏ Yes ❏ No
Other storage: ❏ Yes ❏ No

____

Hazardous materials: ❏ Yes ❏ No
Idle pallets: ❏ Yes ❏ No
Antifreeze systems ❏ Yes ❏ No
Location: __________________
Dry or aux systems ❏ Yes ❏ No
Location: __________________

Date: ______________________
Flow test data:
Static: __________ psi bar
Resid: __________ psi bar
Flow: __________ gpm lpm
Pitot: __________ psi bar
Date: ______________________
Location: ____________________

____

Location of aux/low point drains:

____

____

____

Dry pipe/double interlock preaction valve test results __________

Original main drain test results:
Static: __________ psi bar
Residual: __________ psi bar
Venting valve location: __________

Where injection systems are used to treat MIC or corrosion:

Type of chemical: __________ Concentration: __________ For proper disposal, see:

____

Name of contractor or designer: __________________________
Address: __________________________________
Phone: __________________________________

A.30.1.2

This chapter is intended to apply to evaluations, modifications, or additions to existing systems. As provided by the retroactivity provisions of Section 1.4, the provisions of the standard are generally not intended to apply to existing systems unless otherwise specified herein as being retroactive or where the authority having jurisdiction has determined that the existing condition represents an unacceptable risk.

The development of the standard reflects an ever-changing consensus of what is considered as being an acceptable degree of protection. Evaluation of existing system installations should be based on the provisions of the edition of the standard and approval of the authority having jurisdiction at the time of installation (standard of record), if known. Additional consideration might be given to an evaluation of the level of risk associated with maintaining existing installations evaluated under the standard of record.

A.30.1.4

It is not the intent of this section to require a full hydraulic analysis of the existing piping system. This requirement should only verify that the additional friction loss through the backflow prevention device is not detrimental to the original calculations when compared with the new flow test data.

A.30.1.9

Nitrogen is often added to existing dry pipe and preaction sprinkler systems already identified as having corrosion damage with the intent of extending the life of these systems. The addition of nitrogen will not remediate the corrosion damage already incurred to the sprinkler system piping. It is recommended to assess existing piping to determine where replacement is necessary and where acceptable for continued use. The addition of nitrogen will remove the oxygen from the corrosion process, which will minimize continued corrosion but will not remove any previous damage.

The use of compressed air is not always damaging to dry pipe or preaction sprinkler system piping. It has been used as a supervisory gas for nearly a century without catastrophic effects. Dry air has been found to provide an effective means of limiting corrosion. However, corrosion has been observed in systems having compressed air supplies without dry air. Problems have been observed in hot and humid areas and when compressors generate heating after being run for long periods. Water condensation caused by this process has been identified as a contributing factor to corrosion in dry pipe and preaction sprinkler systems.

A.30.4

Fire protection systems are designed and installed based on a specific set of circumstances and building uses. For example, the volume of water needed for a sprinkler system to control a fire in the built environment is based upon the intended use of the facility known at the time the sprinkler system was designed and installed. Revisions to properties used for storage represent one of the most common scenarios that impact the ability of systems to provide adequate protection. Some of the most common changes include raising the storage height, changing the storage method arrangement such as adding racks, installing solid shelves in rack structures, or decreasing the aisle widths between racks. Changes in product packaging with the use of foam inserts, bubble wrap, or other plastics or encapsulated storage can significantly increase the fire hazard. Changing from wood pallets to plastic pallets, converting to the use of plastic bin boxes, or revising or adding material handling systems such as conveyors could severely impact the effectiveness of the fire protection systems.

The following are some examples of when existing system evaluations should be conducted:

(1) Tenant changes or process changes
(2) Occupancy or storage changes
(3) Fire pump replacements
(4) Water supply changes
(5) Backflow preventers replaced or added
(6) Replacing missing hydraulic information signs with no existing records

A.30.4.1

When conducting an existing system evaluation, the following should be considered:

(1) The current available water supply including any necessary adjustments as required by 30.4.2
(2) The current occupancy classification or commodity classification and maximum permitted storage height and configuration as required by Section 4.2
(3) The appropriate design based on the occupancy using the original building approved design edition of NFPA 13
(4) Hydraulic calculations performed in accordance with Chapter 28 based on existing sprinkler plans or survey of the existing piping and spacing layout

A.30.4.2

Evaluation of existing systems is in references to the adequacy of the pipe schedule hazard classification and design densities (in the case of CMDA systems), as well as the number of sprinklers and pressures calculated with ESFR and CMSA sprinklers or systems. The evaluation of existing systems is not limited to storage applications but encompasses all occupancies. This section provides users with two options for evaluation of existing systems. The first option would be to treat the system as new by applying and using the nonexisting requirements in the current edition. The second option is to apply the edition of NFPA 13 that the sprinkler system was originally designed under.

A.30.5.2.2

It is not the intent of this section to require a full hydraulic analysis of the existing piping system in addition to the new sprinkler layout.

A.31.1.3

In addition to the examples provided in A.4.3, Table A.31.1.3 provides additional examples of occupancy definitions of typical shipboard spaces.

Table A.31.1.3 Examples of Shipboard Space Occupancy Classification

Occupancy Type	Space Types Included		Examples
	CFR[a]	SOLAS[b]	
Light hazard	1[c], 2, 3, 4, 5, 6, 7, 8[d], 13	1[c], 2, 3, 4, 5, 6, 7, 8, 9	Accommodation spaces
			Small pantries
Ordinary hazard (Group 1)	8[d], 9[d]	12, 13[d]	Galleys
			Storage areas
			Sales shops
			Laundries
			Pantries with significant storage
Ordinary hazard (Group 2)	9[d], 11[d]	12[d], 13[d]	Sales shops
			Storage areas
			Stages (with sets)
			Machine shops
Extra hazard (Group 1)	1, 9[d], 10, 11[d]	1, 12[d], 13[d]	Auxiliary machinery — limited-combustible liquids[e]
			Steering rooms — combustible hydraulic fluid in use[e]
Extra hazard (Group 2)	1, 9[d], 10, 11[d]	1, 12[d], 13[d]	Auxiliary machinery — with combustible liquids[e]
			Machinery spaces[e]

[a]Space-type designations are given in 46 CFR 72.05-5.

[b]Space-type designations 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.

[c]Primarily for accommodation-type control stations, such as the wheel house, which would not include generator rooms or similar-type spaces.

[d]Depends on storage type, quantity, and height and distance below sprinkler.

[e]Automatic sprinklers typically will not be the primary means of protection in these areas; total flooding systems are usually used.

The classifications in Table A.31.1.3 are not meant to be applied without giving consideration to the definition of each occupancy hazard given in the standard. Table A.31.1.3 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.31.1.4

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.31.2.1

Sprinklers with a nominal K-factor of 2.8 (40) or less coupled with a system strainer minimize the potential for clogging.

A.31.2.2

Where a marine thermal barrier is penetrated, limiting the opening around the sprinkler pipe to $\frac{1}{16}$ in. (1 mm) is considered as meeting this requirement.

A.31.2.4.1

When nonferrous materials are used, consideration should be given to protecting against galvanic corrosion where the nonferrous materials connect to steel pipe. Consideration should also be given to protection against galvanic corrosion from pipe hangers in areas of high humidity.

The piping between the sea chest and the sprinkler zone valves are likely to see the frequent flow of saltwater when testing. Sprinkler zone piping will rarely, if ever, be exposed to saltwater. In such an event, NFPA 25 requires flushing of the piping. Even if the piping is not flushed, the saltwater will not be replenished and will lose oxygen content in fairly short order.

Even if galvanized, the failure from corrosion from the interior of the pipe is likely to be at all threaded connections, welded assembly connections, and where brass sprinklers thread into ferrous pipe. Only hot dipped galvanized after fabrication of assembly (as opposed to simply hot dipped galvanized pipe and fittings) will protect against some of those failures. Hot dipped galvanized after fabrication of assembly is practical from the sea chest to the sprinkler manifold where spaces are open and pipe is relatively large and uses flanged takedown joints instead of threaded unions. Hot dipped galvanized after fabrication of assembly is not practical in the sprinkler zone pipe where it is mainly field fit.

A.31.2.5.1

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, 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.

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.

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.

A.31.2.5.3

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.31.2.5.4

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.31.2.6.1

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 31.2.6.1 but can be done in addition to the supervision requirement.

A.31.2.7.1

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.31.2.7.7.)*

A.31.2.7.7

Selection of the pipe thread for the fire department connection should be done very carefully. It is recommended that a $2\frac{1}{2}$ in. (63 mm) 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.31.3.1

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.31.4.2

Areas fitted primarily with multiple staterooms and corridors should be considered sleeping accommodation areas.

A.31.4.4

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.31.4.10.1(4)

Because of its melting point, brazing would be considered heat sensitive. The criterion of this paragraph is intended to permit brazed joints without requiring that they be installed behind a marine thermal barrier, while maintaining the fire resistance as stated in 31.4.10.1 under reasonably foreseeable failure modes.

A.31.4.12.1

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, and so forth. The second panel should show the vessel's general arrangement and indicate status of waterflow (i.e., fire location) alarms.

A.31.5.2

For example, a design area of 1500 ft^2 (140 m^2) is used to design a sprinkler system for an unobstructed light hazard occupancy. In this case, the system must supply at least seven sprinklers that are installed within that area. If eight 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.31.5.3

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.31.6.4

In vessels, the elevation of sprinklers with respect to the water supply varies as the vessel heels to either side or trims by the bow or stern. The water demand requirements can be increased or decreased under these conditions. This requirement aligns the operational parameters of this safety system with that required for other machinery vital to the safety of the vessel.

A.31.7.2.7

The purpose of this requirement is to ensure that the pressure tank air supply will not keep the tank “fully” pressurized while water is expelled, thus preventing pump actuation.

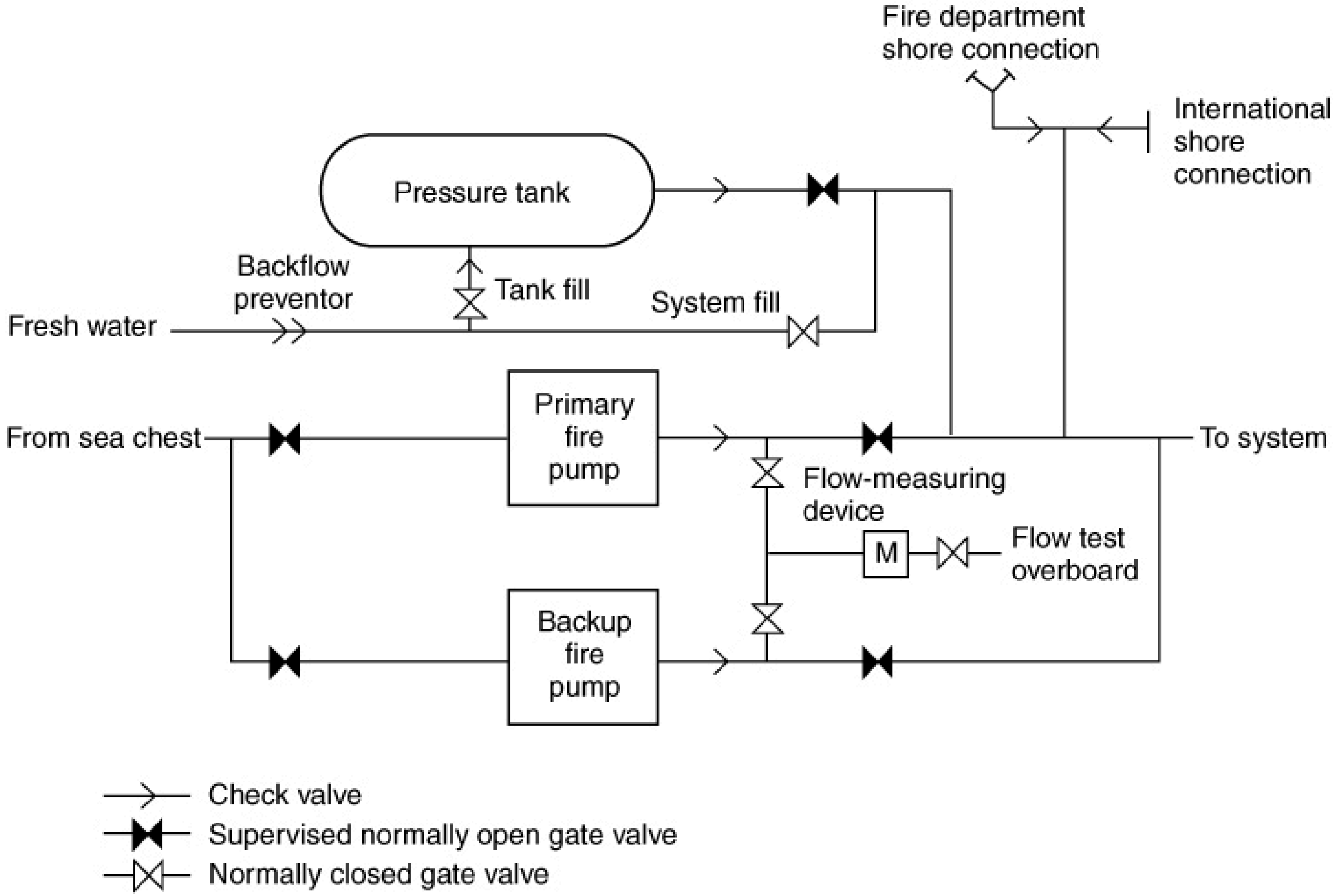
A.31.7.3.3

NFPA 20 requires that fire pumps furnish not less than 150 percent of their rated capacity at not less than 65 percent of their rated heat. The intention of the requirement of 31.7.3.3 is to limit designers to 120 percent of the rated capacity of the pump to provide an additional factor of safety for marine systems.

A.31.7.3.12.2(1)

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. *[See Figure A.31.7.3.12.2(1).]*

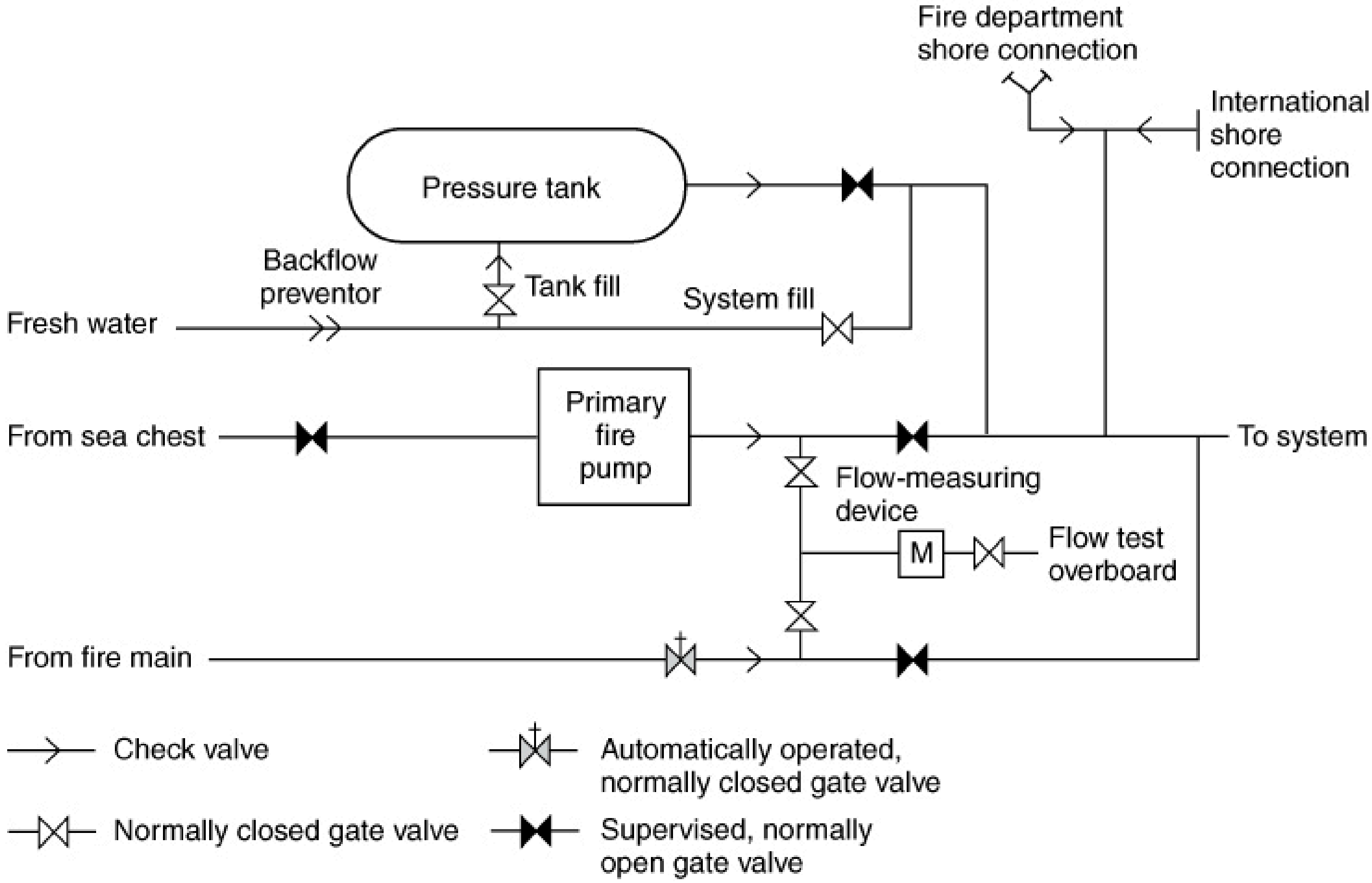
Figure A.31.7.3.12.2(1) Abbreviated Example of Dual Fire Pump Water Supply.



A.31.7.3.13

See Figure A.31.7.3.13.

Figure A.31.7.3.13 Abbreviated Example of Water Supply with Fire Pump Backup.



A.31.7.4.6

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.32.1

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 should be 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.

Maintenance Schedule. The items shown in Table A.32.1 should be checked on a routine basis.

Table A.32.1 Maintenance Schedule

Parts	Activity	Frequency
Flushing piping	Test	5 years
Fire department connections	Inspection	Monthly
Control valves	Inspection	Weekly — sealed
	Inspection	Monthly — locked
	Inspection	Monthly — tamper switch
	Maintenance	Yearly
Main drain	Flow test	Quarterly — annual
Open sprinklers	Test	Annually

Parts	Activity	Frequency
Pressure gauge	Calibration test	
Sprinklers	Test	50 years
Sprinklers — high-temperature	Test	5 years
Sprinklers — residential	Test	20 years
Waterflow alarms	Test	Quarterly
Preaction/deluge detection system	Test	Semiannually
Preaction/deluge systems	Test	Annually
Antifreeze solution	Test	Annually
Cold weather valves	Open and close valves	Fall, close; spring, open
Dry/preaction/deluge systems		
Air pressure and water pressure	Inspection	Weekly
Enclosure	Inspection	Daily — cold weather
Priming water level	Inspection	Quarterly
Low-point drains	Test	Fall
Dry pipe valves	Trip test	Annually — spring
Dry pipe valves	Full flow trip	3 years — spring
Quick-opening devices	Test	Semiannually