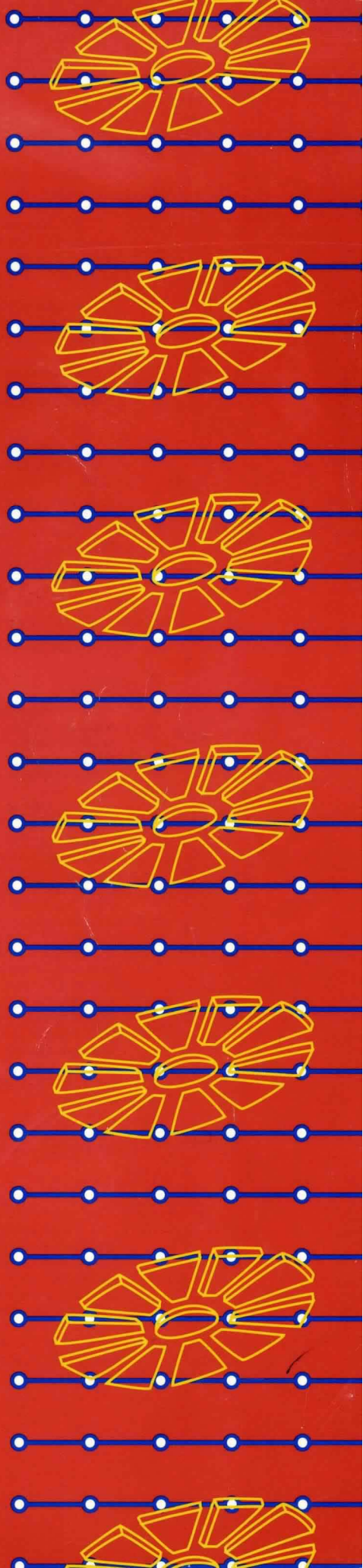
Installation of SPRINKLER SYSTEMS

NFPA

13

1994 Edition



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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

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Errata

NFPA 13

Installation of Sprinkler Systems

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Reference: Table 1-4.7.4.2, 4-4.5.4.2, Table 4-6.3.4.2

The Committee on Automatic Sprinklers notes the following errors in the 1994 edition of NFPA 13, *Standard for the Installation of Sprinkler Systems:*

1. In 4-4.5.4.2, change the dimension "24 in. (610 mm)" *to* "12 in. (305 mm)".

2. In Table 1-4.7.4.2, Commodity Classes I-IV heading, change the Class IV row to read:

IV up to 10 ft	OH-2	OH-2
IV over 10 ft to 12 ft	OH-2	EH-1

3. In Table 1-4.7.4.2, Miscellaneous Tire Storage heading, change the fourth and fifth rows to read:

Single Row Rack, Portable	5 ft to 12 ft	EH-1
Single Row Rack, Fixed	5 ft to 12 ft	EH-1 or OH-2 plus one level of in-rack sprinklers

4. In Table 1-4.7.4.2, Rolled Paper on End heading, change the Tissue row by deleting the following:

"Over 10 ft to 12 ft and EH-2."

5. In Table 1-4.7.4.2, change the title of the Pallet Storage heading to "Idle Pallet Storage."

6. In Table 4-6.3.4.2, change the title of the table to "Drain Size."

Issue Date: November 2, 1994

NFPA 13

Standard for the

Installation of Sprinkler Systems

1994 Edition

This edition of NFPA 13, *Standard for the Installation of Sprinkler Systems*, was prepared by the Technical Committee on Automatic Sprinklers and acted on by the National Fire Protection Association, Inc. at its Fall Meeting held November 15-18, 1993, in Phoenix, AZ. It was issued by the Standards Council on January 14, 1994, with an effective date of February 11, 1994, and supersedes all previous editions.

The 1994 edition of this document has been approved by the American National Standards Institute.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

Origin and Development of NFPA 13

NFPA 13 represents the first standard published under the auspices of the NFPA Committee on Automatic Sprinklers. Originally titled *Rules and Regulations of the National Board of Fire Underwriters for Sprinkler Equipments, Automatic and Open Systems*, the standard has been continuously updated to keep in step with change.

Full information about the NFPA actions on various changes will be found in the NFPA Proceedings. The dates of successive editions are as follows: 1896, 1899, 1902, 1905, 1907, 1908, 1912, 1913, 1915, 1916, 1917, 1919, 1920, 1921, 1922, 1923, 1924, 1925, 1926, 1927, 1928, 1929. In 1930 a separate standard was published on "Class B" systems. This was integrated in the 1931 edition. Further revisions were adopted in 1934, 1935, and 1936. A two-step revision was presented in the form of a progress report in 1939 and finally adopted in 1940. Further amendments were made in 1947, 1950, 1953, 1956, 1958, 1960, 1961, 1963, 1964, 1965, 1966, 1968, 1969, 1971, 1972, 1973, 1974, 1975, 1976, 1978, 1980, 1982, 1984, 1986, and 1989.

The 1991 edition incorporated an entire rewrite of the standard to make the overall format user friendly. Substantive changes were made to numerous terms, definitions, and descriptions.

This edition is a continuation of further refining the standard to enhance the usability of the document. Special areas of interest have been addressed, including electrical equipment rooms and elevator shafts. Other substantive changes have been made with respect to seismic protection requirements as well as adding special requirements for extended coverage sprinklers.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

NOTE: Membership on a Committee shall not in and of itself constitute an endorsement of the Association or any document developed by the Committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on the design, installation, inspection, and maintenance of automatic and of open sprinkler systems, including the character and adequacy of water supplies, and the selection of sprinklers, piping, valves, and all materials and accessories; but not including the installation of fire pumps, nor the construction and installation of gravity and pressure tanks and towers, nor the installation, maintenance, and use of central station, proprietary, auxiliary, and local signaling systems for watchmen, fire alarm, and supervisory service, nor the supervision and care of valves controlling water supplies, nor the design of fire department hose connections, nor the installation of private fire service mains and their appurtenances.

Contents

NFPA 13

Standard for the

Installation of Sprinkler Systems

1994 Edition

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates explanatory material on that paragraph in Appendix A.

Information on referenced publications can be found in Chapter 10 and Appendix C.

Chapter 1 General Information

1-1 Scope. This standard provides the minimum requirements for the design and installation of automatic fire sprinkler systems and exposure protection sprinkler systems, including the character and adequacy of water supplies and the selection of sprinklers, piping, valves, and all materials and accessories, but not including the installation of private fire service mains and water supplies.

NOTE: Consult other NFPA standards for additional requirements relating to water supplies.

Storage in excess of 12 ft (3.7 m) in height or storage in excess of 5 ft (1.5 m) in height of high hazard materials such as Level II and III aerosols, idle pallets, rubber tires, rolled paper stored on end, plastics, and flammable liquids are outside the scope of this standard. (For guidance and limitations regarding areas, quantities, or methods of storage for high hazard materials, see NFPA 30, 30B, 40, 58, 81, 231, 231C, 231D, 231F, and 409.)

Exception No. 1: Wooden pallets stored up to 6 ft (1.8 m) in height or plastic pallets up to 4 ft (1.2 m) in height with not over four stacks of wooden pallets or two stacks of plastic pallets separated from other stacks by at least an 8-ft (2.4-m) aisle. (For heights or quantities exceeding these limits, see NFPA 231, Standard for General Storage.)

Exception No. 2: Storage of rubber tires that is incidental to the main use of the building and not more than 2,000 ft^2 (185.8 m^2). On-tread storage, regardless of piling method, shall not exceed 25 ft (7.62 m) in the direction of the wheel hole. Laced tires in racks shall not exceed 5 ft (1.52 m) in height. Storage arrangements that are acceptable as miscellaneous storage are:*

(a) On floor, on side storage less than 12 ft (3.66 m) in height, or

(b) On floor, on tread storage less than 5 ft (1.52 m) in height, or

(c) Double row or multi-row portable or fixed rack storage less than 5 ft (1.52 m) in height, or

(d) Single row portable or fixed rack storage less than 12 ft (3.66 m) in height.

1-2 Purpose. The purpose of this standard is to provide a reasonable degree of protection for life and property from fire through standardization of design, installation, and testing requirements for sprinkler systems based upon sound engineering principles, test data, and field experience. This standard endeavors to continue the excellent record that has been established by sprinkler systems while meeting the needs of changing technology. Nothing in this standard is intended to restrict new technologies or alternate arrangements, provided the level of safety prescribed by this standard is not lowered. Materials or devices not specifically designated by this standard shall be utilized in complete accord with all conditions, requirements, and limitations of their listings.

NOTE 1: A sprinkler system is a specialized fire protection system and requires knowledgeable and experienced design and installation.

NOTE 2: Since its inception, this document has been developed on the basis of standardized materials, devices, and design practices. However, certain paragraphs, such as 2-3.5, 4-3.2, and this one, 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.

1-3 Retroactivity Clause. The provisions of this document are considered necessary to provide a reasonable level of protection from loss of life and property from fire. They reflect situations and the state of the art at the time the standard was issued.

Unless otherwise noted, it is not intended that the provisions of this document be applied to facilities, equipment, structures, or installations that were existing or approved for construction or installation prior to the effective date of this document.

Exception: In those cases where it is determined by the authority having jurisdiction that the existing situation involves a distinct hazard to life or property, this standard shall apply.

1-4 Definitions.

1-4.1 NFPA Definitions.

Approved. Acceptable to the authority having jurisdiction.

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

Authority Having Jurisdiction. The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since 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.

Listed. Equipment or materials included in a list published by an organization acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

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

Shall. Indicates a mandatory requirement.

Should. Indicates a recommendation or that which is advised but not required.

Standard. A document that contains only mandatory provisions using the word "shall" to indicate requirements. Explanatory material may be included only in the form of fine-print notes, in footnotes, or in an appendix.

1-4.2 General Definitions.

Compartment. As used in 4-3.6.3 and 6-4.4.4, a space completely enclosed by walls and a ceiling. The compartment enclosure is permitted to have openings to an adjoining space if the openings have a minimum lintel depth of 8 in. (203 mm) from the ceiling.

Drop-Out Ceiling. A suspended ceiling system with listed translucent or opaque panels that are heat sensitive and fall from their setting when exposed to heat. This ceiling system is installed below the sprinklers.

Dwelling Unit. One or more rooms arranged for the use of one or more individuals living together, as in a single housekeeping unit normally having cooking, living, sanitary, and sleeping facilities.

For purposes of this standard, dwelling unit includes hotel rooms, dormitory rooms, apartments, condominiums, sleeping rooms in nursing homes, and similar living units.

Fire Control. Limiting the size of a fire by distribution of water so as to decrease the heat release rate and pre-wet adjacent combustibles, while controlling ceiling gas temperatures to avoid structural damage.

Fire Suppression. Sharply reducing the heat release rate of a fire and preventing its regrowth by means of direct and sufficient application of water through the fire plume to the burning fuel surface.

High Challenge Fire Hazard. A fire hazard typical of that produced by fires in combustible high-piled storage.

High-Piled Storage. Solid-piled, palletized, rack storage, bin box, and shelf storage in excess of 12 ft (3.7 m) in height. (*See 5-2.3.1.1.*)

Hydraulically Designed System. A calculated sprinkler system in which pipe sizes are selected on a pressure loss basis to provide a prescribed water density, in gallons per minute per square foot [(L/min)/m^2], or a prescribed minimum discharge pressure or flow per sprinkler, distributed with a reasonable degree of uniformity over a specified area.

Limited-Combustible Material. As applied to a building construction material, a material not complying with the definition of noncombustible material that, in the form in which it is used, has a potential heat value not exceeding 3500 Btu per lb (8141 kJ/kg) and complies with one of the following paragraphs, (a) or (b). Materials subject to increase in combustibility or flame spread rating beyond the limits herein established through the effects of age, moisture, or other atmospheric condition shall be considered combustible.

(a) Materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of $\frac{1}{8}$ in. (3.2 mm) that has a flame spread rating not greater than 50.

(b) Materials, in the form and thickness used, other than as described in (a), having neither a flame spread rating greater than 25 nor evidence of continued progressive combustion and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread rating greater than 25 nor evidence of continued progressive combustion.

Miscellaneous Storage.* Storage that does not exceed 12 ft (3.66 m) in height and is incidental to another occupancy use group as defined in 1-4.7 (see 5-2.3.1.1). Such storage shall not constitute more than 10 percent of the building area or 4,000 sq ft (372 m^2) of the sprinklered area, whichever is greater. Such storage shall not exceed 1,000 sq ft (93 m^2) in one pile or area, and each such pile or area shall be separated from other storage areas by at least 25 ft (7.62 m). Protection criteria for miscellaneous storage are within the scope of this standard.

Noncombustible Material. A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. Materials that are reported as passing ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, shall be considered noncombustible materials.

Pipe Schedule System. A sprinkler system in which the pipe sizing is selected from a schedule that is determined by the occupancy classification. A given number of sprinklers are allowed to be supplied from specific sizes of pipe.

Shop Welded. As used in this standard, shop in the term shop welded means either:

(a) At a sprinkler contractor's or fabricator's premise.

(b) In an area specifically designed or authorized for such work such as a detached outside location, maintenance shop, or other area (either temporary or permanent) of noncombustible or fire-resistive construction free of combustible and flammable contents and suitably segregated from adjacent areas.

Small Rooms. Rooms of Light Hazard Occupancy classification having unobstructed construction and floor areas not exceeding 800 sq ft (74.3 m^2). (*See 1-4.7.1.*)

Sprinkler System.* For fire protection purposes, an integrated system of underground and overhead piping designed in accordance with fire protection engineering standards. The installation includes one or more automatic water supplies. The portion of the sprinkler system aboveground is a network of specially sized or hydraulically designed piping installed in a building, structure, or area, generally overhead, and to which sprinklers are attached in a systematic pattern. The valve controlling each system riser is located in the system riser or its supply piping. Each sprinkler system riser includes a device for actuating an alarm when the system is in operation. The system is usually activated by heat from a fire and discharges water over the fire area.

NOTE: The design and installation of water supply facilities such as gravity tanks, fire pumps, reservoirs or pressure tanks, and underground piping are covered by the following NFPA standards: NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*; NFPA 22, *Standard for Water Tanks for Private Fire Protection*; and NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.

Thermal Barrier. A material that will limit the average temperature rise of the unexposed surface to not more than 250°F (121°C) after 15 minutes of fire exposure complying with the standard time-temperature curve of NFPA 251, *Standard Methods of Fire Tests of Building Construction and Materials*.

1-4.3 Sprinkler System Type Definitions.

Wet Pipe System. A sprinkler system employing automatic sprinklers attached to a piping system containing water and connected to a water supply so that water discharges immediately from sprinklers opened by heat from a fire.

Dry Pipe System. A sprinkler system employing automatic sprinklers attached to a piping system containing air or nitrogen under pressure, the release of which (as from the opening of a sprinkler) permits the water pressure to open a valve known as a dry pipe valve. The water then flows into the piping system and out the opened sprinklers.

Preaction System. A sprinkler system employing automatic sprinklers attached to a piping system containing air that may or may not be under pressure, with a supplemental detection system installed in the same areas as the sprinklers. Actuating means of the valve are described in 3-3.2.1. Actuation of the detection system opens a valve that permits water to flow into the sprinkler piping system and to be discharged from any sprinklers that are open.

Deluge System. A sprinkler system employing open sprinklers attached to a piping system connected to a water supply through a valve that is opened by the operation of a detection system installed in the same areas as the sprinklers. When this valve opens, water flows into the piping system and discharges from all sprinklers attached thereto.

Combined Dry Pipe-Preaction System. A sprinkler system employing automatic sprinklers attached to a piping system containing air under pressure with a supplemental detection system installed in the same areas as the sprinklers. Operation of the detection system actuates tripping devices that open dry pipe valves simultaneously and without loss of air pressure in the system. Operation of the detection system also opens listed air exhaust valves at the end of the feed main, which usually precedes the opening of sprinklers. The detection system also serves as an automatic fire alarm system.

Antifreeze System. A wet pipe sprinkler system employing automatic sprinklers attached to a piping system containing an antifreeze solution and connected to a water supply. The antifreeze solution is discharged, followed by water, immediately upon operation of sprinklers opened by heat from a fire.

Circulating Closed-Loop System. A wet pipe sprinkler system having non-fire-protection connections to automatic sprinkler systems in a closed-loop piping arrangement for the purpose of utilizing sprinkler piping to conduct water for heating or cooling. Water is not removed or used from the system, but only circulated through the piping system.

Gridded System.* A sprinkler system in which parallel cross mains are connected by multiple branch lines. An operating sprinkler will receive water from both ends of its branch line while other branch lines help transfer water between cross mains.

Looped System.* A sprinkler system in which multiple cross mains are tied together so as to provide more than one path for water to flow to an operating sprinkler and branch lines are not tied together.

1-4.4* System Component Definitions.

Branch Lines. The pipes in which the sprinklers are placed, either directly or through risers.

Cross Mains. The pipes supplying the branch lines, either directly or through risers.

Feed Mains. The pipes supplying risers or cross mains.

Flexible Listed Pipe Coupling. A listed coupling or fitting that allows axial displacement, rotation, and at least 1 degree of angular movement of the pipe without inducing harm on the pipe.

Exception: For pipe diameters of 8 in. (203.2 mm) and larger, the angular movement shall be permitted to be less than 1 degree but not less than 0.5 degrees.

Risers. The vertical supply pipes in a sprinkler system.

Supervisory Devices. Devices arranged to supervise the operative condition of automatic sprinkler systems.

System Riser. The aboveground supply pipe directly connected to the water supply.

1-4.5 Sprinkler Definitions.

1-4.5.1 Sprinklers defined according to design and performance characteristics:

Spray Sprinkler. A type of sprinkler listed for its capability to provide fire control for a wide range of fire hazards.

Old-Style/Conventional Sprinkler. Sprinklers that direct from 40 to 60 percent of the total water initially in a downward direction and that are designed to be installed with the deflector either upright or pendent.

Fast-Response Sprinkler. A type of sprinkler with a high level of thermal sensitivity, enabling it to respond at an early stage of fire development. This includes ESFR, QR, QREC, QRES, and residential sprinklers.

Residential Sprinkler. A type of fast-response sprinkler specifically listed for use in protection against the fire hazards typically found in dwelling units.

Extended Coverage (EC) Sprinkler. A type of spray sprinkler listed as a special sprinkler with extended maximum protection area.

Quick-Response (QR) Sprinkler. A type of sprinkler that is both a fast-response and a spray sprinkler.

Quick-Response Extended Coverage (QREC) Sprinkler. Sprinklers that are listed as both quick-response and extended coverage sprinklers.

Quick-Response Early Suppression (QRES) Sprinkler.* Fast response sprinklers that are listed for their capability to provide fire suppression of specific fire hazards.

Large-Drop Sprinkler. A type of 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.

Early Suppression Fast-Response (ESFR) Sprinkler.* A type of fast-response sprinkler listed for its capability to provide fire suppression of specific high challenge fire hazards.

Open Sprinkler. Sprinklers from which the heat responsive and actuating elements have been removed.

Nozzles. Devices for use in applications requiring special water discharge patterns, directional spray, or other unusual discharge characteristics.

Special Sprinkler. Sprinklers that have been tested and listed as prescribed in 4-3.2.

1-4.5.2 Sprinklers defined according to orientation:

Concealed Sprinkler. Recessed sprinklers with cover plates.

Flush Sprinkler. Sprinklers in which all or part of the body, including the shank thread, is mounted above the lower plane of the ceiling.

Pendent Sprinkler. Sprinklers designed to be installed in such a way that the water stream is directed downward against the deflector.

Recessed Sprinkler. Sprinklers in which all or part of the body, other than the shank thread, is mounted within a recessed housing.

Sidewall Sprinkler. Sprinklers having special deflectors that are designed to discharge most of the water away from the nearby wall in a pattern resembling one quarter of a sphere, with a small portion of the discharge directed at the wall behind the sprinkler.

Upright Sprinkler. Sprinklers designed to be installed in such a way that the water spray is directed upwards against the deflector.

1-4.5.3 Sprinklers defined according to special application or environment:

Corrosion-Resistant Sprinkler. Sprinklers fabricated with corrosion-resistant material or with special coatings or platings to be used in an atmosphere that would normally corrode sprinklers.

Dry Sprinkler.* Sprinklers secured in an extension nipple that has a seal at the inlet end to prevent water from entering the nipple until the sprinkler operates. Dry sprinklers are intended to extend into an unheated area from a wet pipe system or (for dry-pendent sprinklers) to be used on a dry pipe system in the pendent position.

Intermediate Level Sprinkler/Rack Storage Sprinkler. Sprinklers equipped with integral shields to protect their operating elements from the discharge of sprinklers installed at higher elevations.

Ornamental/Decorative Sprinkler. Sprinklers that have been painted or plated by the manufacturer.

1-4.6* Construction Definitions.

Obstructed Construction. Construction where beams, trusses, or other members impede heat flow or water distribution in a manner that materially affects the ability of sprinklers to control or suppress a fire.

Unobstructed Construction. Construction where beams, trusses, or other members do not impede heat flow or water distribution in a manner that materially affects the ability of sprinklers to control or suppress a fire. Unobstructed construction has horizontal structural members that are not solid, where the openings are at least 70 percent of the cross section area, and the depth of the member does not exceed the least dimension of the openings, or all construction types where the spacing of structural members exceeds 7½ ft (2.3 m) on center.

For descriptions of construction types, see A-1-4.6(a) and (b).

1-4.7* Classification of Occupancies. Occupancy classifications for this standard relate to sprinkler installations and their water supplies only. They are not intended to be a general classification of occupancy hazards.

1-4.7.1* Light Hazard Occupancies. Occupancies or portions of other occupancies where the quantity and/or combustibility of contents is low, and fires with relatively low rates of heat release are expected.

1-4.7.2 Ordinary Hazard Occupancies.

1-4.7.2.1* Ordinary Hazard (Group 1). Occupancies or portions of other occupancies where combustibility is low, quantity of combustibles is moderate, stockpiles of combustibles do not exceed 8 ft (2.4 m), and fires with moderate rates of heat release are expected.

1-4.7.2.2* Ordinary Hazard (Group 2). Occupancies or portions of other occupancies where quantity and combustibility of contents is moderate to high, stockpiles do not exceed 12 ft (3.7 m), and fires with moderate to high rates of heat release are expected.

1-4.7.3 Extra Hazard Occupancies.

1-4.7.3.1* Occupancies or portions of other occupancies where quantity and combustibility of contents is very high and flammable and combustible liquids, dust, lint, or other materials are present, introducing the probability of rapidly developing fires with high rates of heat release.

1-4.7.3.2 Extra hazard occupancies involve a wide range of variables that may produce severe fires. The following shall be used to evaluate the severity of Extra Hazard Occupancies:

Extra Hazard (Group 1) includes occupancies described in 1-4.7.3.1 with little or no flammable or combustible liquids.

Extra Hazard (Group 2) includes occupancies described in 1-4.7.3.1 with moderate to substantial amounts of flammable or combustible liquids or where shielding of combustibles is extensive.

1-4.7.4 Special Occupancy Hazards.

1-4.7.4.1* Other NFPA standards contain sprinkler system design criteria for fire control or suppression of specific hazards. These are listed in Chapter 10 and include but are not limited to NFPA 30, *Flammable and Combustible Liquids Code*; NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products*; NFPA 40, *Standard for the Storage and Handling of Cellulose Nitrate Motion Picture Film*; NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*; NFPA 81, *Standard for Fur Storage, Fumigation and Cleaning*; NFPA 231, *Standard for General Storage*; NFPA 231C, *Standard for Rack Storage of Materials*; NFPA 231D, *Standard for Storage of Rubber Tires*; NFPA 231E, *Recommended Practice for the Storage of Baled Cotton*; NFPA 231F, *Standard for the Storage of Roll Paper*; NFPA 232, *Standard for the Protection of Records*; and NFPA 409, *Standard on Aircraft Hangars*.

1-4.7.4.2 Miscellaneous storage as defined herein shall be classified as to occupancy group in accordance with Table 1-4.7.4.2.

1-4.7.4.2.1 The commodity classifications and storage characteristics in Table 1-4.7.4.2 shall be as defined in NFPA 231 and NFPA 231C.

1-5 Abbreviations. The standard abbreviations in Table 1-5 shall be used on the hydraulic calculation form.

1-6 Level of Protection.

1-6.1 A building, where protected by an automatic sprinkler system installation, shall be provided with sprinklers in all areas.

Exception: Where specific sections of this standard permit the omission of sprinklers.

1-6.2 Limited Area Systems. When partial sprinkler systems are installed, the requirements of this standard shall be used insofar as they are applicable. The authority having jurisdiction shall be consulted in each case.

Table 1-4.7.4.2 Occupancy Group Classification for Miscellaneous Storage 12 ft (3.7 m) or Less in Height*†

Commodity Classes I through IV

Commodity Classification	Palletized and Bin Box	Rack
I	OH-1	OH-1
II	OH-1	OH-1
III	OH-2	OH-2
IV	OH-2	OH-2

Group A Plastics

Height of Storage	Ceiling Clearance to Top of Storage	Rack-R or Palletized-P	Cartoned		Exposed	
			Solid	Expanded	Solid	Expanded
To 5 ft	No Limit	R-P	OH-2	OH-2	OH-2	OH-2
Over 5 ft to 10 ft	To 5 ft	R-P	EH-1	EH-1	EH-2	EH-2
Over 5 ft to 10 ft	Over 5 ft to 10 ft	R-P	EH-2	EH-2	EH-2	
Over 5 ft to 8 ft	Over 5 ft	P				EH-2
Over 10 ft to 12 ft	To 15 ft	P	EH-2	EH-2		
Over 10 ft to 12 ft	Over 5 ft	R	OH-2 +1 Level In Rack	OH-2 +1 Level In Rack	OH-2 +1 Level In Rack	OH-2 +1 Level In Rack
Over 10 ft to 12 ft	To 5 ft	R-P	EH-2**	EH-2**	EH-2**	EH-2

**For rack storage, OH-2 +1 Level In Rack shall also be permitted.

Table 1-4.7.4.2 (continued)

Miscellaneous Tire Storage

Piling Methods	Height of Storage	Occupancy Group
On Floor, on Side	5 ft to 12 ft	EH-1
On Floor, on Tread or Side	To 5 ft	OH-2
Single, Double, or Multi-Row Racks	To 5 ft	OH-2
Portable or Fixed Single Row Rack	5 ft to 12 ft	EH-1
Portable Single Row Rack, Fixed	5 ft to 12 ft	EH-1 or OH-2 plus one level of in-rack sprinklers

Rolled Paper Stored on End	Height of Storage	Occupancy Group
Heavy and Medium Weight	To 8 ft	OH-2
	Over 8 ft to 12 ft	EH-1
Tissue	To 10 ft	EH-1
	Over 10 ft to 12 ft	EH-2

Pallet Storage	Height of Storage	Occupancy Group
	To 6 ft Wooden	OH-2
	To 4 ft Plastic	OH-2

*For storage heights or clearance to ceiling in excess of the above configurations, see NFPA 231, 231C, 231D, or 231F as appropriate.
†The design of the sprinkler system shall be based on the conditions that will routinely or periodically exist in the building creating the greatest water demand, including pile height and clearance.

Table 1-5 Hydraulic Symbols

Symbol or Abbreviation	Item
p	Pressure in psi
gpm	U.S. gallons per minute
q	Flow increment in gpm to be added at a specific location
Q	Summation of flow in gpm at a specific location
P_t	Total pressure in psi at a point in a pipe
P_f	Pressure loss due to friction between points indicated in location column
P_e	Pressure due to elevation difference between indicated points. This can be a plus value or a minus value. Where minus, the (−) shall be used; where plus, no sign need be indicated
P_v	Velocity pressure in psi at a point in a pipe
P_n	Normal pressure in psi at a point in a pipe
E	90° Ell
EE	45° Ell
Lt.E	Long turn Elbow
Cr	Cross
T	Tee—flow turned 90°
GV	Gate Valve
BV	Butterfly (Wafer) Check Valve
Del V	Deluge Valve
ALV	Alarm Valve
DPV	Dry Pipe Valve
CV	Swing Check Valve
WCV	Butterfly (Wafer) Check Valve
St	Strainer
psi	Pounds per square inch
v	Velocity of water in pipe in feet per second

Chapter 2 System Components and Hardware

2-1 General. This chapter provides requirements for correct use of sprinkler system components.

2-1.1* All materials and devices essential to successful system operation shall be listed.

Exception No. 1: Equipment as permitted in Table 2-3.1, Table 2-4.1, and the Exceptions to 2-6.1 and 2-6.1.1 need not be listed.

Exception No. 2: Components that do not affect system operation such as drain valves and signs need not be listed. The use of reconditioned valves and devices other than sprinklers as replacement equipment in existing systems shall be permitted.

2-1.2 System components shall be rated for the maximum working pressure to which they are exposed but not less than 175 psi (12.1 bars).

2-2 Sprinklers.

2-2.1 Only new sprinklers shall be installed.

2-2.2 Sprinkler Discharge Characteristics. The K factor, relative discharge, and identification for sprinklers having different orifice sizes shall be in accordance with Table 2-2.2.

Exception: Listed sprinklers having pipe threads different from those shown in Table 2-2.2 shall be permitted.

Table 2-2.2 Sprinkler Discharge Characteristics Identification

Nominal Orifice Size (in.)	Orifice Type	K Factor[1]	Percent of Nominal 1/2 in. Discharge	Thread Type	Pintle	Nominal Orifice Size Marked On Frame
1/4	Small	1.3-1.5	25	1/2 in. NPT	Yes	Yes
5/16	Small	1.8-2.0	33.3	1/2 in. NPT	Yes	Yes
3/8	Small	2.6-2.9	50	1/2 in. NPT	Yes	Yes
7/16	Small	4.0-4.4	75	1/2 in. NPT	Yes	Yes
1/2	Standard	5.3-5.8	100	1/2 in. NPT	No	No
17/32	Large	7.4-8.2	140	3/4 in. NPT or	No	No
				1/2 in. NPT	Yes	Yes
5/8	Extra Large	11.0-11.5	200	1/2 in. NPT or	Yes	Yes
				3/4 in. NPT	Yes	Yes
3/4	Very Extra Large	13.5-14.5	250	3/4 in. NPT	Yes	Yes
5/8	Large-Drop	11.0-11.5	200	1/2 in. NPT or	Yes	Yes
				3/4 in. NPT	Yes	Yes
5/8	ESFR	11.0-11.5	200	3/4 in. NPT	Yes	Yes
3/4	ESFR	13.5-14.5	250	3/4 in. NPT	Yes	Yes

[1]K factor is the constant in the formula $Q = K\sqrt{p}$
Where Q = Flow in gpm
p = Pressure in psi

For SI Units: $Q_m = K_m\sqrt{p}_m$
Where Q_m = Flow in L/min
P_m = Pressure in bars
K_m = 14 K

2-2.2.1 For Light Hazard Occupancies not requiring as much water as is discharged by a nominal 1/2-in. (12.7-mm) orifice sprinkler operating at 7 psi (0.5 bar), sprinklers having a smaller orifice shall be permitted subject to the following restrictions:

(a) The system shall be hydraulically calculated. (*See Chapter 6.*)

(b) Small-orifice sprinklers shall be installed in wet systems only.

Exception: Small-orifice outside sprinklers for protection from exposure fires installed in conformance with Section 3-7 shall be permitted.

(c) A listed strainer shall be provided on the supply side of sprinklers having nominal orifice sizes smaller than 3/8 in. (9.5 mm).

2-2.2.2 Sprinklers having orifice sizes exceeding 1/2 in. (12.7 mm) and having 1/2 in. (12.7 mm) NPT shall not be installed in new sprinkler systems.

2-2.3* Temperature Characteristics.

2-2.3.1 The standard temperature ratings of automatic sprinklers are shown in Table 2-2.3.1. Automatic sprinklers shall have their frame arms colored in accordance with the color code designated in Table 2-2.3.1.

Exception No. 1: A dot on the top of the deflector, or the color of the coating material, or colored frame arms shall be permitted for color identification of corrosion-resistant sprinklers.

Exception No. 2: Color identification shall not be required for ornamental sprinklers such as factory-plated or factory-painted sprinklers or for recessed, flush, or concealed sprinklers.

Exception No. 3: The frame arms of bulb-type sprinklers need not be color coded.

2-2.3.2 The liquid in bulb-type sprinklers shall be color coded in accordance with Table 2-2.3.1.

2-2.4 Special Coatings.

2-2.4.1* Listed corrosion-resistant sprinklers shall be installed in locations where chemicals, moisture, or other corrosive vapors sufficient to cause corrosion of such devices exist.

2-2.4.2* Corrosion-resistant coatings shall be applied only by the manufacturer of the sprinkler.

Exception: Any damage to the protective coating occurring at the time of installation shall be repaired at once using only the coating of the manufacturer of the sprinkler in the approved manner so that no part of the sprinkler will be exposed after installation has been completed.

2-2.4.3* Unless applied by the manufacturer, sprinklers shall not be painted, and any sprinklers that have been painted shall be replaced with new listed sprinklers of the same characteristics, including orifice size, thermal response, and water distribution.

Exception: Factory-applied paint or coating to sprinkler frames in accordance with 2-2.3.1 shall be permitted.

2-2.4.4 Ornamental finishes shall not be applied to sprinklers by anyone other than the sprinkler manufacturer, and only sprinklers listed with such finishes shall be used.

2-2.5 Escutcheon Plates.

2-2.5.1 Nonmetallic escutcheon plates shall be listed.

2-2.5.2* Escutcheon plates used with a recessed or flush-type sprinkler shall be part of a listed sprinkler assembly.

2-2.6* Guards and Shields. Sprinklers subject to mechanical injury shall be protected with listed guards.

2-2.7 Stock of Spare Sprinklers.

2-2.7.1 A supply of spare sprinklers (never fewer than 6) shall be maintained on the premises so that any sprinklers that have operated or been damaged in any way can be promptly replaced. These sprinklers shall correspond to

Table 2-2.3.1 Temperature Ratings, Classifications, and Color Codings

Max. Ceiling Temp. °F	Max. Ceiling Temp. °C	Temperature Rating °F	Temperature Rating °C	Temperature Classification	Color Code	Glass Bulb Colors
100	38	135 to 170	57 to 77	Ordinary	Uncolored or Black	Orange or Red
150	66	175 to 225	79 to 107	Intermediate	White	Yellow or Green
225	107	250 to 300	121 to 149	High	Blue	Blue
300	149	325 to 375	163 to 191	Extra High	Red	Purple
375	191	400 to 475	204 to 246	Very Extra High	Green	Black
475	246	500 to 575	260 to 302	Ultra High	Orange	Black
625	329	650	343	Ultra High	Orange	Black

the types and temperature ratings of the sprinklers in the property. The sprinklers shall be kept in a cabinet located where the temperature to which they are subjected will at no time exceed 100°F (38°C).

2-2.7.2 A special sprinkler wrench shall also be provided and kept in the cabinet to be used in the removal and installation of sprinklers.

2-2.7.3 The stock of spare sprinklers shall include all types and ratings installed and shall be as follows:

(a) For systems having less than 300 sprinklers, not fewer than 6 sprinklers.

(b) For systems with 300 to 1000 sprinklers, not fewer than 12 sprinklers.

(c) For systems with over 1000 sprinklers, not fewer than 24 sprinklers.

2-3 Pipe and Tube.

2-3.1 Pipe or tube used in sprinker systems shall meet or exceed one of the standards in Table 2-3.1 or be in accordance with 2-3.5. In addition, steel pipe must be in accordance with 2-3.2 and 2-3.3, copper tube must be in accordance with 2-3.4, and nonmetallic pipe must be in accordance with 2-3.5 and with the portions of the ASTM standards specified in Table 2-3.5 that apply to fire protection service.

2-3.2* When steel pipe listed in Table 2-3.1 is used and joined by welding as referenced in 2-5.2 or by roll-grooved pipe and fittings as referenced in 2-5.3, the minimum nominal wall thickness for pressures up to 300 psi (20.7 bars) shall be in accordance with Schedule 10 for sizes up to 5 in. (127 mm); 0.134 in. (3.40 mm) for 6 in. (152 mm); and 0.188 in. (4.78 mm) for 8- and 10-in. (203- and 254-mm) pipe.

Exception: Pressure limitations and wall thickness for steel pipe listed in accordance with 2-3.5 shall be in accordance with the listing requirements.

2-3.3 When steel pipe listed in Table 2-3.1 is joined by threaded fittings referenced in 2-5.1 or by fittings used with pipe having cut grooves, the minimum wall thickness shall be in accordance with Schedule 30 [in sizes 8 in. (203 mm) and larger] or Schedule 40 [in sizes less than 8 in. (203 mm)] pipe for pressures up to 300 psi (20.7 bars).

Exception: Pressure limitations and wall thickness for steel pipe specially listed in accordance with 2-3.5 shall be in accordance with the listing requirements.

2-3.4* Copper tube as specified in the standards listed in Table 2-3.1 shall have a wall thickness of Type K, L, or M where used in sprinkler systems.

Table 2-3.1 Pipe or Tube Materials and Dimensions

Materials and Dimensions	Standard
Ferrous Piping (Welded and Seamless)	
† Spec. for Black and Hot-Dipped Zinc Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use	ASTM A795
† Spec. for Welded and Seamless Steel Pipe	ANSI/ ASTM A53
Wrought Steel Pipe	ANSI B36.10M
Spec. for Elec.-Resistance Welded Steel Pipe	ASTM A135
Copper Tube (Drawn, Seamless)	
† Spec. for Seamless Copper Tube	ASTM B75
† Spec. for Seamless Copper Water Tube	ASTM B88
Spec. for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube	ASTM B251
Fluxes for Soldering Applications of Copper and Copper Alloy Tube	ASTM B813
Brazing Filler Metal (Classification BCuP-3 or BCuP-4)	AWS A5.8
Solder Metal, 95-5 (Tin-Antimony-Grade 95TA)	ASTM B32

† Denotes pipe or tubing suitable for bending (see 2-3.6) according to ASTM standards.

2-3.5* Other types of pipe or tube investigated for suitability in automatic sprinkler installations and listed for this service, including but not limited to polybutylene, chlorinated polyvinyl chloride (CPVC), and steel differing from that provided in Table 2-3.1, shall be permitted where installed in accordance with their listing limitations, including installation instructions. Pipe or tube shall not be listed for portions of an occupancy classification. Bending of pipe conforming to 2-3.5 shall be permitted as allowed by the listing.

Table 2-3.5 Specially Listed Pipe or Tube Materials and Dimensions

Materials and Dimensions	Standard
Nonmetallic Piping	
Specification for Special Listed Chlorinated Polyvinyl Chloride (CPVC) Pipe	ASTM F442
Specification for Special Listed Polybutylene (PB) Pipe	ASTM D3309

2-3.6 Pipe Bending. Bending of Schedule 40 steel pipe and Types K and L copper tube shall be permitted where bends are made with no kinks, ripples, distortions, reductions in diameter, or any noticeable deviations from round. The minimum radius of a bend shall be 6 pipe diameters for pipe sizes 2 in. (51 mm) and smaller, and 5 pipe diameters for pipe sizes 2½ in. (64 mm) and larger.

2-3.7 Pipe Identification. All pipe, including specially listed pipe allowed by 2-3.5, shall be marked continuously along its length by the manufacturer in such a way as to properly identify the type of pipe. This identification shall include the manufacturer's name, model designation, or schedule.

2-4 Fittings.

2-4.1 Fittings used in sprinkler systems shall meet or exceed the standards in Table 2-4.1 or be in accordance with 2-4.2. In addition to the standards in Table 2-4.1, CPVC fittings shall also be in accordance with 2-4.2 and with the portions of the ASTM standards specified in Table 2-4.2 that apply to fire protection service.

Table 2-4.1 Fittings Materials and Dimensions

Materials and Dimensions	Standard
Cast Iron	
Cast Iron Threaded Fittings, Class 125 and 250	ANSI B16.4
Cast Iron Pipe Flanges and Flanged Fittings	ANSI B16.1
Malleable Iron	
Malleable Iron Threaded Fittings, Class 150 and 300	ANSI B16.3
Steel	
Factory-made Wrought Steel Buttweld Fittings	ANSI B16.9
Buttwelding Ends for Pipe, Valves, Flanges, and Fittings	ANSI B16.25
Spec. for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures	ASTM A234
Steel Pipe Flanges and Flanged Fittings	ANSI B16.5
Forged Steel Fittings, Socket Welded and Threaded	ANSI B16.11
Copper	
Wrought Copper and Bronze Solder-Joint Pressure Fittings	ANSI B16.22
Cast Bronze Solder-Joint Pressure Fittings	ANSI B16.18

2-4.2* Other types of fittings investigated for suitability in automatic sprinkler installations and listed for this service, including but not limited to polybutylene, chlorinated polyvinyl chloride (CPVC), and steel differing from that provided in Table 2-4.1, shall be permitted when installed in accordance with their listing limitations, including installation instructions.

2-4.3 Fittings shall be extra-heavy pattern where pressures exceed 175 psi (12.1 bars).

Exception No. 1: Standard weight pattern cast-iron fittings 2 in. (51 mm) in size and smaller shall be permitted where pressures do not exceed 300 psi (20.7 bars).

Table 2-4.2 Specially Listed Fittings Materials and Dimensions

Materials and Dimensions	Standard
Chlorinated Polyvinyl Chloride (CPVC) Specification for Schedule 80 CPVC Threaded Fittings	ASTM F437
Specification for Schedule 40 CPVC Socket-type Fittings	ASTM F438
Specification for Schedule 80 CPVC Socket-type Fittings	ASTM F439

Exception No. 2: Standard weight pattern malleable iron fittings 6 in. (152 mm) in size and smaller shall be permitted where pressures do not exceed 300 psi (20.7 bars).

Exception No. 3: Fittings shall be permitted for system pressures up to the limits specified in their listings.

2-4.4* Couplings and Unions. Screwed unions shall not be used on pipe larger than 2 in. (51 mm). Couplings and unions of other than screwed-type shall be of types listed specifically for use in sprinkler systems.

2-4.5 Reducers and Bushings. A one-piece reducing fitting shall be used wherever a change is made in the size of the pipe.

Exception No. 1: Hexagonal or face bushings shall be permitted in reducing the size of openings of fittings when standard fittings of the required size are not available.

Exception No. 2: Hexagonal bushings as permitted in 4-5.18.1 are acceptable.

2-5 Joining of Pipe and Fittings.

2-5.1 Threaded Pipe and Fittings.

2-5.1.1 All threaded pipe and fittings shall have threads cut to ANSI/ASME B1.20.1, *Pipe Threads, General Purpose.*

2-5.1.2* Steel pipe with wall thicknesses less than Schedule 30 [in sizes 8 in. (203 mm) and larger] or Schedule 40 [in sizes less than 8 in. (203 mm)] shall not be joined by threaded fittings.

Exception: A threaded assembly investigated for suitability in automatic sprinkler installations and listed for this service shall be permitted.

2-5.1.3 Joint compound or tape shall be applied only to male threads.

2-5.2* Welded Pipe and Fittings.

2-5.2.1 Welding methods that comply with all of the requirements of AWS D10.9, *Specification for Qualification of Welding Procedures and Welders for Piping and Tubing,* Level AR-3, are acceptable means of joining fire protection piping.

2-5.2.2* Sprinkler piping shall be shop welded.

Exception No 1: Welding of tabs for longitudinal earthquake bracing to in-place piping shall be permitted where the welding process is performed in accordance with NFPA 51B, Standard for Fire Prevention in Use of Cutting and Welding Processes.

Exception No. 2: Where the design specifications call for all or part of the piping to be welded in place, welding of sprinkler piping in place shall be permitted where the welding process is performed in accordance with NFPA 51B, and the mechanical fittings required by 4-5.15 and 4-5.22 are provided.

2-5.2.3 Fittings used to join pipe shall be listed fabricated fittings or manufactured in accordance with Table 2-4.1. Such fittings joined in conformance with a qualified welding procedure as set forth in this section are an acceptable product under this standard, provided that materials and wall thickness are compatible with other sections of this standard.

Exception: Fittings are not required where pipe ends are butt-welded.

2-5.2.4 No welding shall be performed if there is impingement of rain, snow, sleet, or high wind on the weld area of the pipe product.

2-5.2.5 When welding is performed:

(a)* Holes in piping for outlets shall be cut to the full inside diameter of fittings prior to welding in place of the fittings.

(b) Discs shall be retrieved.

(c) Openings cut into piping shall be smooth bore, and all internal slag and welding residue shall be removed.

(d) Fittings shall not penetrate the internal diameter of the piping.

(e) Steel plates shall not be welded to the ends of piping or fittings.

(f) Fittings shall not be modified.

(g) Nuts, clips, eye rods, angle brackets, or other fasteners shall not be welded to pipe or fittings.

Exception: Only tabs welded to pipe for longitudinal earthquake braces shall be permitted. (See 4-6.4.3.5.3.)

2-5.2.6 When the pipe size in a run of piping is reduced, a reducing fitting designed for that purpose shall be used.

2-5.2.7 Torch cutting and welding shall not be permitted as a means of modifying or repairing sprinkler systems.

2-5.2.8 Qualifications.

2-5.2.8.1 A welding procedure shall be prepared and qualified by the contractor or fabricator before any welding is done. Qualification of the welding procedure to be used and the performance of all welders and welding operators is required and shall meet or exceed the requirements of American Welding Society Standard AWS D10.9, Level AR-3.

2-5.2.8.2 Contractors or fabricators shall be responsible for all welding they produce. Each contractor or fabricator shall have available to the authority having jurisdiction an established written quality assurance procedure ensuring compliance with the requirements of 2-5.2.5.

2-5.2.9 Records.

2-5.2.9.1 Welders or welding machine operators shall, upon completion of each weld, stamp an imprint of their identification into the side of the pipe adjacent to the weld.

2-5.2.9.2 Contractors or fabricators shall maintain certified records, which shall be available to the authority having jurisdiction, of the procedures used and the welders or welding machine operators employed by them along with their welding identification imprints. Records shall show the date and the results of procedure and performance qualifications.

2-5.3 Groove Joining Methods.

2-5.3.1 Pipe joined with grooved fittings shall be joined by a listed combination of fittings, gaskets, and grooves. Grooves cut or rolled on pipe shall be dimensionally compatible with the fittings.

2-5.3.2 Grooved fittings including gaskets used on dry pipe systems shall be listed for dry pipe service.

2-5.4* Brazed and Soldered Joints. Joints for the connection of copper tube shall be brazed.

Exception No. 1: Solder joints shall be permitted for exposed wet pipe systems in Light Hazard Occupancies where the temperature classification of the installed sprinklers is ordinary or intermediate.

Exception No. 2: Solder joints shall be permitted for wet pipe systems in Light Hazard and Ordinary Hazard (Group 1) Occupancies where the piping is concealed, irrespective of sprinkler temperature ratings.

2-5.4.1* Soldering fluxes shall be in accordance with Table 2-3.1. Brazing fluxes, if used, shall not be of a highly corrosive type.

2-5.5 Other Types. Other joining methods investigated for suitability in automatic sprinkler installations and listed for this service shall be permitted where installed in accordance with their listing limitations, including installation instructions.

2-5.6 End Treatment. After cutting, pipe ends shall have burrs and fins removed.

2-5.6.1 Pipe used with listed fittings and its end treatment shall be in accordance with the fitting manufacturer's installation instructions and the fitting's listing.

2-6 Hangers.

2-6.1* General. Types of hangers shall be in accordance with the requirements of Section 2-6.

Exception: Hangers certified by a registered professional engineer to include all of the following shall be acceptable:

(a) Hangers are designed to support five times the weight of the water-filled pipe plus 250 lb (114 kg) at each point of piping support.

(b) These points of support are adequate to support the sprinkler system.

(c) Hanger components shall be ferrous.

Detailed calculations shall be submitted, when required by the reviewing authority, showing stresses developed both in hangers and piping and safety factors allowed.

2-6.1.1 The components of hanger assemblies that directly attach to the pipe or to the building structure shall be listed.

Exception: Mild steel hangers formed from rods need not be listed.

2-6.1.2 Hangers and their components shall be ferrous.

Exception: Nonferrous components that have been proven by fire tests to be adequate for the hazard application, that are listed for this purpose, and that are in compliance with the other requirements of this section shall be acceptable.

2-6.1.3 Sprinkler piping shall be substantially supported from the building structure, which must support the added load of the water-filled pipe plus a minimum of 250 lb (114 kg) applied at the point of hanging.

2-6.1.4 Where sprinkler piping is installed below ductwork, piping shall be supported from the building structure or from the ductwork supports, provided such supports are capable of handling both the load of the ductwork and the load specified in 2-6.1.3.

2-6.1.5* For trapeze hangers, the minimum size of steel angle or pipe span between purlins or joists shall be such that the available section modulus of the trapeze member from Table 2-6.1.5(b) equals or exceeds the section modulus required in Table 2-6.1.5(a).

Any other sizes or shapes giving equal or greater section modulus shall be acceptable. All angles shall be used with the longer leg vertical. The trapeze member shall be secured to prevent slippage. Where a pipe is suspended from a pipe trapeze of a diameter less than the diameter of the pipe being supported, ring, strap, or clevis hangers of the size corresponding to the suspended pipe shall be used on both ends.

2-6.1.6 The size of hanger rods and fasteners required to support the steel angle iron or pipe indicated in Table 2-6.1.5(a) shall comply with 2-6.4.

2-6.1.7* Sprinkler piping or hangers shall not be used to support nonsystem components.

2-6.2 Hangers in Concrete.

2-6.2.1 The use of listed inserts set in concrete to support hangers shall be permitted.

2-6.2.2 Listed expansion shields for supporting pipes under concrete construction shall be permitted to be used in a horizontal position in the sides of beams. In concrete having gravel or crushed stone aggregate, expansion shields shall be permitted to be used in the vertical position to support pipes 4 in. (102 mm) or less in diameter.

2-6.2.3 For the support of pipes 5 in. (127 mm) and larger, expansion shields, if used in the vertical position, shall alternate with hangers connected directly to the structural members, such as trusses and girders, or to the sides of concrete beams. In the absence of convenient structural members, pipes 5 in. (127 mm) and larger shall be permitted to be supported entirely by expansion shields in the vertical position, but spaced not over 10 ft (3 m) apart.

2-6.2.4 Expansion shields shall not be used in ceilings of gypsum or similar soft material. In cinder concrete, expansion shields shall not be used except on branch lines where they shall alternate with through-bolts or hangers attached to beams.

2-6.2.5 Where expansion shields are used in the vertical position, the holes shall be drilled to provide uniform contact with the shield over its entire circumference. Depth of the hole shall not be less than specified for the type of shield used.

2-6.2.6 Holes for expansion shields in the side of concrete beams shall be above the center line of the beam or above the bottom reinforcement steel rods.

Table 2-6.1.5(a) Section Modulus Required for Trapeze Members ($in.^3$)

Span of Trapeze	1 in.	1¼ in.	1½ in.	2 in.	2½ in.	3 in.	3½ in.	4 in.	5 in.	6 in.	8 in.	10 in.
1 ft 6 in.	.08	.09	.09	.09	.10	.11	.12	.13	.15	.18	.24	.32
	.08	.09	.09	.10	.11	.12	.13	.15	.18	.22	.30	.41
2 ft 0 in.	.11	.12	.12	.13	.13	.15	.16	.17	.20	.24	.32	.43
	.11	.12	.12	.13	.15	.16	.18	.20	.24	.29	.40	.55
2 ft 6 in.	.14	.14	.15	.16	.17	.18	.20	.21	.25	.30	.40	.54
	.14	.15	.15	.16	.18	.21	.22	.25	.30	.36	.50	.68
3 ft 0 in.	.17	.17	.18	.19	.20	.22	.24	.26	.31	.36	.48	.65
	.17	.18	.18	.20	.22	.25	.27	.30	.36	.43	.60	.82
4 ft 0 in.	.22	.23	.24	.25	.27	.29	.32	.34	.41	.48	.64	.87
	.22	.24	.24	.26	.29	.33	.36	.40	.48	.58	.80	1.09
5 ft 0 in.	.28	.29	.30	.31	.34	.37	.40	.43	.51	.59	.80	1.08
	.28	.29	.30	.33	.37	.41	.45	.49	.60	.72	1.00	1.37
6 ft 0 in.	.33	.35	.36	.38	.41	.44	.48	.51	.61	.71	.97	1.30
	.34	.35	.36	.39	.44	.49	.54	.59	.72	.87	1.20	1.64
7 ft 0 in.	.39	.40	.41	.44	.47	.52	.55	.60	.71	.83	1.13	1.52
	.39	.41	.43	.46	.51	.58	.63	.69	.84	1.01	1.41	1.92
8 ft 0 in.	.44	.46	.47	.50	.54	.59	.63	.68	.81	.95	1.29	1.73
	.45	.47	.49	.52	.59	.66	.72	.79	.96	1.16	1.61	2.19
9 ft 0 in.	.50	.52	.53	.56	.61	.66	.71	.77	.92	1.07	1.45	1.95
	.50	.53	.55	.59	.66	.74	.81	.89	1.08	1.30	1.81	2.46
10 ft 0 in.	.56	.58	.59	.63	.68	.74	.79	.85	1.02	1.19	1.61	2.17
	.56	.59	.61	.65	.74	.82	.90	.99	1.20	1.44	2.01	2.74

For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Top values are for Schedule 10 pipe; bottom values are for Schedule 40 pipe.
NOTE: The table is based on a maximum allowable bending stress of 15 KSI and a midspan concentrated load from 15 ft (4.6 m) of water-filled pipe, plus 250 lb (114 kg).

Table 2-6.1.5(b) Available Section Moduli of Common Trapeze Hangers

Pipe	Modulus	Angles					Modulus
Schedule 10							
1 in.	.12	1 1/2	×	1 1/2	×	3/16	.10
1 1/4 in.	.19	2	×	2	×	1/8	.13
1 1/2 in.	.26	2	×	1 1/2	×	3/16	.18
2 in.	.42	2	×	2	×	3/16	.19
2 1/2 in.	.69	2	×	2	×	1/4	.25
3 in.	1.04	2 1/2	×	1 1/2	×	3/16	.28
3 1/2 in.	1.38	2 1/2	×	2	×	3/16	.29
4 in.	1.76	2	×	2	×	5/16	.30
5 in.	3.03	2 1/2	×	2 1/2	×	3/16	.30
6 in.	4.35	2	×	2	×	3/8	.35
		2 1/2	×	2 1/2	×	1/4	.39
		3	×	2	×	3/16	.41
Schedule 40		3	×	2 1/2	×	3/16	.43
1 in.	.13	3	×	3	×	3/16	.44
1 1/4 in.	.23	2 1/2	×	2 1/2	×	5/16	.48
1 1/2 in.	.33	3	×	2	×	1/4	.54
2 in.	.56	2 1/2	×	2	×	3/8	.55
2 1/2 in.	1.06	2 1/2	×	2 1/2	×	3/8	.57
3 in.	1.72	3	×	3	×	1/4	.58
3 1/2 in.	2.39	3	×	3	×	5/16	.71
4 in.	3.21	2 1/2	×	2 1/2	×	1/2	.72
5 in.	5.45	3 1/2	×	2 1/2	×	1/4	.75
6 in.	8.50	3	×	2 1/2	×	3/8	.81
		3	×	3	×	3/8	.83
		3 1/2	×	2 1/2	×	5/16	.93
		3	×	3	×	7/16	.95
		4	×	4	×	1/4	1.05
		3	×	3	×	1/2	1.07
		4	×	3	×	5/16	1.23
		4	×	4	×	5/16	1.29
		4	×	3	×	3/8	1.46
		4	×	4	×	3/8	1.52
		5	×	3 1/2	×	5/16	1.94
		4	×	4	×	1/2	1.97
		4	×	4	×	5/8	2.40
		4	×	4	×	3/4	2.81
		6	×	4	×	3/8	3.32
		6	×	4	×	1/2	4.33
		6	×	4	×	3/4	6.25
		6	×	6	×	1	8.57

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

2-6.3 Powder-Driven Studs and Welding Studs.

2-6.3.1* Powder-driven studs, welding studs, and the tools used for installing these devices shall be listed. Pipe size, installation position, and construction material into which they are installed shall be in accordance with individual listings.

2-6.3.2* Representative samples of concrete into which studs are to be driven shall be tested to determine that the studs will hold a minimum load of 750 lb (341 kg) for 2-in. (51-mm) or smaller pipe, 1000 lb (454 kg) for 2 1/2-, 3-, or 3 1/2-in. (64-, 76-, or 89-mm) pipe, and 1200 lb (545 kg) for 4- or 5-in. (102- or 127-mm) pipe.

2-6.3.3 Increaser couplings shall be attached directly to the powder-driven studs or welding studs.

2-6.3.4 Welding studs or other hanger parts shall not be attached by welding to steel less than U.S. Standard, 12 gauge.

2-6.4 Rods and "U" Hooks.

2-6.4.1 Hanger rod size shall be the same as that approved for use with the hanger assembly, and the size of rods shall not be less than that given in Table 2-6.4.1.

Exception: Rods of smaller diameter shall be permitted where the hanger assembly has been tested and listed by a testing laboratory and installed within the limits of pipe sizes expressed in individual listings. For rolled threads, the rod size shall not be less than the root diameter of the thread.

Table 2-6.4.1 Hanger Rod Sizes

Pipe Size	Diam. of Rod in.	mm	Pipe Size	Diam. of Rod in.	mm
Up to and including 4 in.	3/8	9.5	5, 6, and 8 in.	1/2	12.7
			10 and 12 in.	5/8	15.9

For SI Units: 1 in. = 25.4 mm.

2-6.4.2 U-Hooks. The size of the rod material of U-hooks shall not be less than that given in Table 2-6.4.2. Drive screws shall be used only in a horizontal position as in the side of a beam in conjunction with U-hangers only.

Table 2-6.4.2 U-Hook Rod Sizes

Pipe Size	Hook Material Diameter in.	mm
Up to 2 in.	5/16	7.9
2 1/2 in. to 6 in.	3/8	9.5
8 in.	1/2	12.7

For SI Units: 1 in. = 25.4 mm.

2-6.4.3 The size of the rod material for eye rods shall not be less than specified in Table 2-6.4.3. When eye rods are fastened to wood structural members, the eye rod shall be backed with a large flat washer bearing directly against the structural member, in addition to the lock washer.

Table 2-6.4.3 Eye Rod Sizes

Pipe Size	Diameter of Rod With Bent Eye in.	mm	With Welded Eye in.	mm
Up to 4 in.	3/8	9.5	3/8	9.5
5-6 in.	1/2	12.7	1/2	12.7
8 in.	3/4	19.1	1/2	12.7

For SI Units: 1 in. = 25.4 mm.

2-6.4.3.1 Eye rods shall be secured with lock washers to prevent lateral motion.

2-6.4.4 Threaded sections of rods shall not be formed or bent.

2-6.4.5 Screws. For ceiling flanges and U-hooks, screw dimensions shall not be less than those given in Table 2-6.4.5.

Exception: When the thickness of planking and thickness of flange do not permit the use of screws 2 in. (51 mm) long, screws 1¾ in. (44 mm) long shall be permitted with hangers spaced not over 10 ft (3 m) apart. When the thickness of beams or joists does not permit the use of screws 2½ in. (64 mm) long, screws 2 in. (51 mm) long shall be permitted with hangers spaced not over 10 ft (3 m) apart.

Table 2-6.4.5 Screw Dimensions for Ceiling Flanges and U-Hooks

Pipe Size	2 Screw Flanges
Up to 2 in.	Wood Screw No. 18 × 1½ in. or Lag Screw 5/16 in. × 1½ in.
Pipe Size	**3 Screw Flanges**
Up to 2 in.	Wood Screw No. 18 × 1½ in.
2½ in., 3 in., 3½ in.	Lag Screw ⅜ in. × 2 in.
4 in., 5 in., 6 in.	Lag Screw ½ in. × 2 in.
8 in.	Lag Screw ⅝ in. × 2 in.
Pipe Size	**4 Screw Flanges**
Up to 2 in.	Wood Screw No. 18 × 1½ in.
2½ in., 3 in., 3½ in.	Lag Screw ⅜ in. × 1½ in.
4 in., 5 in., 6 in.	Lag Screw ½ in. × 2 in.
8 in.	Lag Screw ⅝ in. × 2 in.
Pipe Size	**U Hooks Flanges**
Up to 2 in.	Drive Screw No. 16 × 2 in.
2½ in., 3 in., 3½ in.	Lag Screw ⅜ in. × 2½ in.
4 in., 5 in., 6 in.	Lag Screw ½ in. × 3 in.
8 in.	Lag Screw ⅝ in. × 3 in.

For SI Units: 1 in. = 25.4 mm.

2-6.4.6 The size bolt or lag (coach) screw used with an eye rod or flange on the side of the beam shall not be less than specified in Table 2-6.4.6.

Exception: Where the thickness of beams or joists does not permit the use of screws 2½ in. (64 mm) long, screws 2 in. (51 mm) long shall be permitted with hangers spaced not over 10 ft (3 m) apart.

Table 2-6.4.6 Minimum Bolt or Lag Screw Sizes

Size of Pipe	Size of Bolt or Lag Screw in.	Size of Bolt or Lag Screw mm	Length of Lag Screw Used with Wood Beams in.	Length of Lag Screw Used with Wood Beams mm
Up to and including 2 in.	⅜	9.5	2½	64
2½ to 6 in. (inclusive)	½	12.7	3	76
8 in.	⅝	15.9	3	76

2-6.4.7 Wood screws shall be installed with a screwdriver. Nails are not acceptable for fastening hangers.

2-6.4.8 Screws in the side of a timber or joist shall be not less than 2½ in. (64 mm) from the lower edge where supporting branch lines and not less than 3 in. (76 mm) where supporting main lines.

Exception: This requirement shall not apply to 2-in. (51-mm) or thicker nailing strips resting on top of steel beams.

2-6.4.9 The minimum plank thickness and the minimum width of the lower face of beams or joists in which lag screw rods are used shall be as given in Table 2-6.4.9.

Table 2-6.4.9 Minimum Plank Thicknesses and Beam or Joist Widths

Pipe Size	Nominal Plank Thickness in.	Nominal Plank Thickness mm	Nominal Width of Beam or Joist Face in.	Nominal Width of Beam or Joist Face mm
Up to 2 in.	3	76	2	51
2½ in. to 3½ in.	4	102	2	51
4 in. and 5 in.	4	102	3	76
6 in.	4	102	4	102

2-6.4.10 Lag screw rods shall not be used for support of pipes larger than 6 in. (152 mm). All holes for lag screw rods shall be predrilled ⅛ in. (3.2 mm) less in diameter than the maximum root diameter of the lag screw thread.

2-7 Valves.

2-7.1 Types of Valves to Be Used.

2-7.1.1 All valves controlling connections to water supplies and to supply pipes to sprinklers shall be listed indicating valves. Such valves shall not close in less than 5 sec when operated at maximum possible speed from the fully open position.

Exception No. 1: A listed underground gate valve equipped with a listed indicator post shall be permitted.

Exception No. 2: A listed water control valve assembly with a reliable position indication connected to a remote supervisory station shall be permitted.

Exception No. 3: A nonindicating valve, such as an underground gate valve with approved roadway box complete with T-wrench, accepted by the authority having jurisdiction, shall be permitted.

2-7.1.2 When water pressures exceed 175 psi (12.1 bars), valves shall be used in accordance with their pressure ratings.

2-7.1.3 Wafer-type valves with components that extend beyond the valve body shall be installed in a manner that does not interfere with the operation of any system components.

2-7.2 Drain Valves and Test Valves. Drain valves and test valves shall be approved.

2-7.3* Identification of Valves. All control, drain, and test connection valves shall be provided with permanently marked weather-proof metal or rigid plastic identification signs. The sign shall be secured with corrosion-resistant wire, chain, or other approved means.

2-8 Fire Department Connections.

2-8.1 The fire department connection(s) shall be internal threaded swivel fitting(s) having threads compatible with those of the local fire department.

2-8.2 Connections shall be equipped with listed plugs or caps.

2-9 Waterflow Alarms.

2-9.1 Waterflow alarm apparatus shall be listed for the service and so constructed and installed that any flow of water from a sprinkler system equal to or greater than that from a single automatic sprinkler of the smallest orifice size installed on the system will result in an audible alarm on the premises within 5 min after such flow begins.

2-9.2 Waterflow Detecting Devices.

2-9.2.1 Wet Pipe Systems. The alarm apparatus for a wet pipe system shall consist of a listed alarm check valve or other listed waterflow detecting alarm device with the necessary attachments required to give an alarm.

2-9.2.2 Dry Pipe Systems. The alarm apparatus for a dry pipe system shall consist of listed alarm attachments to the dry pipe valve. When a dry pipe valve is located on the system side of an alarm valve, connection of the actuating device of the alarms for the dry pipe valve to the alarms on the wet pipe system is permitted.

2-9.2.3 Preaction and Deluge Systems. The alarm apparatus for deluge and preaction systems shall consist of alarms actuated independently by the detection system and the flow of water.

2-9.2.4* Paddle-type waterflow alarm indicators shall be installed in wet systems only.

2-9.3 Attachments — General.

2-9.3.1* An alarm unit shall include a listed mechanical alarm, horn, or siren or a listed electric gong, bell, speaker, horn, or siren.

2-9.3.2* Outdoor water motor operated or electrically operated bells shall be weatherproofed and guarded.

2-9.4 All piping to water motor operated devices shall be galvanized or brass or other corrosion-resistant material acceptable under this standard and of a size not less than $^{3}/_{4}$ in. (19 mm).

2-9.5 Attachments — Electrically Operated.

2-9.5.1* Electrically operated alarm attachments forming part of an auxiliary, central station, local protective, proprietary, or remote station signaling system shall be installed in accordance with NFPA 72, *National Fire Alarm Code*.

Exception: Sprinkler waterflow alarm systems that are not part of a required protective signaling system need not be supervised and shall be installed in accordance with NFPA 70, National Electrical Code®, Article 760.

2-9.5.2 Outdoor electric alarm devices shall be listed for outdoor use.

2-9.6 Drains from alarm devices shall be so arranged that there will be no overflowing at the alarm apparatus, at domestic connections, or elsewhere with the sprinkler drains wide open and under system pressure. (*See 4-6.3.6.1.*)

Chapter 3 System Requirements

3-1 Wet Pipe Systems.

3-1.1 Pressure Gauges. A listed pressure gauge conforming to 4-7.3.2 shall be installed in each system riser. Pressure gauges shall be installed above and below each alarm check valve where such devices are present.

3-1.2 Relief Valves. A gridded wet pipe system shall be provided with a relief valve not less than $^{1}/_{4}$ in. (6.4 mm) in size set to operate at pressures not greater than 175 psi (12.1 bars).

Exception No. 1: When the maximum system pressure exceeds 165 psi (11.4 bars), the relief valve shall operate at 10 psi (0.7 bars) in excess of the maximum system pressure.

Exception No. 2: Where auxiliary air reservoirs are installed to absorb pressure increases, a relief valve shall not be required.

3-1.3 Auxiliary Systems. A wet pipe system shall be permitted to supply an auxiliary dry pipe, preaction, or deluge system, provided the water supply is adequate.

3-2* Dry Pipe Systems.

3-2.1 Pressure Gauges. Listed pressure gauges conforming to 4-7.3.2 shall be connected:

(a) On the water side and air side of the dry pipe valve,

(b) At the air pump supplying the air receiver where one is provided,

(c) At the air receiver where one is provided,

(d) In each independent pipe from air supply to dry pipe system, and

(e) At exhausters and accelerators.

3-2.2 Upright Sprinklers. Only upright sprinklers shall be installed on dry pipe systems.

Exception No. 1: Listed dry-pendent sprinklers shall be permitted.

Exception No. 2: Pendent sprinkles installed on return bends shall be permitted where both the sprinklers and the return bends are located in a heated area.

3-2.3* Size of Systems.

3-2.3.1* Volume Limitations. Not more than 750 gal (2839 L) system capacity shall be controlled by one dry pipe valve.

Exception: Piping volume shall be permitted to exceed 750 gal (2839 L) for nongridded systems if the system design is such that water is delivered to the system test connection in not more than 60 seconds, starting at the normal air pressure on the system and at the time of fully opened inspection test connection.

3-2.3.2 Gridded dry pipe systems shall not be installed. (*See 4-6.3.5.3.3.*)

3-2.4 Quick-Opening Devices.

3-2.4.1 Dry pipe valves shall be provided with a listed quick-opening device where system capacity exceeds 500 gal (1893 L).

Exception: A quick-opening device shall not be required if the requirements of 3-2.3.1 Exception can be met without such a device.

3-2.4.2 The quick-opening device shall be located as close as practical to the dry pipe valve. To protect the restriction orifice and other operating parts of the quick-opening device against submergence, the connection to the riser shall be above the point at which water (priming water and back drainage) is expected when the dry pipe valve and quick-opening device are set, except where design features of the particular quick-opening device make these requirements unnecessary.

3-2.4.3 A soft disc globe or angle valve shall be installed in the connection between the dry pipe sprinkler riser and the quick-opening device.

3-2.4.4 A check valve shall be installed between the quick-opening device and the intermediate chamber of the dry pipe valve. If the quick-opening device requires pressure feedback from the intermediate chamber, a valve type that will clearly indicate whether it is opened or closed shall be permitted in place of that check valve. This valve shall be constructed so that it may be locked or sealed in the open position.

3-2.4.5 A listed antiflooding device shall be installed in the connection between the dry pipe sprinkler riser and the quick-opening device.

Exception: Where the quick-opening device has built-in antiflooding design features.

3-2.5* Location and Protection of Dry Pipe Valve.

3-2.5.1 The dry pipe valve and supply pipe shall be protected against freezing and mechanical injury.

3-2.5.2 Valve rooms shall be lighted and heated. The source of heat shall be of a permanently installed type. Heat tape shall not be used in lieu of heated valve enclosures to protect the dry pipe valve and supply pipe against freezing.

3-2.5.3 The supply for the sprinkler in the dry pipe valve enclosure shall be from the dry side of the system.

3-2.5.4 Protection against accumulation of water above the clapper shall be provided for a low differential dry pipe valve. An automatic high water level signaling device or an automatic drain device is acceptable.

3-2.6 Air Pressure and Supply.

3-2.6.1 Maintenance of Air Pressure. Air or nitrogen pressure shall be maintained on dry pipe systems throughout the year.

3-2.6.2* Air Supply. The compressed air supply shall be from a source available at all times and having a capacity capable of restoring normal air pressure in the system within 30 min.

3-2.6.3 Air Filling Connection. The connection pipe from the air compressor shall not be less than ½ in. (13 mm) in diameter and shall enter the system above the priming water level of the dry pipe valve. A check valve shall be installed in this air line, and a shutoff valve of the renewable disc type shall be installed on the supply side of this check valve and shall remain closed unless filling the system.

3-2.6.4 Relief Valve. A listed relief valve shall be provided between the compressor and controlling valve, set to relieve at a pressure 5 psi (0.3 bars) in excess of maximum air pressure carried in the system.

3-2.6.5 Shop Air Supply. Where the air supply is taken from a shop system having a normal pressure greater than that required for dry pipe systems and an automatic air maintenance device is not used, the relief valve shall be installed between two control valves in the air line, and a small air cock, which is normally left open, shall be installed in the fitting below the relief valve. (*See Figure 3-2.6.5.*)

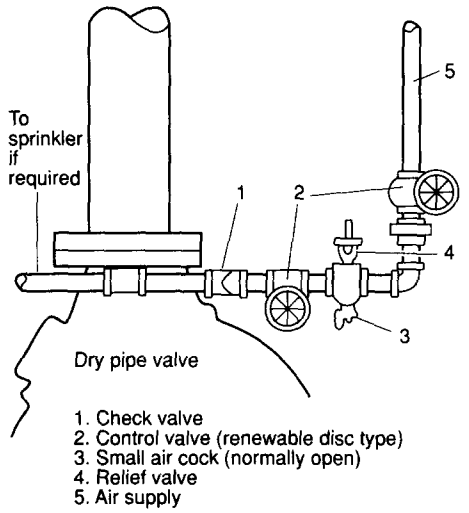


Figure 3-2.6.5 Air supply from shop system.

3-2.6.6 Automatic Air Compressor. Where a dry pipe system is supplied by an automatic air compressor or plant air system, any device or apparatus used for automatic maintenance of air pressure shall be of a type specifically listed for such service and capable of maintaining the required air pressure on the dry pipe system. Automatic air supply to more than one dry pipe system shall be connected to enable individual maintenance of air pressure in each system. A check valve or other positive backflow prevention device shall be installed in the air supply to each system to prevent air- or waterflow from one system to another.

3-2.6.7 System Air Pressure. The system air pressure shall be maintained in accordance with the instruction sheet furnished with the dry pipe valve, or 20 psi (1.4 bars) in excess of the calculated trip pressure of the dry pipe valve, based on the highest normal water pressure of the system supply. The permitted rate of air leakage shall be as specified in 8-2.3.

3-2.6.8 Nitrogen. Where used, nitrogen shall be introduced through a pressure regulator set to maintain system pressure in accordance with 3-2.6.7.

3-3 Preaction Systems and Deluge Systems.

3-3.1* General.

3-3.1.1 All components of pneumatic, hydraulic, or electrical systems shall be compatible.

3-3.1.2 The automatic water control valve shall be provided with hydraulic, pneumatic, or mechanical manual means for operation that is independent of detection devices and of the sprinklers.

3-3.1.3 Pressure Gauges. Listed pressure gauges conforming to 4-7.3.2 shall be installed as follows:

(a) Above and below preaction valve and below deluge valve.

(b) On air supply to preaction and deluge valves.

3-3.1.4 A supply of spare fusible elements for heat-responsive devices, not less than two of each temperature rating, shall be maintained on the premises for replacement purposes.

3-3.1.5 Hydraulic release systems shall be designed and installed in accordance with manufacturer's requirements and listing for height limitations above deluge valves or deluge valve actuators to prevent water column.

3-3.1.6 Location and Spacing of Detection Devices. Spacing of detection devices, including automatic sprinklers used as detectors, shall be in accordance with their listing and manufacturer's specifications.

3-3.1.7 Devices for Test Purposes and Testing Apparatus.

3-3.1.7.1 Where detection devices installed in circuits are located where not readily accessible, an additional detection device shall be provided on each circuit for test purposes at an accessible location and shall be connected to the circuit at a point that will assure a proper test of the circuit.

3-3.1.7.2 Testing apparatus capable of producing the heat or impulse necessary to operate any normal detection device shall be furnished to the owner of the property with each installation. Where explosive vapors or materials are present, hot water, steam, or other methods of testing not involving an ignition source shall be used.

3-3.1.8 Location and Protection of System Water Control Valves.

3-3.1.8.1 System water control valves and supply pipes shall be protected against freezing and mechanical injury.

3-3.1.8.2 Valve rooms shall be lighted and heated. The source of heat shall be of a permanently installed type. Heat tape shall not be used in lieu of heated valve enclosure rooms to protect preaction and deluge valves and supply pipe against freezing.

3-3.2 Preaction Systems.

3-3.2.1 Preaction systems shall operate by one of the means described in (a) through (c) below.

(a) Systems that admit water to sprinkler piping upon operation of detection devices.

(b) Systems that admit water to sprinkler piping upon operation of detection devices or automatic sprinklers.

(c)* Systems that admit water to sprinkler piping upon operation of both detection devices and automatic sprinklers.

3-3.2.2 Size of Systems. Not more than 1000 automatic sprinklers shall be controlled by any one preaction valve.

Exception: For preaction system types described in 3-3.2.1(c), system volume shall not exceed 750 gal (2839 L) controlled by one preaction valve unless the system is designed to deliver water to the system test connection in not more than 60 sec, starting at the normal air pressure on the system with the detection system operated and at the time of fully opened inspection test connection. Air pressure and supply shall comply with 3-2.6.

3-3.2.3 Supervision. Sprinkler piping and fire detection devices shall be automatically supervised where there are more than 20 sprinklers on the system. All preaction system types described in 3-3.2.1(b) and (c) shall maintain a minimum supervising air pressure of 7 psi (0.5 bars.)

3-3.2.4 Upright Sprinklers. Only upright sprinklers shall be installed on preactions systems.

Exception No. 1: Listed dry-pendent sprinklers shall be permitted.

Exception No. 2: Pendent sprinklers installed on return bends shall be permitted where both the sprinklers and the return bends are located in a heated area.

3-3.2.5 System Configuration. Preaction systems of the type described in 3-3.2.1(c) with pressures in excess of 10 psi (0.7 bars) shall not be gridded.

3-3.3* Deluge Systems.

3-3.3.1 The detection devices or systems shall be automatically supervised.

3-3.3.2 Deluge systems shall be hydraulically calculated.

3-4 Combined Dry Pipe and Preaction Systems.

3-4.1* General.

3-4.1.1* Combined automatic dry pipe and preaction systems shall be so constructed that failure of the detection system shall not prevent the system from functioning as a conventional automatic dry pipe system.

3-4.1.2 Combined automatic dry pipe and preaction systems shall be so constructed that failure of the dry pipe system of automatic sprinklers shall not prevent the detection system from properly functioning as an automatic fire alarm system.

3-4.1.3 Provisions shall be made for the manual operation of the detection system at locations requiring not more than 200 ft (61 m) of travel.

3-4.1.4 Upright Sprinklers. Only upright sprinklers shall be installed on combined dry pipe and preaction systems.

Exception No. 1: Listed dry-pendent sprinklers shall be permitted.

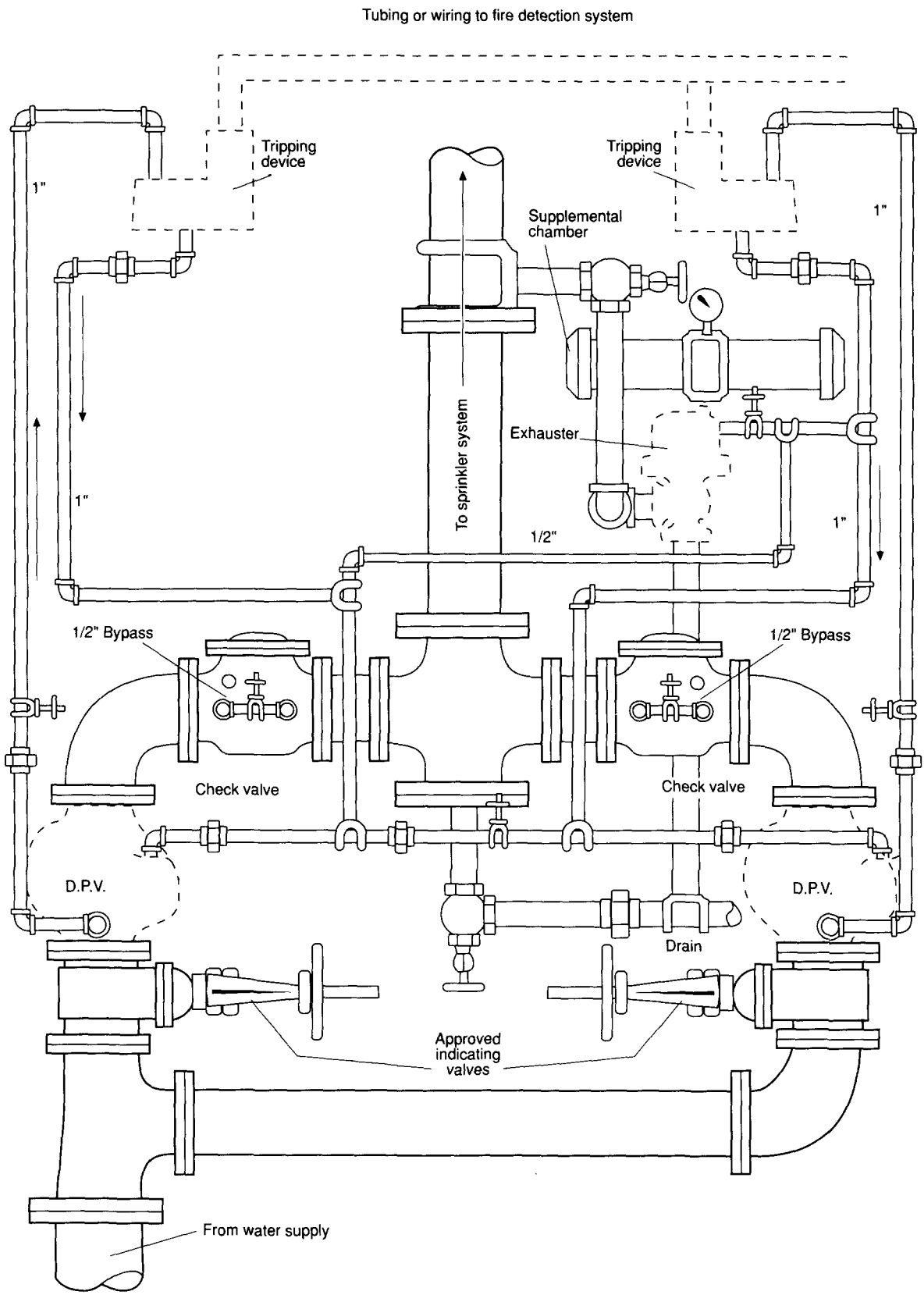
Exception No. 2: Pendent sprinklers installed on return bends shall be permitted where both sprinklers and return bends are located in a heated area.

3-4.2 Dry Pipe Valves in Combined Systems.

3-4.2.1 Where the system consists of more than 600 sprinklers or has more than 275 sprinklers in any fire area, the entire system shall be controlled through two 6-in. (152-mm) dry pipe valves connected in parallel and shall feed into a common feed main. These valves shall be checked against each other. (*See Figure 3-4.2.*)

3-4.2.2 Each dry pipe valve shall be provided with a listed tripping device actuated by the detection system. Dry pipe valves shall be cross-connected through a 1-in. (25.4-mm) pipe connection to permit simultaneous tripping of both dry pipe valves. This 1-in. (25.4-mm) pipe connection shall be equipped with an indicating valve so that either dry pipe valve can be shut off and worked on while the other remains in service.

3-4.2.3 The check valves between the dry pipe valves and the common feed main shall be equipped with $\frac{1}{2}$-in. (13-mm) bypasses so that a loss of air from leakage in the trimmings of a dry pipe valve will not cause the valve to trip until the pressure in the feed main is reduced to the tripping point. An indicating valve shall be installed in each of these bypasses so that either dry pipe valve can be completely isolated from the main riser or feed main and from the other dry pipe valve.



For SI Units: 1 in. = 25.4 mm.

Figure 3-4.2 Header for dry pipe valves installed in parallel for combined systems; standard trimmings not shown. Arrows indicate direction of fluid flow.

3-4.2.4 Each combined dry pipe and preaction system shall be provided with listed quick-opening devices at the dry pipe valves.

3-4.3* Air Exhaust Valves. One or more listed air exhaust valves of 2-in. (51-mm) or larger size controlled by operation of a fire detection system shall be installed at the end of the common feed main. These air exhaust valves shall have soft-seated globe or angle valves in their intakes; also, approved strainers shall be installed between these globe valves and the air exhaust valves.

3-4.4 Subdivision of System Using Check Valves.

3-4.4.1 Where more than 275 sprinklers are required in a single fire area, the system shall be divided into sections of 275 sprinklers or less by means of check valves. If the system is installed in more than one fire area or story, not more than 600 sprinklers shall be supplied through any one check valve. Each section shall have a 1¼-in. (33-mm) drain on the system side of each check valve supplemented by a dry pipe system auxiliary drain.

3-4.4.2 Section drain lines and dry pipe system auxiliary drains shall be located in heated areas or inside of heated cabinets to enclose drain valves and auxiliary drains for each section.

3-4.4.3 Air exhaust valves at the end of a feed main and associated check valves shall be protected against freezing.

3-4.5 Time Limitation. The sprinkler system shall be so constructed and the number of sprinklers controlled shall be so limited that water shall reach the farthest sprinkler within a period of time not exceeding 1 minute for each 400 ft (122 m) of common feed main from the time the heat-responsive system operates. Maximum time permitted shall not exceed 3 min.

3-4.6 System Test Connection. The end section shall have a system test connection as required for dry pipe systems.

3-5 Antifreeze Systems.

3-5.1* Where Used. The use of antifreeze solutions shall be in conformity with state and local health regulations.

3-5.2* Antifreeze Solutions.

3-5.2.1 Where sprinkler systems are supplied by potable water connections, the use of antifreeze solutions other than water solutions of pure glycerine (C.P. or U.S.P. 96.5 percent grade) or propylene glycol shall not be permitted. Suitable glycerine-water and propylene glycol-water mixtures are shown in Table 3-5.2.1.

3-5.2.2 If potable water is not connected to sprinklers, the commercially available materials indicated in Table 3-5.2.2 are permitted for use in antifreeze solutions.

3-5.2.3* An antifreeze solution shall be prepared with a freezing point below the expected minimum temperature for the locality. The specific gravity of the prepared solution shall be checked by a hydrometer with suitable scale or refractometer having a scale calibrated for the antifreeze solution involved. [*See Figures 3-5.2.3(a) and (b).*]

3-5.3* Arrangement of Supply Piping and Valves. Sprinklers shall be below the interface between the water and antifreeze solutions.

Table 3-5.2.1 Antifreeze Solutions to Be Used if Potable Water Is Connected to Sprinklers

Material	Solution (by Volume)	Specific Gravity at 60°F (15.6°C)	Freezing Point °F	Freezing Point °C
Glycerine	50% Water	1.133	−15	−26.1
C.P. or U.S.P. Grade*	40% Water	1.151	−22	−30.0
	30% Water	1.165	−40	−40.0
Hydrometer Scale 1.000 to 1.200				
Propylene Glycol	70% Water	1.027	+ 9	−12.8
	60% Water	1.034	− 6	−21.1
	50% Water	1.041	−26	−32.2
	40% Water	1.045	−60	−51.1
Hydrometer Scale 1.000 to 1.200 (Subdivisions 0.002)				

*C.P.—Chemically Pure. U.S.P.—United States Pharmacopoeia 96.5%.

Table 3-5.2.2 Antifreeze Solution to Be Used if Nonpotable Water Is Connected to Sprinklers

Material	Solution (by Volume)	Specific Gravity at 60°F (15.6°C)	Freezing Point °F	Freezing Point °C
Glycerine	If glycerine is used, see Table 3-5.2.1			
Diethylene Glycol	50% Water	1.078	−13	−25.0
	45% Water	1.081	−27	−32.8
	40% Water	1.086	−42	−41.1
Hydrometer Scale 1.000 to 1.120 (Subdivisions 0.002)				
Ethylene Glycol	61% Water	1.056	−10	−23.3
	56% Water	1.063	−20	−28.9
	51% Water	1.069	−30	−34.4
	47% Water	1.073	−40	−40.0
Hydrometer Scale 1.000 to 1.120 (Subdivisions 0.002)				
Propylene Glycol	If propylene glycol is used, see Table 3-5.2.1			
Calcium Chloride 80% "Flake"	lb $CaCl_2$ per gal of Water			
Fire Protection Grade†	2.83	1.183	0	−17.8
Add corrosion inhibitor	3.38	1.212	−10	−23.3
of sodium bichromate	3.89	1.237	−20	−28.9
¼ oz per gal water	4.37	1.258	−30	−34.4
	4.73	1.274	−40	−40.0
	4.93	1.283	−50	−45.6

† Free from magnesium chloride and other impurities.

Exception: Sprinklers are permitted to be above the water/antifreeze interface where a check valve with a 1/32-in. (0.8-mm) hole in the clapper is provided in a U-loop. In most cases, this necessitates the use of a 5-ft (1.5-m) drop pipe or U-loop as illustrated in Figure 3-5.3.

3-5.3.1 A water control valve and two small solution test valves shall be provided as illustrated in Figure 3-5.3.

Exception: Where the connection between the antifreeze system and the wet pipe system incorporates a backflow prevention device, an expansion chamber shall be provided to compensate for the expansion of the antifreeze solution.

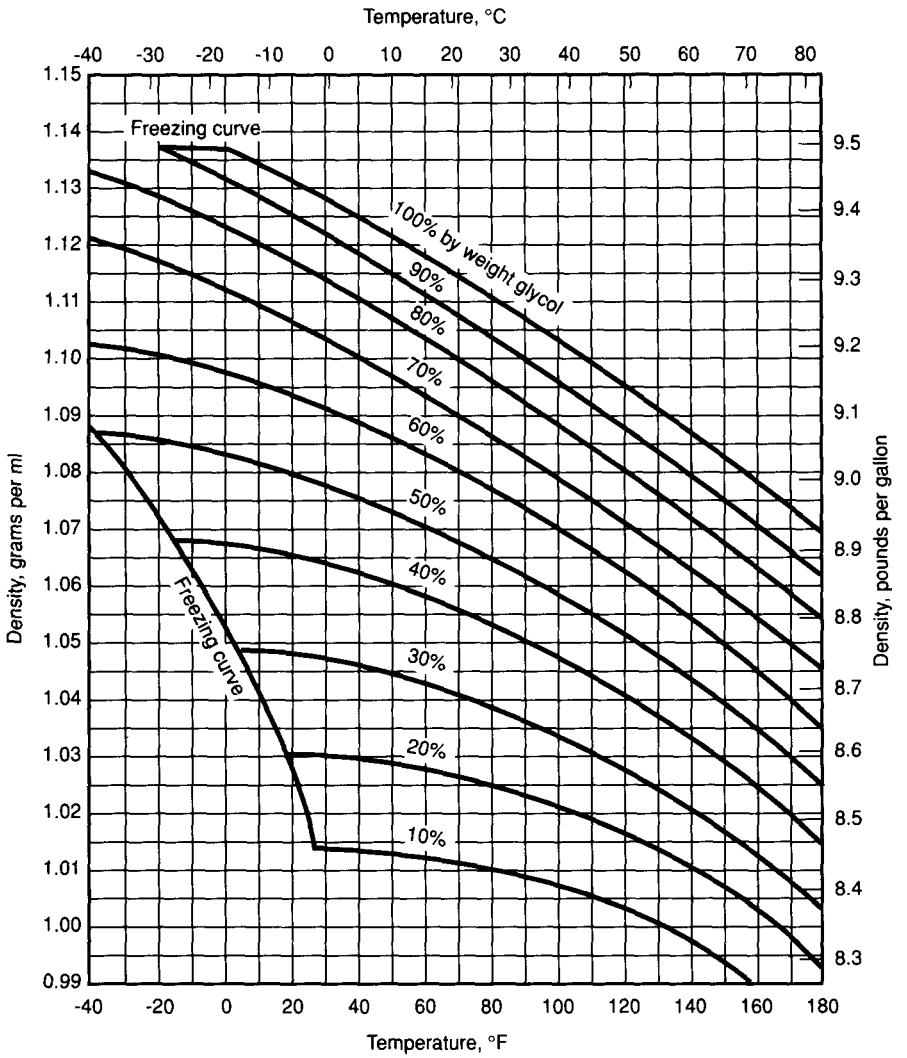


Figure 3-5.2.3(a) Densities of aqueous ethylene glycol solutions (percent by weight).

3-6 Automatic Sprinkler Systems with Nonfire Protection Connections.

3-6.1 Circulating Closed-Loop Systems.

3-6.1.1 System Components.

3-6.1.1.1 A circulating closed-loop system is primarily a sprinkler system and shall comply with all provisions of this standard such as those for control valves, area limitations of a system, alarms, fire department connections, sprinkler spacing, etc.

Exception: Items as specifically detailed within 3-6.1.

3-6.1.1.2 Piping, fittings, valves, and pipe hangers shall meet the requirements specified in Chapter 2.

3-6.1.1.3 A dielectric fitting shall be installed in the junction where dissimilar piping materials are joined, e.g., copper to steel.

Exception: Dielectric fittings are not required in the junction where sprinklers are connected to piping.

3-6.1.1.4 It is not required that other auxiliary devices be listed for sprinkler service; however, these devices, such as pumps, circulating pumps, heat exchangers, radiators, and luminaries, shall be pressure rated at 175 or 300 psi (12.1 or 20.7 bars) (rupture pressure of 5 times rated water working pressure) to match the required rating of sprinkler system components.

3-6.1.1.5 Auxiliary devices shall incorporate materials of construction and be so constructed that they will maintain their physical integrity under fire conditions to avoid impairment to the fire protection system.

3-6.1.1.6 Auxiliary devices, where hung from the building structure, shall be supported independently from the sprinkler portion of the system, following recognized engineering practices.

3-6.1.2* Hydraulic Characteristics. Piping systems for attached heating and cooling equipment shall have auxiliary pumps or an arrangement made to return water to the piping system in order to assure the following:

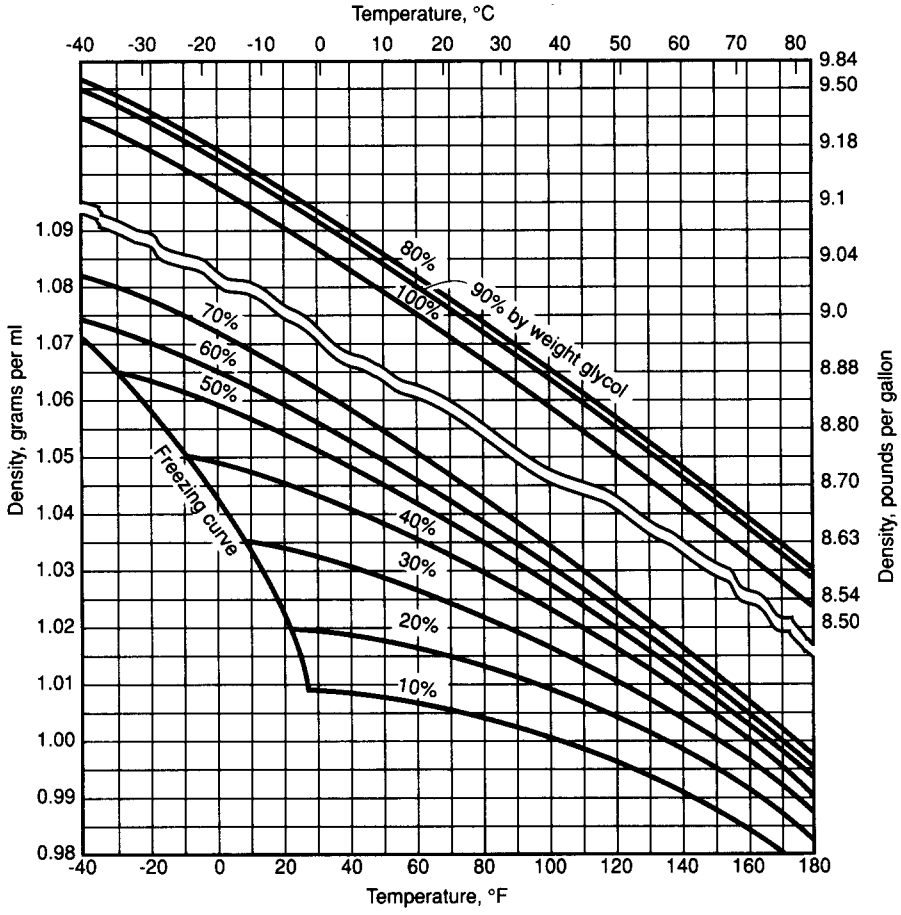
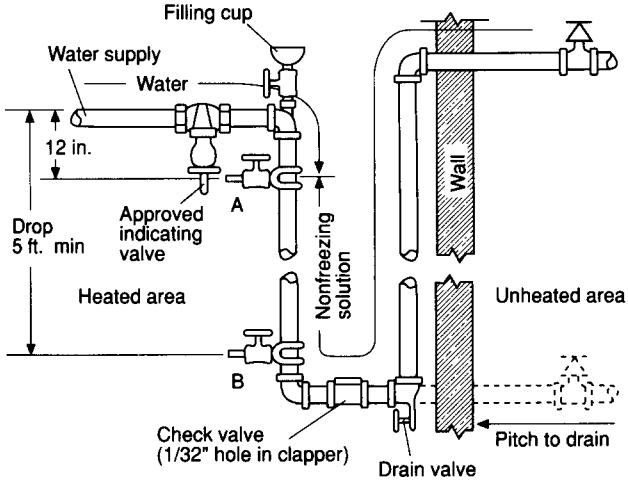


Figure 3-5.2.3(b) Densities of aqueous propylene glycol solutions (percent by weight).



NOTE 1: Check valve may be omitted where sprinklers are below level of valve A.
NOTE 2: The $\frac{1}{32}$-in. (0.8-mm) hole in the check valve clapper is needed to allow for expansion of the solution during a temperature rise, thus preventing damage to sprinklers.
For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.

Figure 3-5.3 Arrangement of supply piping and valves.

(a) Water for sprinklers shall not be required to pass through heating or cooling equipment. At least one direct path shall exist for waterflow from the sprinkler water supply to every sprinkler. Pipe sizing in the direct path shall be in accordance with design requirements of this standard.

(b) No portions of the sprinkler piping shall have less than the sprinkler system design pressure regardless of the mode of operation of the attached heating or cooling equipment.

(c) There shall be no loss or outflow of water from the system due to or resulting from the operation of heating or cooling equipment.

(d) Shutoff valves and a means of drainage shall be provided on piping to heating or cooling equipment at all points of connection to sprinkler piping and shall be installed in such a manner as to make possible repair or removal of any auxiliary component without impairing the serviceability and response to the sprinkler system. All auxiliary components, including the strainer, shall be installed on the auxiliary equipment side of the shutoff valves.

3-6.1.3 Water Temperature.

3-6.1.3.1 Maximum. In no case shall maximum water temperature flowing through the sprinkler portion of the system exceed 120°F (49°C). Protective control devices listed for

this purpose shall be installed to shut down heating or cooling systems when temperature of water flowing through the sprinkler portion of the system exceeds 120°F (49°C). When water temperature exceeds 100°F (37.8°C), intermediate or higher temperature rated sprinklers shall be used.

3-6.1.3.2 Minimum. Precautions shall be taken to ensure that temperatures below 40°F (4°C) are not permitted.

3-6.1.4 Obstruction to Discharge. Automatic sprinklers shall not be obstructed by auxiliary devices, piping, insulation, etc., from detecting fire or from proper distribution of water.

3-6.1.5 Signs. Caution signs shall be attached to all valves controlling sprinklers. The caution sign shall be worded as follows:

"This valve controls fire protection equipment. Do not close until after fire has been extinguished. Use auxiliary valves when necessary to shut off supply to auxiliary equipment.

CAUTION: Automatic alarm will be sounded if this valve is closed."

3-6.1.6 Water Additives. Materials added to water shall not adversely affect the fire fighting properties of the water and shall be in conformity with any state or local health regulations. Due care and caution shall be given to the use of additives that may remove or suspend scale from older piping systems. Where additives are necessary for proper system operation, due care shall be taken to ensure that additives are replenished after alarm testing or whenever water is removed from the system.

3-6.1.7 Waterflow Detection. The supply of water from sprinkler piping through auxiliary devices, circulatory piping, and pumps shall not under any condition or operation, transient or static, cause false sprinkler waterflow signals.

3-6.1.7.1 A sprinkler waterflow signal shall not be impaired when water is discharged through an opened sprinkler or through the system test connection while auxiliary equipment is in any mode of operation (on, off, transient, stable).

3-7 Outside Sprinklers for Protection against Exposure Fires.

3-7.1 Applications. Exposure protection systems shall be permitted on buildings regardless of whether the building's interior is protected by a sprinkler system.

3-7.2 Water Supply and Control.

3-7.2.1* Sprinklers installed for protection against exposure fires shall be supplied from a standard water supply as outlined in Chapter 7.

Exception: Where approved, other supplies, such as manual valves or pumps or fire department connections, shall be acceptable.

3-7.2.2 Where fire department connections are used for water supply, they shall be so located that they will not be affected by the exposing fire.

3-7.3 Control.

3-7.3.1 Each system of outside sprinklers shall have an independent control valve.

3-7.3.2 Manually controlled open sprinklers shall be used only where constant supervision is present.

3-7.3.3 Sprinklers shall be of the open or automatic type. Automatic sprinklers in areas subject to freezing shall be on dry pipe systems conforming to Section 3-2 or antifreeze systems conforming to Section 3-5.

3-7.3.4 Automatic systems of open sprinklers shall be controlled by the operation of fire detection devices designed for the specific application.

3-7.4 System Components.

3-7.4.1 Drain Valves. Each system of outside sprinklers shall have a separate drain valve installed on the system side of each control valve.

Exception: Open sprinkler-top fed systems arranged to facilitate drainage.

3-7.4.2 Check Valves. Where sprinklers are installed on two adjacent sides of a building, protecting against two separate and distinct exposures, with separate control valves for each side, the end lines shall be connected with check valves located so that one sprinkler around the corner will operate. (*See Figure 3-7.4.2.*) The intermediate pipe between the two check valves shall be arranged to drain. As an alternate solution, an additional sprinkler shall be installed on each system located around the corner from the system involved.

3-7.4.3 System Arrangement. Where one exposure affects two sides of the protected structure, the system shall not be subdivided between the two sides, but rather shall be arranged to operate as a single system.

3-7.5 Pipe and Fittings. Pipe and fittings installed on the exterior of the building shall be corrosion resistant.

3-7.6 Strainers. A listed strainer shall be provided in the riser or feed main that supplies sprinklers having nominal orifice sizes smaller than $^{3}/_{8}$ in. (9.5 mm).

3-7.7 Gauge Connections. A listed pressure gauge conforming to 4-7.3.2 shall be installed immediately below the control valve of each system.

3-7.8 Sprinklers. Only sprinklers of such type as are listed for window, cornice, sidewall, or ridge pole service shall be installed for such use except where adequate coverage by use of other types of listed sprinklers and/or nozzles has been demonstrated. Small-orifice or large-orifice sprinklers shall be permitted.

3-8* Cold Storage Rooms.

3-8.1* Fittings for visual internal inspection of piping in cold storage rooms shall be provided wherever the following occurs:

(a)* A cross main connects to a riser or feed main,

(b)* Feed mains change direction,

(c)* A riser or feed main passes through a wall or floor from a warm room to a cold room.

3-8.2 A low air pressure alarm to a constantly attended location shall be installed on sprinkler systems supplying freezer sections.

Exception: Dry pipe systems equipped with local low air pressure alarms and an automatic air maintenance device.

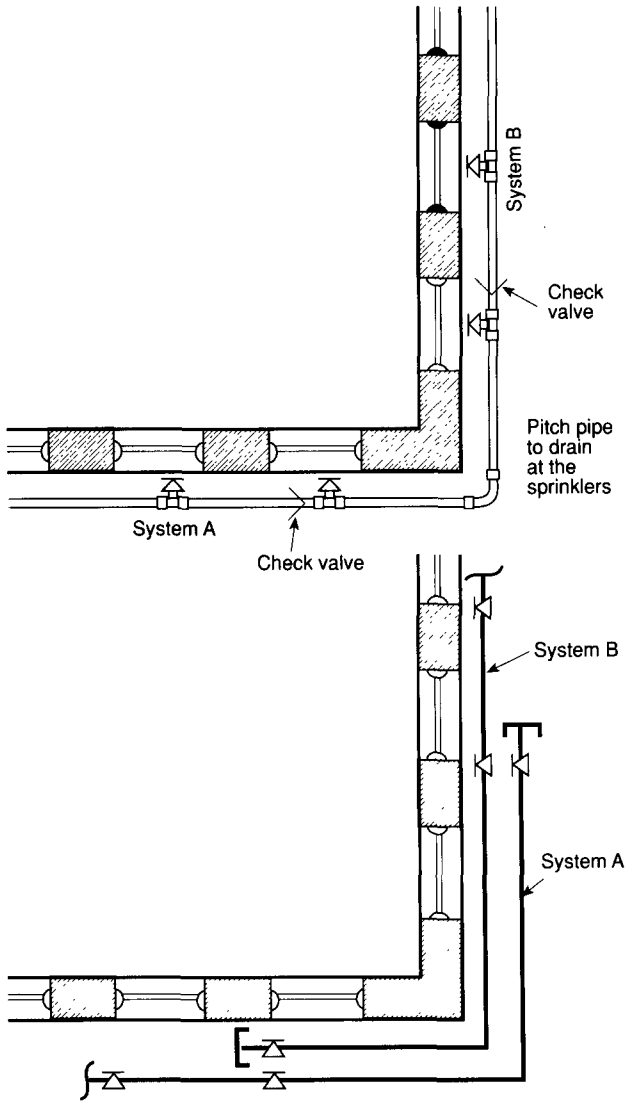


Figure 3-7.4.2 Arrangement of check valves. Top: typical. Bottom: alternate.

3-8.3 Piping in cold storage rooms shall be installed with pitch, as outlined in 4-6.3.3.

3-8.4* The air supply for systems shall be taken from the room of lowest temperature, or through a chemical dehydrator, to eliminate introducing moisture. Compressed nitrogen gas from cylinders shall be acceptable in lieu of air.

3-8.5 Fittings that can be removed, or other arrangements for operational testing of dry pipe and preaction systems, shall be provided outside the freezer space.

3-9 Commercial-Type Cooking Equipment and Ventilation.

3-9.1 In cooking areas protected by automatic sprinklers, additional sprinklers or automatic spray nozzles shall be provided to protect commercial-type cooking equipment and ventilation systems that are designed to carry away grease-laden vapors unless otherwise protected. (*See NFPA 96, Standard on Ventilation Control and Fire Protection of Commercial Cooking Operations.*)

3-9.2* Standard sprinklers or automatic spray nozzles shall be so located as to provide for the protection of exhaust ducts, hood exhaust duct collars, and hood exhaust plenum chambers.

Exception: Sprinklers or automatic spray nozzles in ducts, duct collars, and plenum chambers may be omitted where all cooking equipment is served by listed grease extractors.

3-9.3 Exhaust ducts shall have one sprinkler or automatic spray nozzle located at the top of each vertical riser and at the midpoint of each offset. The first sprinkler or automatic spray nozzle in a horizontal duct shall be installed at the duct entrance. Horizontal exhaust ducts shall have such devices located on 10-ft (3-m) centers beginning no more than 5 ft (1.5 m) from the duct entrance. Sprinkler(s) or automatic spray nozzle(s) in exhaust ducts subject to freezing shall be properly protected against freezing by approved means. (*See 4-6.4.1.*)

Exception: Sprinklers or automatic spray nozzles shall not be required in a vertical riser located outside of a building provided the riser does not expose combustible material or provided the interior of a building and the horizontal distance between the hood outlet and the vertical riser is at least 25 ft (7.6 m).

3-9.4 Each hood exhaust duct collar shall have one sprinkler or automatic spray nozzle located 1 in. minimum to 12 in. maximum (25.4 mm min. to 305 mm max.) above the point of duct collar connection in the hood plenum. Hoods that have listed fire dampers located in the duct collar shall be protected with a sprinkler or automatic spray nozzle located on the discharge side of the damper and be so positioned as not to interfere with damper operation.

3-9.5 Hood exhaust plenum chambers shall have one sprinkler or automatic spray nozzle centered in each chamber not exceeding 10 ft (3 m) in length. Plenum chambers greater than 10 ft (3 m) in length shall have two sprinklers or automatic spray nozzles evenly spaced with the maximum distance between the two sprinklers not to exceed 10 ft (3 m).

3-9.6 Sprinklers or automatic spray nozzles being used in duct, duct collar, and plenum areas shall be of the extra high temperature classification [325 to 375°F (163 to 191°C)] and shall have orifice sizes not less than $\frac{1}{4}$ in. (6.4 mm) and not more than $\frac{1}{2}$ in. (13 mm).

Exception: When use of a temperature measuring device indicates temperatures above 300°F (149°C), a sprinkler or automatic spray nozzle of higher classification shall be used.

3-9.7 Access must be provided to all sprinklers or automatic spray nozzles for examination and replacement.

3-9.8 Cooking Equipment.

3-9.8.1 Cooking equipment (such as deep fat fryers, ranges, griddles, and broilers) that may be a source of ignition shall be protected in accordance with the provisions of 3-9.1.

3-9.8.2 A sprinkler or automatic spray nozzle used for protection of deep fat fryers shall be listed for that application. The position, arrangement, location, and water supply for each sprinkler or automatic spray nozzle shall be in accordance with its listing.

3-9.8.3 The operation of any cooking equipment sprinkler or automatic spray nozzle shall automatically shut off all sources of fuel and heat to all equipment requiring pro-

tection. Any gas appliance not requiring protection but located under ventilating equipment shall also be shut off. All shutdown devices shall be of the type that requires manual resetting prior to fuel or power being restored.

3-9.9 A listed indicating valve shall be installed in the water supply line to the sprinklers and spray nozzles protecting the cooking and ventilating system.

3-9.10 A listed line strainer shall be installed in the main water supply preceding sprinklers or automatic spray nozzles having nominal orifice sizes smaller than 3/8 in. (9.5 mm.)

3-9.11 A system test connection shall be provided to verify proper operation of equipment specified in 3-9.8.3.

3-9.12 Sprinklers and automatic spray nozzles used for protecting commercial-type cooking equipment and ventilating systems shall be replaced annually.

Exception: Where automatic bulb-type sprinklers or spray nozzles are used and annual examination shows no build-up of grease or other material on the sprinklers or spray nozzles.

Chapter 4 Installation Requirements

4-1* Basic Requirements.

4-1.1* The requirements for spacing, location, and position of sprinklers are based on the following principles:

(a) Sprinklers installed throughout the premises,

(b) Sprinklers located so as not to exceed maximum protection area per sprinkler,

(c) Sprinklers positioned and located so as to provide satisfactory performance with respect to activation time and distribution.

Exception No. 1: For locations permitting omission of sprinklers, see 4-5.1, 4-5.2, and 4-5.8.

Exception No. 2: When sprinklers are specifically tested and test results demonstrate that deviations from clearance requirements to structural members do not impair the ability of the sprinkler to control or suppress a fire, their positioning and locating in accordance with the test results shall be permitted.

Exception No. 3: Clearance between sprinklers and ceilings exceeding the maximum specified in 4-4.1.4 shall be permitted provided that tests or calculations demonstrate comparable sensitivity and performance of the sprinklers to those installed in conformance with 4-4.1.4.

4-1.2* System valves and gauges shall be accessible for operation, inspection, tests, and maintenance.

4-2 Protection Area Limitations.

4-2.1 Systems. The maximum floor area on any one floor to be protected by sprinklers supplied by any one sprinkler system riser or combined system riser shall be as follows:

Light Hazard	52,000 sq ft (4831 m^2)
Ordinary Hazard	52,000 sq ft (4831 m^2)
Extra Hazard	
Pipe Schedule	25,000 sq ft (2323 m^2)
Hydraulically Calculated	40,000 sq ft (3716 m^2)
Storage — High-piled storage (as defined in 1-4.2) and storage covered by other NFPA standards	40,000 sq ft (3716 m^2)

Exception No. 1: The floor area occupied by mezzanines shall not be included in the above area.

Exception No. 2: Where single systems protect extra hazard, high-piled storage, or storage covered by other NFPA standards, and ordinary or light hazard areas, the extra hazard or storage area coverage shall not exceed the floor area specified for that hazard and the total area coverage shall not exceed 52,000 sq ft (4831 m^2).

4-2.2* Sprinklers. The maximum protection area per sprinkler shall comply with Table 4-2.2.

4-2.2.1 The protection area per sprinkler shall be determined as follows:

4-2.2.1.1 Along Branch Lines. Determine distance to next sprinkler (or to wall or obstruction in case of end sprinkler on branch line) upstream and downstream. Choose the larger of either twice the distance to the wall or the distance to the next sprinkler. Call this S.

4-2.2.1.2 Between Branch Lines. Determine perpendicular distance to sprinkler on branch lines (or to wall or obstruction in the case of the last branch line) on each side of the branch line on which the subject sprinkler is positioned. Choose the larger of either twice the distance to the wall or obstruction or the distance to the next sprinkler. Call this L.

4-2.2.1.3 Protection area of the sprinkler = S × L.

Exception: In a small room as defined in 1-4.2, the protection area of each sprinkler in the small room shall be the area of the room divided by the number of sprinklers in the room.

4-3 Use of Sprinklers.

4-3.1 General.

4-3.1.1* Sprinklers shall be installed in accordance with their listing.

Exception: Where construction features or other special situations require unusual water distribution, listed sprinklers shall be permitted to be installed in positions other than anticipated by their listing to achieve specific results.

4-3.1.2* Upright sprinklers shall be installed with the frame arms parallel to the branch line.

4-3.1.3 Temperature Ratings.

4-3.1.3.1 Ordinary-temperature-rated sprinklers shall be used throughout buildings.

Exception No. 1: Where maximum ceiling temperatures exceed 100°F (38°C), sprinklers with temperature ratings in accordance with the maximum ceiling temperatures of Table 2-2.3.1 shall be used.

Exception No. 2: Intermediate- and high-temperature sprinklers shall be permitted to be used throughout Ordinary and Extra Hazard Occupancies.

Exception No. 3: Sprinklers of intermediate and high temperature classifications shall be installed in specific locations as required by 4-3.1.3.2.

4-3.1.3.2 The following practices shall be observed to provide sprinklers of other than ordinary temperature classification unless other temperatures are determined or unless high-temperature sprinklers are used throughout [*see Tables 4-3.1.3.2(a) and (b) and Figure 4-3.1.3.2.*].

Table 4-2.2 Maximum Sprinkler Protection Areas (sq ft)[8]

	Light Hazard	Ordinary Hazard	Extra Hazard[5]	High-Piled Storage[6]	Large-Drop Sprinklers[7]	Early Suppression Fast-Response Sprinklers[7]
Unobstructed Construction[1]	225[2]	130	100	100	130	100
Noncombustible Obstructed Construction	225[2]	130	100	100	130	100
Combustible Obstructed Construction	168[3,4]	130	100	100	100	N/A

Note 1: Wood truss construction as defined in A-1-4.6(b)(v) is classified as obstructed construction for the purpose of determining sprinkler protection areas.
Note 2: For Light Hazard Occupancies, the protection area per sprinkler for pipe schedule systems shall not exceed 200 sq ft per sprinkler.
Note 3: For light combustible framing members spaced less than 3 ft on center, maximum spacing is 130 sq ft [for examples, see A-1-4.6(a)(ii), A-1-4.6(a)(v), and A-1-4.6(b)(v)].
Note 4: For heavy combustible framing members spaced 3 ft or more on center, maximum spacing is 225 sq ft [for examples, see A-1-4.6(a)(i)].
Note 5: For Extra Hazard Occupancies:
1) The protection area per sprinkler for pipe schedule systems shall not exceed 90 sq ft.
2) The protection area per sprinkler for hydraulically designed systems with densities below 0.25 gpm/ft is permitted to exceed 100 sq ft, but shall not exceed 130 sq ft.
Note 6: For high-piled storage occupancies:
1) The protection area per sprinkler is permitted to exceed 100 sq ft but shall not exceed 130 sq ft for systems hydraulically designed in accordance with NFPA 231 and 231C for densities below 0.25 gpm/sq ft.
2) Where protection areas are specifically indicated in the design criteria of other portions of this standard or other NFPA standards, those protection areas shall be used.
3) For protection involving large-drop sprinklers, use the large-drop sprinkler column in the table.
Note 7: For large-drop and ESFR sprinklers, the minimum spacing is 80 sq ft per sprinkler.
Note 8: For special sprinkler protection areas, see 4-3.2.
N/A Denotes data not available in current standard.
For SI Units: 1 sq ft = 0.0929 m^2; 1 ft = 0.3048 m; 1 gpm/ft^2 = 40.746 L/min/m^2.

(a) Sprinklers in the heater zone shall be of the high temperature classification, and sprinklers in the danger zone of the intermediate temperature classification.

(b) Sprinklers located within 12 in. (305 mm) to one side or 30 in. (762 mm) above an uncovered steam main, heating coil, or radiator shall be of the intermediate temperature classification.

(c) Sprinklers within 7 ft (2.1 m) of a low-pressure blow-off valve that discharges free in a large room shall be of the high temperature classification.

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

(e) Sprinklers in an unventilated, concealed space, under an uninsulated roof, or in an unventilated attic shall be of the intermediate temperature classification.

(f) Sprinklers in unventilated show windows having high-powered electric lights near the ceiling shall be of the intermediate temperature classification.

(g) Sprinklers protecting commercial-type cooking equipment and ventilation systems shall be of the high or extra high temperature classification as determined by use of a temperature measuring device. (*See 3-9.6.*)

4-3.1.3.3 In case of occupancy change involving temperature change, the sprinklers shall be changed accordingly.

4-3.2* Special Sprinklers. Installation of special sprinklers with protection areas, locations, and distances between sprinklers differing from those specified in Table 4-2.2 and Section 4-4 shall be permitted where found suitable for such use based on: fire tests related to the hazard category; tests to evaluate distribution, wetting of floors and walls, and interference to distribution by structural elements; and tests to characterize response sensitivity. K factors and temperature ratings of special sprinklers shall be within the range established in Table 2-2.2 and Table 2-2.3.1.

Exception No. 1: The maximum protection area for special sprinklers shall not exceed 400 sq ft (36 m^2) per sprinkler.

Exception No. 2: Maximum area of coverage for individual extended coverage pendent and upright sprinklers shall be limited to areas having equal-sided dimensions of 12 ft × 12 ft (3.66 m × 3.66 m), 14 ft × 14 ft (4.23 m × 4.23 m), 16 ft × 16 ft (4.90 m × 4.90 m), 18 ft × 18 ft (5.49 m × 5.49 m), or 20 ft × 20 ft (6.10 m × 6.10 m).

Exception No. 3: Extended coverage sprinklers shall be listed with and designed for the minimum flow corresponding to the density for the smallest area of operation for the hazard as specified in Figure 5-2.3.

Exception No. 4: Extended coverage sprinklers shall not be permitted within trusses or bar joists having web members greater than 1-in. (25.4-m) maximum dimension.

4-3.2.1 Extended coverage sprinklers shall be limited for use under horizontal, smooth, flat ceilings or pitched ceilings with a slope not exceeding 2 in. per ft (168 mm per m).

Exception: Where sprinklers are specifically listed for other construction features, they shall be permitted for such use.

4-3.3 Old-Style Sprinklers. Old-style sprinklers shall not be used in a new installation.

Exception No. 1: Old-style sprinklers shall be installed in fur storage vaults. See 4-5.13.

Exception No. 2: Use of old-style sprinklers shall be permitted where construction features or other special situations require unique water distribution.

Table 4-3.1.3.2(a) Temperature Ratings of Sprinklers Based on Distance from Heat Sources

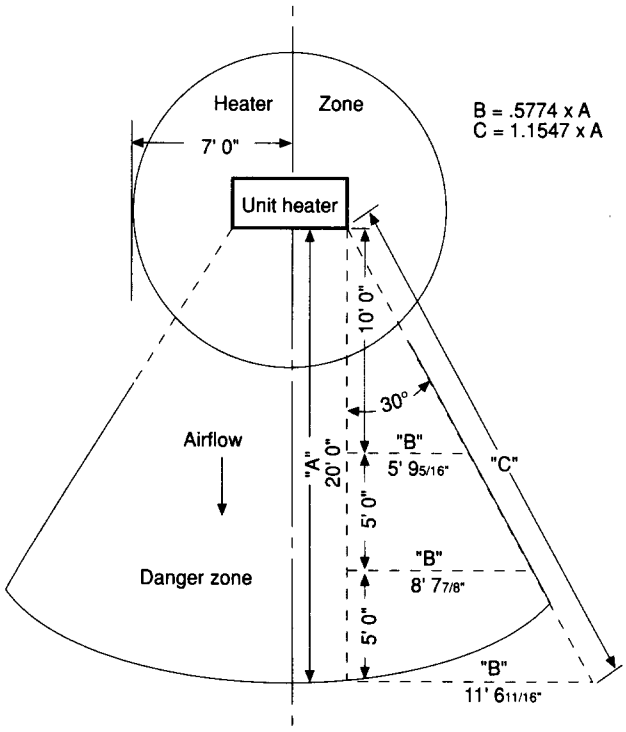
Type of Heat Condition	Ordinary Degree Rating	Intermediate Degree Rating	High Degree Rating
1. Heating Ducts (a) Above	More than 2 ft 6 in.	2 ft 6 in. or less	—
(b) Side and Below	More than 1 ft 0 in.	1 ft 0 in. or less	—
(c) Diffuser Downward Discharge Horizontal Discharge	Any distance except as shown under Intermediate	*Downward:* Cylinder with 1 ft 0 in. radius from edge, extending 1 ft 0 in. below and 2 ft 6 in. above *Horizontal:* Semi-cylinder with 2 ft 6 in. radius in direction of flow, extending 1 ft 0 in. below and 2 ft 6 in. above	—
2. Unit Heater (a) Horizontal Discharge	—	*Discharge Side:* 7 ft 0 in. to 20 ft 0 in. radius pie-shaped cylinder [see Figure 4-3.1.3.2] extending 7 ft 0 in. above and 2 ft 0 in. below heater; also 7 ft 0 in. radius cylinder more than 7 ft 0 in. above unit heater	7 ft 0 in. radius cylinder extending 7 ft 0 in. above and 2 ft 0 in. below unit heater
(b) Vertical Downward Discharge [Note: For sprinklers below unit heater, see Figure 4-3.1.3.2.]	—	7 ft 0 in. radius cylinder extending upward from an elevation 7 ft 0 in. above unit heater	7 ft 0 in. radius cylinder extending from the top of the unit heater to an elevation 7 ft 0 in. above unit heater
3. Steam Mains (Uncovered) (a) Above	More than 2 ft 6 in.	2 ft 6 in. or less	—
(b) Side and Below	More than 1 ft 0 in.	1 ft 0 in. or less	—
(c) Blowoff Valve	More than 7 ft 0 in.	—	7 ft 0 in. or less

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

Table 4-3.1.3.2(b) Ratings of Sprinklers in Specified Locations

Location	Ordinary Degree Rating	Intermediate Degree Rating	High Degree Rating
Skylights	—	Glass or plastic	—
Attics	Ventilated	Unventilated	—
Peaked Roof: Metal or thin boards; concealed or not concealed; insulated or uninsulated	Ventilated	Unventilated	—
Flat Roof: Metal, not concealed; insulated or uninsulated	Ventilated or unventilated	Note: For uninsulated roof, climate and occupancy may necessitate intermediate sprinklers. Check on job.	—
Flat Roof: Metal; concealed; insulated or uninsulated	Ventilated	Unventilated	—
Show Windows	Ventilated	Unventilated	—

Note: A check of job condition by means of thermometers may be necessary.



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

Figure 4-3.1.3.2 Heater and danger zones at unit heaters.

4-3.4 Sidewall Spray Sprinklers. Sidewall sprinklers shall be installed only in Light Hazard Occupancies.

Exception: Sidewall sprinklers shall be permitted to be used in Ordinary Hazard Occupancies where specifically listed for such use.

4-3.5 Open Sprinklers. Open sprinklers shall be permitted to protect special hazards, for protection against exposures, or in other special locations.

4-3.6 Residential Sprinklers.

4-3.6.1* Residential sprinklers shall be permitted in dwelling units and their adjoining corridors located in any occupancy provided they are installed in conformance with their listing and the positioning requirements of NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, or NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height.*

4-3.6.2 Residential sprinklers shall be used only in wet systems.

Exception: Residential sprinklers shall be permitted for use in dry systems if specifically listed for such service.

4-3.6.3 All residential sprinklers within a compartment (as defined in 1-4.2) shall be within 10°F (3.3°C) in temperature rating.

4-3.7 Early Suppression Fast-Response (ESFR) Sprinklers.

4-3.7.1 ESFR sprinklers shall be used only in wet pipe systems.

4-3.7.2 ESFR sprinklers shall be installed only in buildings with roof or ceiling slope not exceeding 1 in. per ft (84 mm/m).

4-3.7.3 ESFR sprinklers shall be permitted for use in buildings with the following types of construction:

(a) Smooth ceiling, joists consisting of steel truss shaped members, wood truss shaped members that consist of wood top and bottom chord members not exceeding 4 in. (102 mm) in depth with steel tube or bar web.

(b) Wood beams of 4 in. by 4 in. (102 mm by 102 mm) or greater nominal dimension, concrete or steel beams spaced 3½ to 7½ ft (0.9 to 2.3 m) on center and either supported on or framed into girders; ceiling panels formed by members capable of trapping heat to aid the operation of sprinklers with members spaced greater than 7½ ft (2.3 m) and limited to a maximum of 300 sq ft (27.9 m^2) in area.

(c) Paragraphs (a) and (b) apply to construction with noncombustible or combustible roof or decks.

(d) Construction with ceiling panels formed by members capable of trapping heat to aid the operation of sprinklers with members spaced greater than 7½ ft (2.3 m) and limited to a maximum of 300 sq ft (27.9 m^2) in area.

4-3.7.4 Temperature Rating. Sprinkler temperature ratings shall be nominal 165°F (74°C).

Exception: Sprinklers of intermediate and high temperature ratings shall be installed in specific locations as required by 4-3.1.3.

4-3.8 Large-Drop Sprinklers.

4-3.8.1 Large-drop sprinklers shall be permitted to be used in wet, dry, or preaction systems.

4-3.8.2* In preaction and dry pipe systems, piping materials shall be limited to internally galvanized steel or copper.

Exception: Nongalvanized fittings shall be permitted.

4-3.8.3 Sprinkler temperature ratings shall be the same as those indicated in Tables 4-3.1.3.2(a) and (b) or those used in large-scale fire testing to determine the protection requirements for the hazard involved.

Exception: Sprinklers of intermediate and high temperature ratings shall be installed in specific locations as required by 4-3.1.3.

4-3.9 Quick-Response Early Suppression (QRES) Sprinklers. (Reserved)

4-4 Sprinkler Spacing and Location.

4-4.1 Upright and Pendent Spray Sprinklers.

4-4.1.1 Sprinkler Spacing Limitations. The maximum distance between sprinklers, either on branch lines or between branch lines, shall be as follows:

Light Hazard Occupancies	15 ft (4.6 m)
Ordinary Hazard Occupancies	15 ft (4.6 m)
Extra Hazard Occupancies	12 ft (3.7 m)
High-Piled Storage	12 ft (3.7 m)

Where sprinklers are spaced less than 6 ft (1.8 m) on center, see 4-4.1.7.1.

Exception No. 1: For Extra Hazard Occupancies and high-piled storage in bays 25 ft (7.6 m) wide, a spacing of 12 ft 6 in. (3.8 m) shall be permitted.

Exception No. 2: For densities less than 0.25 gpm per sq ft [10.2 (L/min)/m²)], a spacing of 15 ft (4.6 m) shall be permitted.

4-4.1.2 Distance from Walls.

4-4.1.2.1 The distance from sprinklers to walls shall not exceed one-half of the allowable distance between sprinklers.

Exception: Within small rooms, sprinklers shall be permitted to be located not more than 9 ft (2.7 m) from any single wall. Sprinkler spacing limitations of 4-4.1.1 and area limitations of Table 4-2.2 shall not be exceeded.*

4-4.1.2.2 Sprinklers shall be located a minimum of 4 in. (102 mm) from a wall.

4-4.1.3 Obstructions to Sprinkler Discharge.

4-4.1.3.1* Obstructions Located at the Ceiling. Noncontinuous obstructions at the ceiling or roof such as columns, bar joists, truss webs, and light fixtures shall be treated as vertical obstructions.

Exception: Obstructions that can meet the separation requirements for horizontal obstructions in 4-4.1.3.1.2.

4-4.1.3.1.1 Vertical Obstructions. The minimum separation between vertical obstructions and a sprinkler shall be as shown in Table 4-4.1.3.1.1 and Figures 4-4.1.3.1.1(a), (b), (c), and (d).

Exception No. 1: Sprinklers shall be permitted to be spaced on opposite sides of the obstruction provided the distance from the centerline of the obstruction to the sprinklers does not exceed one-half the allowable distance between sprinklers.

Exception No. 2: Where vertical obstructions consist of open trusses 20 in. (0.51 m) or greater apart [24 in. (0.61 m) on center], sprinklers shall be permitted to be located one-half the distance between the vertical obstructions provided that all truss members are not greater than 4 in. (102 mm) (nominal) in width.

Exception No. 3: Where the sprinklers are installed in the centerline of bar joists or a truss, the provisions of 4-4.1.3.2.3 shall apply.

Table 4-4.1.3.1.1 Minimum Distance from Vertical Obstructions

Maximum Dimension of Obstruction	Minimum Horizontal Distance
½ – 1 in.	6 in.
>1 in. – 4 in.	12 in.
>4 in.	24 in.

For SI Units: 1 in. = 25.4 mm.

4-4.1.3.1.2 Horizontal Obstructions. The minimum separation of a sprinkler from a horizontal obstruction shall be determined by the height of the deflector above the bottom of the obstruction as shown in Table 4-4.1.3.1.2 and Figure 4-4.1.3.1.2.

Exception: Sprinklers shall be permitted to be spaced on opposite sides of the obstruction provided the distance from the centerline of the obstruction to the sprinklers does not exceed one-half the allowable distance between sprinklers.

4-4.1.3.1.3 Horizontal Obstructions Against Walls. Where upright or pendent sprinklers are installed near horizontal obstructions against walls (like cabinets or soffits), they shall be located in accordance with Figure 4-4.1.3.1.3.

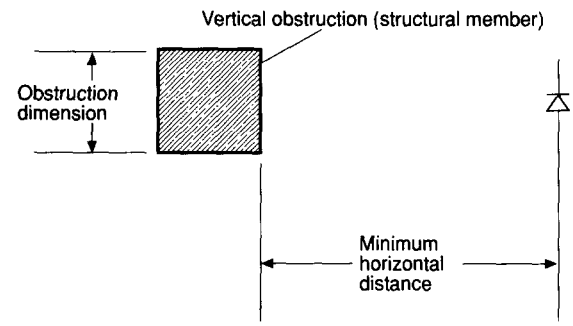


Figure 4-4.1.3.1.1(a) Vertical obstructions.

4-4.1.3.2 Obstructions Located below Sprinklers.

4-4.1.3.2.1* Sprinklers shall be installed under ducts, decks, and other obstructions over 4 ft (1.2 m) wide.

Exception: Ceiling sprinklers shall be permitted to be spaced in accordance with Table 4-4.1.3.1.2.

4-4.1.3.2.2 Sprinklers installed under open gratings shall be of the intermediate level/rack storage type or otherwise shielded from the discharge of overhead sprinklers.

4-4.1.3.2.3 Sprinklers shall be permitted to be installed on the centerline of a truss, bar joist, or directly above a beam provided the truss chord or beam dimension is not more than 8 in. (203 mm) and the sprinkler deflector is located at least 6 in. (152 mm) above the structural member.

Exception: Where ESFR sprinklers are installed, the sprinklers shall be located so that the deflectors are at least 1 ft (0.31 m) horizontally from the nearest edge of any bottom chords at open trusses or open bar joists.

4-4.1.3.3* Suspended or Floor-Mounted Vertical Obstructions. The distance from sprinklers to privacy curtains, free-standing partitions, room dividers, and similar obstructions in Light Hazard Occupancies shall be as shown in Table 4-4.1.3.3 and Figure 4-4.1.3.3.

4-4.1.3.4 Double Joist Obstructions. Where there are two sets of joists under a roof or ceiling, and there is no flooring over the lower set, sprinklers shall be installed above and below the lower set of joists where there is a clearance of 6 in. (152 mm) or more between the top of the lower joist and the bottom of the upper joist. (*See Figure 4-4.1.3.4.*)

Exception: Sprinklers are permitted to be omitted from below the lower set of joists where at least 18 in. (457 mm) is maintained between the sprinkler deflector and the top of the lower joist.

4-4.1.4 Distance below Ceilings.

4-4.1.4.1 Under unobstructed construction, the distance between the sprinkler deflector and the ceiling shall be a minimum of 1 in. (25.4 mm) and a maximum of 12 in. (305 mm).

Exception: Special ceiling-type sprinklers (concealed, recessed, and flush types) shall be permitted to have the operating element above the ceiling and the deflector located nearer to the ceiling where installed in accordance with their listing.

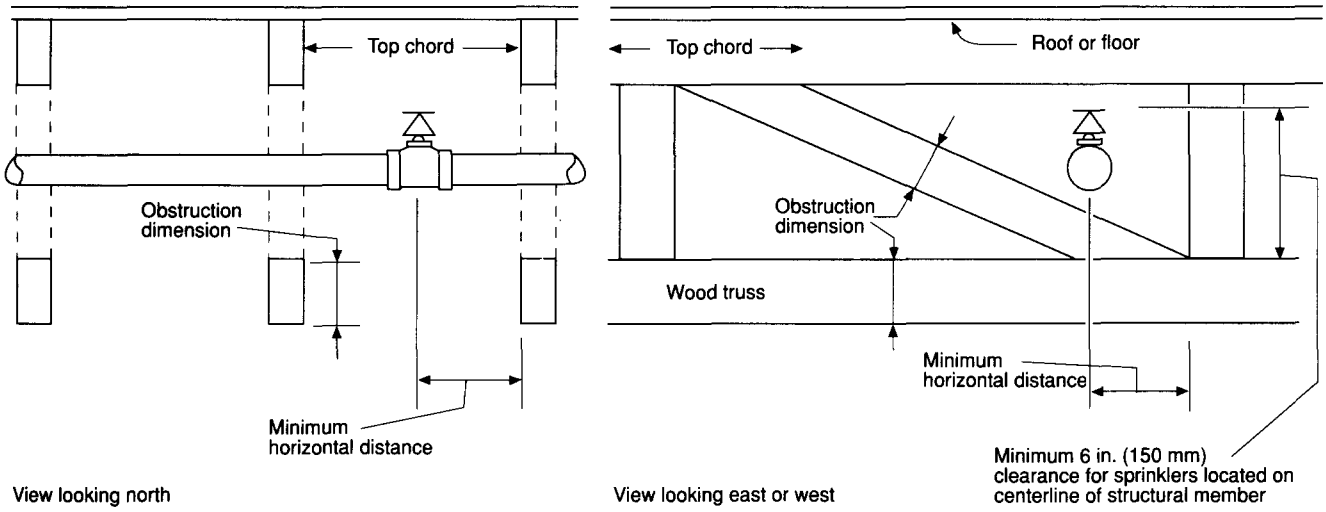


Figure 4-4.1.3.1.1(b) Vertical obstructions.

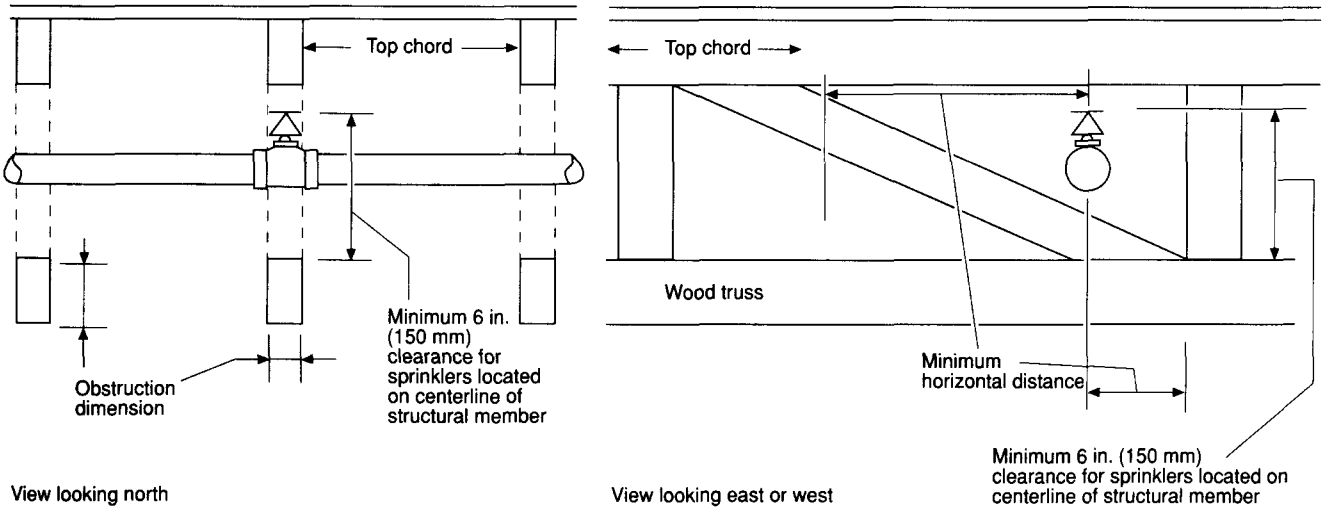


Figure 4-4.1.3.1.1(c) Vertical obstructions.

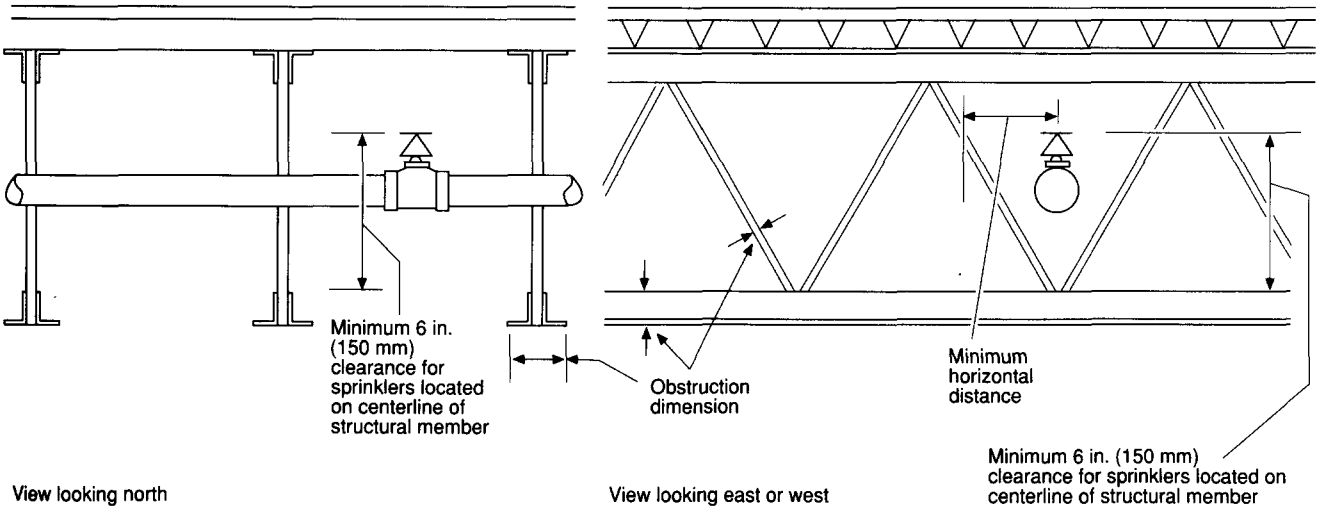


Figure 4-4.1.3.1.1(d) Vertical obstructions.

Table 4-4.1.3.1.2 Position of Deflector when Located above Bottom of Obstruction

Distance from Sprinkler to Side of Obstruction	Maximum Allowable Distance of Deflector Above Bottom of Obstruction	Maximum Allowable Distance of Deflector Above Bottom of Obstruction
	Standard Sprinklers	Extended Coverage Sprinklers
Less than 1 ft	0 in.	0 in.
1 ft to less than 1 ft 6 in.	1 in.	0 in.
1 ft 6 in. to less than 2 ft	1 in.	1 in.
2 ft to less than 2 ft 6 in.	2 in.	1 in.
2 ft 6 in. to less than 3 ft	3 in.	1 in.
3 ft to less than 3 ft 6 in.	4 in.	3 in.
3 ft 6 in. to less than 4 ft	6 in.	3 in.
4 ft to less than 4 ft 6 in.	7 in.	5 in.
4 ft 6 in. to less than 5 ft	9 in.	7 in.
5 ft to less than 5 ft 6 in.	11 in.	7 in.
5 ft 6 in. to less than 6 ft	14 in.	7 in.
6 ft to less than 6 ft 6 in.	N/A	9 in.
6 ft 6 in. to less than 7 ft	N/A	11 in.
7 ft and greater	N/A	14 in.

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

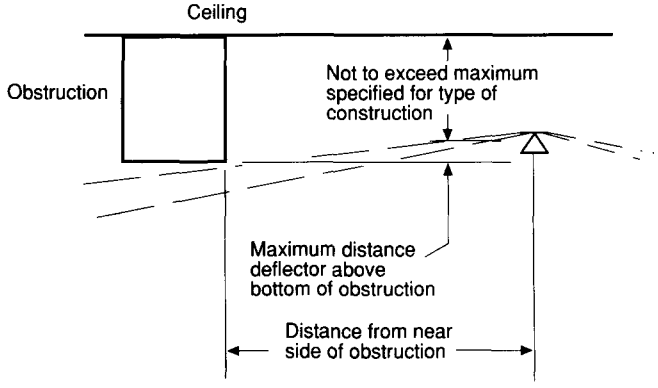


Figure 4-4.1.3.1.2 Position of deflector, upright, or pendent sprinkler when located above bottom of obstructions.

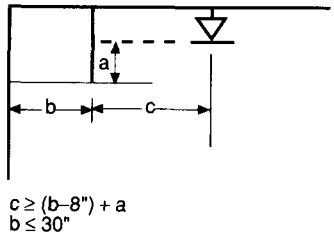


Figure 4-4.1.3.1.3 Horizontal obstructions against walls.

4-4.1.4.2 Under obstructed construction, the sprinkler deflector shall be located 1 to 6 in. (25.4 to 152 mm) below the structural members and a maximum distance of 22 in. (559 mm) below the ceiling/roof deck.

Exception No. 1: Sprinklers shall be permitted to be installed with the deflector at or above the bottom of the structural member to a maximum of 22 in. (559 mm) below the ceiling/roof deck where the sprinkler is installed in conformance with 4-4.1.3.1.2.

Table 4-4.1.3.3 Horizontal and Minimum Vertical Distances for Sprinklers

Horizontal Distance	Minimum Vertical Distance below Deflector
6 in. or less	3 in.
More than 6 in. to 9 in.	4 in.
More than 9 in. to 12 in.	6 in.
More than 12 in. to 15 in.	8 in.
More than 15 in. to 18 in.	9 1/2 in.
More than 18 in. to 24 in.	12 1/2 in.
More than 24 in. to 30 in.	15 1/2 in.
More than 30 in.	18 in.

For SI Units: 1 in. = 25.4 mm.

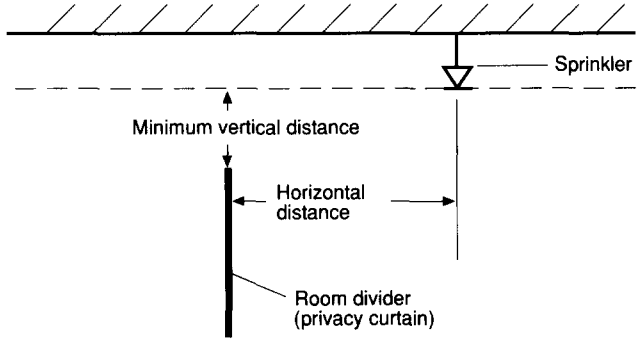
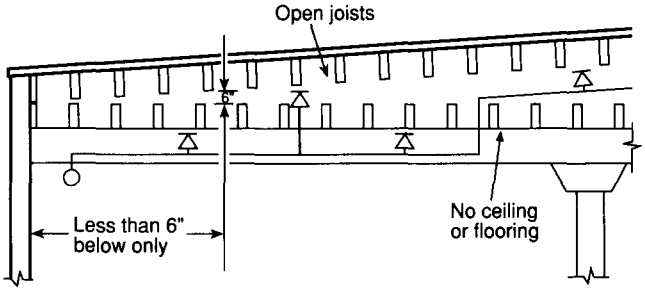


Figure 4-4.1.3.3 Sprinklers installed near privacy curtains, free-standing partitions, or room dividers.



For SI Units: 1 in. = 25.4 mm.

Figure 4-4.1.3.4 Arrangement of sprinklers under two sets of open joists — no sheathing on lower joists.

Exception No. 2: Where sprinklers are installed in each bay of obstructed construction, deflectors shall be a minimum of 1 in. (25.4 mm) and a maximum of 12 in. (152 mm) below the ceiling.

Exception No. 3: Sprinklers shall only be permitted below composite wood joists where joist channels are firestopped to the full depth of the joists with material equivalent to the web construction so that individual channel areas do not exceed 300 sq ft (27.9 m^2).

Exception No. 4: Deflectors of sprinklers under concrete tee construction with stems spaced less than 7 1/2 ft (2.3 m) but more than 3 ft (0.9 m) on centers shall, regardless of the depth of the tee, be permitted to be located at or above the plane 1 in. (25.4 mm) below the bottom of the stems of the tees and shall comply with Table 4-4.1.3.1.2.*

4-4.1.5* Position of Deflectors. Deflectors of sprinklers shall be parallel to ceilings, roofs, or the incline of stairs.

Exception No. 1: Where sprinklers are installed in the peak of a pitched roof, the sprinkler shall be installed with the deflector horizontal.

Exception No. 2: Pitched roofs having slopes less than 1 in. per ft (83 mm/m) are considered level in the application of this rule, and sprinklers shall be permitted to be installed with deflectors horizontal.

4-4.1.6* Clear Space below Sprinklers. A minimum of 18 in. (457 mm) clearance shall be maintained between the top of storage and ceiling sprinkler deflectors.

Exception No. 1: Where other standards specify greater minimums, they shall be followed.

Exception No. 2: A minimum clearance of 36 in. (0.91 m) shall be permitted for special sprinklers.

4-4.1.7 Special Situations.

4-4.1.7.1 Baffles. Baffles shall be installed wherever sprinklers are less than 6 ft (1.8 m) apart to prevent operating sprinklers from wetting adjacent sprinklers, thus delaying or preventing their operation. Baffles shall be located midway between sprinklers and arranged to protect the actuating elements. Baffles shall be of noncombustible or limited-combustible material that will stay in place before and during sprinkler operation. The baffles shall be approximately 8 in. (203 mm) wide and 6 in. (152 mm) high. The tops of baffles shall extend 2 to 3 in. (51 to 76 mm) above the deflectors of upright sprinklers. The bottoms of baffles shall extend downward to a level at least even with the deflectors of pendent sprinklers. (*See A-4-5.3.4.*)

Exception No. 1: For in-rack sprinklers, see NFPA 231C, Standard for Rack Storage of Materials.

Exception No. 2: Baffles are not required for old-style sprinklers protecting fur storage vaults.

4-4.1.7.2 Spacing under Pitched Surfaces.

4-4.1.7.2.1 The distance between sprinklers either on the branch lines or between the branch lines, running up or down the slope of a pitched surface, shall be measured along the slope.

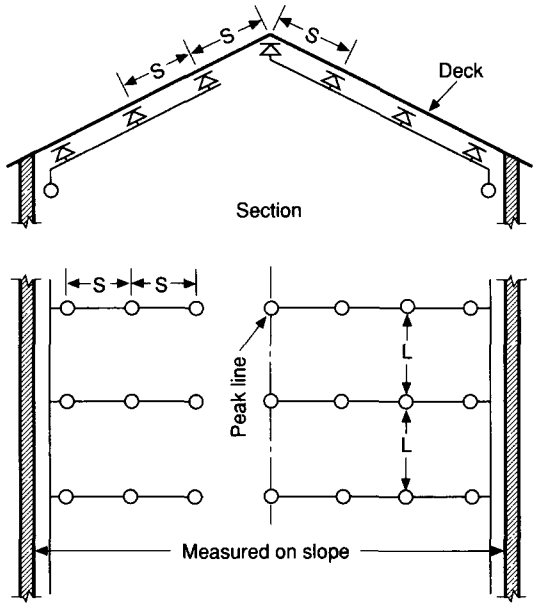
4-4.1.7.2.2* Sprinklers under or near the peak shall have deflectors located not more than 3 ft (0.9 m) vertically down from the peak. [*See Figures 4-4.1.7.2.2(a) and 4-4.1.7.2.2(b).*]

Exception No. 1: Under saw-toothed roofs, sprinklers at the highest elevation shall not exceed a distance of 3 ft (0.9 m) measured down the slope from the peak.

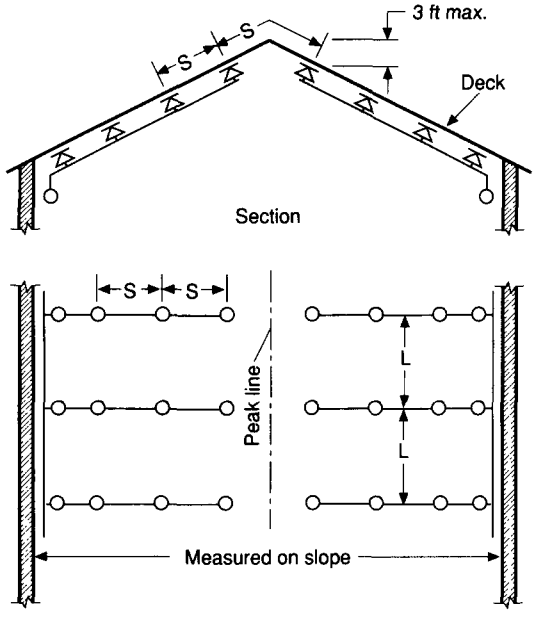
Exception No. 2: Under a steeply pitched surface, the distance from the peak to the deflectors shall be permitted to be increased to maintain a horizontal clearance of not less than 2 ft (0.6 m) from other structural members. [See Figure 4-4.1.7.2.2(c).]

4-4.1.7.3 Spacing of Sprinklers under Curved Roof Buildings.

4-4.1.7.3.1 Under curved surfaces, the horizontal distance measured at the floor level from the wall to the nearest sprinkler shall not be greater than one-half the allowable distance between sprinklers.



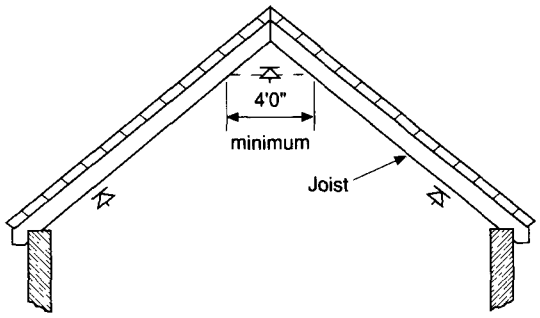
For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Figure 4-4.1.7.2.2(a) Sprinklers at pitched roofs; branch lines run up the slope.



For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Figure 4-4.1.7.2.2(b) Sprinklers at pitched roofs; branch lines run up the slope.

4-4.1.7.3.2 Deflectors of sprinklers shall be parallel with the curve of the surface.

4-4.1.7.3.3 Where Extra Hazard Occupancy spacing of sprinklers is used under curved ceilings of other than fire resistive construction, the sprinkler spacing as projected on the floor shall not be greater than that required for Extra Hazard Occupancies, but in no case shall the spacing at the roof or ceiling be wider than that required for Ordinary Hazard Occupancies.



For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Figure 4-4.1.7.2.2(c) Desirable horizontal clearance for sprinklers at peak of pitched roof.

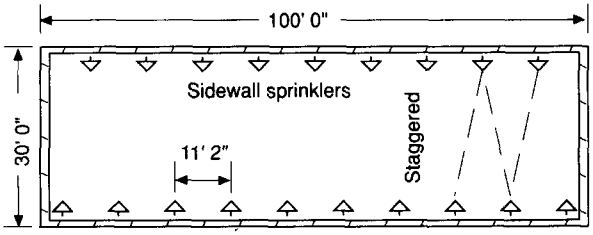
4-4.2 Sidewall Spray Sprinklers.

4-4.2.1 Distance between Sprinklers on Branch Lines. Sidewall sprinklers shall be installed along the length of a single wall of rooms or bays not exceeding the width dimension specified in Table 4-4.2.1.

Exception: Where the width of the room or bay exceeds the maximum allowed, up to 30 ft (9.1 m) for Light Hazard Occupancy, or 20 ft (6.1 m) for Ordinary Hazard Occupancy, sidewall sprinklers on a staggered basis shall be provided on two opposite walls or sides of bays with spacing as required by Table 4-4.2.1. (See Figure 4-4.2.1.)

4-4.2.2 Protection Area Limitations.

4-4.2.2.1* Protection area limitations for sidewall sprinklers shall be in conformity with Table 4-4.2.1.



For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Figure 4-4.2.1 Spacing of sidewall sprinklers under unobstructed construction in Light Hazard Occupancies.

4-4.2.2.2 The distance from a sidewall sprinkler to an end wall shall not exceed one-half the allowable distance between sidewall sprinklers.

4-4.2.3 Position of Sidewall Sprinklers.

4-4.2.3.1 Sidewall sprinklers shall only be installed along walls, lintels, or soffits where the distance from the ceiling to the bottom of the lintel or soffit is at least 2 in. (51 mm) greater than the distances from the ceiling to sidewall sprinkler deflectors.

4-4.2.3.2 Sidewall sprinklers shall not be installed back-to-back without being separated by a continuous lintel or soffit.

4-4.2.3.3 Sidewall sprinkler deflectors (vertical type) shall be located not more than 6 in. (152 mm) nor less than 4 in. (102 mm) from walls and ceilings.

Exception No. 1: Horizontal sidewall sprinklers are permitted to be located 6 to 12 in. (152 to 305 mm) below noncombustible ceilings where listed for these positions.

Exception No. 2: Horizontal sidewall sprinklers are permitted to be located with their deflectors less than 4 in. (102 mm) from the wall on which they are mounted.

4-4.2.3.4 Sidewall sprinklers, where installed under a sloped ceiling, shall be located at the high point of the slope and positioned to discharge downward, and the deflector shall be parallel to the sloped ceiling.

4-4.2.3.5 Where soffits are used for the installation of sidewall sprinklers, they shall not exceed 8 in. (203 mm) in width or projection from the wall.

Exception: Where soffits exceed 8 in. (203 mm), additional sprinklers shall be installed below the soffit.

4-4.2.4 Obstructions to Sidewall Sprinklers. Sidewall sprinklers shall be installed no closer than 4 ft (2.3 m) from beams or similar obstructions. Beams or similar obstructions located more than 4 ft (2.3 m) from the sprinkler shall be in conformity with Table 4-4.2.4.

4-4.3 Large-Drop Sprinklers.

4-4.3.1* Spacing. The distance between sprinklers shall be limited to not more than 12 ft (3.7 m) nor less than 8 ft (2.4 m).

Table 4-4.2.1 Dimensions for Sidewall Sprinkler Installation for Various Ceiling Types

	Light Hazard Occupancy			Ordinary Hazard Occupancy	
	Combustible Sheathing	Combustible Construction with Noncombustible or Limited Combustible Sheathing, Wood Lath, and Plaster	Noncombustible Construction with Noncombustible or Limited Combustible Sheathing	Combustible Sheathing	Noncombustible or Limited Combustible Sheathing
Maximum distance between sprinklers on branch line	14	14	14	10	10
Maximum room width for single branch line along wall (ft)	12	12	14	10	10
Maximum area coverage (ft^2)	120	168	196	80	100

For SI Units: 1 ft = 0.3048 m; 1 ft^2 = 0.0929 m^2.

Table 4-4.2.4 Sidewall Sprinkler Clearance

Distance from Sidewall Sprinkler to Side of Obstruction	Maximum Allowable Distance of Deflector above Bottom of Obstruction (in.)
Less than 4 ft	0
4 ft to less than 5 ft	1
5 ft to less than 5 ft 6 in.	2
5 ft 6 in. to less than 6 ft	3
6 ft to less than 6 ft 6 in.	4
6 ft 6 in. to less than 7 ft	6
7 ft to less than 7 ft 6 in.	7
7 ft 6 in. to less than 8 ft	9
8 ft to less than 8 ft 6 in.	11
8 ft 6 in. or greater	14

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

Exception: Under obstructed combustible construction, the maximum distance shall be limited to 10 ft (3.0 m).

4-4.3.2 Clear Space below Sprinklers. A minimum of 36 in. (914 mm) shall be maintained between the top of storage and ceiling sprinkler deflectors.

4-4.3.3* Distance below Ceiling.

4-4.3.3.1 Under unobstructed construction, the distance between the sprinkler deflector and the ceiling shall be a minimum of 6 in. (152 mm) and a maximum of 8 in. (203 mm).

4-4.3.3.2 Under obstructed construction, the distance between the sprinkler deflector and the ceiling shall be a minimum of 6 in. (152 mm) and a maximum of 12 in. (305 mm).

Exception: Under wood joist or composite wood joist construction, the sprinklers shall be located 1 to 6 in. (25.4 to 152 mm) below the structural members to a maximum distance of 22 in. (559 mm) below the ceiling/roof or deck.

4-4.3.4* Obstructions to Distribution.

4-4.3.4.1 Obstructions Located at the Ceiling. Where sprinkler deflectors are located above the bottom of obstructions such as beams, girders, ducts, fluorescent lighting fixtures, etc., located at the ceiling, the sprinklers shall be positioned so that the maximum distance from the bottom of the obstruction to the deflectors does not exceed the values specified in 4-4.1.3.

4-4.3.4.2 Obstructions Located below the Sprinklers.

4-4.3.4.2.1 Sprinklers shall be positioned with respect to fluorescent lighting fixtures, ducts, and obstructions more than 24 in. (610 mm) wide and located entirely below the sprinklers so that the minimum horizontal distance from the near side of the obstruction to the center of the sprinkler is not less than the value specified in Table 4-4.3.4.2.1. (*See Figure 4-4.3.4.2.1.*)

4-4.3.4.2.2 Where the bottom of the obstruction is located 24 in. (610 mm) or more below the sprinkler deflectors:

(a) Sprinklers shall be positioned so that the obstruction is centered between adjacent sprinklers. (*See Figure 4-4.3.4.2.2.*)

(b) The obstruction shall be limited to a maximum width of 24 in. (610 mm). (*See Figure 4-4.3.4.2.2.*)

Table 4-4.3.4.2.1 Position of Sprinklers in Relation to Obstruction Located Entirely Below the Sprinklers

Distance of Deflector above Bottom of Obstruction	Minimum Distance to Side of Obstruction, ft (m)
Less than 6 in. (152 mm)	1½ (0.5)
6 in. (152 mm) to less than 12 in. (305 mm)	3 (0.9)
12 in. (305 mm) to less than 18 in. (457 mm)	4 (1.2)
18 in. (457 mm) to less than 24 in. (610 mm)	5 (1.5)
24 in. (610 mm) to less than 30 in. (660 mm)	6 (1.8)

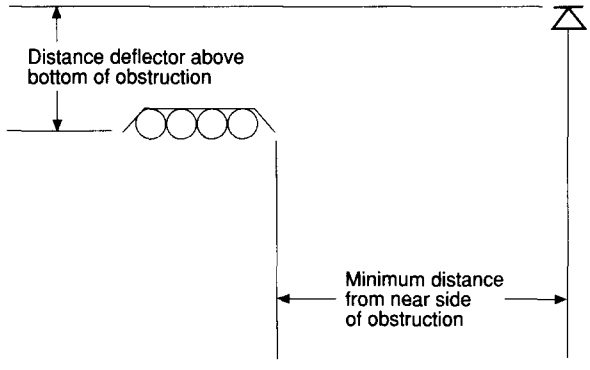


Figure 4-4.3.4.2.1 Position of sprinklers in relation to obstructions located entirely below the sprinklers. (To be used with Table 4-4.3.4.2.1.)

Exception: Where the obstruction is greater than 24 in. (610 mm) wide, one or more lines of sprinklers shall be installed below the obstruction.

(c) The obstruction shall not extend more than 12 in. (305 mm) to either side of the midpoint between sprinklers. (*See Figure 4-4.3.4.2.2.*)

Exception: When the extensions of the obstruction exceed 12 in. (305 mm), one or more lines of sprinklers shall be installed below the obstruction.

(d) At least 18 in. (457 mm) clearance shall be maintained between the top of storage and the bottom of the obstruction. (*See Figure 4-4.3.4.2.2.*)

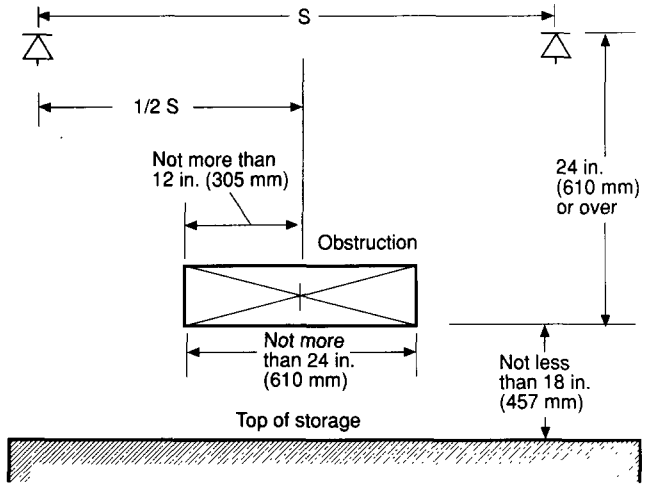


Figure 4-4.3.4.2.2 Position of sprinklers in relation to obstructions located 24 in. (610 mm) or more below deflectors.

4-4.3.4.2.3 Obstructions Parallel to and Directly below Branch Lines. In the special case of an obstruction running parallel to and directly below a branch line:

(a) The sprinkler shall be located at least 36 in. (914 mm) above the top of the obstruction. (*See Figure 4-4.3.4.2.3.*)

(b) The obstruction shall be limited to a maximum width of 12 in. (305 mm). (*See Figure 4-4.3.4.2.3.*)

(c) The obstruction shall be limited to a maximum extension of 6 in. (152 mm) to either side of the centerline of the branch line. (*See Figure 4-4.3.4.2.3.*)

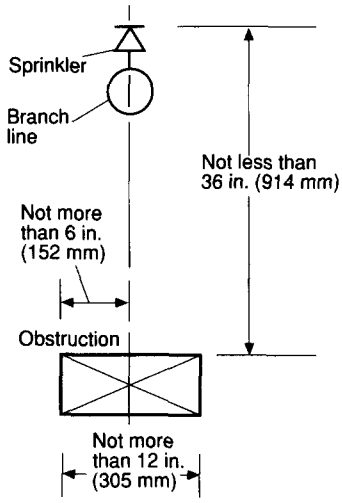


Figure 4-4.3.4.2.3 Position of sprinklers in relation to obstructions running parallel to and directly below branch lines.

4-4.4 Quick-Response Early Suppression (QRES) Sprinklers. (Reserved)

4-4.5 Early Suppression Fast-Response (ESFR) Sprinklers.

4-4.5.1 Spacing. The distance between branch lines and between sprinklers on branch lines shall be not more than 10 ft (3.1 m) nor less than 8 ft (2.4 m) for buildings higher than 30 ft (9.1 m) up to 40 ft (12.2 m), and not more than 12 ft (3.7 m) nor less than 8 ft (2.4 m) for buildings up to 30 ft (9.1 m) high.

4-4.5.2 Distances.

4-4.5.2.1 Distance from Walls. The distance from walls to sprinklers shall not exceed one-half of the allowable distance between sprinklers.

4-4.5.2.2 Clear Space below Sprinklers. At least 36 in. (914 mm) shall be maintained between sprinkler deflectors and the top of storage.

4-4.5.2.3 Distances below Ceiling. Pendent sprinklers shall be positioned so that deflectors are a maximum 14 in. (356 mm) and a minimum 6 in. (152 mm) below the ceiling. Upright sprinklers shall be positioned so that the centerline of the thermal fusible element is 4 to 6 in. (101 to 152 mm) below the roof/ceiling. Upright sprinklers shall also be positioned so that the deflector is a minimum of 7 in. (178 mm) above the top of the sprinkler pipe.

4-4.5.3 Location of Sprinklers in Obstructed Construction. With obstructed construction, the branch lines shall be permitted to be installed across the beams, but sprinklers shall be located in the bays and not under the beams.

4-4.5.4 Obstruction to Discharge.

4-4.5.4.1 Obstructions Located at or near the Ceiling. Where sprinkler deflectors are located above the bottom of beams, girders, bottom chords of trusses, bottom chords of joists, ducts, fluorescent lighting fixtures, or other obstructions located at the ceiling, the sprinklers shall be positioned so that the maximum distance from the bottom of the obstruction to the deflector does not exceed the value specified in 4-4.1.3.

4-4.5.4.2 Obstructions Located Entirely below the Sprinklers. Sprinklers shall be positioned with respect to any fluorescent lighting fixtures, ducts, or any other obstruction more than 24 in. (610 mm) wide and located entirely below the sprinklers so that the minimum horizontal distance from the near side of the obstruction to the center of the sprinkler is not less than the value specified in Table 4-4.3.4.2.1. (*See Figure 4-4.3.4.2.1.*)

Exception: Sprinklers shall not be required to comply with spacing limitations of Table 4-4.3.4.2.1 where additional sprinklers are located beneath the obstruction and are included in the water demand.

4-4.6 In-Rack Sprinklers.

4-4.6.1 System Size. The area protected by a single system of sprinklers in racks shall not exceed 40,000 sq ft (3716 m^2) of floor area occupied by the racks, including aisles, regardless of the number of levels of in-rack sprinklers.

4-4.6.2 Control Valves. Where sprinklers are installed in racks, separate indicating control valves and drains shall be provided for ceiling sprinklers and sprinklers in racks.

Exception No. 1: In-rack installations of 20 or fewer sprinklers.

Exception No. 2: The separate indicating valve shall be permitted to be arranged as sectional control valves where the racks occupy only a portion of the area protected by ceiling sprinklers.

4-4.6.3 Type of Sprinklers. In-rack sprinklers shall be ordinary temperature $\frac{1}{2}$- or $\frac{17}{32}$-in. (12.7- or 13.5-mm) sprinklers.

4-4.6.4 Location of In-Rack Sprinklers.

4-4.6.4.1 A minimum 6-in. (152-mm) vertical clear space shall be maintained between the sprinkler deflector and the top tier of storage.

4-4.6.4.2 The maximum spacing between sprinklers shall be 10 ft (3.05 m).

4-4.6.4.3 Sprinklers shall be located in transverse flue spaces.

4-4.6.4.4 In-rack sprinklers shall be located at the first tier level at or above one-half of the storage height.

4-5 Special Situations.

4-5.1 Concealed Spaces.

4-5.1.1* All concealed spaces enclosed wholly or partly by exposed combustible construction shall be protected by sprinklers.

Exception No. 1: Concealed spaces formed by studs or joists with less than 6 in. (152 mm) between the inside or near edges of the studs or joists. (See Figure 4-4.1.3.4.)

Exception No. 2: Concealed spaces formed by bar joists with less than 6 in. (152 mm) between the roof or floor deck and ceiling.

Exception No. 3: Concealed spaces formed by ceilings attached directly to or within 6 in. (152 mm) of wood joist construction.

Exception No. 4: Concealed spaces formed by ceilings attached directly to the underside of composite wood joist construction, provided the joist channels are firestopped into volumes each not exceeding 160 cu ft (4.53 m^3) using materials equivalent to the web construction.

Exception No. 5: Concealed spaces entirely filled with noncombustible insulation.

Exception No. 6: Concealed spaces within wood joist construction and composite wood joist construction having noncombustible insulation filling the space from the ceiling up to the bottom edge of the joist of the roof or floor deck, provided that in composite wood joist construction the joist channels are firestopped into volumes each not exceeding 160 cu ft (4.53 m^3). The joists shall be firestopped to the full depth of the joist with material equivalent to the web construction.

Exception No. 7: Concealed spaces over isolated small rooms not exceeding 55 sq ft (4.6 m^2) in area.

Exception No. 8: Where the exposed surfaces have a flame spread rating of 25 or less and the materials have been demonstrated not to propagate fire in the form in which they are installed in the space.

Exception No. 9: Noncombustible concealed spaces having exposed combustible insulation where the heat content of the facing and substrate of the insulation material does not exceed 1000 Btu per sq ft (11 356 kJ/m^2).

4-5.1.2 Sprinklers in concealed spaces having no access for storage or other use shall be installed in accordance with the requirements for Light Hazard Occupancy.

4-5.1.3 Where heat-producing devices such as furnaces or process equipment are located in the joist channels above a ceiling attached directly to the underside of composite wood joist construction that would not otherwise require sprinkler protection of the spaces, the joist channel containing the heat-producing devices shall be sprinklered by installing sprinklers in each joist channel, on each side, adjacent to the heat-producing device.

4-5.2 Vertical Shafts.

4-5.2.1 One sprinkler shall be installed at the top of shafts.

Exception No. 1: Noncombustible, nonaccessible vertical duct shafts.

Exception No. 2: Noncombustible, nonaccessible vertical electrical shafts.

Exception No. 3: Noncombustible, nonaccessible vertical pipe shafts.

4-5.2.2* Where vertical shafts have combustible surfaces, one sprinkler shall be installed at each alternate floor level. Where a shaft having combustible surfaces is trapped, an additional sprinkler shall be installed at the top of each trapped section.

4-5.2.3 Where accessible vertical shafts have noncombustible surfaces, one sprinkler shall be installed near the bottom.

4-5.2.4 Where vertical openings are not protected by fire-rated enclosures, sprinklers shall be placed so as to fully protect the openings.

4-5.3 Stairways.

4-5.3.1 Sprinklers shall be installed beneath all stairways of combustible construction.

4-5.3.2 In noncombustible stair shafts with noncombustible stairs, sprinklers shall be installed at the top of the shaft and under the first landing above the bottom of the shaft.

Exception: Sprinklers shall be installed beneath landings or stairways where the area beneath is used for storage.

4-5.3.3* Sprinklers shall be installed in the stair shaft at each floor landing serving two or more separate fire divisions located at the same level as the landing.

4-5.3.4* Where moving stairways, staircases, or similar floor openings are unenclosed, the floor openings involved shall be protected by closely spaced sprinklers in combination with draft stops.

The draft stops shall be located immediately adjacent to the opening, shall be at least 18 in. (457 mm) deep, and shall be of noncombustible or limited-combustible material that will stay in place before and during sprinkler operation. Sprinklers shall be spaced not more than 6 ft (1.8 m) apart and placed 6 to 12 in. (152 to 305 mm) from the draft stop on the side away from the opening. Where sprinklers are closer than 6 ft (1.8 m), cross baffles shall be provided in accordance with 4-4.1.7.8.

Exception: Closely spaced sprinklers and draft stops are not required around large openings such as those found in shopping malls, atrium buildings, and similar structures where all adjoining levels and spaces are protected by automatic sprinklers in accordance with this standard and where the openings have all horizontal dimensions between opposite edges of 20 ft (6 m) or greater and an area of 1000 sq ft (93 m^2) or greater.

4-5.4* Building Service Chutes. Building service chutes (linen, rubbish, etc.) shall be protected internally by automatic sprinklers. A sprinkler shall be provided above the top service opening of the chute, above the lowest service opening, and above service openings at alternate levels in buildings over two stories in height. The room or area into which the chute discharges shall also be protected by automatic sprinklers.

4-5.5 Elevator Hoistways and Machine Rooms.

4-5.5.1* Sidewall spray sprinklers shall be installed at the bottom of each elevator hoistway, not more than 2 ft (0.61 m) above the floor of the pit.

Exception: For enclosed, noncombustible elevator shafts that do not contain combustible hydraulic fluids, the sprinklers at the bottom of the shaft are not required.

4-5.5.2* Automatic sprinklers in elevator machine rooms or at the tops of hoistways shall be of ordinary or intermediate temperature rating.

4-5.5.3* Upright or pendent spray sprinklers shall be installed at the top of elevator hoistways.

Exception: Sprinklers are not required at the tops of noncombustible hoistways of passenger elevators whose car enclosure materials meet the requirements of ASME A17.1, Safety Code for Elevators and Escalators.

4-5.6 Spaces under Ground Floors, Exterior Docks, and Platforms. Sprinklers shall be installed in spaces under all combustible ground floors, exterior docks, and platforms.

Exception: Sprinklers shall be permitted to be omitted where all of the following conditions prevail:

(a) The space is not accessible for storage purposes and is protected against accumulation of wind-borne debris;

(b) The space contains no equipment such as conveyors or fuel-fired heating units;

(c) The floor over the space is of tight construction;

(d) No combustible or flammable liquids or materials that under fire conditions would convert into combustible or flammable liquids are processed, handled, or stored on the floor above the space.

4-5.7* Exterior Roofs or Canopies.

4-5.7.1 Sprinklers shall be installed under roofs or canopies over areas where combustibles are stored or handled.

Exception: Sprinklers are permitted to be omitted where construction is noncombustible and areas under the roofs or canopies are not used for storage or handling of combustibles.

4-5.7.2 Sprinklers shall be installed under exterior combustible roofs or canopies exceeding 4 ft (1.2 m) in width.

4-5.8 Dwelling Units.

4-5.8.1 Sprinklers are not required in bathrooms that are located within dwelling units, that do not exceed 55 sq ft (5.1 m^2) in area, and that have walls and ceilings of noncombustible or limited-combustible materials with a 15-min thermal barrier rating including the walls and ceilings behind fixtures.

Exception: Sprinklers are required in bathrooms of nursing homes and in bathrooms opening directly onto public corridors or exitways.

4-5.8.2* Sprinklers are not required in clothes closets, linen closets, and pantries within dwelling units in hotels and motels where the area of the space does not exceed 24 sq ft (2.2 m^2), the least dimension does not exceed 3 ft (0.9 m), and the walls and ceilings are surfaced with noncombustible or limited-combustible materials.

4-5.9 Library Stack Rooms. Sprinklers shall be installed in every aisle and at every tier of stacks with distance between sprinklers along aisles not to exceed 12 ft (3.6 m). [*See Figure 4-5.9(a).*]

Exception No. 1: Where vertical shelf dividers are incomplete and allow water distribution to adjacent aisles, sprinklers are permitted to be omitted in ate aisles on each tier. Where ventilation openings are also provided in tier floors, sprinklers shall be staggered vertically. [See Figure 4-5.9(b).]

Exception No. 2: Sprinklers are permitted to be installed without regard to aisles when there is 18 in. (457 mm) or more clearance between sprinkler deflectors and tops of racks.

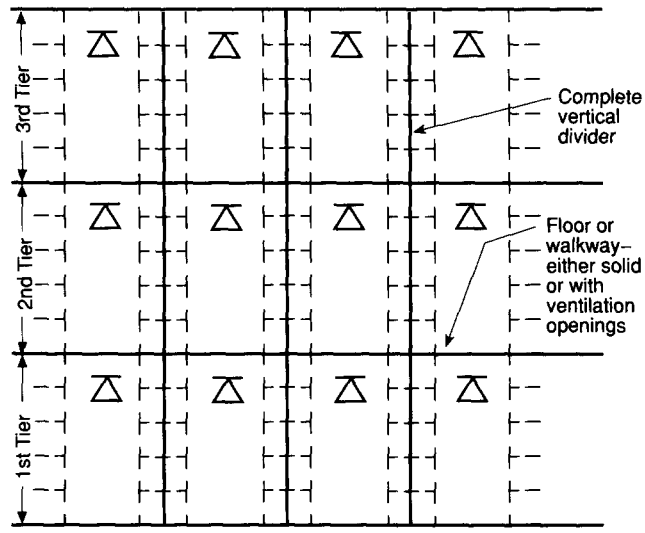


Figure 4-5.9(a) Sprinklers in multitier library bookstacks with complete vertical dividers.

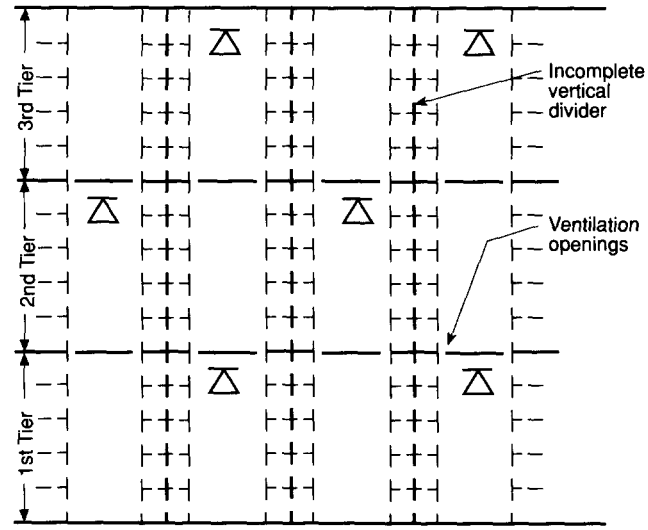


Figure 4-5.9(b) Sprinklers in multitier library bookstacks with incomplete vertical dividers.

4-5.10 Electrical Equipment. Sprinkler protection shall be required in electrical equipment rooms. Hoods or shields installed to protect important electrical equipment from sprinkler discharge shall be noncombustible.

Exception: Sprinklers shall not be required where all of the following conditions are met:

(a) The room is dedicated to electrical equipment only.

(b) Only dry-type electrical equipment is used.

(c) Equipment is installed in a 2-hr fire-rated enclosure including protection for penetrations.

(d) No combustible storage is permitted to be stored in the room.

4-5.11* Open-Grid Ceilings. Open-grid ceilings shall not be installed beneath sprinklers.

Exception No. 1: Open-grid ceilings in which the openings are 1/4 in. (6.4 mm) or larger in the least dimension, where the thickness or depth of the material does not exceed the least dimension of the opening, and where such openings constitute 70 percent of the area of the ceiling material. The spacing of the sprinklers over the open-grid ceiling shall then comply with the following:

(a) In Light Hazard Occupancies where sprinkler spacing (either spray or old-style sprinklers) is less than 10 ft by 10 ft (3 m by 3 m), a minimum clearance of at least 18 in. (457 mm) shall be provided between the sprinkler deflectors and the upper surface of the open-grid ceiling. Where spacing is greater than 10 ft by 10 ft (3 m by 3 m) but less than 10 ft by 12 ft (3 m by 3.7 m), a clearance of at least 24 in. (610 mm) shall be provided from spray sprinklers and at least 36 in. (914 mm) from old-style sprinklers. Where spacing is greater than 10 ft by 12 ft (3 m by 3.7 m), a clearance of at least 48 in. (1219 mm) shall be provided.

(b) In Ordinary Hazard Occupancies, open-grid ceilings shall be permitted to be installed beneath spray sprinklers only. Where sprinkler spacing is less than 10 ft by 10 ft (3 m by 3 m), a minimum clearance of at least 24 in. (610 mm) shall be provided between the sprinkler deflectors and the upper surface of the open-grid ceiling. Where spacing is greater than 10 ft by 10 ft (3 m by 3 m), a clearance of at least 36 in. (914 mm) shall be provided.

Exception No. 2: Other types of open-grid ceilings shall not be installed beneath sprinklers unless they are listed for such service and are installed in accordance with instructions contained in each package of ceiling material.

4-5.12 Drop-Out Ceilings.

4-5.12.1 Drop-out ceilings shall be permitted to be installed beneath sprinklers where ceilings are listed for that service and are installed in accordance with their listings.

Exception: Special sprinklers shall not be installed above drop-out ceilings unless specifically listed for this purpose.

4-5.12.2 Drop-out ceilings shall not be considered ceilings within the context of this standard.

4-5.12.3* Piping installed above drop-out ceilings shall not be considered concealed piping (*see 2-5.4, Exception No. 2*).

4-5.12.4* Sprinklers shall not be installed beneath drop-out ceilings.

4-5.13* Fur Vaults.

4-5.13.1 Sprinklers shall be listed old-style having orifice sizes selected to provide as closely as possible but not less than 20 gal per min (76 L/min) per sprinkler, for four sprinklers, based on the water pressure available.

4-5.13.2 Sprinklers in fur storage vaults shall be located centrally over the aisles between racks and shall be spaced not over 5 ft (1.5 m) apart along the aisles.

4-5.13.3 Where sprinklers are spaced 5 ft (1.5 m) apart along the sprinkler branch lines, pipe sizes shall be in accordance with the following schedule:

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

4-5.14 Stages. Sprinklers shall be installed under the roof at the ceiling, in spaces under the stage either containing combustible materials or constructed of combustible materials, and in all adjacent spaces and dressing rooms, storerooms, and workshops.

4-5.14.1 Where proscenium opening protection is required, a deluge system shall be provided with open sprinklers located not more than 3 ft (0.9 m) away from the stage side of the proscenium arch and spaced up to a maximum of 6 ft (1.8 m) on center. (*See Chapter 5 for design criteria.*)

4-5.15 Provision for Flushing Systems. All sprinkler systems shall be arranged for flushing. Readily removable fittings shall be provided at the end of all cross mains. All cross mains shall terminate in 1 1/4-in. (33-mm) or larger pipe. All branch lines on gridded systems shall be arranged to facilitate flushing.

4-5.16 Stair Towers. Stairs, towers, or other construction with incomplete floors, if piped on independent risers, shall be treated as one area with reference to pipe sizes.

4-5.17 Return Bends. Return bends shall be used where pendent sprinklers are supplied from a raw water source, mill pond, or from open-top reservoirs. Return bends shall be connected to the top of branch lines in order to avoid accumulation of sediment in the drop nipples. (*See Figure 4-5.17.*)

Exception No. 1: Return bends are not required for deluge systems.

Exception No. 2: Return bends are not required where dry-pendent sprinklers are used.

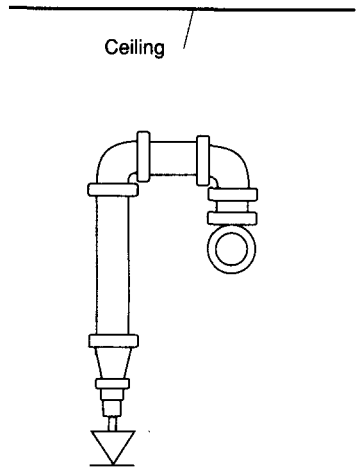


Figure 4-5.17 Return bend arrangement.

4-5.18 Piping to Sprinklers below Ceilings.

4-5.18.1 In new installations expected to supply sprinklers below a ceiling, minimum 1-in. (25-mm) outlets shall be provided.

Exception: Hexagonal bushings shall be permitted to accommodate temporary sprinklers and shall be removed with the temporary sprinklers when the permanent ceiling sprinklers are installed.

4-5.18.2 When pipe schedule systems are revamped, a nipple not exceeding 4 in. (102 mm) in length shall be permitted to be installed in the branch line fitting. All other piping shall be 1 in. (25.4 mm) where it supplies a single sprinkler in an area. [*See Figure 4-5.18.2(a).*]

Exception: When it is necessary to pipe 2 new ceiling sprinklers from an existing outlet in an overhead system, the use of a nipple not exceeding 4 in. (102 mm) in length and of the same pipe thread size as the existing outlet shall be permitted, provided that a hydraulic calculation verifies that the design flow rate will be achieved. [See Figure 4-5.18.2(b).]

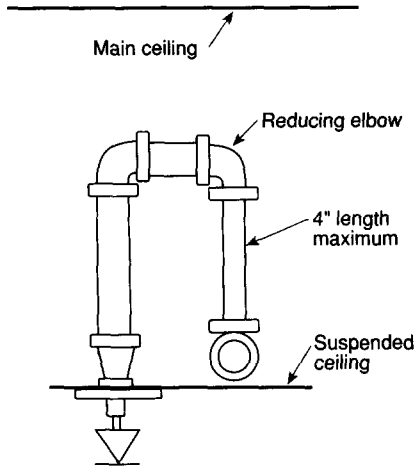


Figure 4-5.18.2(a) Nipple and reducing elbow supplying sprinkler below ceiling.

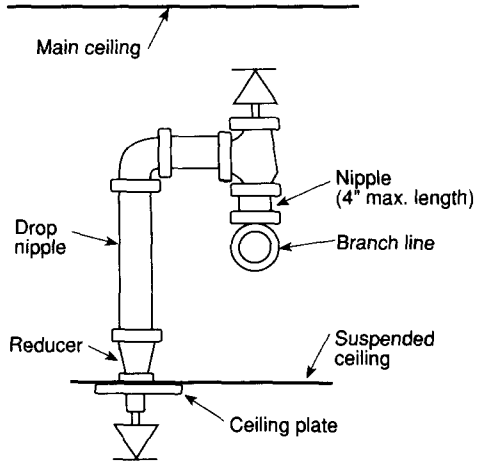


Figure 4-5.18.2(b) Sprinklers in concealed space and below ceiling.

4-5.18.3 When hydraulically designed systems are revamped, any existing bushing shall be removed and a nipple not exceeding 4 in. (102 mm) in length shall be permitted to be installed in the branch line fitting. Calculations shall be provided to verify that the system design flow rate will be achieved.

Exception: When it is necessary to pipe 2 new ceiling sprinklers from an existing outlet in an overhead system, any bushings shall be removed and the use of a nipple not exceeding 4 in. (102 mm) in length and of the same pipe thread size as the existing outlet shall be permitted, provided that a hydraulic calculation verifies that the design flow rate will be achieved.

4-5.19 Dry Pipe Underground. Where necessary to place pipe that will be under air pressure underground, the pipe shall be protected against corrosion (*see 4-6.4.2*).

Exception: Unprotected cast or ductile iron pipe shall be permitted where joined with a gasketed joint listed for air service underground.

4-5.20* One-and-One-Half-Inch Hose Connections. One-and-one-half-inch [1½-in. (38-mm)] hose used for fire purposes only shall be permitted to be connected to wet sprinkler systems only, subject to the following restrictions:

(a) Hose station's supply pipes shall not be connected to any pipe smaller than 2½ in. (64 mm).

Exception: For hydraulically designed loops and grids, the minimum size pipe between the hose station's supply pipe and the source shall be permitted to be 2 in. (51 mm).

(b) For piping serving a single hose station, pipe shall be minimum 1 in. (25.4 mm) for horizontal runs up to 20 ft (6.1 m), minimum 1¼ in. (33 mm) for the entire run for runs between 20 and 80 ft (6.1 and 24.4 m), and minimum 1½ in. (38 mm) for the entire run for runs greater than 80 ft (24.4 m). For piping serving multiple hose stations, runs shall be a minimum of 1½ in. (38 mm) throughout.

(c) Piping shall be at least 1 in. (25 mm) for vertical runs.

(d) When the pressure at any hose station outlet exceeds 100 psi (6.9 bars), an approved device shall be installed at the outlet to reduce the pressure at the outlet to 100 psi (6.9 bars).

4-5.21* Hose Connections for Fire Department Use. In buildings of Light or Ordinary Hazard Occupancy, 2½-in. (64-mm) hose valves for fire department use are permitted to be attached to wet pipe sprinkler system risers. [*See 5-2.3.1.3(d).*] The following restrictions shall apply:

(a) Sprinklers shall be under separate floor control valves.

(b) The minimum size of the riser shall be 4 in. (102 mm) unless hydraulic calculations indicate that a smaller size riser will satisfy sprinkler and hose stream demands.

(c) Each combined sprinkler and standpipe riser shall be equipped with a riser control valve to permit isolating a riser without interrupting the supply to other risers from the same source of supply.

(d) For fire department connections serving standpipe and sprinkler systems, refer to Section 2-8.

4-5.22* System Subdivision. Where individual floor/zone control valves are not provided, a flanged joint or mechanical coupling shall be used at the riser at each floor for connections to piping serving floor areas in excess of 5,000 sq ft (465 m^2).

4-6 Piping Installation.

4-6.1 Valves.

4-6.1.1* Valves Controlling Sprinkler Systems. (*See 2-7.1.*)

4-6.1.1.1* Each system shall be provided with a listed indicating valve in an accessible location, so located as to control all automatic sources of water supply.

4-6.1.1.2 At least one listed indicating valve shall be installed in each source of water supply.

Exception: There shall be no shutoff valve in the fire department connection.

4-6.1.1.3 Valves on connections to water supplies, sectional control valves, and other valves in supply pipes to sprinklers shall be supervised open by one of the following methods:

(a) Central station, proprietary, or remote station signaling service.

(b) Local signaling service that will cause the sounding of an audible signal at a constantly attended point.

(c) Valves locked in the open position.

(d) Valves located within fenced enclosures under the control of the owner, sealed in the open position, and inspected weekly as part of an approved procedure.

Floor control valves in high-rise buildings and valves controlling flow to sprinklers in circulating closed loop systems shall comply with (a) or (b) above.

Exception: Supervision of underground gate valves with roadway boxes shall not be required.

4-6.1.1.4 Where control valves are installed overhead, they shall be positioned so that the indicating feature is visible from the floor below.

4-6.1.1.5 Where there is more than one source of water supply, a check valve shall be installed in each connection.

4-6.1.1.6 Check valves shall be installed in a vertical or horizontal position in accordance with their listing.

4-6.1.1.7* Where a single wet pipe sprinkler system is equipped with a fire department connection, the alarm valve is considered a check valve and an additional check valve shall not be required.

4-6.1.1.8* In a city connection serving as one source of supply, listed indicating valves or indicator post valves shall be installed on both sides of the check valve required in 4-6.1.1.5.

Exception: Where a wet pipe sprinkler system is equipped with an (alarm) check valve, a gate valve is not required on the system side of the (alarm) check valve.

4-6.1.2 Pressure-Reducing Valves.

4-6.1.2.1 In portions of systems where all components are not listed for pressure greater than 175 psi (12.1 bars) and the potential exists for normal (nonfire condition) water pressure in excess of 175 psi (12.1 bars), a listed pressure-reducing valve shall be installed and set for an outlet pressure not exceeding 165 psi (2.4 bars) at the maximum inlet pressure.

4-6.1.2.2 Pressure gauges shall be installed on the inlet and outlet sides of each pressure-reducing valve.

4-6.1.2.3* A relief valve of not less than $\frac{1}{2}$ in. (13 mm) in size shall be provided on the discharge side of the pressure-reducing valve set to operate at a pressure not exceeding 175 psi (12.1 bars).

4-6.1.2.4 A listed indicating valve shall be provided on the inlet side of each pressure-reducing valve.

Exception: A listed indicating valve is not required where the pressure-reducing valve meets the listing requirements for use as an indicating valve.

4-6.2 Pipe Support.

4-6.2.1 General.

4-6.2.1.1 Sprinkler piping shall be supported independently of the ceiling sheathing.

Exception: Toggle hangers shall be permitted only for the support of pipe $1\frac{1}{2}$ in. (38 mm) or smaller in size under ceilings of hollow tile or metal lath and plaster.

4-6.2.1.2 Where sprinkler piping is installed in storage racks as defined in NFPA 231C, *Standard for Rack Storage of Materials*, piping shall be supported from the storage rack structure or building in accordance with all applicable provisions of 4-6.2 and 4-6.4.3.

4-6.2.2 Maximum Distance between Hangers.

4-6.2.2.1* The maximum distance between hangers shall not exceed that in Table 4-6.2.2.1.

Exception No. 1: The maximum distance between hangers for steel pipe and copper tube shall be modified as specified in 4-6.2.1 and 4-6.2.2.

Exception No. 2: The maximum distance between hangers for CPVC pipe and polybutylene pipe shall be modified as specified in the individual product listings.

Exception No. 3: Holes through concrete beams shall be acceptable for the support of steel pipe as a substitute for hangers.

4-6.2.3 Location of Hangers on Branch Lines. This subsection applies to the support of steel pipe or copper tube as specified in 2-3.1 and subject to the provisions of 4-6.2.2.

4-6.2.3.1 There shall be not less than one hanger for each section of pipe.

Exception No. 1: Where sprinklers are spaced less than 6 ft (1.8 m) apart, hangers spaced up to a maximum of 12 ft (3.7 m) shall be permitted.*

Exception No. 2: Starter lengths less than 6 ft (1.8 m) shall not require a hanger, unless on the end line of a sidefeed system or where an intermediate cross main hanger has been omitted.

4-6.2.3.2 The distance between a hanger and the centerline of an upright sprinkler shall not be less than 3 in. (76 mm).

4-6.2.3.3* The unsupported length between the end sprinkler and the last hanger on the line shall not be greater than 36 in. (914 mm) for 1-in. (2.5-cm) pipe or 48 in. (1219 mm) for $1\frac{1}{4}$-in. (3.2-cm) pipe, and 60 in. (15.2 cm) for $1\frac{1}{2}$-in. (3.8-cm) or larger pipe. Where any of these limits is exceeded, the pipe shall be extended beyond the end sprinkler and shall be supported by an additional hanger.

Exception No. 1: When the maximum pressure at the sprinkler exceeds 100 psi (6.9 bars), and a branch line above a ceiling supplies sprinklers in a pendent position below the ceiling, the hanger assembly supporting the pipe supplying an end sprinkler in a pendent position shall be of a type that prevents upward movement of the pipe.*

Exception No. 2: When the maximum pressure at the sprinkler exceeds 100 psi (6.9 bars), the unsupported length between the end sprinkler in a pendent position or drop nipple and the last hanger on the branch line shall not be greater than 12 in. (305 mm) for steel pipe or 6 in. (152 mm) for copper pipe. When this limit is exceeded, the pipe shall be extended beyond the end sprinkler and supported by an additional hanger. The hanger closest to the sprinkler shall be of a type that prevents upward movement of the piping.*

Table 4-6.2.2.1 Maximum Distance between Hangers (ft - in.)

Nominal Pipe Size (in.)	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8
Steel Pipe Except Threaded Light-wall	N/A	12-0	12-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0
Threaded Light-wall Steel Pipe	N/A	12-0	12-0	12-0	12-0	12-0	12-0	N/A	N/A	N/A	N/A	N/A
Copper Tube	8-0	8-0	10-0	10-0	12-0	12-0	12-0	15-0	15-0	15-0	15-0	15-0
CPVC	5-6	6-0	6-6	7-0	8-0	9-0	10-0	N/A	N/A	N/A	N/A	N/A
Polybutylene (IPS)	N/A	3-9	4-7	5-0	5-11	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Polybutylene (CTS)	2-11	3-4	3-11	4-5	5-5	N/A	N/A	N/A	N/A	N/A	N/A	N/A

For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.
NOTE: (IPS) Iron Pipe Size.
(CTS) Copper Tube Size.

4-6.2.3.4* The length of an unsupported armover to a sprinkler shall not exceed 24 in. (610 mm) for steel pipe or 12 in. (305 mm) for copper tube.

Exception: Where the maximum pressure at the sprinkler exceeds 100 psi (6.9 bars) and a branch line above a ceiling supplies sprinklers in a pendent position below the ceiling, the length of an unsupported armover to a sprinkler and drop nipple shall not exceed 12 in. (305 mm) for steel pipe and 6 in. (152 mm) for copper tube.*

Where the limits of the unsupported armover lengths of 4-6.2.3.4 or this Exception are exceeded, the hanger closest to the sprinkler shall be of a type that prevents upward movement of the piping.

4-6.2.3.5 Wall-mounted sidewall sprinklers shall be restrained to prevent movement.

4-6.2.4 Location of Hangers on Cross Mains. This subsection applies to the support of steel pipe only as specified in 4-6.2.3, subject to the provisions of 4-6.2.2.

4-6.2.4.1 On cross mains there shall be at least one hanger between each two branch lines.

Exception No. 1: In bays having two branch lines, the intermediate hanger shall be permitted to be omitted provided that a hanger attached to a purlin is installed on each branch line located as near to the cross main as the location of the purlin permits. Remaining branch line hangers shall be installed in accordance with 4-6.2.3.

Exception No. 2: In bays having three branch lines, either side or center feed, one (only) intermediate hanger shall be permitted to be omitted provided that a hanger attached to a purlin is installed on each branch line located as near to the cross main as the location of the purlin permits. Remaining branch line hangers shall be installed in accordance with 4-6.2.3.

Exception No. 3: In bays having four or more branch lines, either side or center feed, two intermediate hangers shall be permitted to be omitted provided the maximum distance between hangers does not exceed the distances specified in 4-6.2.2.1 and a hanger attached to a purlin on each branch line is located as near to the cross main as the purlin permits.

4-6.2.4.2 Intermediate hangers shall not be omitted for copper tube.

4-6.2.4.3 At the end of the cross main, intermediate trapeze hangers shall be installed unless the cross main is extended to the next framing member with a hanger installed at this point, in which event an intermediate hanger shall be permitted to be omitted in accordance with 4-6.2.4.1, Exceptions No. 1, No. 2, and No. 3.

4-6.2.5 Support of Risers.

4-6.2.5.1 Risers shall be supported by pipe clamps or by hangers located on the horizontal connections close to the riser.

4-6.2.5.2 Clamps supporting pipe by means of setscrews shall not be used.

4-6.2.5.3 In multistory buildings, riser supports shall be provided at the lowest level, at each alternate level above, above and below offsets, and at the top of the riser. Supports above the lowest level shall also restrain the pipe to prevent movement by an upward thrust where flexible fittings are used. Where risers are supported from the ground, the ground support constitutes the first level of riser support. Where risers are offset or do not rise from the ground, the first ceiling level above the offset constitutes the first level of riser support.

4-6.2.5.4 Risers in vertical shafts, or in buildings with ceilings over 25 ft (7.6 m) high, shall have at least one support for each riser pipe section.

4-6.3 Drainage.

4-6.3.1* All sprinkler pipe and fittings shall be so installed that the system can be drained.

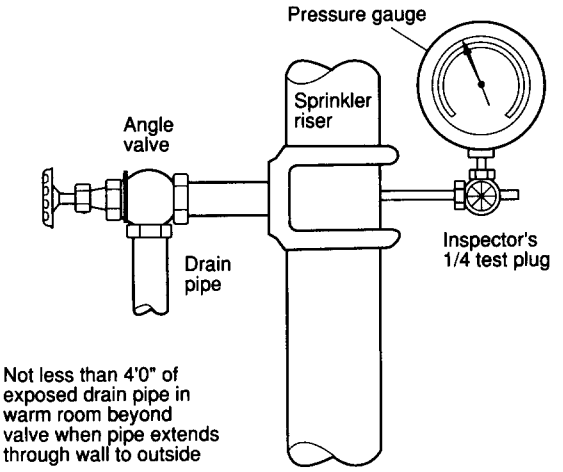
4-6.3.2 On wet pipe systems, sprinkler pipes shall be permitted to be installed level. Trapped piping shall be drained in accordance with 4-6.3.5.

4-6.3.3 In dry pipe systems and portions of preaction systems subject to freezing, branch lines shall be pitched at least ½ in. per 10 ft (4 mm/m) and mains shall be pitched at least ¼ in. per 10 ft (2 mm/m).

Exception: Mains shall be pitched at least ½ in. per 10 ft (4 mm/m) in refrigerated areas.

4-6.3.4 System, Main Drain, or Sectional Drain Connections. [*See Figures 4-6.3.4 and A-4-7.4.2(b).*]

4-6.3.4.1 Provisions shall be made to properly drain all parts of the system.



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

Figure 4-6.3.4 Drain connection for system riser.

4-6.3.4.2 Drain connections for systems' supply risers and mains shall be sized as shown in Table 4-6.3.4.2.

Table 4-6.3.4.2 Drain Site

Riser or Main Size	Size of Drain Connection
Up to 2 in.	3/4 in. or larger
2 1/2 in., 3 in., 3 1/2 in.	1 1/4 in. or larger
4 in. and larger	2 in. only

For SI Units: 1 in. = 25.4 mm.

4-6.3.4.3 Where interior sectional or floor control valve(s) are provided, they shall be provided with a drain connection sized as shown in Table 4-6.3.4.2 to drain that portion of the system controlled by the sectional valve. Drains shall discharge outside or to a drain connection. [*See Figure A-4-7.4.2(b).*]

Exception: For those drains serving pressure reducing valves, the drain, drain connection, and all other downstream drain piping shall be sized to permit a flow of at least the greatest system demand supplied by the pressure-reducing valve.

4-6.3.4.4 The test connections required by 4-7.4.1 shall be permitted to be used as main drain connections.

Exception: Where drain connections for floor control valves are tied into a common drain riser, the drain riser shall be one pipe size larger than the largest size drain connection tying into it.

4-6.3.5 Auxiliary Drains.

4-6.3.5.1 Auxiliary drains shall be provided where a change in piping direction prevents drainage of system piping through the main drain valve.

4-6.3.5.2 Auxiliary Drains for Wet Pipe Systems and Preaction Systems in Areas Not Subject to Freezing.

4-6.3.5.2.1 Where the capacity of trapped sections of pipes in wet systems is less than 5 gal (18.9 L), the auxiliary drain shall consist of a nipple and cap or plug not less than 1/2 in. (12 mm) in size.

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

4-6.3.5.2.2 Where the capacity of isolated trapped sections of pipe is more than 5 gal (18.9 L) and less than 50 gal (189 L), the auxiliary drain shall consist of a valve 3/4 in. (19 mm) or larger and a plug or a nipple and cap.

4-6.3.5.2.3* Where the capacity of isolated trapped sections of pipe is 50 gal (18.9 L) or more, the auxiliary drain shall consist of a valve not smaller than 1 in. (25.4 mm), piped to an accessible location.

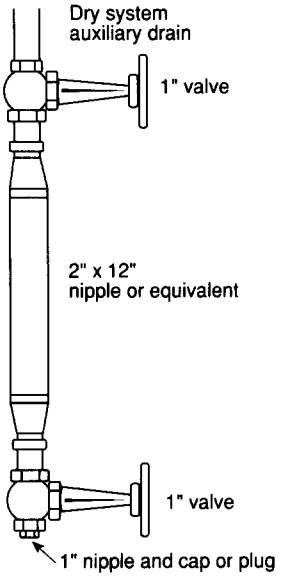
4-6.3.5.2.4 Tie-in drains are not required on wet pipe and preaction systems.

4-6.3.5.3 Auxiliary Drains for Dry Pipe Systems and Preaction Systems in Areas Subject to Freezing.

4-6.3.5.3.1 Where the capacity of trapped sections of pipe is less than 5 gal (18.9 L), the auxiliary drain shall consist of a valve not smaller than 1/2 in. (12 mm) and a plug or a nipple and cap.

Exception: Auxiliary drains are not required for pipe drops supplying dry-pendent sprinklers installed in accordance with 3-2.2.

4-6.3.5.3.2 Where the capacity of isolated trapped sections of system piping is more than 5 gal (18.9 L), the auxiliary drain shall consist of two 1-in. (25.4-mm) valves and one 2-in. by 12-in. (50-mm by 300-mm) condensate nipple or equivalent, accessibly located. (*See Figure 4-6.3.5.3.2.*)



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

Figure 4-6.3.5.3.2 Dry system auxiliary drain.

4-6.3.5.3.3 Tie-in drains shall be provided for multiple adjacent trapped branch pipes and shall be only 1 in. (25.4 mm). Tie-in drain lines shall be pitched a minimum of 1/2 in. per 10 ft (4 mm/m).

4-6.3.6 Discharge of Drain Valves.

4-6.3.6.1* Direct interconnections shall not be made between sprinkler drains and sewers. The drain discharge shall conform to any health or water department regulations.

4-6.3.6.2 Where drain pipes are buried underground, approved corrosion-resistant pipe shall be used.

4-6.3.6.3 Drain pipes shall not terminate in blind spaces under the building.

4-6.3.6.4 Where exposed to the atmosphere, drain pipes shall be fitted with a turned down elbow.

4-6.3.6.5 Drain pipes shall be arranged to avoid exposing any part of the sprinkler system to freezing conditions.

4-6.4 Protection of Piping.

4-6.4.1 Protection of Piping against Freezing.

4-6.4.1.1 Where portions of systems are subject to freezing and temperatures cannot reliably be maintained at or above 40°F (4°C), sprinklers shall be installed as a dry pipe or preaction system.

Exception: Small unheated areas are permitted to be protected by antifreeze systems or by other systems specifically listed for this purpose. (See 3-5.2.)

4-6.4.1.2 Where water-filled supply pipes, risers, system risers, or feed mains pass through open areas, cold rooms, passageways, or other areas exposed to freezing, the pipe shall be protected against freezing by insulating coverings, frostproof casings, or other reliable means capable of maintaining a minimum temperature of 40°F (4°C).

4-6.4.2 Protection of Piping against Corrosion.

4-6.4.2.1* Where corrosive conditions are known to exist due to moisture or fumes from corrosive chemicals or both, special types of fittings, pipes, and hangers that resist corrosion shall be used or a protective coating shall be applied to all unprotected exposed surfaces of the sprinkler system. (*See 2-2.4.*)

4-6.4.2.2 Where water supplies are known to have unusual corrosive properties and threaded or cut-groove steel pipe is to be used, wall thickness shall be in accordance with Schedule 30 [in sizes 8 in. (200 mm) or larger] or Schedule 40 [in sizes less than 8 in. (200 mm)].

4-6.4.2.3 Steel pipe, where exposed to weather, shall be externally galvanized or otherwise protected against corrosion.

4-6.4.2.4 Where steel pipe is used underground, the pipe shall be protected against corrosion.

4-6.4.3 Protection of Piping against Damage Where Subject to Earthquakes.

4-6.4.3.1* General. Sprinkler systems shall be protected to prevent pipe breakage where subject to earthquakes in accordance with the requirements of 4-6.4.3.

Exception: Alternative methods of providing earthquake protection of sprinkler systems based on a dynamic seismic analysis certified by a registered professional engineer such that system performance will be at least equal to that of the building structure under expected seismic forces.

4-6.4.3.2* Couplings. Listed flexible pipe couplings joining grooved end pipe shall be provided as flexure joints to allow individual sections of piping 2½ in. (64 mm) or larger to move differentially with the individual sections of the building to which it is attached. Couplings shall be arranged to coincide with structural separations within a building. They shall be installed:

(a) Within 24 in. (610 mm) of the top and bottom of all risers.

Exception No. 1: In risers less than 3 ft (0.9 m) in length, flexible couplings are permitted to be omitted.

Exception No. 2: In risers 3 to 7 ft (0.9 to 2.1 m) in length, one flexible coupling is adequate.

(b) Within 12 in. (305 mm) above and below the floor in multistory buildings such that the flexible coupling below the floor is below the main supplying that floor.

(c) On one side of concrete or masonry walls within 3 ft (0.9 m) of the wall surface.

Exception: Flexible pipe couplings are not required where clearance around the pipe is provided in accordance with 4-6.4.3.4.

(d)* At or near building expansion joints.

(e) Within 24 in. (610 mm) of the top of drops to hose lines, rack sprinklers, and mezzanines, regardless of pipe size.

(f) Within 24 in. (610 mm) of the top of drops exceeding 15 ft (4.6 m) in length to portions of systems supplying more than one sprinkler, regardless of pipe size.

(g) Above and below any intermediate points of support for a riser or other vertical pipe.

4-6.4.3.3* Seismic Separation Assembly. Seismic separation assemblies with flexible fittings shall be installed where sprinkler piping, regardless of size, crosses building seismic separation joints above ground level.

4-6.4.3.4* Clearance. Clearance shall be provided around all piping extending through walls, floors, platforms, and foundations, including drains, fire department connections, and other auxiliary piping.

4-6.4.3.4.1 Minimum clearance on all sides shall be not less than 1 in. (25.4 mm) for pipes 1 in. (25.4 mm) through 3½ in. (90 mm), and 2 in. (51 mm) for pipe sizes 4 in. (100 mm) and larger.

Exception No. 1: Where clearance is provided by a pipe sleeve, a nominal diameter 2 in. (51 mm) larger than the nominal diameter of the pipe is acceptable for pipe sizes 1 in. (25.4 mm) through 3½ in. (89 mm), and the clearance provided by a pipe sleeve of nominal diameter 4 in. (102 mm) larger than the nominal diameter of the pipe is acceptable for pipe sizes 4 in. (102 mm) and larger.

Exception No. 2: No clearance is necessary for piping passing through gypsum board or equally frangible construction that is not required to have a fire-resistance rating.

Exception No. 3: No clearance is necessary if flexible couplings are located within 1 ft (0.31 m) of each side of a wall, platform, or foundation.

4-6.4.3.4.2 Where required, the clearance shall be filled with a flexible material such as mastic.

4-6.4.3.5 Sway Bracing.

4-6.4.3.5.1 The system piping shall be supported to resist both lateral and longitudinal horizontal loads.

4-6.4.3.5.2* The assigned loads for both lateral and longitudinal sway bracing shall be determined using Table 4-6.4.3.5.2, based on a horizontal force of $F_p = 0.5\ W_p$, where F_p is the horizontal force factor and W_p is the weight of the water-filled piping.

Exception No. 1: In lieu of using Table 4-6.4.3.5.2, horizontal loads for braces shall be permitted to be determined by analysis. Sway braces shall be designed to withstand a force in tension or compression equivalent to not less than half the weight of water-filled piping. For lateral braces, the load shall include all branch lines and mains (unless the branch lines are provided with longitudinal bracing) within the zone of influence of the brace. For longitudinal braces, the load shall include all mains within the zone of influence of the brace.

Exception No. 2: When the use of other horizontal force factors is required or permitted by the authority having jurisdiction, the loads of Table 4-6.4.3.5.2 or those determined in accordance with Exception No. 1 shall be adjusted by the following multipliers:

Horizontal Force Factor F_p	Multiplying Factor
0.2 W_p	0.4
0.4 W_p	0.8
0.6 W_p	1.2
0.8 W_p	1.6
1.0 W_p	2.0
1.2 W_p	2.4

4-6.4.3.5.3 Sway bracing shall be tight and concentric. All parts and fittings of a brace shall lie in a straight line to avoid eccentric loadings on fittings and fasteners. For longitudinal braces only, the brace shall be permitted to be connected to a tab welded to the pipe in conformance with 2-5.2. For individual braces, the slenderness ratio, l/r, shall not exceed 300 where l is the length of the brace and r is the least radius of gyration. The loads on braces determined in 4-6.4.3.5.2 shall not exceed the maximum allowable loads provided in Table 4-6.4.3.5.3.

Exception: Other pipe schedules and materials not specifically included in Table 4-6.4.3.5.3 are acceptable for use if certified by a registered professional engineer to support the loads determined in accordance with the above criteria. Calculations shall be submitted where required by the authority having jurisdiction.

4-6.4.3.5.4 For individual fasteners, the loads determined in 4-6.4.3.5.2 shall not exceed the allowable loads provided in Table 4-6.4.3.5.4.

4-6.4.3.5.5 Longitudinal sway bracing spaced at a maximum of 80 ft (24 m) on center shall be provided for feed and cross mains.

Exception: Longitudinal sway bracing shall not be required on pipes individually supported by rods less than 6 in. (152 mm) long.

4-6.4.3.5.6* Tops of risers shall be secured against drifting in any direction, utilizing a four-way sway brace.

4-6.4.3.5.7 Lateral sway bracing spaced at a maximum of 40 ft (12 m) on center shall be provided for feed and cross mains.

Exception No. 1: Lateral sway bracing shall not be required on pipes individually supported by rods less than 6 in. (152 mm) long.

Exception No. 2: Wraparound U-type hangers used to support the mains shall be permitted to be used to satisfy the requirements for lateral sway bracing provided the legs are bent out at least 30 degrees from the vertical and the maximum length of each leg satisfies the conditions of Table 4-6.4.3.5.3.

Exception No. 3: Where flexible couplings are installed on mains other than as required in 4-6.4.3.2, a lateral brace shall be provided within 24 in. (610 mm) of every other coupling, but not more than 40 ft (12 m) on center.

Exception No. 4: Where building primary structural members exceed 40 ft (12 m) on center, lateral braces shall be permitted to be spaced up to 50 ft (15.2 m) on center.

4-6.4.3.5.8 Bracing shall be attached directly to feed and cross mains.

4-6.4.3.5.9 A length of pipe shall not be braced to sections of the building that will move differentially.

4-6.4.3.5.10 The last length of pipe at the end of a feed or cross main shall be provided with a lateral brace. Lateral braces shall be allowed to act as longitudinal braces if they are within 24 in. (610 mm) of the centerline of the piping braced longitudinally.

4-6.4.3.5.11* Sway bracing is not required for branch lines.

Exception No. 1: The end sprinkler on a line shall be restrained against excessive movement by use of a wraparound U-hook (see Figure A-2-6.1) or by other approved means.

Exception No. 2: Branch lines 2½ in. (64 mm) or larger shall be provided with lateral bracing in accordance with 4-6.4.3.5.7.

Exception No. 3: Where upward or lateral movement of sprinklers would result in an impact against the building structure, equipment, or finish materials, branch lines shall be provided at intervals not exceeding 30 ft (9 m) with a wraparound U-hook, lateral sway brace, or #12, 440-lb (200-kg) splayed seismic brace wire installed at least 45 degrees from the vertical plane and anchored on both sides of the pipe. This bracing shall be located within 2 ft (610 mm) of a hanger. The hanger closest to a splayed wire restraint shall be of a type that resists upward movement of a branch line.*

Table 4-6.4.3.5.2 Assigned Load Table (Based on half the weight of the water-filled pipe)

Spacing of Lateral Braces (ft)	Spacing of Longitudinal Braces** (ft)	Assigned Load for Pipe Size to Be Braced (lb)						
		2	2½	3	4	5	6	8
10	20	380	395	410	435	470	655	915
20	40	760	785	815	870	940	1305	1830
25	50	950	980	1020	1090	1175	1630	2290
30	60	1140	1180	1225	1305	1410	1960	2745
40	80	1515	1570	1630	1740	1880	2610	3660
50*		1895	1965	2035	2175	2350	3260	4575

*Permitted only under Exception No. 4 to 4-6.4.3.5.7.
**If branch lines are provided with lateral bracing or hung with U-hooks bent out at least 30 degrees from vertical, half the assigned load is permitted to be used for longitudinal braces.

Table 4-6.4.3.5.3

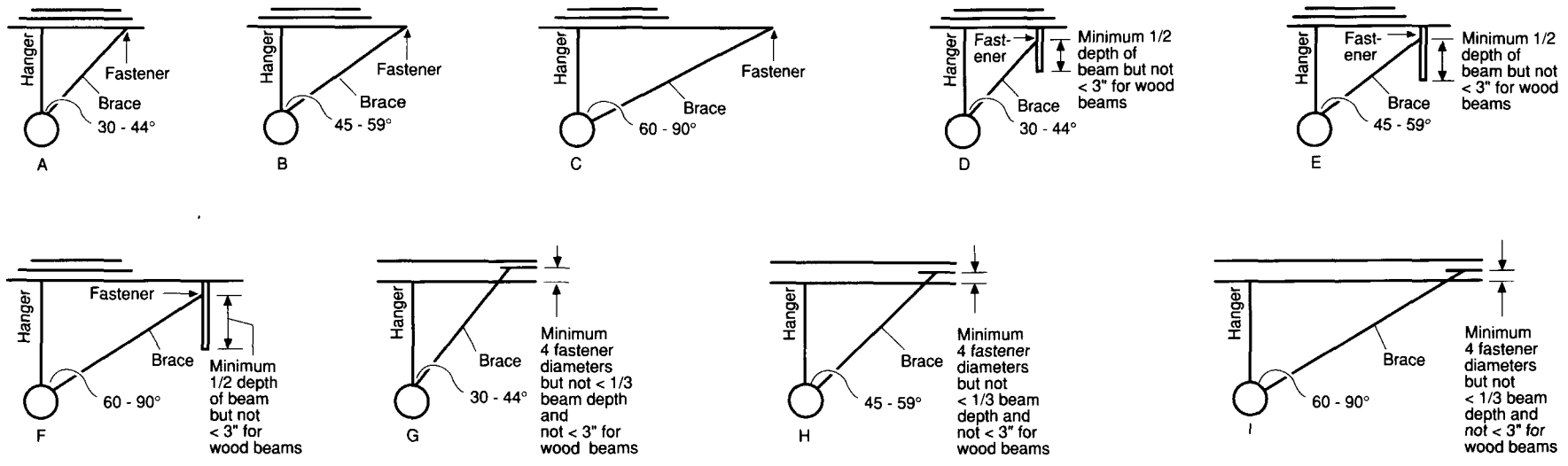
Shape and Size	Least Radius of Gyration	Maximum Length for l/r = 200	Maximum Horizontal Load (lb) 30°-44° Angle from Vertical	45°-59° Angle from Vertical	60°-90° Angle from Vertical
Pipe (Schedule 40)	$= \frac{\sqrt{r_0^2 + r_i^2}}{2}$				
1 in.	.42	7 ft 0 in.	1767	2500	3061
1¼ in.	.54	9 ft 0 in.	2393	3385	4145
1½ in.	.623	10 ft 4 in.	2858	4043	4955
2 in.	.787	13 ft 1 in.	3828	5414	6630
Pipe (Schedule 10)	$= \frac{\sqrt{r_0^2 + r_i^2}}{2}$				
1 in.	.43	7 ft 2 in.	1477	2090	2559
1¼ in.	.55	9 ft 2 in.	1900	2687	3291
1½ in.	.634	10 ft 7 in.	2194	3103	3800
2 in.	.802	13 ft 4 in.	2771	3926	4803
Angles					
1½ × 1½ × ¼	.292	4 ft 10 in.	2461	3481	4263
2 × 2 × ¼	.391	6 ft 6 in.	3356	4746	5813
2½ × 2 × ¼	.424	7 ft 0 in.	3792	5363	6569
2½ × 2½ × ¼	.491	8 ft 2 in.	4257	6021	7374
3 × 2½ × ¼	.528	8 ft 10 in.	4687	6628	8118
3 × 3 × ¼	.592	9 ft 10 in.	5152	7286	8923
Rods	$= \frac{r}{2}$				
⅜	.094	1 ft 6 in.	395	559	685
½	.125	2 ft 6 in.	702	993	1217
⅝	.156	2 ft 7 in.	1087	1537	1883
¾	.188	3 ft 1 in.	1580	2235	2737
⅞	.219	3 ft 7 in.	2151	3043	3726
Flats	= 0.29 h (where h is smaller of two side dimensions)				
1½ × ¼	.0725	1 ft 2 in.	1118	1581	1936
2 × ¼ in.	.0725	1 ft 2 in.	1789	2530	3098
2 × ⅜	.109	1 ft 9 in.	2683	3795	4648

Table 4-6.4.3.5.3 (cont.)

Shape and Size	Least Radius of Gyration	Maximum Length for l/r = 100	Maximum Horizontal Load (lb) 30°-44° Angle from Vertical	45°-59° Angle from Vertical	60°-90° Angle from Vertical
Pipe (Schedule 40)	$= \frac{\sqrt{r_0^2 + r_i^2}}{2}$				
1 in.	.42	3 ft 6 in.	7068	9996	12242
1 1/4 in.	.54	4 ft 6 in.	9567	13530	16570
1 1/2 in.	.623	5 ft 2 in.	11441	16181	19817
2 in.	.787	6 ft 6 in.	15377	21746	26634
Pipe (Schedule 10)	$= \frac{\sqrt{r_0^2 + r_i^2}}{2}$				
1 in.	.43	3 ft 7 in.	5910	8359	10237
1 1/4 in.	.55	4 ft 7 in.	7600	10749	13164
1 1/2 in.	.634	5 ft 3 in.	8777	12412	15202
2 in.	.802	6 ft 8 in.	11105	15705	19235
Rods	$= \frac{r}{2}$				
3/8 in.	.094	0 ft 9 in.	1580	2234	2737
1/2 in.	.125	1 ft 0 in.	2809	3972	4865
5/8 in.	.156	1 ft 3 in.	4390	6209	7605
3/4 in.	.188	1 ft 6 in.	6322	8941	10951
7/8 in.	.219	1 ft 9 in.	8675	12169	14904
Pipe (Schedule 40)	$= \frac{\sqrt{r_0^2 + r_i^2}}{2}$	**l/r = 300**			
1	.42	10 ft 6 in.	786	1111	1360
1 1/2 in.	.54	13 ft 6 in.	1063	1503	1841
1 1/2 in.	.623	15 ft 7 in.	1272	1798	2202
2 in.	.787	19 ft 8 in.	1666	2355	2885
Pipe (Schedule 10)	$= \frac{\sqrt{r_0^2 + r_i^2}}{2}$				
1 in.	.43	10 ft 9 in.	656	928	1137
1 1/4 in.	.55	13 ft 9 in.	844	1194	1463
1 1/2 in.	.634	15 ft 10 in.	975	1379	1194
2 in.	.802	20 ft 0 in.	1234	1745	2137
Rods	$= \frac{r}{2}$				
3/8 in.	.094	2 ft 4 in.	176	248	304
1/2 in.	.125	3 ft 1 in.	312	441	540
5/8 in.	.156	3 ft 11 in.	488	690	845
3/4 in.	.188	4 ft 8 in.	702	993	1217
7/8 in.	.219	5 ft 6 in.	956	1352	1656

Table 4-6.4.3.5.4 Maximum Loads for Various Types of Structure
Maximum Loads for Various Types of Fasteners to Structure

NOTE: Loads (given in pounds) are keyed to vertical angles of braces and orientation of connecting surface. These values are based on concentric loadings of the fastener. Use figures to determine proper reference within table. For angles between those shown, use most restrictive case. Braces should not be attached to light structure members.



Note 1: For wooden beams not less than 3 in. (76 mm).

Lag Screws in Wood (load perpendicular to grain—holes predrilled using good practice)
Shank Diameter of Lag (in.)

		3/8									1/2									5/8									7/8								
		A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
Length Under Head (in.)	3	304	325	292	168	325	526	230	324	400	366	—	—	—	—	632	—	—	—	410	—	—	—	—	716	—	—	—	487	—	—	—	—	843	—	—	—
	4	392	354	317	183	354	678	250	352	435	473	509	456	264	509	818	360	507	626	538	—	—	—	—	929	—	—	—	548	—	—	—	—	1122	—	—	—
	5	476	375	336	194	375	824	265	373	461	582	545	488	282	545	1008	385	542	670	687	728	653	277	728	1154	515	725	896	813	—	—	—	—	1407	—	—	—
	6	564	382	342	196	382	976	270	380	470	689	559	501	288	559	1192	395	556	687	791	778	697	403	778	1360	550	775	957	971	—	—	—	—	1630	—	—	—
	8	—	—	—	—	—	—	—	—	—	905	573	513	296	573	1586	405	570	704	1044	806	723	416	806	1807	570	803	991	1297	1365	1223	685	1365	2244	965	1359	1678

Table 4-6.4.3.5.4 Maximum Loads for Various Types of Structure (cont.)

Through Bolts in Wood (load perpendicular to grain)
Diameter of Bolt (in.)

		3/8						1/2						5/8						7/8					
		ABCE	D	F	G	H	I	ABCE	D	F	G	H	I	ABCE	D	F	G	H	I	ABCE	D	F	G	H	I
Length of Bolt in Timber (in.)	1½	300	173	519	150	211	261	340	197	589	170	239	296	390	225	675	195	275	339	470	272	614	235	331	409
	2	370	214	641	185	261	322	420	243	727	210	296	365	470	272	814	235	331	409	580	335	1004	290	408	504
	2½	460	266	796	230	324	400	550	318	952	275	387	478	620	358	1074	310	437	539	760	439	1316	380	535	661
	3	480	277	831	240	338	417	630	364	1091	315	444	548	710	410	1229	355	500	617	870	503	1506	435	613	757
	3⅞	460	268	797	230	324	400	720	416	1247	360	507	626	850	491	1472	425	599	739	1050	607	1818	525	739	913
	5½	—	—	—	—	—	—	680	393	1177	340	479	591	1020	590	1766	510	718	887	1580	913	2736	790	1113	1374

Expansion Shields in Concrete
Diameter of Bolt (in.)

		3/8									1/2									5/8									7/8				
		A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
Min Depth of Hole (in.)	2½	498	962	1173	678	668	860	925	1303	1609	—	—	—	—	—	—	1638	2306	2848	—	—	—	—	—	—	2080	2930	3617	—	—	—	—	—	—	2470	4113	5078
	3¼	—	—	—	—	—	—	925	1303	1609	923	1782	2076	1200	1782	1597	1638	2306	2848	—	—	—	—	—	—	2080	2930	3617	—	—	—	—	—	—	2970	4113	5078
	3¾	—	—	—	—	—	—	925	1303	1609	—	—	—	—	—	—	1638	2306	2848	1480	2857	2637	1524	2857	2581	2080	2930	3617	—	—	—	—	—	—	2970	4113	5078
	4½	—	—	—	—	—	—	925	1303	1609	—	—	—	—	—	—	1638	2306	2848	—	—	—	—	—	—	2080	2930	3617	3070	4130	3702	2139	4130	5312	2970	4113	5078

Connections to Steel (values assume bolt perpendicular to mounting surface)
Diameter of Unfinished Steel Bolt (in.)

1/4									3/8									1/2									5/8								
A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
400	500	600	300	500	650	325	458	565	900	1200	1400	800	1200	1550	735	1035	1278	1600	2050	2550	1450	2050	2850	1300	1830	2260	2500	3300	3950	2250	3300	4400	2045	2880	3557

For SI Units: 1 in. = 25.4 mm.

4-6.4.3.5.12* Sprigs exceeding 8 ft (2.4 m) in length shall be restrained against lateral movement.

4-6.4.3.5.13 C-type clamps (including beam and large flange clamps) used to attach hangers to the building structure in areas subject to earthquakes shall be equipped with a retaining strap or other approved means to prevent movement. (*See Figure A-2-6.1.*)

4-6.4.3.5.14 C-type clamps (including beam and large flange clamps), with or without retaining straps, shall not be used to attach braces to the building structure.

4-6.4.3.5.15 Powder-driven fasteners shall not be used to attach braces to the building structure.

Exception: Powder-driven fasteners shall be permitted where they are specifically listed for this service.

4-7 System Attachments.

4-7.1 Sprinkler Alarms.

4-7.1.1* Waterflow Alarms.

4-7.1.1.1 Local waterflow alarms shall be provided on all sprinkler systems having more than 20 sprinklers.

4-7.1.1.2 On each alarm check valve used under conditions of variable water pressure, a retarding device shall be installed. Valves shall be provided in the connections to retarding devices to permit repair or removal without shutting off sprinklers; these valves shall be so arranged that they may be locked or sealed in the open position.

4-7.1.1.3 Alarm, dry pipe, preaction, and deluge valves shall be fitted with an alarm bypass test connection for an electric alarm switch, water motor gong, or both. This pipe connection shall be made on the water supply side of the system and provided with a control valve and drain for the alarm piping. A check valve shall be installed in the pipe connection from the intermediate chamber of a dry pipe valve.

Exception: The alarm test connection at the riser shall be permitted to be made on the system side of an alarm valve.

4-7.1.1.4 An indicating control valve shall be installed in the connection to pressure-type contactors or water-motor-operated alarm devices. Such valves shall be locked or sealed in the open position. The control valve for the retarding chamber on alarm check valves shall be accepted as complying with this paragraph.

4-7.1.1.5* Attachments — Mechanically Operated. For all types of sprinkler systems employing water-motor-operated alarms, a listed 3/4-in. (19-mm) strainer shall be installed at the alarm outlet of the waterflow detecting device.

Exception: Where a retarding chamber is used in connection with an alarm valve, the strainer shall be located at the outlet of the retarding chamber unless the retarding chamber is provided with an approved integral strainer in its outlet.

4-7.1.1.6* Alarm Attachments — High-Rise Buildings. When a fire must be fought internally due to the height of a building, the following additional alarm apparatus shall be provided:

(a) Where each sprinkler system on each floor is equipped with a separate waterflow device, it shall be connected to an alarm system in such a manner that operation of one sprinkler will actuate the alarm system and the location of the operated flow device shall be indicated on an annunciator and/or register. The annunciator or register shall be located at grade level at the normal point of fire department access, at a constantly attended building security control center, or at both locations.

Exception: Where the location within the protected buildings where supervisory or alarm signals are received is not under constant supervision by qualified personnel in the employ of the owner, a connection shall be provided to transmit a signal to a remote central station.

(b) A distinct trouble signal shall be provided to indicate a condition that will impair the satisfactory operation of the sprinkler system.

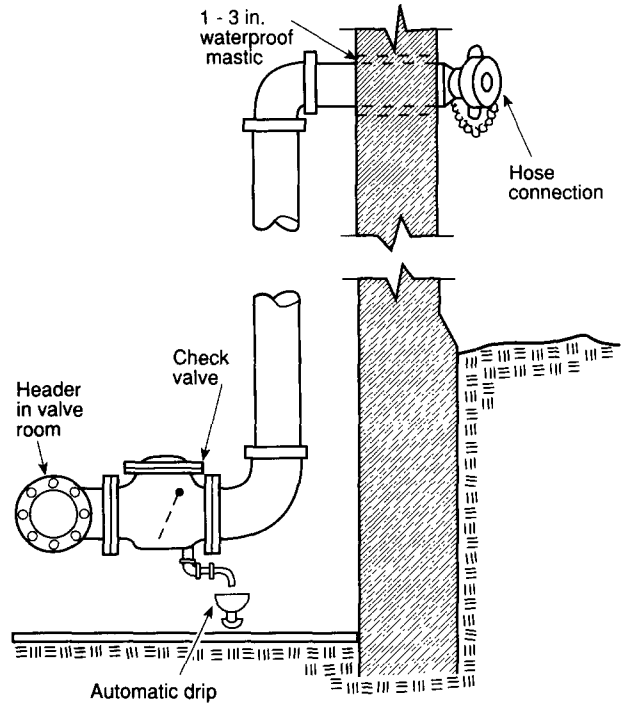
4-7.2* Fire Department Connections.

4-7.2.1* A fire department connection shall be provided as described in this section. (*See Figure 4-7.2.1.*)

Exception No. 1: Buildings located in remote areas that are inaccessible for fire department support.

Exception No. 2: Large-capacity deluge systems exceeding the pumping capacity of the fire department.

Exception No. 3: Single- story buildings not exceeding 2,000 sq ft (186 m^2) in area.



For SI Units: 1 in. = 25.4 mm.

Figure 4-7.2.1 Fire department connection.

4-7.2.2 Size. Pipe size shall be 4 in. (102 mm) for fire engine connections and 6 in. (152 mm) for fire boat connections.

Exception No. 1: For hydraulically calculated systems, fire department connection pipe as small as the system riser shall be permitted where serving one system riser.

Exception No. 2: A single-outlet fire department connection shall be acceptable where piped to a 3-in. (76-mm) or smaller riser.

4-7.2.3* Arrangement. (*See Figure 4-7.2.1.*)

4-7.2.3.1 The fire department connection shall be on the system side of the water supply check valve.

4-7.2.3.2 For single systems, the fire department connection shall be installed as follows:

(a) *Wet System.* On the system side of system control, check, and alarm valves. (*See Figure A-4-6.1.1.*)

(b) *Dry System.* Between the system control valve and the dry pipe valve.

(c) *Preaction System.* Between the preaction valve and the check valve on the system side of the preaction valve.

(d) *Deluge System.* On the system side of the deluge valve.

Exception: Connection of the fire department connection to underground piping is acceptable.

4-7.2.3.3 For multiple systems, the fire department connection shall be connected between the supply control valves and the system control valves.

Exception: Connection of the fire department connection to underground piping is acceptable.

4-7.2.3.4 Fire department connections shall be located and arranged so that hose can be readily and conveniently attached.

Each fire department connection to sprinkler systems shall be designated by a sign having raised letters at least 1 in. (25.4 mm) in height cast on plate or fitting reading service design, e.g., "AUTOSPKR.," "OPEN SPKR. AND STANDPIPE." A sign shall also indicate the pressure required at the inlets to deliver the greatest system demand.

Exception: The sign is not required where the system demand pressure is less than 150 psi (10.3 bars).

4-7.2.3.5 Fire department connections shall not be connected on the suction side of fire pumps.

4-7.2.4 Valves.

4-7.2.4.1 A listed check valve shall be installed in each fire department connection.

4-7.2.4.2 There shall be no shutoff valve in the fire department connection piping.

4-7.2.5 Drainage. The piping between the check valve and the outside hose coupling shall be equipped with an approved automatic drip.

Exception: An automatic drip is not required in areas not subject to freezing.

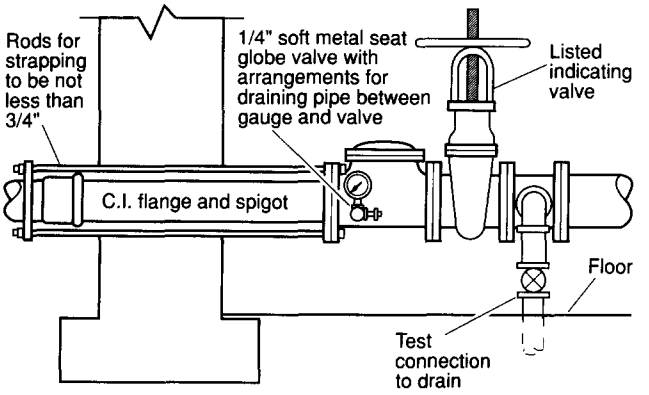
4-7.3 Gauges.

4-7.3.1 A pressure gauge with a connection not smaller than 1/4 in. (6.4 mm) shall be installed at the system main drain, at each main drain associated with a floor control valve, and on the inlet and outlet side of each pressure reducing valve. Each gauge connection shall be equipped with a shutoff valve and provisions for draining.

4-7.3.2 The required pressure gauges shall be listed and shall have a maximum limit not less than twice the normal working pressure at the point where installed. They shall be installed to permit removal and shall be located where they will not be subject to freezing.

4-7.4 System Connections.

4-7.4.1 Main Drain Test Connections. Main drain test connections shall be provided at locations that will permit flow tests of water supplies and connections. They shall be so installed that the valve can be opened wide for a sufficient time to assure a proper test without causing water damage. Main drain connections shall be sized in accordance with 4-6.3.4 and 4-6.3.6.



For SI Units: 1 in. = 25.4 mm.

Figure 4-7.4.1 Water supply connection with test connection.

4-7.4.2* Wet Pipe Systems. An alarm test connection not less than 1 in. (25.4 mm) in diameter, terminating in a smooth bore corrosion-resistant orifice, giving a flow equivalent to one sprinkler of a type having the smallest orifice installed on the particular system, shall be provided to test each waterflow alarm device for each system. The test connection valve shall be readily accessible. The discharge shall be to the outside, to a drain connection capable of accepting full flow under system pressure, or to another location where water damage will not result.

4-7.4.3* Dry Pipe Systems. A trip test connection not less than 1 in. (25.4 mm) in diameter, terminating in a smooth bore corrosion-resistant orifice, to provide a flow equivalent to one sprinkler of a type installed on the particular system, shall be installed on the end of the most distant sprinkler pipe in the upper story and be equipped with a readily accessible 1-in. (25.4-mm) shutoff valve and plug, at least one of which shall be brass. In lieu of a plug, a nipple and cap shall be acceptable.

4-7.4.4 Preaction Systems. A test connection shall be provided on a preaction system using supervisory air. The connection used to control the level of priming water is adequate to test the operation of the alarms monitoring the supervisory air pressure.

4-7.4.5 Deluge Systems. A test connection is not required on a deluge system.

Chapter 5 Design Approaches

5-1 General. Water demand requirements shall be determined from the occupancy hazard fire control approach of Section 5-2.

Exception: Special design approaches shall be permitted for specific hazards in Section 5-3.

5-2 Occupancy Hazard Fire Control Approach.

5-2.1 Occupancy Classifications.

5-2.1.1 Occupancy classifications for this standard relate to sprinkler installations and their water supplies only. They shall not be used as a general classification of occupancy hazards.

5-2.1.2 Occupancies or portions of occupancies shall be classified according to the quantity and combustibility of contents, the expected rates of heat release, the total potential for energy release, the heights of stockpiles, and the presence of flammable and combustible liquids, using the definitions contained in 1-4.7. Classifications are as follows:

Light Hazard

Ordinary Hazard (Groups 1 and 2)

Extra Hazard (Groups 1 and 2)

Special Occupancy Hazard.

5-2.2 Water Demand Requirements—Pipe Schedule Method.

5-2.2.1 Table 5-2.2 shall be used in determining the minimum water supply requirements for Light and Ordinary Hazard Occupancies protected by systems with pipe sized according to the pipe schedules of 6-5. Pressure and flow requirements for Extra Hazard Occupancies shall be based on the hydraulic calculation methods of 5-2.3. The pipe schedule method shall be permitted only for new installations of 5000 sq ft (465 m^2) or less or for additions or modifications to existing pipe schedule systems.

Exception No. 1: The pipe schedule design method shall be permitted for use in systems exceeding 5000 sq ft (465 m^2) where the flows required in Table 5-2.2 are available at a minimum residual pressure of 50 psi (3.4 bar) at the elevation of the highest sprinkler.

Exception No. 2: The pipe schedule method shall be permitted for additions or modifications to existing extra hazard pipe schedule systems if the pressures and flows are determined to be acceptable to the authority having jurisdiction.

Table 5-2.2 Water Supply Requirements for Pipe Schedule Sprinkler Systems

Occupancy Classification	Minimum Residual Pressure Required	Acceptable Flow at Base of Riser	Duration in Minutes
Light Hazard	15 psi	500-750 gpm	30-60
Ordinary Hazard	20 psi	850-1500 gpm	60-90

For SI Units: 1 gpm = 3.785L/min; 1 psi = 0.0689 bar.

5-2.2.2 The lower duration value of Table 5-2.2 shall be acceptable only where remote station or central station waterflow alarm service is provided.

5-2.2.3* The residual pressure requirement of Table 5-2.2 shall be met at the elevation of the highest sprinkler. (*See the Exceptions to 5-2.2.1.*)

5-2.2.4 The lower flow figure of Table 5-2.2 shall be permitted only where the building is of noncombustible construction or the potential areas of fire are limited by building size or compartmentation such that no open areas exceed 3000 sq ft (279 m^2) for Light Hazard or 4000 sq ft (372 m^2) for Ordinary Hazard.

5-2.3 Water Demand Requirements—Hydraulic Calculation Methods.

5-2.3.1 General.

5-2.3.1.1* The minimum water supply requirements for a hydraulically designed occupancy hazard fire control sprinkler system shall be determined by adding the hose stream demand from Table 5-2.3 to the water supply for sprinklers determined in 5-2.3.1.2. This supply shall be available for the minimum duration specified in Table 5-2.3.

Exception No. 1: Where other NFPA standards have developed sprinkler system area/density or other design criteria and water supply requirements appropriate for fire control or suppression of Special Occupancy Hazards, they shall take precedence.

Exception No. 2: An allowance for inside and outside hose shall not be required where tanks supply sprinklers only.

Exception No. 3: Where pumps taking suction from a private fire service main supply sprinklers only, the pump need not be sized to accommodate inside and outside hose. Such hose allowance shall be considered in evaluating the available water supplies.

Table 5-2.3 Hose Stream Demand and Water Supply Duration Requirements

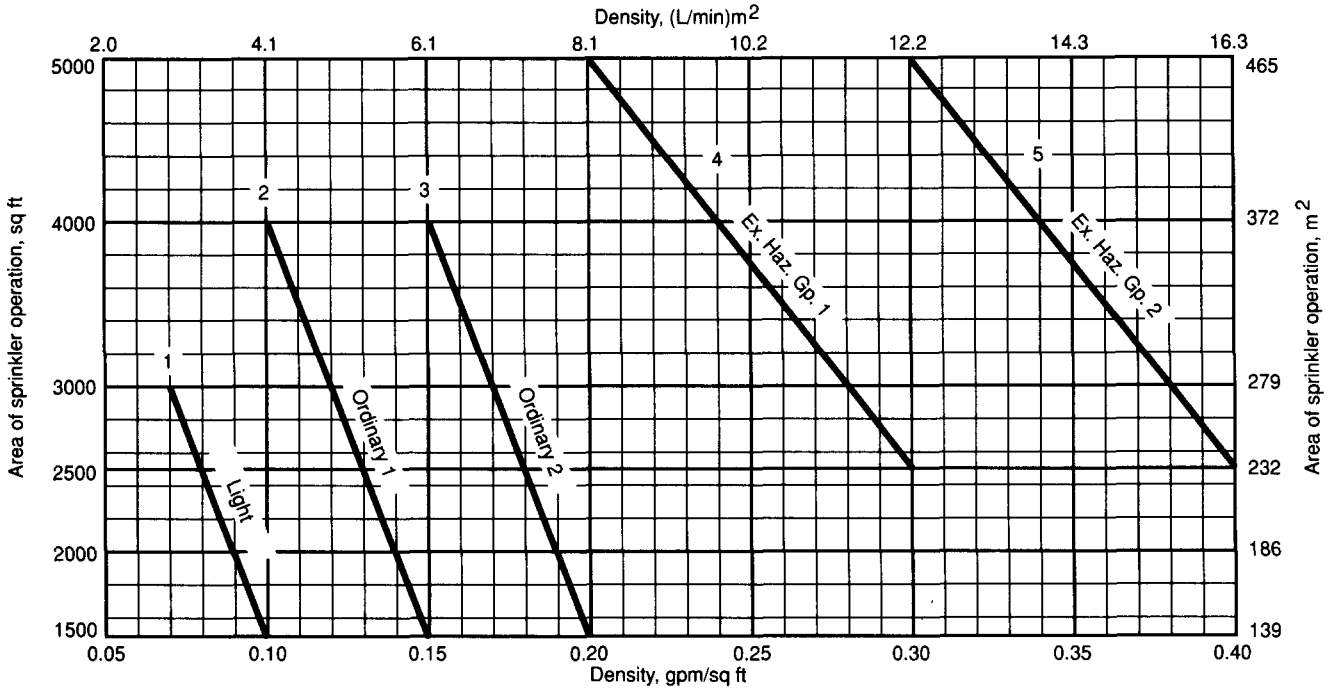
Hazard Classification	Inside Hose (gpm)	Total Combined Inside and Outside Hose (gpm)	Duration in Minutes
Light	0, 50, or 100	100	30
Ordinary	0, 50, or 100	250	60-90
Extra Hazard	0, 50, or 100	500	90-120

For SI Units: 1 gpm = 3.785L/min.

5-2.3.1.2 The water supply for sprinklers only shall be determined either from the area/density curves of Figure 5-2.3 in accordance with the method of 5-2.3.2 or be based upon the room design method in accordance with 5-2.3.3, at the discretion of the designer. For special areas under consideration, as described in 5-2.3.4, separate hydraulic calculations shall be required in addition to those required by 5-2.3.2 or 5-2.3.3.

5-2.3.1.3 Regardless of which of the two methods is used, the following restrictions apply:

(a) For areas of sprinkler operation less than 1500 sq ft (139 m^2) used for Light and Ordinary Hazard Occupancies, the density for 1500 sq ft (139 m^2) shall be used. For areas of sprinkler operation less than 2500 sq ft (232 m^2) for Extra Hazard Occupancies, the density for 2500 sq ft (232 m^2) shall be used.



For SI Units: 1 sq ft = 0.0929 m^2; 1 gpm/sq ft = 40.746 (L/min)/m^2.

Figure 5-2.3 Area/density curves.

(b)* For buildings having unsprinklered combustible concealed spaces (as described in 4-5.1.1), the minimum area of sprinkler operation shall be 3000 sq ft (279 m^2).

Exception No. 1: Combustible concealed spaces filled entirely with noncombustible insulation.

Exception No. 2: Light or Ordinary Hazard Occupancies where noncombustible or limited combustible ceilings are directly attached to the bottom of solid wood joists so as to create enclosed joist spaces 160 cu ft (4.8 m^3) or less in volume.*

Exception No. 3: Concealed spaces where the exposed surfaces have a flame spread rating of 25 or less and the materials have been demonstrated to not propagate fire in the form in which they are installed in the space.*

(c) Water demand of sprinklers installed in racks or water curtains shall be added to the ceiling sprinkler water demand at the point of connection. Demands shall be balanced to the higher pressure. (See Chapter 6.)

Water demand of sprinklers installed in concealed spaces or under obstructions such as ducts and cutting tables need not be added to ceiling demand.

(d) Where inside hose stations are planned or are required by other standards, a total water allowance of 50 gpm (189 L/min) for a single hose station installation or 100 gpm (378 L/min) for a multiple hose station installation shall be added to the sprinkler requirements. The water allowance shall be added in 50-gpm (189-L/min) increments beginning at the most remote hose station, with each increment added at the pressure required by the sprinkler system design at that point.

(e) When hose valves for fire department use are attached to wet pipe sprinkler system risers in accordance with 4-5.21, the water supply need not be added to standpipe demand as determined from NFPA 14, *Standard for the Installation of Standpipe and Hose Systems.*

Exception No. 1: Where the combined sprinkler system demand and hose stream allowance of Table 5-2.3 exceeds the requirements of NFPA 14, Standard for the Installation of Standpipe and Hose Systems, this higher demand shall be used.

Exception No. 2: For partially sprinklered buildings, the sprinkler demand, not including hose stream allowance, as indicated in Table 5-2.3 shall be added to the requirements given in NFPA 14, Standard for the Installation of Standpipe and Hose Systems.

(f) Water allowance for outside hose shall be added to the sprinkler and inside hose requirement at the connection to the city water main, or a yard hydrant, whichever is closer to the system riser.

(g) The lower duration values in Table 5-2.3 shall be permitted where remote station or central station waterflow alarm service is provided.

(h) Where pumps, gravity tanks, or pressure tanks supply sprinklers only, requirements for inside and outside hose need not be considered in determining the size of such pumps or tanks.

5-2.3.1.4 Total system water supply requirements shall be determined in accordance with the hydraulic calculation procedures of Section 6-4.

5-2.3.2 Area/Density Method.

5-2.3.2.1 The water supply requirement for sprinklers only shall be calculated from the area/density curves in Figure 5-2.3. The calculations shall satisfy any single point on the appropriate area/density curve as follows:

(a) Light HazardArea/Density Curve 1

(b) Ordinary Hazard (Group 1)Area/Density Curve 2

(c) Ordinary Hazard (Group 2)Area/Density Curve 3

(d) Extra Hazard (Group 1)Area/Density Curve 4

(e) Extra Hazard (Group 2)Area/Density Curve 5

It is not necessary to meet all points on the selected curve.

5-2.3.2.2 The densities and areas provided in Figure 5-2.3 are for use only with spray sprinklers. For use with other types of sprinklers, see Section 5-3.

Exception No. 1: Quick-response sprinklers shall not be permitted for use with Curves 4 and 5 (Extra Hazard).*

Exception No. 2: Sidewall spray sprinklers shall be permitted for use with Area/Density Curve 1 (Light Hazard) and, if specifically listed, with Area/Density Curves 2 or 3 (Ordinary Hazard).

Exception No. 3: For extended coverage sprinklers, the minimum design area shall be that corresponding to the maximum density for the hazard in Figure 5-2.3 or the area protected by 5 sprinklers, whichever is greater.

5-2.3.2.3 For dry pipe systems, the area of sprinkler operation shall be increased by 30 percent without revising the density.

5-2.3.2.4 Where high temperature sprinklers are used for Extra Hazard Occupancies, the area of sprinkler operation shall be permitted to be reduced by 25 percent without revising the density, but to not less than 2000 sq ft (186 m^2).

5-2.3.3 Room Design Method.

5-2.3.3.1* The water supply requirements for sprinklers only shall be based upon the room that creates the greatest demand. The density selected shall be that from Figure 5-2.3 corresponding to the room size. To utilize this method, all rooms shall be enclosed with walls having a fire-resistance rating equal to the water supply duration indicated in Table 5-2.3.

5-2.3.3.2 If the room is smaller than the smallest area shown in the applicable curve in Figure 5-2.3, the provisions of 5-2.3.1.3(a) shall apply.

5-2.3.3.3 Minimum protection of openings shall be as follows:

(a) Light Hazard — automatic or self-closing doors.

Exception: Where openings are not protected, calculations shall include the sprinklers in the room plus two sprinklers in the communicating space nearest each such unprotected opening unless the communicating space has only one sprinkler, in which case calculations shall be extended to the operation of that sprinkler. The selection of the room and communicating space sprinklers to be calculated shall be that which produces the greatest hydraulic demand.

(b) Ordinary and Extra Hazard — automatic or self-closing doors with appropriate fire-resistance ratings for the enclosure.

5-2.3.4 Special Design Methods.

5-2.3.4.1 Where the design area consists of a building service chute supplied by a separate riser, the maximum number of sprinklers that needs to be calculated is 3.

5-2.3.4.2 Where the room design method is used, and the area under consideration is a corridor protected by one row of sprinklers, the maximum number of sprinklers that needs to be calculated is 5. (*See 5-2.3.1.*)

Exception: Where the area under consideration is a corridor protected by a single row of sprinklers and the openings are not protected, the design area shall include all sprinklers in the corridor to a maximum of 7.

5-3 Special Design Approaches.

5-3.1 General. All special design approaches utilize the hydraulic calculation procedures of Section 6-4, except as specified.

5-3.2 Residential Sprinklers.

5-3.2.1 Sprinkler discharge rates shall be provided in accordance with minimum flow rates indicated in individual residential sprinkler listings, both for the single sprinkler discharge and the multiple sprinkler discharge of the design sprinklers.

5-3.2.2* The design area shall be that area that includes the 4 hydraulically most demanding sprinklers. Calculations shall be provided to verify the single (1) operating sprinkler criteria and the multiple (4) operating sprinkler criteria.

5-3.2.3 Where areas such as attics, basements, or other types of occupancies are outside of dwelling units but within the same structure, these areas shall be protected in accordance with the provisions of this standard, including appropriate design criteria of 5-2.3.

5-3.2.4 Hose stream demand and water supply duration requirements shall be in accordance with those for Light Hazard Occupancies in Table 5-2.3.

5-3.3 Quick-Response Early Suppression (QRES) Sprinklers. (Reserved) (*See 1-4.5.1 and A-1-4.5.1.*)

5-3.4* Large-Drop Sprinklers.

5-3.4.1 Protection shall be provided as specified in Table A-5-3.4 or appropriate NFPA standards in terms of minimum operating pressure and the number of sprinklers to be included in the design area.

5-3.4.2 Large-drop sprinkler systems shall be designed such that the minimum operating pressure is not less than 25 psi (170 kPa).

Exception: Lower pressures shall be permitted if proven successful by large-scale fire testing for a particular hazard.

5-3.4.3 For design purposes, 95 psi (650 kPa) shall be the maximum discharge pressure at the hydraulically most remote sprinkler.

5-3.4.4 The nominal diameter of branch line pipes (including riser nipples) shall be not less than 1¼ in. (33 mm) nor greater than 2 in. (51 mm).

Exception No. 1: Starter pieces shall be permitted to be 2½ in. (64 mm).

Exception No. 2: Where branch lines are larger than 2 in. (51 mm), the sprinkler shall be supplied by a riser nipple to elevate the sprinkler 13 in. (330 mm) for 2½-in. (64-mm) pipe and 15 in. (380 mm) for 3-in. (76-mm) pipe. These dimensions are measured from the centerline of the pipe to the deflector. In lieu of this, sprinklers may be offset horizontally a minimum of 12 in. (305 mm).

5-3.4.5 Hose stream demand and water supply duration requirements shall be in accordance with those for extra hazard occupancies in Table 5-2.3.

5-3.5* Early Suppression Fast-Response (ESFR) Sprinklers.

5-3.5.1 ESFR sprinklers are suitable for use with the hazards listed in Table A-5-3.5 and shall be permitted to be used in other specific hazard classifications and configurations only when proven by large-scale or other suitable fire testing. ESFR sprinklers listed for use in buildings up to 30 ft (9.1 m) high shall be used only in buildings up to 30 ft (9.1 m) high. ESFR sprinklers listed for use in buildings up to 40 ft (12.2 m) high shall used where building height exceeds 30 ft (9.1 m) to a maximum of 40 ft (12.2 m.)

5-3.5.2 ESFR sprinkler systems shall be designed such that the minimum operating pressure is not less than that indicated in Table A-5-3.5 for type of storage, commodity, storage height, and building height involved.

5-3.5.3 The design area shall consist of the most hydraulically demanding area of 12 sprinklers, consisting of 4 sprinklers on each of 3 branch lines. Design shall include a minimum of 960 sq ft (89 m^2).

5-3.5.4 Water supply duration shall be at least 60 min.

5-3.6 Exposure Protection.

5-3.6.1* Piping shall be hydraulically calculated in accordance with Section 6-4 to furnish a minimum of 7 psi (48 kPa) at any sprinkler with all sprinklers facing the exposure operating.

5-3.6.2 Where the water supply feeds other fire protection systems, it shall be capable of furnishing total demand for such systems as well as the exposure system demand.

5-3.7 Water Curtains. Sprinklers in a water curtain as described in 4-5.3.4 shall be hydraulically designed to provide a discharge of 3 gpm per lineal foot [37 (L/min)/m] of water curtain, with no sprinklers discharging less than 15 gpm (56.8 L/min). The number of sprinklers calculated in this water curtain shall be the number in the length corresponding to the length parallel to the branch lines in the area determined by 6-4.4.1(a). If a single fire can be expected to operate sprinklers within the water curtain and within the design area of a hydraulically calculated system, the water supply to the water curtain shall be added to the water demand of the hydraulic calculations and shall be balanced to the calculated area demand. Hydraulic design calculations shall include a design area selected to include ceiling sprinklers adjacent to the water curtain.

5-4 In-Rack Sprinklers. In-rack sprinklers mandated by this standard shall meet the requirements of this section.

5-4.1 In-rack sprinklers shall operate at a minimum of 15 psi (1 bar.)

5-4.2 Water Demand.

5-4.2.1 Where one level of in-rack sprinklers is installed, water demand shall be based on simultaneous operation of the hydraulically most demanding 4 adjacent sprinklers.

Chapter 6 Plans and Calculations

6-1* Working Plans.

6-1.1* Working plans shall be submitted for approval to the authority having jurisdiction before any equipment is installed or remodeled. Deviation from approved plans will require permission of the authority having jurisdiction.

6-1.1.1 Working plans shall be drawn to an indicated scale, on sheets of uniform size, with a plan of each floor, and shall show those items from the following list that pertain to the design of the system.

(a) Name of owner and occupant.

(b) Location, including street address.

(c) Point of compass.

(d) Full height cross section, or schematic diagram, if required for clarity; including ceiling construction and method of protection for nonmetallic piping.

(e) Location of partitions.

(f) Location of fire walls.

(g) Occupancy class of each area or room.

(h) Location and size of concealed spaces, closets, attics, and bathrooms.

(i) Any small enclosures in which no sprinklers are to be installed.

(j) Size of city main in street and whether dead-end or circulating; and, if dead-end, direction and distance to nearest circulating main. City main test results and system elevation relative to test hydrant (*see A-7-2.1.*)

(k) Other sources of water supply, with pressure or elevation.

(l) Make, type, and nominal orifice size of sprinklers.

(m) Temperature rating and location of high-temperature sprinklers.

(n) Total area protected by each system on each floor.

(o) Number of sprinklers on each riser per floor.

(p) Total number of sprinklers on each dry pipe system, preaction system, combined dry pipe-preaction system, or deluge system.

(q) Approximate capacity in gal of each dry pipe system.

(r) Pipe type and schedule of wall thickness.

(s) Nominal pipe size and cutting lengths of pipe (or center-to-center dimensions).

NOTE: Where typical branch lines prevail, it will be necessary to size only one typical line.

(t) Location and size of riser nipples.

(u) Type of fittings and joints and location of all welds and bends. The contractor shall specify on drawing any sections to be shop welded and the type of fittings or formations to be used.

(v) Type and locations of hangers, sleeves, braces, and methods of securing sprinklers when applicable.

(w) All control valves, check valves, drain pipes, and test connections.

(x) Make, type, model, and size of alarm or dry pipe valve.

(y) Make, type, model, and size of preaction or deluge valve.

(z) Kind and location of alarm bells.

(aa) Size and location of hose outlets, hand hose, and related equipment.

(bb) Underground pipe size, length, location, weight, material, point of connection to city main; the type of valves, meters, and valve pits; and the depth that the top of the pipe is laid below grade.

(cc) Piping provisions for flushing.

(dd) Where the equipment is to be installed as an addition to an existing system, enough of the existing system indicated on the plans to make all conditions clear.

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

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

(gg) Name and address of contractor.

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

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

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

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

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

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

(nn) The setting for pressure-reducing valves.

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

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

6-1.1.2* Working plans for automatic sprinkler systems with nonfire protection connections. Special symbols shall be used and explained for auxiliary piping, pumps, heat exchangers, valves, strainers, and the like, clearly distinguishing these devices and piping runs from those of the sprinkler system. Model number, type, and manufacturer's name shall be identified for each piece of auxiliary equipment.

6-2 Hydraulic Calculation Forms.

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

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

(a) Date.

(b) Location.

(c) Name of owner and occupant.

(d) Building number or other identification.

(e) Description of hazard.

(f) Name and address of contractor or designer.

(g) Name of approving agency.

(h) System design requirements.

1. Design area of water application, sq ft (m^2).

2. Minimum rate of water application (density), gpm per sq ft (L/min/m^2).

3. Area per sprinkler, sq ft (m^2).

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

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

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

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

(a) Sheet number.

(b) Sprinkler description and discharge constant (K).

(c) Hydraulic reference points.

(d) Flow in gpm (L/min).

(e) Pipe size.

(f) Pipe lengths, center-to-center of fittings.

(g) Equivalent pipe lengths for fittings and devices.

(h) Friction loss in psi per ft (bars/m) of pipe.

(i) Total friction loss between reference points.

(j) In-rack sprinkler demand balanced to ceiling demand.

(k) Elevation head in psi (bars) between reference points.

(l) Required pressure in psi (bars) at each reference point.

(m) Velocity pressure and normal pressure if included in calculations.

(n) Notes to indicate starting points, reference to other sheets, or to clarify data shown.

(o)* Diagram to accompany gridded system calculations to indicate flow quantities and directions for lines with sprinklers operating in the remote area.

(p) Combined K-factor calculations for sprinklers on drops, armovers, or sprigs where calculations do not begin at sprinkler.

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

(a) Water supply curve.

(b) Sprinkler system demand.

(c) Hose demand (where applicable).

(d) In-rack sprinkler demand (where applicable).

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

(a) Location and elevation of static and residual test gauge with relation to the riser reference point.

(b) Flow location.

(c) Static pressure, psi (bars).

(d) Residual pressure, psi (bars).

(e) Flow, gpm (L/min).

(f) Date.

(g) Time.

(h) Test conducted by or information supplied by.

(i) Other sources of water supply, with pressure or elevation.

6-4 Hydraulic Calculation Procedures.

6-4.1* General. A calculated system for a building, or a calculated addition to a system in an existing sprinklered building, supersedes the rules in this standard governing pipe schedules, except that all systems continue to be limited by area, and pipe sizes shall be no less than 1 in. (25.4 mm) nominal for ferrous piping and ¾ in. (19 mm) nominal for copper tubing or nonmetallic piping listed for fire sprinkler service. The size of pipe, number of sprinklers per branch line, and number of branch lines per cross main are otherwise limited only by the available water supply. However, sprinkler spacing and all other rules covered in this and other applicable standards shall be observed.

6-4.2 Formulas.

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

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

where p is the frictional resistance in pounds pressure per square inch per foot of pipe, Q is the gallons per minute flowing, and d is the actual internal diameter of pipe in inches and C is the friction loss coefficient.

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

where P_m is the frictional resistance in bars per meter of pipe, Q_m is the flow in L/min, d_m is the actual internal diameter in mm, and C is the friction loss coefficient.

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

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

where:

P_v = velocity pressure in psi

Q = flow in gpm

D = inside diameter in inches.

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

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

$$P_n = P_t - P_v$$

where:

P_n = normal pressure

P_t = total pressure in psi (bars)

P_v = velocity pressure in psi (bars).

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

6-4.3 Equivalent Pipe Lengths of Valves and Fittings.

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

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

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

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

Table 6-4.3.1 Equivalent Schedule 40 Steel Pipe Length Chart

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

For SI Units: 1 ft = 0.3048 m.

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

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

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

Table 6-4.3.2 C Value Multiplier

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

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

6-4.3.3 Specific friction loss values or equivalent pipe lengths for alarm valves, dry pipe valves, deluge valves, strainers, and other devices shall be made available to the authority having jurisdiction.

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

6-4.4* Calculation Procedure.

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

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

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

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

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

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

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

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

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

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

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

Exception No. 1: Where area of application is equal to or greater than 1500 sq ft, sprinkler discharge in closets, washrooms, and similar small compartments requiring only one sprinkler shall be permitted to be omitted from hydraulic calculations within the area of application. Sprinklers in these small compartments shall, however, be capable of discharging minimum densities in accordance with Figure 5-2.3.

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

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

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

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

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

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

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

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

Table 6-4.4.5 Hazen-Williams C Values

Pipe or Tube	C Value*
Unlined Cast or Ductile Iron	100
Black Steel (Dry Systems including Preaction)	100
Black Steel (Wet Systems including Deluge)	120
Galvanized (all)	120
Plastic (listed)—All	150
Cement Lined Cast or Ductile Iron	140
Copper Tube or Stainless Steel	150

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

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

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

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

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

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

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

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

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

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

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

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

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

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

6-5.2 Schedule for Light Hazard Occupancies.

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

Exception: Where more than 8 sprinklers on a branch line are necessary, lines may be increased to 9 sprinklers by making the 2 end lengths 1 in. (25.4 mm) and 1 1/4 in. (33 mm), respectively, and the sizes thereafter standard. Ten sprinklers may be placed on a branch line making the 2 end lengths 1 in. (25.4 mm) and 1 1/4 in. (33 mm), respectively, and feeding the tenth sprinkler by a 2 1/2-in. (64-mm) pipe.

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

Exception: Each area requiring more sprinklers than the number specified for 3 1/2-in. (89-mm) pipe in Table 6-5.2.2 and without subdividing partitions (not necessarily fire walls) shall be supplied by mains or risers sized for Ordinary Hazard Occupancies.

Table 6-5.2.2 Light Hazard Pipe Schedules

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

For SI Units: 1 in. = 25.4 mm.

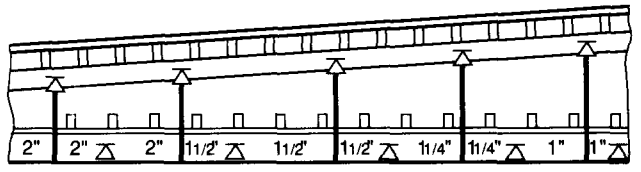
6-5.2.3 Where sprinklers are installed above and below ceilings [see Figures 6-5.2.3(a), (b), and (c)] and such sprinklers are supplied from a common set of branch lines or separate branch lines from a common cross main, such branch lines shall not exceed 8 sprinklers above and 8 sprinklers below any ceiling on either side of the cross main. Pipe sizing up to and including 2 1/2 in. (64 mm) shall be as shown in Table 6-5.2.3 utilizing the greatest number of sprinklers to be found on any two adjacent levels.

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

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

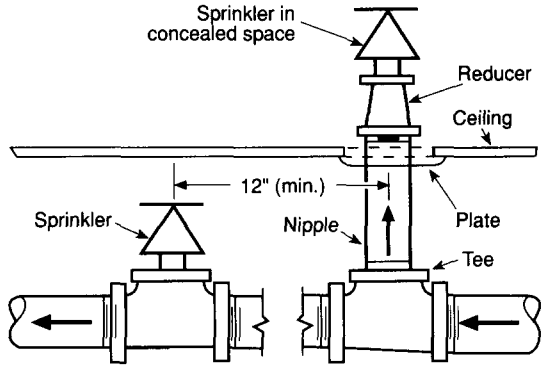
Steel		Copper	
1 in.	2 sprinklers	1 in.	2 sprinklers
1 1/4 in.	4 sprinklers	1 1/4 in.	4 sprinklers
1 1/2 in.	7 sprinklers	1 1/2 in.	7 sprinklers
2 in.	15 sprinklers	2 in.	18 sprinklers
2 1/2 in.	50 sprinklers	2 1/2 in.	65 sprinklers

6-5.2.3.1* Where the total number of sprinklers above and below a ceiling exceeds the number specified in Table 6-5.2.3 for 2 1/2-in. (64-mm) pipe, the pipe supplying such sprinklers shall be increased to 3 in. (76 mm) and sized thereafter according to the schedule shown in Table 6-5.2.2 for the number of sprinklers above or below a ceiling, whichever is larger.



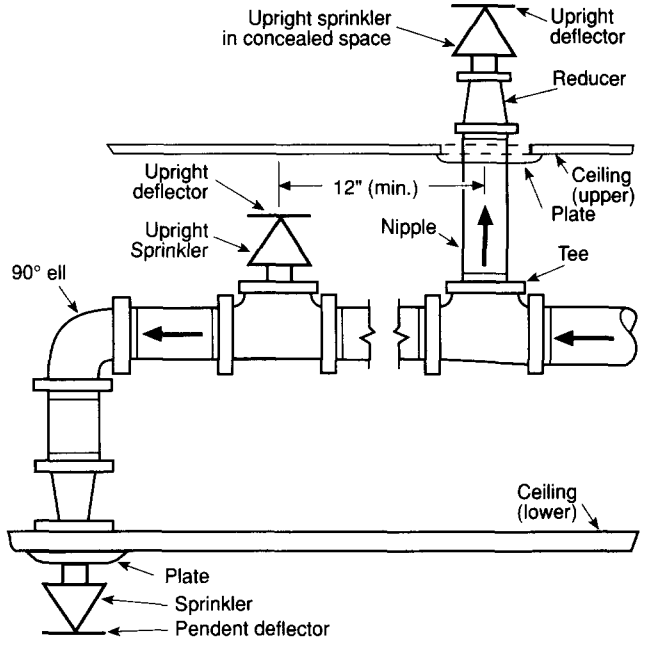
For SI Units: 1 in. = 25.4 mm.

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



For SI Units: 1 in. = 25.4 mm.

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



For SI Units: 1 in. = 25.4 mm.

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

6-5.3 Schedule for Ordinary Hazard Occupancies.

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

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

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

Table 6-5.3.2(a) Ordinary Hazard Pipe Schedule

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

For SI Units: 1 in. = 25.4 mm.

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

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

Steel		Copper	
2½ in.	15 sprinklers	2½ in.	20 sprinklers
3 in.	30 sprinklers	3 in.	35 sprinklers
3½ in.	60 sprinklers	3½ in.	65 sprinklers
For other pipe and tube sizes, see Table 6-5.3.2(a)			

For SI Units: 1 in. = 25.4 mm.

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

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

6-5.3.3.1* Where the total number of sprinklers above and below a ceiling exceeds the number specified in Table 6-5.3.3 for 3-in. (76-mm) pipe, the pipe supplying such

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

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

For SI Units: 1 in. = 25.4 mm.

sprinklers shall be increased to 3½ in. (89 mm) and sized thereafter according to the schedule shown in Table 6-5.2.2 or Table 6-5.3.2(a) for the number of sprinklers above or below a ceiling, whichever is larger.

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

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

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

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

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

6-6 In-Rack Sprinklers.

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

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

Chapter 7 Water Supplies

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

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

7-1.2 Arrangement.

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

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

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

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

Table 6-5.6 Exposure Protection

Section A—Window Sprinklers

Guide Number	Level of Window Sprinkler	Window Sprinkler Orifice Size	Discharge Coefficient (K Factor)	Flow Rate (Q)	Application Rate over 25 ft² of Window Area
1.50 or less	Top 2 levels	⅜ in. (9.5 mm)	2.8	7.4 gpm	0.30 gpm/ft²
	Next lower 2 levels	5/16 in. (7.9 mm)	1.9	5.0 gpm	0.20 gpm/ft²
	Next lower 2 levels	¼ in. (6.4 mm)	1.4	3.7 gpm	0.15 gpm/ft²
1.51 to 2.20	Top 2 levels	½ in. (12.7 mm)	5.6	14.8 gpm	0.59 gpm/ft²
	Next lower 2 levels	7/16 in. (11.1 mm)	4.2	11.1 gpm	0.44 gpm/ft²
	Next lower 2 levels	⅜ in. (9.5 mm)	2.8	7.4 gpm	0.30 gpm/ft²
2.21 to 13.15	Top 2 levels	⅝ in. (15.9 mm)	11.2	29.6 gpm	1.18 gpm/ft²
	Next lower 2 levels	17/32 in. (13.5 mm)	8.0	21.2 gpm	0.85 gpm/ft²
	Next lower 2 levels	½ in. (12.7 mm)	5.6	14.8 gpm	0.59 gpm/ft²

Section B—Cornice Sprinklers

Guide Number	Cornice Sprinkler Orifice Size	Application Rate per Lineal Foot
1.50 or less	⅜ in. (9.5 mm)	0.75 gpm
1.51 to 2.20	½ in. (12.7 mm)	1.50 gpm
2.21 to 13.15	⅝ in. (15.9 mm)	3.00 gpm

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

7-2 Types.

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

7-2.2 Pumps.

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

7-2.3 Pressure Tanks.

7-2.3.1 Acceptability.

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

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

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

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

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

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

Chapter 8 System Acceptance

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

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

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

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

8-2 Acceptance Requirements.

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

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

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

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

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

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

8-2.2 Hydrostatic Tests.

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

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

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

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

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

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

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

Contractor's Material and Test Certificate for Aboveground Piping

PROCEDURE

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

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

PROPERTY NAME	DATE
PROPERTY ADDRESS	

PLANS

ACCEPTED BY APPROVING AUTHORITIES (NAMES)

ADDRESS

INSTALLATION CONFORMS TO ACCEPTED PLANS ☐ YES ☐ NO

EQUIPMENT USED IS APPROVED ☐ YES ☐ NO

IF NO, EXPLAIN DEVIATIONS

INSTRUCTIONS

HAS PERSON IN CHARGE OF FIRE EQUIPMENT BEEN INSTRUCTED AS TO LOCATION OF CONTROL VALVES AND CARE AND MAINTENANCE OF THIS NEW EQUIPMENT? ☐ YES ☐ NO

IF NO, EXPLAIN

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	ORIFICE SIZE	QUANTITY	TEMPERATURE RATING

PIPE AND FITTINGS

Type of Pipe _____

Type of Fittings _____

ALARM VALVE OR FLOW INDICATOR

ALARM DEVICE			MAXIMUM TIME TO OPERATE THROUGH TEST CONNECTION	
TYPE	MAKE	MODEL	MIN.	SEC.

DRY PIPE OPERATING TEST

DRY VALVE			Q. O. D.		
MAKE	MODEL	SERIAL NO.	MAKE	MODEL	SERIAL NO.

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

IF NO, EXPLAIN

*MEASURED FROM TIME INSPECTOR'S TEST CONNECTION IS OPENED.

Figure 8-1(a).

DELUGE & PREACTION VALVES

OPERATION ☐ PNEUMATIC ☐ ELECTRIC ☐ HYDRAULIC

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

DOES VALVE OPERATE FROM THE MANUAL TRIP AND/OR REMOTE 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	MIN.	SEC.

PRESSURE REDUCING VALVE TEST

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

TEST DESCRIPTION

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

PNEUMATIC: Establish 40 psi (2.7 bars) air pressure and measure drop, which shall not exceed 1-1/2 psi (0.1 bars) in 24 hours. Test pressure tanks at normal water level and air pressure and measure air pressure drop, which shall not exceed 1-1/2 psi (0.1 bars) in 24 hours.

TESTS

ALL PIPING HYDROSTATICALLY TESTED AT ____ PSI FOR ____ HRS. | IF NO, STATE REASON

DRY PIPING PNEUMATICALLY TESTED ☐ YES ☐ NO

EQUIPMENT OPERATES PROPERLY ☐ YES ☐ NO

DO YOU CERTIFY AS THE SPRINKLER CONTRACTOR THAT ADDITIVES AND CORROSIVE CHEMICALS, SODIUM SILICATE OR DERIVATIVES OF SODIUM SILICATE, BRINE, OR OTHER CORROSIVE CHEMICALS WERE NOT USED FOR TESTING SYSTEMS OR STOPPING LEAKS? ☐ YES ☐ NO

DRAIN TEST READING OF GAGE LOCATED NEAR WATER SUPPLY TEST CONNECTION: _____ PSI | RESIDUAL PRESSURE WITH VALVE IN TEST CONNECTION OPEN WIDE _____ PSI

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

VERIFIED BY COPY OF THE U FORM NO. 85B FLUSHED BY INSTALLER OF UNDERGROUND SPRINKLER PIPING ☐ YES ☐ NO ☐ 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

WELDED PIPING ☐ YES ☐ NO

IF YES. . .

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

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

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

CUTOUTS (DISCS)

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

Figure 8-1(a) (cont).

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

Figure 8-1(a) (cont).

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

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

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

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

8-2.3 Dry System Air Test. In addition to the standard hydrostatic test, an air pressure leakage test at 40 psi (2.8 bars) shall be conducted for 24 hours. Any leakage that results in a loss of pressure in excess of 1½ psi (0.1 bar) for the 24 hours shall be corrected.

8-2.4 System Operational Tests.

8-2.4.1 Waterflow detecting devices including the associated alarm circuits shall be flow tested through the inspector's test connection to result in an alarm on the premises within 5 min after such flow begins.

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

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

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

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

8-2.6 Operating tests shall be made of exposure protection systems upon completion of the installation, where such tests do not risk water damage to the building on which they are installed or to adjacent buildings.

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

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

Contractor's Material and Test Certificate for Underground Piping

PROCEDURE

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

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

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

Figure 8-1(b).

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

Figure 8-1(b) (cont).

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

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

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

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

8-4 Instructions.

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

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

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

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

(a) Location of the design area or areas.

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

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

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

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

Chapter 9 System Maintenance

9-1 General.

9-1.1* A sprinkler system installed in accordance with this standard shall be properly maintained in accordance with NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, to provide at least the same level of performance and protection as designed. The owner shall be responsible for maintaining the system and keeping the system in good operating condition.

Chapter 10 Referenced Publications

10-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

10-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, 1994 edition.

NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height*, 1994 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 1993 edition.

NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*, 1993 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 1993 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 1992 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 1992 edition.

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

NFPA 70, *National Electrical Code*, 1993 edition.

NFPA 72, *National Fire Alarm Code*, 1993 edition.

NFPA 96, *Standard on Ventilation Control and Fire Protection of Commercial Cooking Operations*, 1994 edition.

NFPA 231, *Standard for General Storage*, 1990 edition.

NFPA 231C, *Standard for Rack Storage of Materials*, 1991 edition.

10-1.2 The following NFPA codes, standards, and recommended practices contain specific sprinkler design criteria.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, 1994 edition.

NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies Up to and Including Four Stories in Height*, 1994 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 1990 edition.

NFPA 16, *Standard on Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*, 1991 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 1993 edition.

NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products*, 1990 edition.

NFPA 33, *Standard for Spray Application Using Flammable and Combustible Materials*, 1989 edition.

NFPA 34, *Standard for Dipping and Coating Processes Using Flammable or Combustible Liquids*, 1989 edition.

NFPA 35, *Standard for the Manufacture of Organic Coatings*, 1987 edition.

NFPA 40, *Standard for the Storage and Handling of Cellulose Nitrate Motion Picture Film*, 1988 edition.

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

NFPA 43A, *Code for the Storage of Liquid and Solid Oxidizers*, 1990 edition.

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

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 1991 edition.

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

NFPA 51A, *Standard for Acetylene Cylinder Charging Plants*, 1989 edition.

NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*, 1992 edition.

NFPA 61B, *Standard for the Prevention of Fires and Explosions in Grain Elevators and Facilities Handling Bulk Raw Agricultural Commodities*, 1989 edition.

NFPA 75, *Standard for the Protection of Electronic Computer/Data Processing Equipment*, 1992 edition.

NFPA 81, *Standard for Fur Storage, Fumigation and Cleaning*, 1986 edition.

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

NFPA 86, *Standard for Ovens and Furnaces*, 1990 edition.

NFPA 86C, *Standard for Industrial Furnaces Using a Special Processing Atmosphere*, 1991 edition.

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

NFPA 99, *Standard for Health Care Facilities*, 1993 edition.

NFPA 99B, *Standard for Hypobaric Facilities*, 1993 edition.

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

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

NFPA 122, *Standard for the Storage of Flammable and Combustible Liquids Within Underground Metal and Nonmetal Mines (Other than Coal)*, 1990 edition.

NFPA 123, *Standard for Fire Prevention and Control in Underground Bituminous Coal Mines*, 1990 edition.

NFPA 130, *Standard for Fixed Guideway Transit Systems*, 1993 edition.

NFPA 150, *Standard on Firesafety in Racetrack Stables*, 1991 edition.

NFPA 214, *Standard on Water-Cooling Towers*, 1992 edition.

NFPA 231, *Standard for General Storage*, 1990 edition.

NFPA 231C, *Standard for Rack Storage of Materials*, 1991 edition.

NFPA 231D, *Standard for Storage of Rubber Tires*, 1989 edition.

NFPA 231E, *Recommended Practice for the Storage of Baled Cotton*, 1989 edition.

NFPA 231F, *Standard for Storage of Roll Paper*, 1987 edition.

NFPA 232, *Standard for the Protection of Records*, 1991 edition.

NFPA 307, *Standard for the Construction and Fire Protection of Marine Terminals, Piers, and Wharves*, 1990 edition.

NFPA 318, *Standard for the Protection of Cleanrooms*, 1992 edition.

NFPA 409, *Standard on Aircraft Hangars*, 1990 edition.

NFPA 423, *Standard for Construction and Protection of Aircraft Engine Test Facilities*, 1989 edition.

NFPA 850, *Recommended Practice for Fire Protection for Electric Generating Plants*, 1992 edition.

NFPA 851, *Recommended Practice for Fire Protection for Hydroelectric Generating Plants*, 1992 edition.

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

10-1.3 Other Publications.

10-1.3.1 ANSI Publications. American National Standards Institute, Inc., 1450 Broadway, New York, NY 10018.

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

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

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

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

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

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

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

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

ANSI B16.22-1989, *Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.*

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

ANSI B36.10M-1985, *Welded and Seamless Wrought Steel Pipe.*

10-1.3.2 ASME Publication. American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

ASME A17.1-1990, *Safety Code for Elevators and Escalators.*

10-1.3.3 ASTM Publications. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19105.

ASTM A53-1992, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless Steel Pipe.*

ASTM A135-1992, *Standard Specification for Electric-Resistance Welded Steel Pipe.*

ASTM A234-1992, *Standard Specification for Piping Fittings of Wrought-Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.*

ASTM A795-1992, *Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use.*

ASTM B32-1993, *Standard Specification for Solder Metal.*

ASTM B75-1992, *Standard Specification for Seamless Copper Tube.*

ASTM B88-1993, *Standard Specification for Seamless Copper Water Tube.*

ASTM B251-1993, *Standard Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube.*

ASTM B813-1991, *Standard Specification for Liquid and Paste Fluxes for Soldering Applications of Copper and Copper-Alloy Tube.*

ASTM D3309-1989, *Standard Specification for Polybutylene (PB) Plastic Hot and Cold Water Distribution Systems.*

ASTM E136-1982, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C.*

ASTM F437-1982, *Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fitting, Schedule 80.*

ASTM F438-1982, *Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.*

ASTM F439-1982, *Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride (CPVC) Plastic Pipe Fittings, Schedule 80.*

ASTM F442-1989, *Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR).*

10-1.3.4 AWS Publications. American Welding Society, 550 N.W. LeJeune, Miami, FL 33135.

AWS A5.8-1989, *Specification for Brazing Filler Metal.*

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

Appendix A Explanatory Material

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

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

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

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

A-1-4.3 See Figures A-1-4.3(a) and (b).

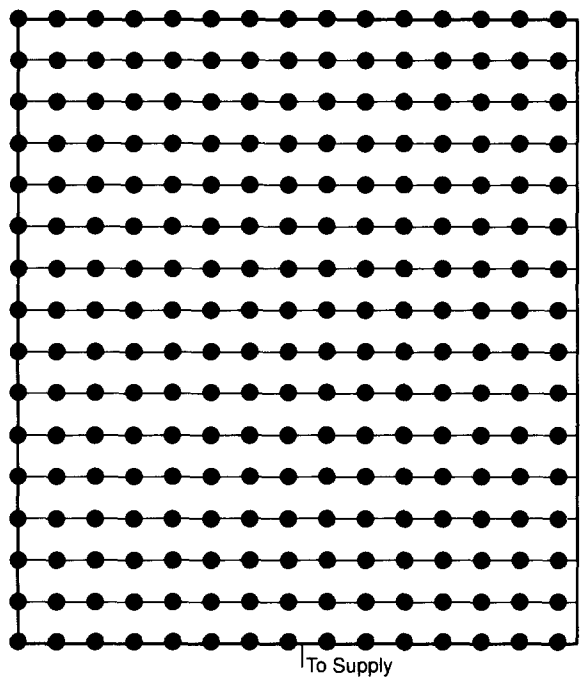


Figure A-1-4.3(a) Gridded system.

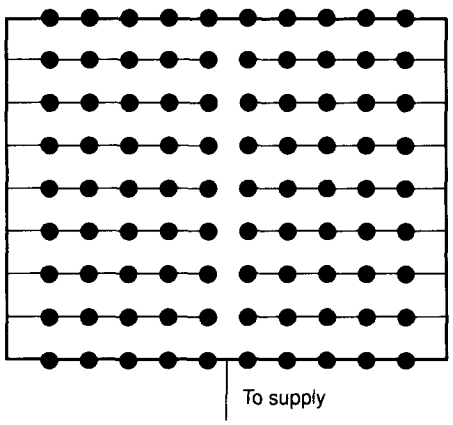


Figure A-1-4.3(b) Looped system.

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

A-1-4.5.1 QRES Sprinkler. Research into the development of QRES sprinklers is continuing under the auspices of the National Fire Protection Research Foundation. It is expected that the proposed design criteria will be added to the standard when a thorough analysis of the test data is completed.

A-1-4.5.1 ESFR Sprinkler. It is important to realize that the effectiveness of these highly tested and engineered sprinklers depends on the combination of fast response and the quality and uniformity of the sprinkler discharge. It should also be realized that ESFR sprinklers cannot be relied upon to provide fire control, let alone suppression, if they are used outside the guidelines specified in 5-3.5.

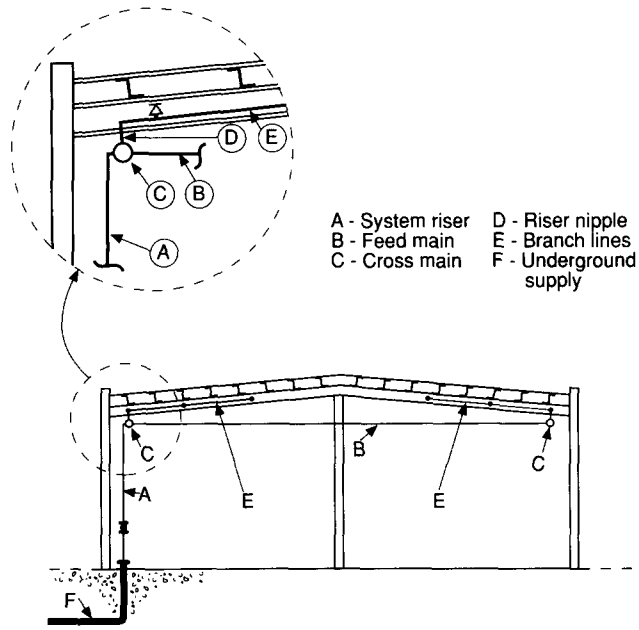


Figure A-1-4.4 Building elevation showing parts of sprinkler piping system.

A-1-4.5.3 Dry Sprinkler. Under certain ambient conditions, wet pipe systems having dry-pendent (or upright) sprinklers may freeze due to heat loss by conduction. Therefore, due consideration should be given to the amount of heat maintained in the heated space, the length of the nipple in the heated space, and other relevant factors.

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

(i) *Beam and Girder Construction.* The term *beam and girder construction* as used in this standard includes noncombustible and combustible roof or floor decks supported by wood beams of 4 in. (102 mm) or greater nominal thickness or concrete or steel beams spaced 3 to 7½ ft (0.9 to 2.3 m) on center and either supported on or framed into girders. [Where supporting a wood plank deck, this includes semi-mill and panel construction, and where supporting (with steel framing) gypsum plank, steel deck, concrete, tile, or similar material, this would include much of the so-called noncombustible construction.]

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

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

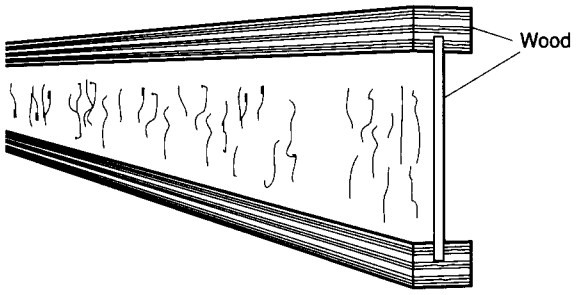


Figure A-1-4.6(a)(ii) Typical composite wood joist construction.

framed into girders qualify for panel construction provided the 300-sq ft (27.9-m^2) area limitation is met.

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

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

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

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

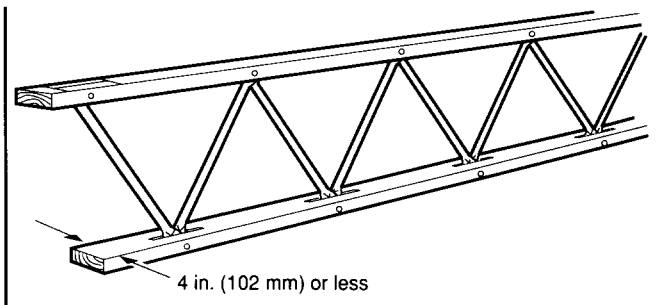


Figure A-1-4.6(b)(i)1 Wood bar joist construction.

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

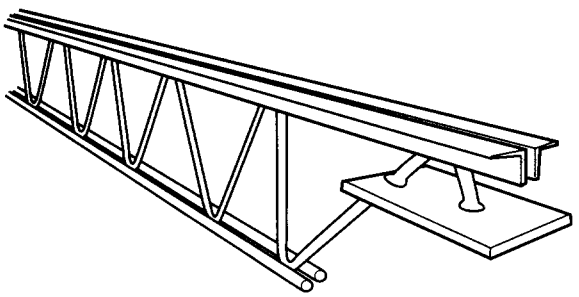


Figure A-1-4.6(b)(i)2 Open-web bar joist construction.

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

a. Flat slab, pan-type reinforced concrete.

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

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

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

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

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

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

g. Suspended ceilings of combustible or noncombustible construction.

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

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

(v) *Wood Truss Construction.* The term *wood truss construction* refers to parallel or pitched wood chord members connected by open wood members (webbing) supporting a roof or floor deck. Trusses with steel webbing, similar to bar joist construction, having top and bottom wood chords exceeding 4 in. (102 mm) in depth, should also be considered wood truss construction. [*See Figure A-1-4.6(b)(v).*]

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

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

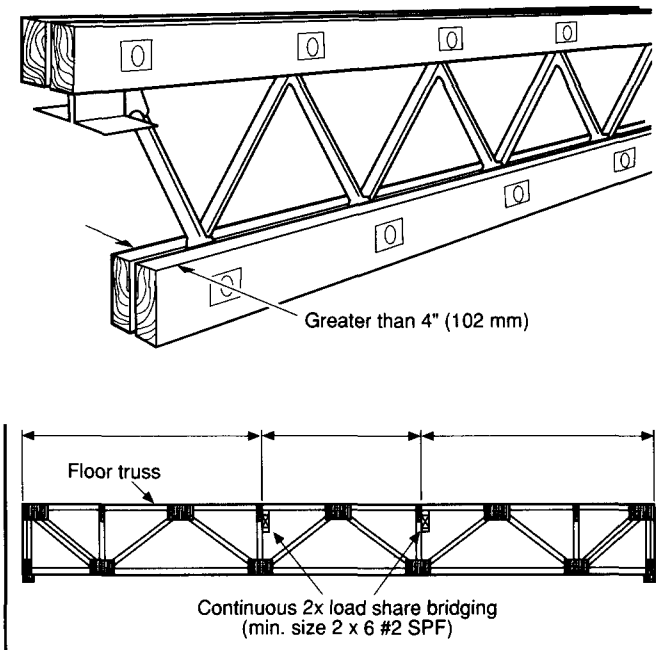


Figure A-1-4.6(b)(v) Examples of wood truss construction.

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

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

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

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

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

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

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

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

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

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

A-1-4.7.4.1 Other NFPA standards contain design criteria for fire control or fire suppression (*see 1-4.7.4 and Chapter 10*). While these may form the basis of design criteria, this standard describes the methods of design, installation, fabrication, calculation, and evaluation of water supplies that should be used for the specific design of the system.

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

A-2-2.3 Information regarding the highest temperature that may be encountered in any location in a particular installation may be obtained by use of a thermometer that will register the highest temperature encountered; it should be hung for several days in the location in question, with the plant in operation.

A-2-2.4.1 Examples of such locations are paper mills, packing houses, tanneries, alkali plants, organic fertilizer plants, foundries, forge shops, fumigation, pickle and vinegar works, stables, storage battery rooms, electroplating rooms, galvanizing rooms, steam rooms of all descriptions including moist vapor dry kilns, salt storage rooms, locomotive sheds or houses, driveways, areas exposed to outside weather such as piers and wharves exposed to salt air, areas under sidewalks, around bleaching equipment in flour mills, all portions of cold storage buildings where a direct ammonia expansion system is used, and portions of any plant where corrosive vapors prevail.

A-2-2.4.2 Care should be taken in the handling and installation of wax-coated or similar sprinklers to avoid damaging the coating.

A-2-2.4.3 Painting of sprinklers may retard the thermal response of the heat-responsive element, may interfere with the free movement of parts, and may render the sprinkler inoperative. Moreover, painting may invite the application of subsequent coatings, thus increasing the possibility of a malfunction of the sprinkler.

A-2-2.5.2 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-2-2.6 Sprinklers under open gratings should be provided with shields. Shields over automatic sprinklers should not be less, in least dimension, than four times the distance between the shield and fusible element, except special sprinklers incorporating a built-in shield need not comply with this recommendation if listed for the particular application.

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

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

Table A-2-3.2 Steel Pipe Dimensions

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

NOTE 1: Schedule 10 defined to 5 in. (127 mm) nominal pipe size by ASTM A135.
NOTE 2: Wall thickness specified in 2-3.2.

Table A-2-3.4 Copper Tube Dimensions

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

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

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

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

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

Not all fittings made to ASTM F437, F438, and F439 as described in 2-4.2 are listed for fire sprinkler service. Listed fittings are identified by the logo of the listing agency.

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

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

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

(a) Pressure rating.

(b) Beam strength (hangers).

(c) Unsupported vertical stability.

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

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

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

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

(h) Physical characteristics related to integrity during earthquakes.

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

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

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

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

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

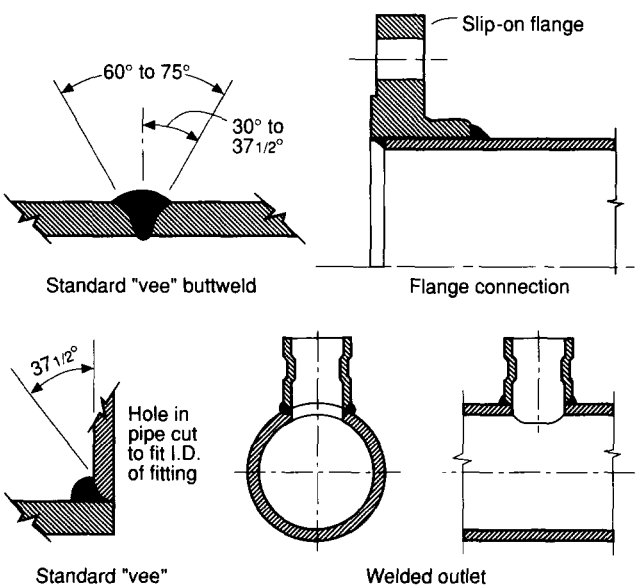


Figure A-2-5.2(a) Acceptable weld joints.

A-2-5.2.2 Cutting and welding operations account for 4 percent of fires each year in nonresidential properties and 8 percent in industrial and manufacturing properties.

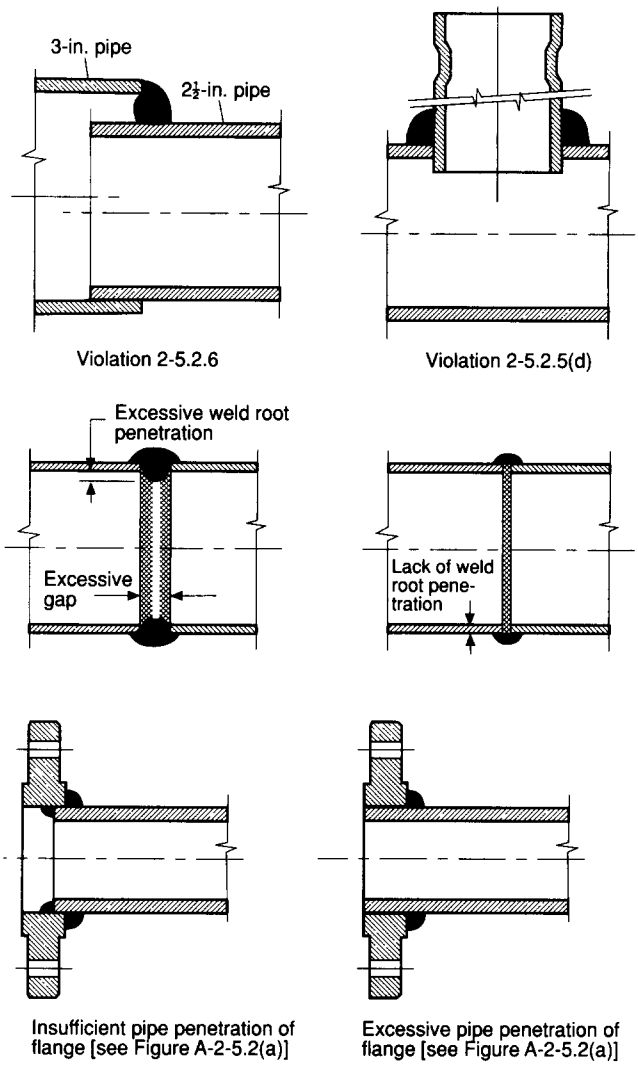


Figure A-2-5.2(b) Unacceptable weld joints.

In-place welding of sprinkler piping introduces a significant hazard that can normally be avoided by shop-welding the piping and installing the welded sections with mechanical fittings. As a result, the standard requires that all piping be shop-welded. When such situations cannot be avoided, the exceptions outline procedures and practices that minimize the increase in hazard.

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

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

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

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

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

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

where "L" is the equivalent length, "a" is the distance from one support to the load, and "b" is the distance from the other support to the load.

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

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

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

A-2-6.3.2 The ability of concrete to hold the studs varies widely according to type of aggregate, quality of concrete, and proper installation.

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

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

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

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

A-2-9.5.1 Switches that will silence electric alarm sounding devices by interruption of electrical current are not desirable; however, if such means are provided, then the electrical alarm-sounding device circuit should be arranged so that, when the sounding device is electrically silenced, that fact should be indicated by means of a conspicuous light located in the vicinity of the riser or alarm control panel. This light should remain in operation during the entire period of the electrical circuit interruption.

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

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

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

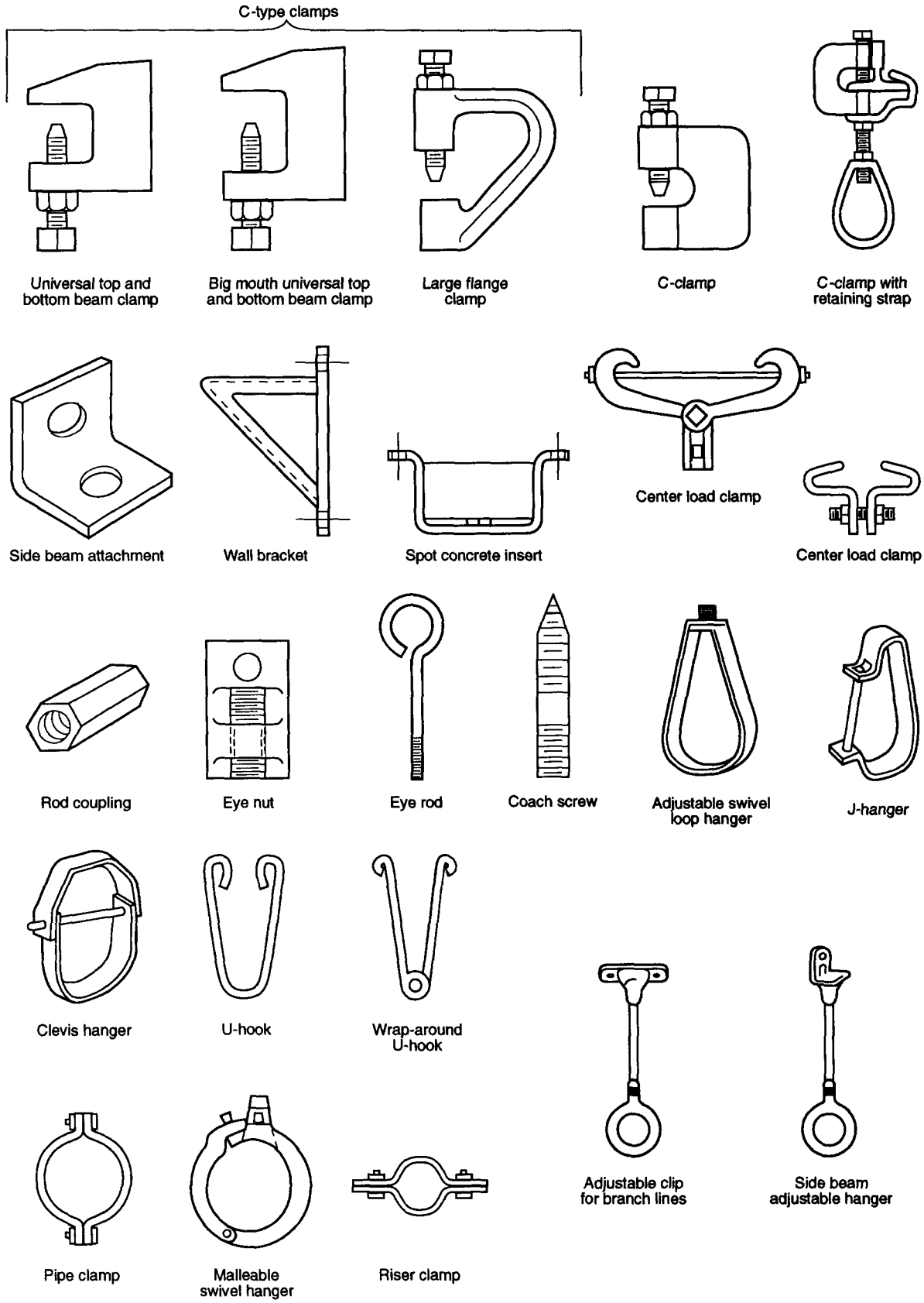


Figure A-2-6.1 Common types of acceptable hangers.

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

Table A-3-2.3 Capacity of One Foot of Pipe (Based on actual internal pipe diameter)

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

For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m; 1 gal = 3.785 L.
[1] 0.134 Wall Pipe.
[2] 0.188 Wall Pipe.
[3] Schedule 30.

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

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

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

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

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

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

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

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

(a) Dry systems may be manifolded to a deluge valve, the protected area not exceeding 40,000 sq ft (3716 m^2). The distance between valves should be as short as possible to minimize water hammer.

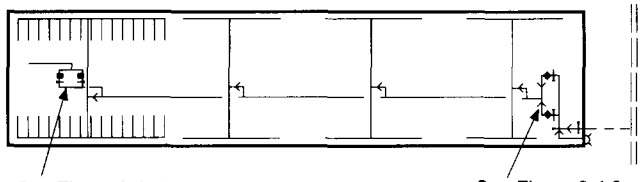
(b) The dry pipe valves should be pressurized to 50 psi (3.4 bars) to reduce the possibility of dry pipe valve operation from water hammer.

A-3-3.2.1(c) This is sometimes referred to as a double interlock preaction system.

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

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

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



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

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

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

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

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

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

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

Glycerine, diethylene glycol, ethylene glycol, and propylene glycol should never be used without mixing with water in proper proportions, because these materials tend to thicken near 32°F (0°C).

A-3-5.3 All permitted antifreeze solutions are heavier than water. At the point of contact (interface), the heavier liquid will be below the lighter liquid, preventing diffusion of water into the unheated areas.

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

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

A-3-8 Careful installation and maintenance, and some special arrangements of piping and devices as outlined in

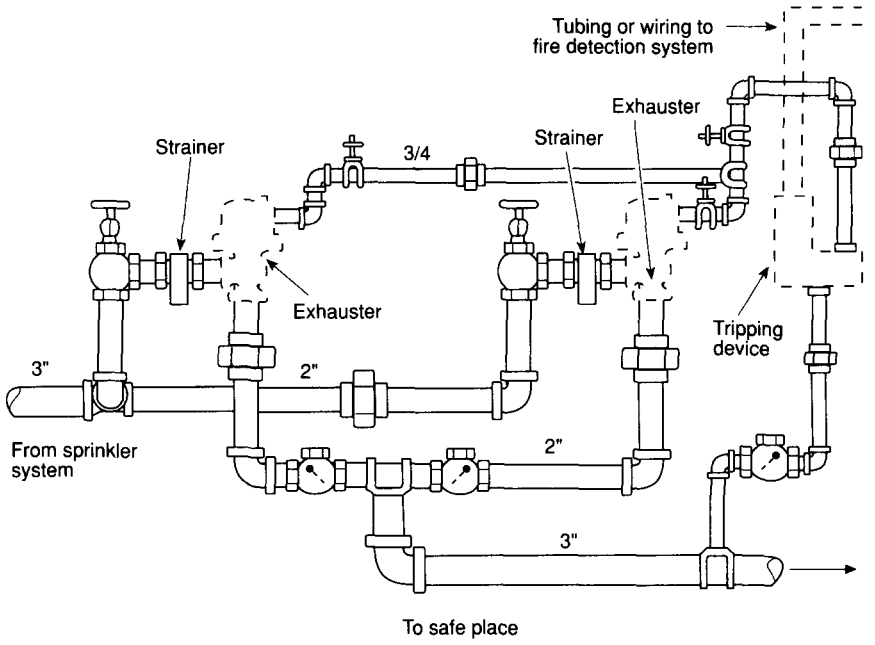


Figure A-3-4.3 Arrangement of air exhaust valves for combined dry pipe and preaction sprinkler system.

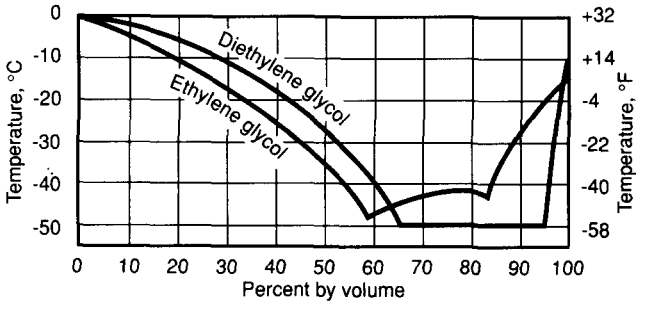


Figure A-3-5.2.3 Freezing points of water solutions of ethylene glycol and diethylene glycol.

this section, are needed to avoid the formation of ice and frost inside piping in cold storage rooms that will be maintained at or below 32°F (0°C). Conditions are particularly favorable to condensation where pipes enter cold rooms from rooms having temperatures above freezing.

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

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

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

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

A-3-8.1 Joining of pipe and fittings using split housing couplings may allow separation of pipe for internal inspection.

A-3-8.1(a) This may be accomplished by a blind flange on a fitting (tee or cross) in the riser or cross main or a removable section 24 in. (610 mm) long in the feed main as shown in Figure A-3-8.1(a). Such fittings in conjunction with the flushing connections specified in 4-5.15 permit examination of the entire length of the cross mains. Branch lines may be examined by disconnecting them from cross mains.

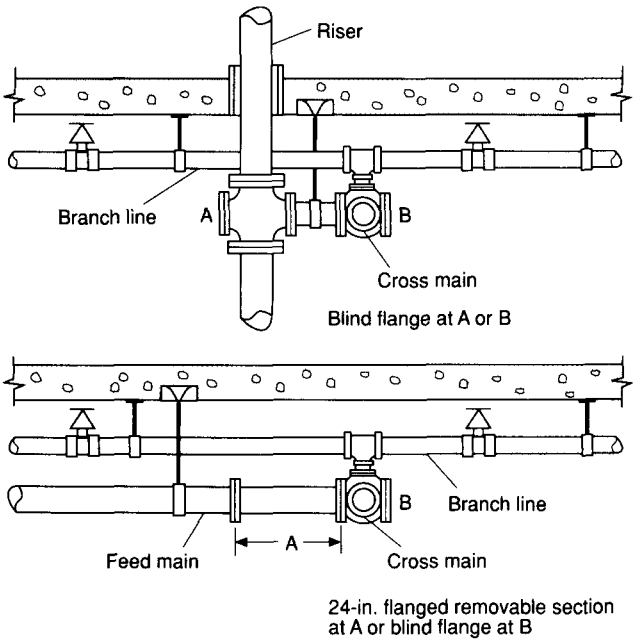
A-3-8.1(b) This may be accomplished by means of 2-in. (51-mm) capped nipples or blind flanges on fittings.

A-3-8.1(c) This can be accomplished at floor penetrations by a tee with a blind flange in the cold room and at wall penetrations by a 24-in. (610-mm) flanged removable section in the warm room as shown in Figure A-3-8.1(c).

A-3-8.4 Propylene glycol or other suitable material may be used as a substitute for priming water to prevent evaporation of the priming fluid and thus reduce ice formation within the system, subject to state and local health regulations.

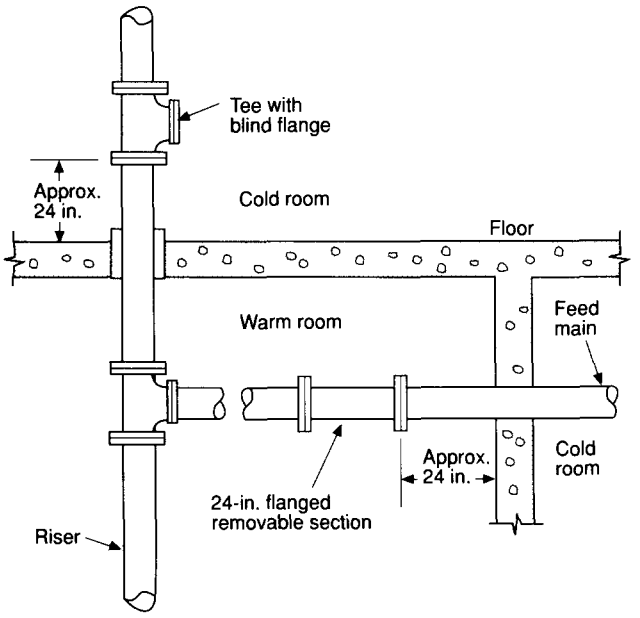
A-3-9.2 See Figure A-3-9.2.

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



For SI Units: 1 in. = 25.4 mm.

Figure A-3-8.1(a) Fittings to facilitate examination of feed mains, risers, and cross mains in freezing areas. Top: elevation at riser and cross main. Bottom: elevation at feed main and cross main.



For SI Units: 1 in. = 25.4 mm.

Figure A-3-8.1(c) Fittings in feed main or riser passing through wall or floor from warm room to cold room.

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 may 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 non-sprinklered area may overpower the partial sprinkler system.

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

A-4-1.1 This standard contemplates full sprinkler protection for all areas. Other NFPA standards that mandate sprinkler installation may not require sprinklers in certain areas. The requirements of this standard should be used insofar as they are applicable. The authority having jurisdiction should be consulted in each case.

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

A-4-2.2 Tests involving areas of coverage over 100 sq ft (9.3 m^2) for large-drop sprinklers are limited in number, and use of areas of coverage over 100 sq ft (9.3 m^2) should be carefully considered. Figure A-4-2.2 shows placement of sprinklers under wood joist construction.

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

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

A-4-3.2 Tests of standard sprinklers by approved laboratories have traditionally encompassed a fire test using a 350-lb (160-kg) wood crib and water distribution tests in which water is collected in pans from several arrangements of sprinklers to evaluate distribution under nonfire conditions.

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

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

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

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

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

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

A-4-3.6.1 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.

A-4-3.8.2 This requirement is to avoid scale accumulation.

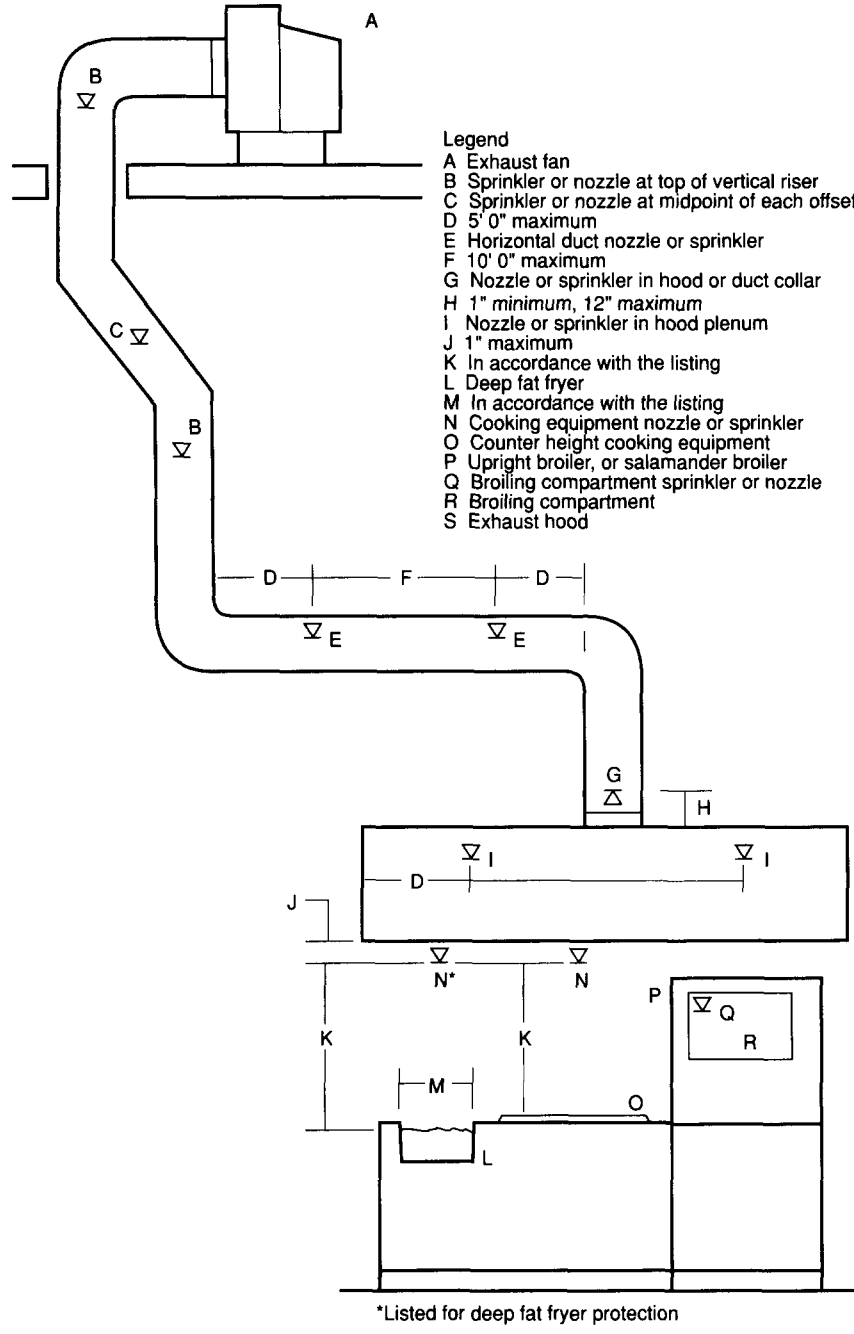
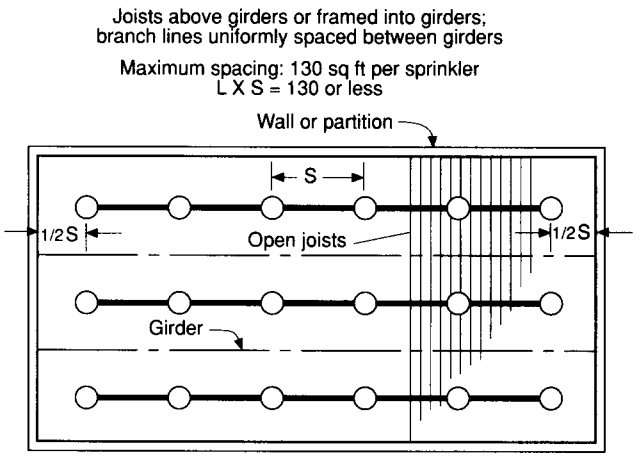


Figure A-3-9.2 Typical installation showing automatic sprinklers or automatic nozzles being used for the protection of commercial cooking equipment and ventilation systems.



L = Distance between branch lines, limit 15 ft
S = Distance between sprinklers on branch lines, limit 15 ft
Y = Maximum distance between girders

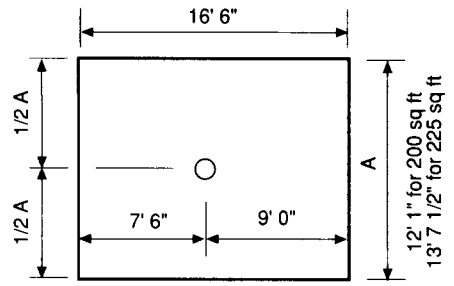
Examples

Y	L	S (Max)	Y	L	S (Max)
10 ft 9 in.	10 ft 9 in.	12 ft 1 in.	10 ft 10 in. 12 ft 1 in.	10 ft 10 in. 12 ft 1 in.	12 ft 0 in. 10 ft 9 in.

For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m; 1 sq ft = 0.0929 m^2.

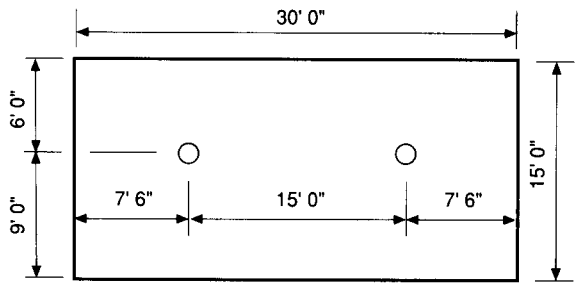
Figure A-4-2.2 Layout of sprinklers under open wood joist construction—Ordinary Hazard Occupancies.

A-4-4.1.2.1 Exception An example of sprinklers in small rooms for hydraulically designed and pipe schedule systems is shown in Figure A-4-4.1.2.1(a), and examples for hydraulically designed systems only are shown in Figures A-4-4.1.2.1(b), (c), and (d).



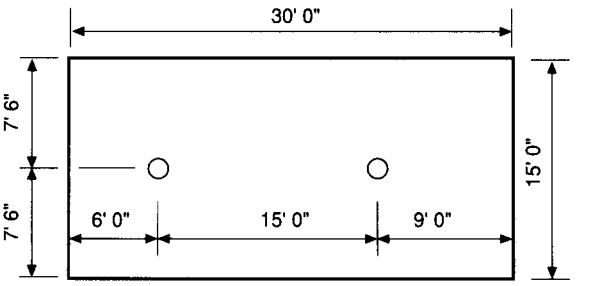
For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.

Figure A-4-4.1.2.1(a) Small room provision.



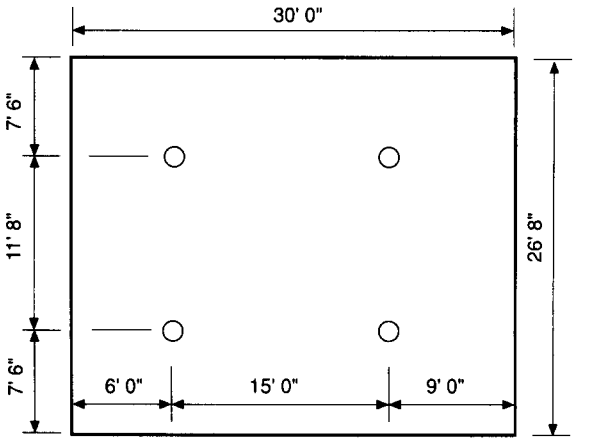
For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.

Figure A-4-4.1.2.1(b) Small room provision.



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

Figure A-4-4.1.2.1(c) Small room provision.



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

Figure A-4-4.1.2.1(d) Small room provision.

A-4-4.1.3.1 Where of a depth that will obstruct the spray discharge pattern, girders, beams, or trusses forming narrow pockets of combustible construction along walls may require additional sprinklers.

A-4-4.1.3.2.1 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-4-4.1.3.3 The distances given in Table 4-4.1.3.3 were determined through tests in which privacy curtains with either a solid fabric or close mesh [1/4 in. (6.4 mm)] top panel were installed. For broader-mesh top panels, e.g., 1/2 in. (13 mm), the obstruction of the sprinkler spray is not likely to be severe and the authority having jurisdiction may not need to apply the requirements in 4-4.1.3.3.

A-4-4.1.4.2 Exception No. 4 For concrete joists spaced less than 3 ft (.91 m) on center, the rules for obstructed construction shown in 4-4.1.4.2 apply. (*See Figure A-4-4.1.4.2.*)

Figure A-4-4.1.4.2 Typical concrete joist construction.

A-4-4.1.5 On sprinkler lines larger than 2 in. (51 mm), consideration should be given to the distribution interference caused by the pipe, which can be minimized by installing sprinklers on riser nipples or installing sprinklers in the pendent position.

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

A-4-4.1.7.2.2 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 (0.91 m) down the slope from the peak because of the effect of venting on sprinkler sensitivity.

A-4-4.2.2.1 The protection area per sprinkler should be determined using the S x L = Protection Area rule as follows:

1. "S" — Determine distance to the next sprinkler (or to the wall, in the case of an end sprinkler on a branch line) upstream and downstream. Choose the larger of either twice the distance to the wall or the distance to the next sprinkler.

2. "L" — The distance to the opposite side of the room will be "L." Where sprinklers are provided on both sides of the room, "L" should be half the distance between the walls.

A-4-4.3.1 It is important that sprinklers in the immediate vicinity of the fire center not skip, and this requirement imposes certain restrictions on the spacing.

A-4-4.3.3 If all other factors are held constant, the operating time of the first sprinkler will vary exponentially with the distance between the ceiling and deflector. At distances greater than 7 in. (178 mm), for other than open wood joist construction, the delayed operating time will permit the fire to gain headway, with the result that substantially more sprinklers operate. At distances less than 7 in. (178 mm), other effects occur. Changes in distribution, penetration, and cooling nullify the advantage gained by faster operation. The net result again is increased fire damage accompanied by an increase in the number of sprinklers operated. The optimum clearance between deflectors and ceiling is, therefore, 7 in. (178 mm). For open wood joist construction, the optimum clearance between deflectors and the bottom of joists is $3\frac{1}{2}$ in. (89 mm).

A-4-4.3.4 To a great extent, large-drop sprinklers rely on direct attack to gain rapid control of both the burning fuel and ceiling temperatures. Therefore, interference with the discharge pattern and obstructions to the distribution should be avoided.

A-4-5.1.1 Exceptions Nos. 1, 2, and 3 do not require sprinkler protection because it is not physically practical to install sprinklers in these spaces. To reduce the possibility of uncontrolled fire spread, consideration should be given in these unsprinklered concealed space situations to using Exceptions Nos. 5, 8, and 9.

A-4-5.2.2 When practicable, sprinklers should be staggered at the alternate floor levels, particularly where only one sprinkler is installed at each floor level.

A-4-5.3.3 See Figures A-4-5.3.3(a) and (b).

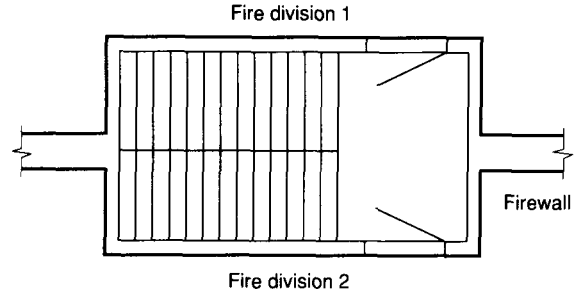


Figure A-4-5.3.3(a) Noncombustible stair shaft serving two fire sections.

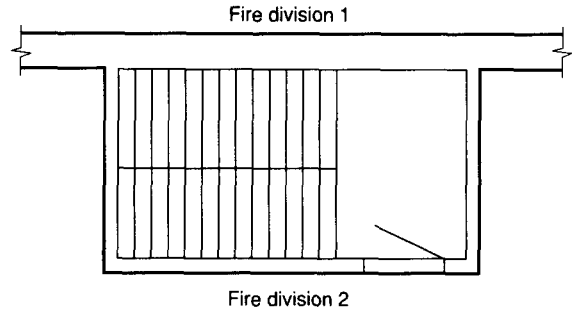


Figure A-4-5.3.3(b) Noncombustible stair shaft serving one fire section.

A-4-5.3.4 Where sprinklers in the normal ceiling pattern are closer than 6 ft (1.8 m) from the water curtain, it may be preferable to locate the water curtain sprinklers in recessed baffle pockets. (*See Figure A-4-5.3.4.*)

A-4-5.4 The installation of sprinklers at floor levels should be arranged so as to protect the sprinklers from mechanical injury and from falling materials and not cause obstruction within the chute. This can usually be accomplished by recessing the sprinkler in the wall of the chute or by providing a protective deflector canopy over the sprinkler. Sprinklers should be placed so that there will be minimum interference of the discharge therefrom. Sprinklers with special directional discharge characteristics may be advantageous. (*See Figure A-4-5.4.*)

A-4-5.5.1 The sprinklers in the pit are intended to protect against fires cause by debris, which can accumulate over time. Ideally, the sprinklers should be located near the side of the pit below the elevator doors, where most debris accumulates. However, care should be taken that the sprinkler location does not interfere with the elevator toe guard, which extends below the face of the door opening.

A-4-5.5.2 The ASME A17.1 code requires the shutdown of power to the elevator upon or prior to the application of water in elevator machine rooms or hoistways. This may be accomplished by a detection system with sufficient sensitivity to operate prior to the activation of the sprinklers (see also NFPA 72). As an alternative, the system may be arranged using devices or sprinklers capable of effecting power shutdown immediately upon sprinkler activation, such as a waterflow switch without a time delay. This is intended to interrupt power before significant sprinkler discharge.

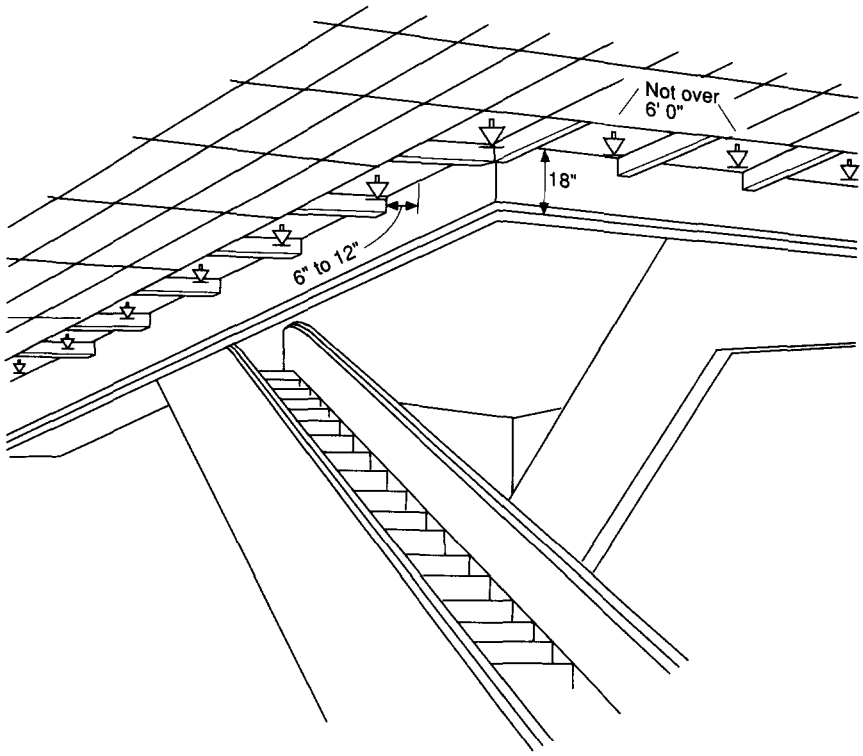


Figure A-4-5.3.4 Sprinklers around escalators.

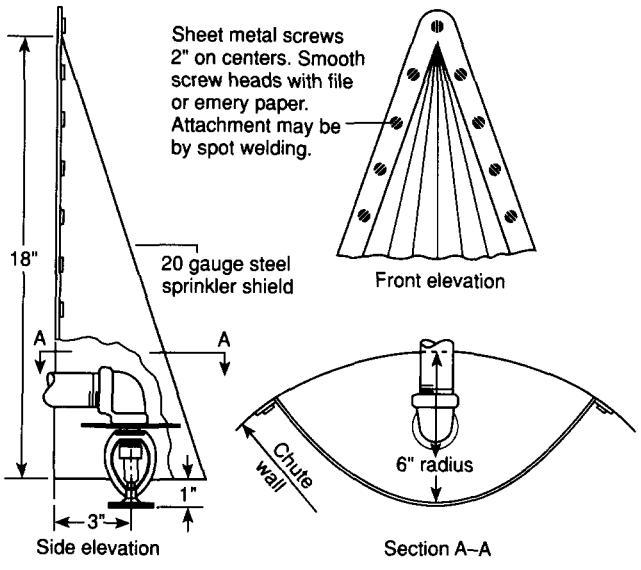


Figure A-4-5.4 Canopy for protecting sprinklers in building service chutes.

A-4-5.5.3 Passenger elevator cars that have been constructed in accordance with A17.1 Rule 204.2a (under A17.1a-1985 and later editions of the Code) have limited combustibility. Materials exposed to the interior of the car and the hoistway, in their end-use composition, are limited to a flame spread rating of 0 to 75, and a smoke development rating of 0 to 450.

A-4-5.7 Small loading docks, covered platforms, ducts, or similar small unheated areas may be protected by dry-pendent sprinklers extending through the wall from wet sprinkler piping in an adjacent heated area. Where protecting covered platforms, loading docks, and similar areas, a dry-pendent sprinkler should extend down at a 45 degree angle. The width of the area to be protected should not exceed 7½ ft (2.3 m). Sprinklers should be spaced not over 12 ft (3.7 m) apart. (*See Figure A-4-5.7.*)

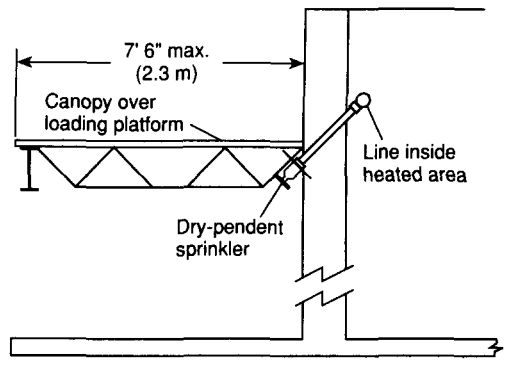


Figure A-4-5.7 Dry-pendent sprinklers for protection of covered platforms, loading docks, and similar areas.

A-4-5.8.2 Portable wardrobe units, such as those typically used in nursing homes and mounted to the wall, do not require sprinklers to be installed in them. Although the

units may be attached to the finished structure, the standard views those units as pieces of furniture rather than a part of the structure; thus, sprinklers are not required.

A-4-5.11 The installation of open-grid egg crate, louver, or honeycomb ceilings beneath sprinklers restricts the sideways travel of the sprinkler discharge and may change the character of discharge.

A-4-5.12.3 Drop-out ceilings do not provide the required protection for soft-soldered copper joints or other piping that requires protection.

A-4-5.12.4 The ceiling tiles may drop before sprinkler operation. Delayed operation may occur because heat must then bank down from the deck above before sprinklers will operate.

A-4-5.13 See NFPA 81, *Standard on Fur Storage, Fumigation and Cleaning*. 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.

A-4-5.20 One-and-one-half ($1\frac{1}{2}$) in. hose connections for use in storage occupancies and other locations where standpipe systems are not required are covered by this standard. Where Class II standpipe systems are required, see the appropriate provisions of NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, with respect to hose stations and water supply for hose connections from sprinkler systems.

A-4-5.21 Combined automatic sprinkler and standpipe risers should not be interconnected by sprinkler system piping.

A-4-5.22 See Figure A-4-5.22.

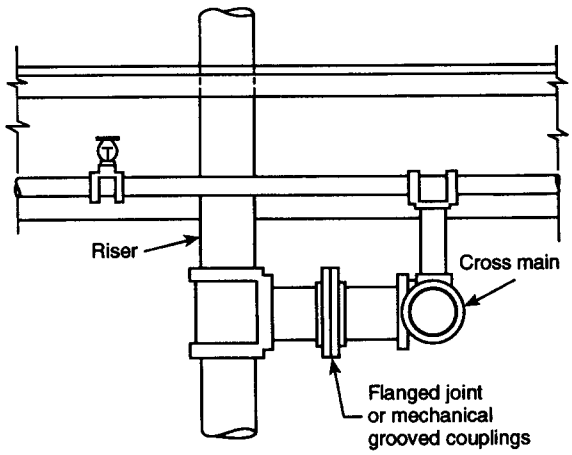


Figure A-4-5.22 One arrangement of flanged joint at sprinkler riser.

A-4-6.1.1 See Figure A-4-6.1.1.

A-4-6.1.1.1 A water supply connection should not extend into a building or through a building wall unless such connection is under the control of an outside listed indicating valve or an inside listed indicating valve located near the outside wall of the building.

All valves controlling water supplies for sprinkler systems or portions thereof, including floor control valves,

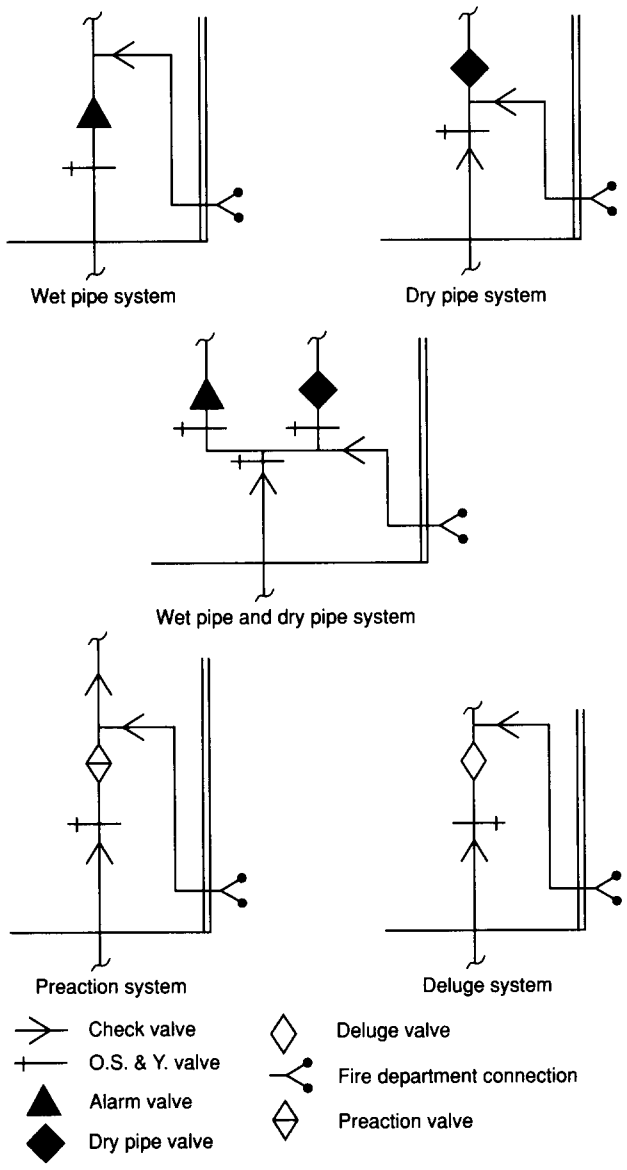


Figure A-4-6.1.1 Examples of acceptable valve arrangements.

should be accessible to authorized persons during emergencies. Permanent ladders, clamped treads on risers, chain-operated hand wheels, or other accepted means should be provided where necessary.

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

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

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

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

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

A-4-6.1.1.7 Where a system having only one dry pipe valve is supplied with city water and fire department connection, it will be satisfactory to install the main check valve in the water supply connection immediately inside of the building. In instances where there is no outside control valve, the system indicating valve should be placed at the service flange, on the supply side of all fittings.

A-4-6.1.1.8 See Figure A-4-6.1.1.8.

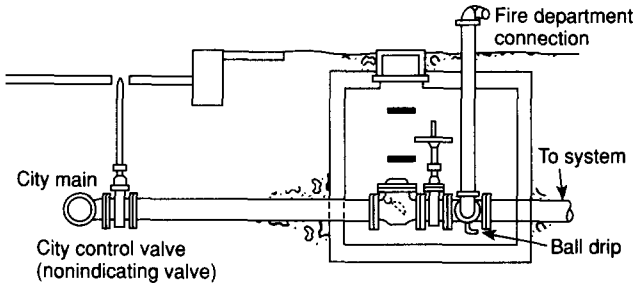
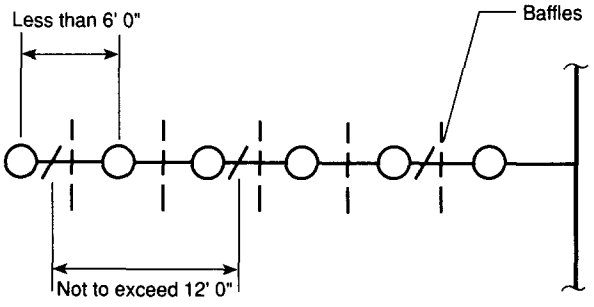


Figure A-4-6.1.1.8 Pit for gate valve, check valve, and fire department connection.

A-4-6.1.2.3 Where the relief valve operation would result in water being discharged onto interior walking or working surfaces, consideration should be given to piping the discharge from the valve to a drain connection or other safe location.

A-4-6.2.2.1 Where copper tube is to be installed in moist areas or other environments conducive to galvanic corrosion, copper hangers or ferrous hangers with an insulating material should be used.

A-4-6.2.3.1 Exception No. 1 See Figure A-4-6.2.3.1.



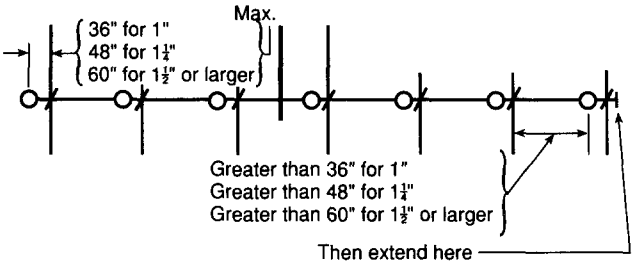
For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.

Figure A-4-6.2.3.1 Distance between hangers.

A-4-6.2.3.3 Sprinkler piping should be adequately secured to restrict the movement of piping upon sprinkler operation. The reaction forces caused by the flow of water through the sprinkler could result in displacement of the sprinkler, thereby adversely affecting sprinkler discharge. Listed CPVC pipe and listed polybutylene pipe have specific requirements for piping support to include additional pipe bracing of sprinklers. (*See Figure A-4-6.2.3.3.*)

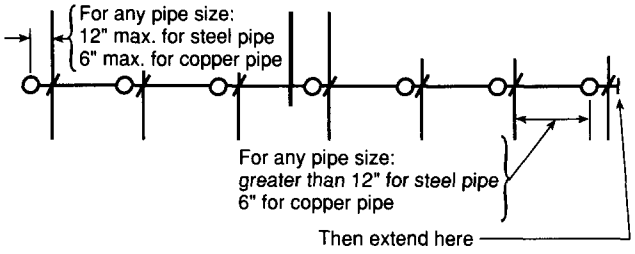
A-4-6.2.3.3 Exception No. 1 See Figure A-4-6.2.3.3 Exception No. 1.

A-4-6.2.3.3 Exception No. 2 See Figure A-4-6.2.3.3 Exception No. 2.



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

Figure A-4-6.2.3.3 Distance from sprinkler to hanger.



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

Figure A-4-6.2.3.3 Exception No. 1 Distance from sprinkler to hanger where maximum pressure exceeds 100 psi (6.9 bars) and a branch line above a ceiling supplies pendent sprinklers below the ceiling.

A-4-6.2.3.4 See Figure A-4-6.2.3.4.

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

A-4-6.3.1 All piping should be arranged where practicable to drain to the main drain valve.

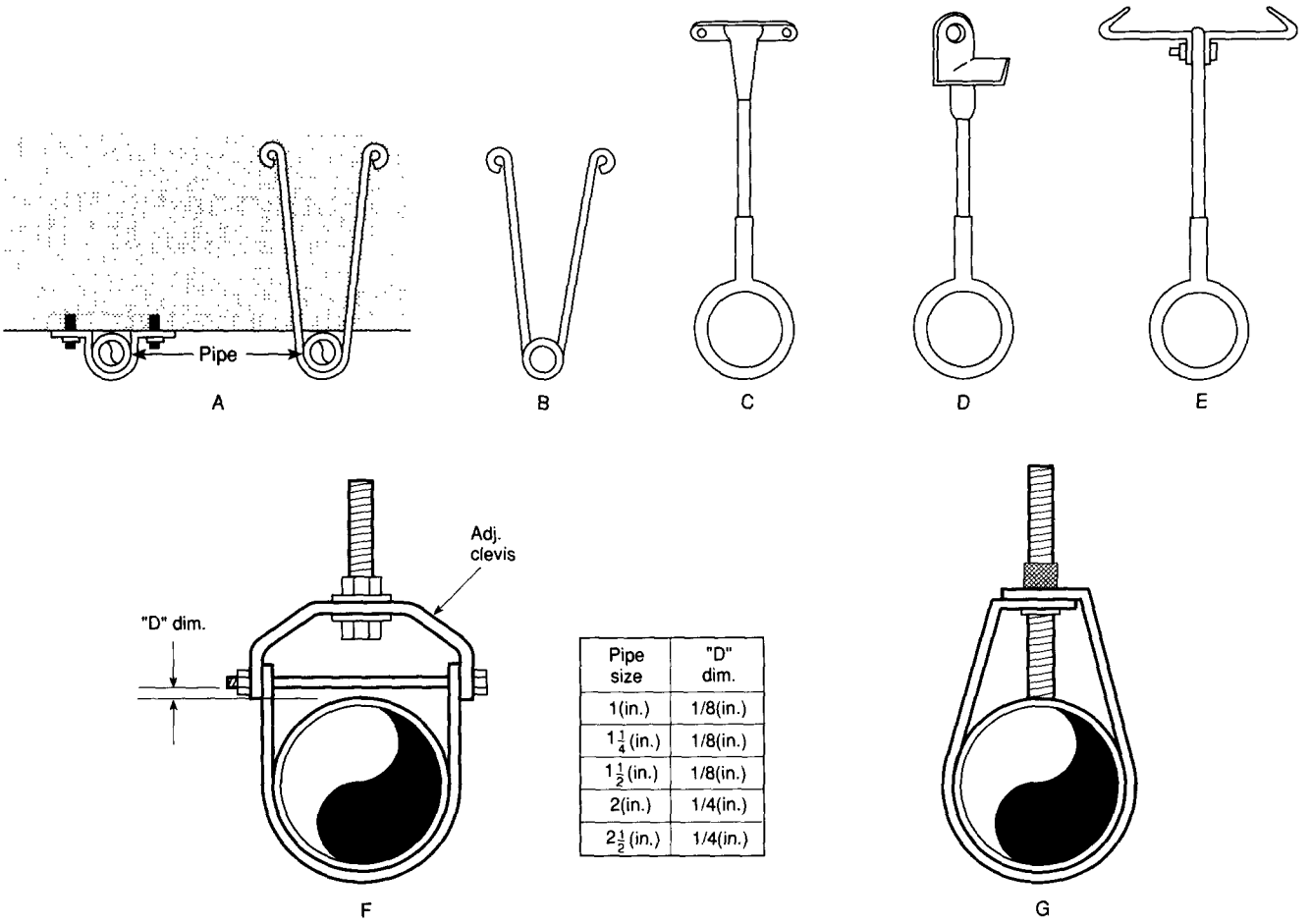
A-4-6.3.5.2.3 An example of an accessible location would be a valve located approximately 7 ft (2 m) above the floor level to which a hose could be connected to discharge the water in an acceptable manner.

A-4-6.3.6.1 Where possible, the main sprinkler riser drain should discharge outside the building at a point free from the possibility of causing water damage. Where it is not possible to discharge outside the building wall, the drain should be piped to a sump, which in turn should discharge by gravity or be pumped to a waste water drain or sewer. The main sprinkler riser drain connection should be of a size sufficient to carry off water from the fully open drain valve while it is discharging under normal water system pressures. Where this is not possible, a supplementary drain of equal size should be provided for test purposes with free discharge, located at or above grade.

A-4-6.4.2.1 Types of locations where corrosive conditions may exist include bleacheries, dye houses, metal plating processes, animal pens, and certain chemical plants.

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

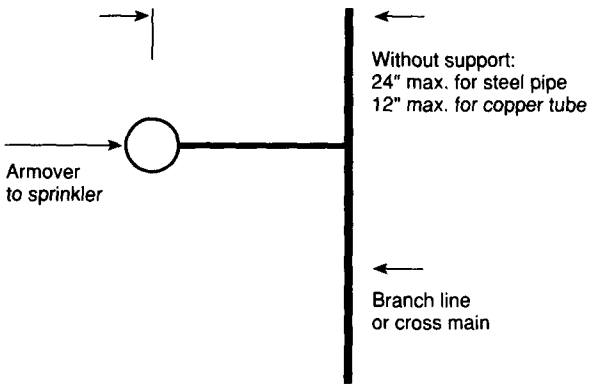
Where moisture conditions are severe but corrosive conditions are not of great intensity, copper tube or galvanized steel pipe, fittings, and hangers may be suitable. The exposed threads of steel pipe should be painted.



Pipe size	"D" dim.
1(in.)	1/8(in.)
$1\frac{1}{4}$(in.)	1/8(in.)
$1\frac{1}{2}$(in.)	1/8(in.)
2(in.)	1/4(in.)
$2\frac{1}{2}$(in.)	1/4(in.)

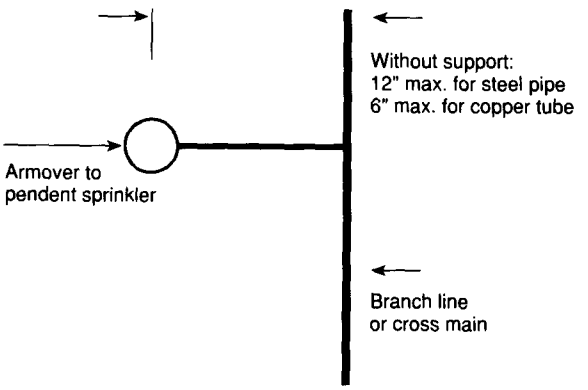
A U-type hangers for branch lines
B Wraparound U-hook
C Adjustable clip for branch lines
D Side beam adjustable hanger
E Adjustable coach screw clip for branch lines
F Clevis hanger
G Adjustable swivel loop hanger

Figure A-4-6.2.3.3 Exception No. 2 Examples of acceptable hangers for end of line (or armover) pendent sprinklers.



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

Figure A-4-6.2.3.4 Maximum length for unsupported armover.



For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.
NOTE: The pendent sprinkler may be installed either directly in the fitting at the end of the armover or in a fitting at the bottom of a drop nipple.

Figure A-4-6.2.3.4 Exception Maximum length of unsupported armover where the maximum pressure exceeds 100 psi (6.9 bars) and a branch line above a ceiling supplies pendent sprinklers below the ceiling.

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

A-4-6.4.3.1 Sprinkler systems are protected against earthquake damage by means of the following:

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

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

Areas known to have a potential for earthquakes have been identified in building code and insurance maps. Examples of two such maps are shown in Figures A-4-6.4.3.1(a) and A-4-6.4.3.1(b).

A-4-6.4.3.2 Strains on sprinkler piping can be greatly lessened and, in many cases, damage prevented by increasing the flexibility between major parts of the sprinkler system. One part of the piping should never be held rigidly and another part allowed to move freely without provision for relieving the strain. Flexibility can be provided by using listed flexible couplings, by joining grooved end pipe at critical points, and by allowing clearances at walls and floors.

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

Piping 2 in. (50 mm) or smaller in size is pliable enough so that flexible couplings are not usually necessary. "Rigid-type" couplings that permit less than 1 degree of angular movement at the grooved connections are not considered to be flexible couplings. [*See Figures A-4-6.4.3.2(a) and (b).*]

A-4-6.4.3.2(d) A building expansion joint is usually a bituminous fiber strip used to separate blocks or units of concrete to prevent cracking due to expansion as a result of temperature changes. In this case, the flexible coupling required on one side by 4-6.4.3.2(d) will suffice.

For seismic separation joints, considerably more flexibility is needed, particularly for piping above the first floor. Figure A-4-6.4.3.3 shows a method of providing additional flexibility through the use of swing joints.

A-4-6.4.3.3 Plan and elevation views of a seismic separation assembly assembled with flexible elbows are shown in Figure A-4-6.4.3.3.

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

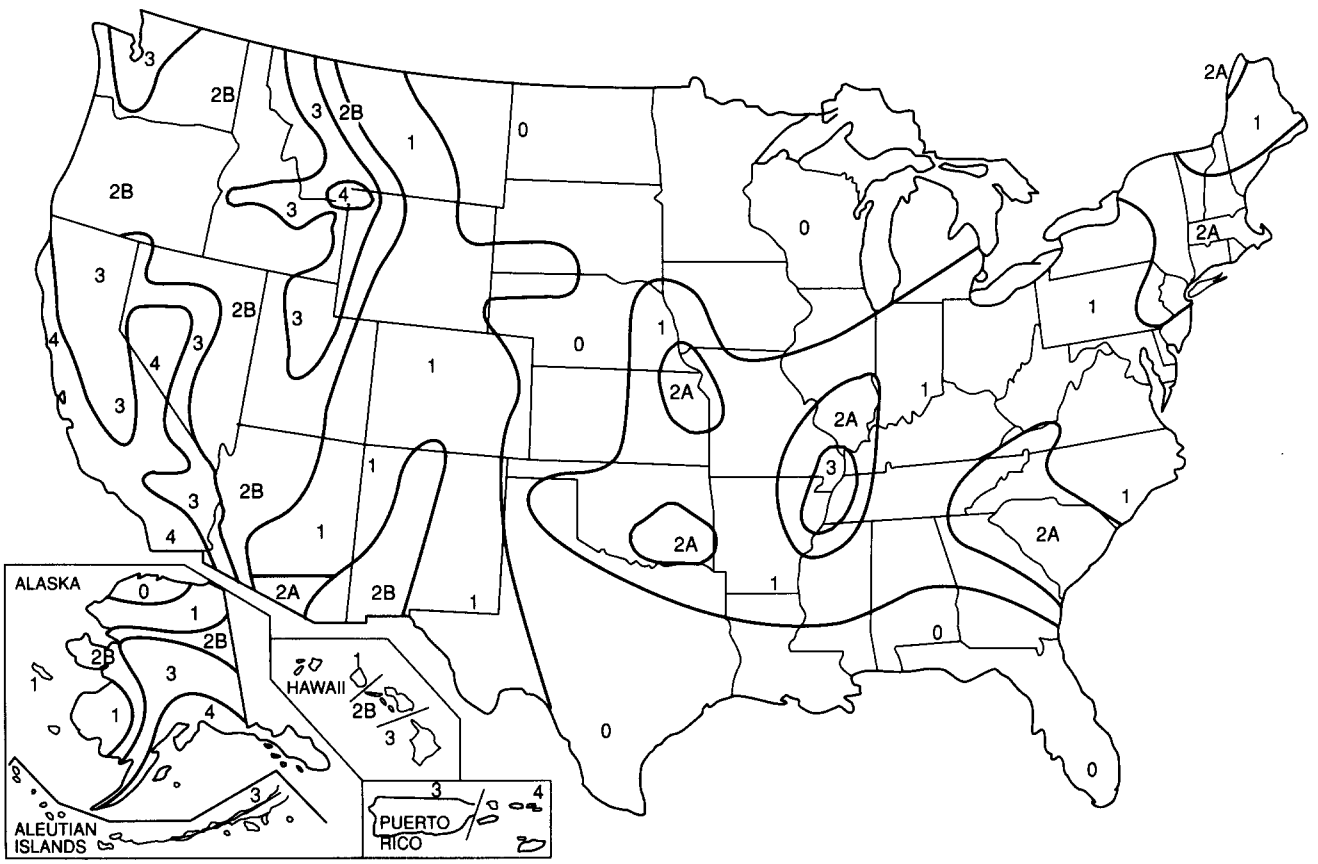


Figure A-4-6.4.3.1(a) Seismic zone map of the United States.

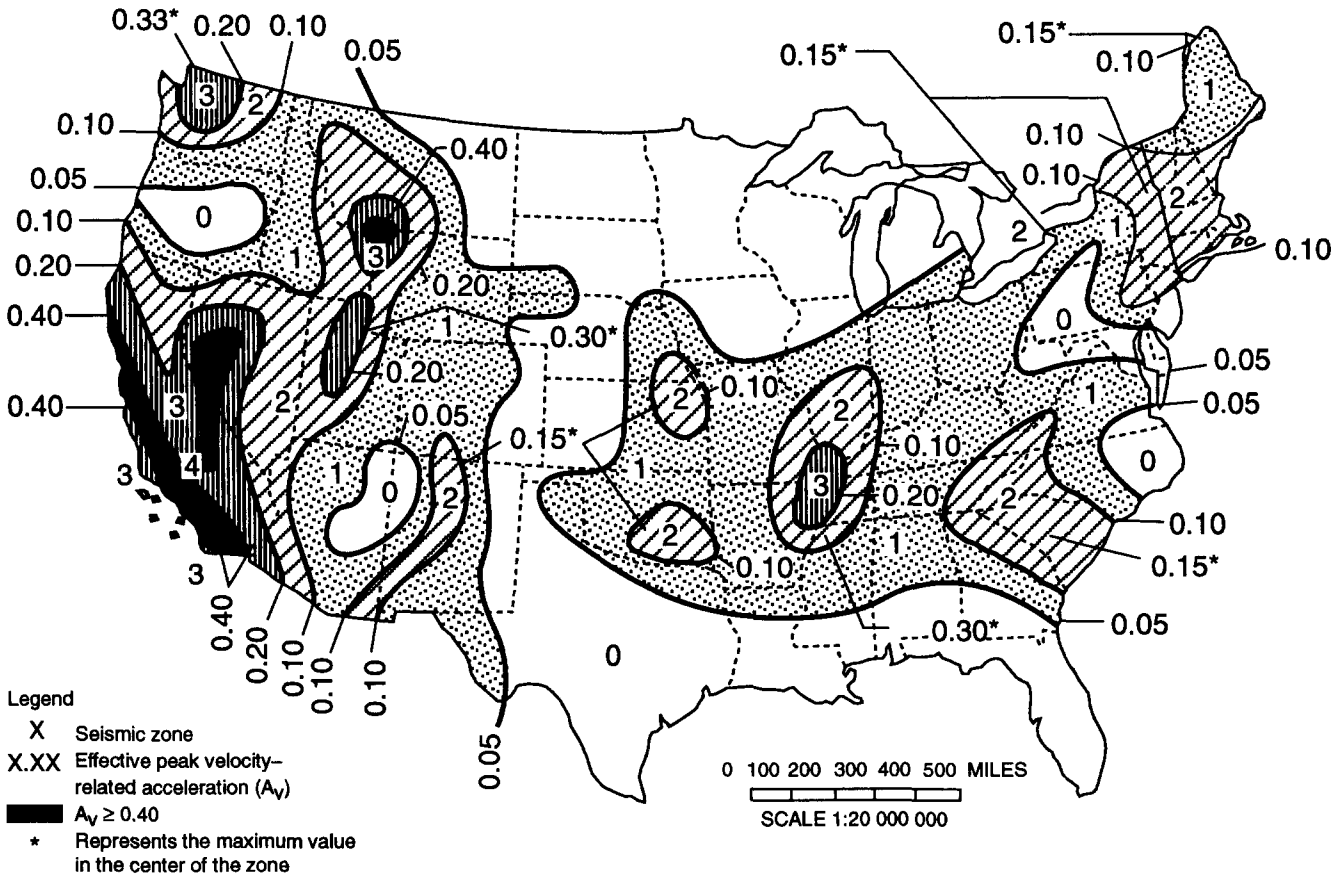
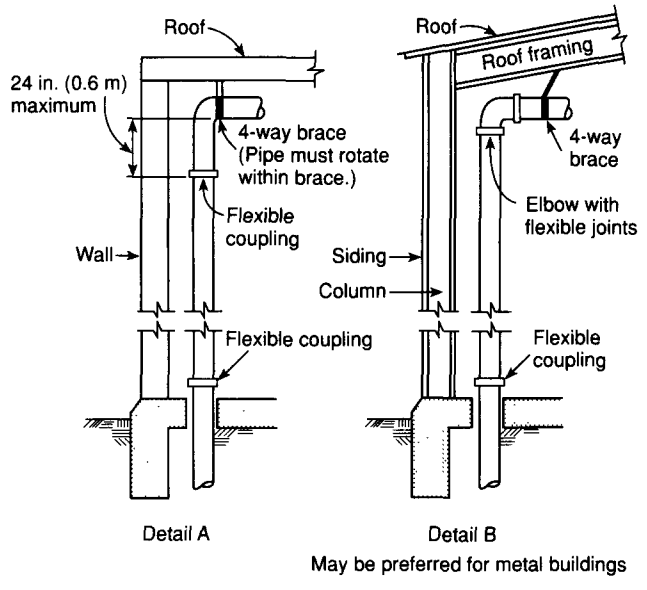


Figure A-4-6.4.3.1(b) Map of seismic zones and effective peak velocity-related acceleration (A_v) for contiguous 48 states. Linear interpolation between contours is acceptable.



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

Figure A-4-6.4.3.2(a) Riser details.

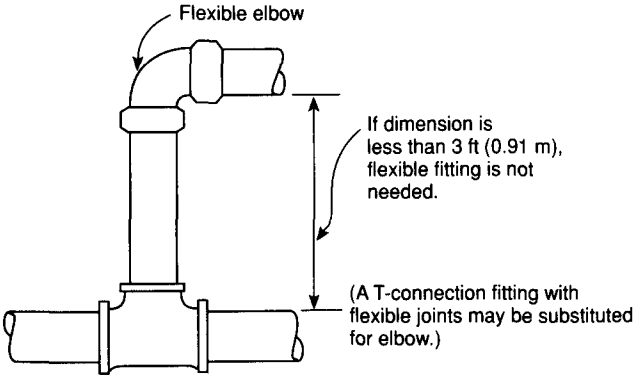
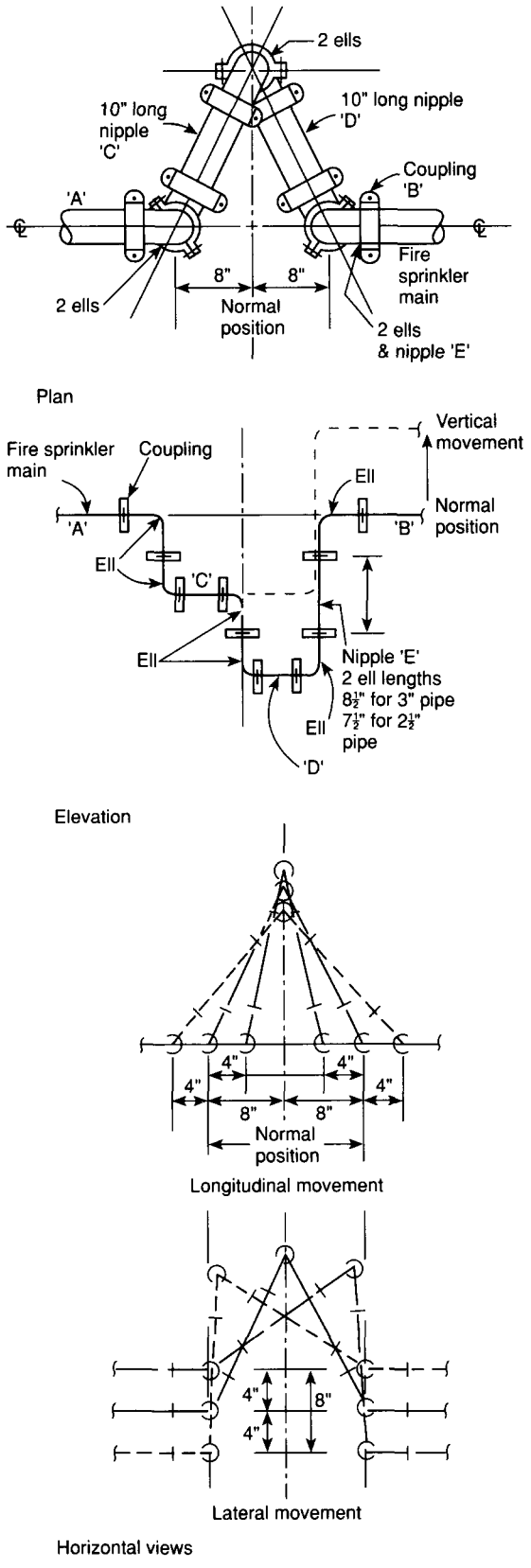


Figure A-4-6.4.3.2(b) Detail at short riser.



For SI Units: 1 in. = 25.4 mm; 1 ft = 0.305 m.

Figure A-4-6.4.3.3 Seismic separation assembly. Illustrates an 8-in. separation crossed by pipes up to 4 in. in nominal diameter. For other separation distances and pipe sizes, lengths and distances should be modified proportionally.

A-4-6.4.3.4 While clearances are necessary around the sprinkler piping to prevent breakage due to building movement, suitable provision should also be made to prevent passage of water, smoke, or fire.

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

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

A-4-6.4.3.5.2 Location of Sway Bracing. Two-way braces are either longitudinal or lateral depending on their orientation with the axis of the piping. [*See Figures A-4-6.4.3.5.2(a), (b), (c), and (d).*] The simplest form of two-way brace is a piece of steel pipe or angle. Because the brace must act in both compression and tension, it is necessary to size the brace to prevent buckling.

An important aspect of sway bracing is its location. In Building 1 of Figure A-4-6.4.3.5.2(a), the relatively heavy main will pull on the branch lines when shaking occurs. If the branch lines are held rigidly to the roof or floor above, the fittings can fracture due to the induced stresses.

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

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

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

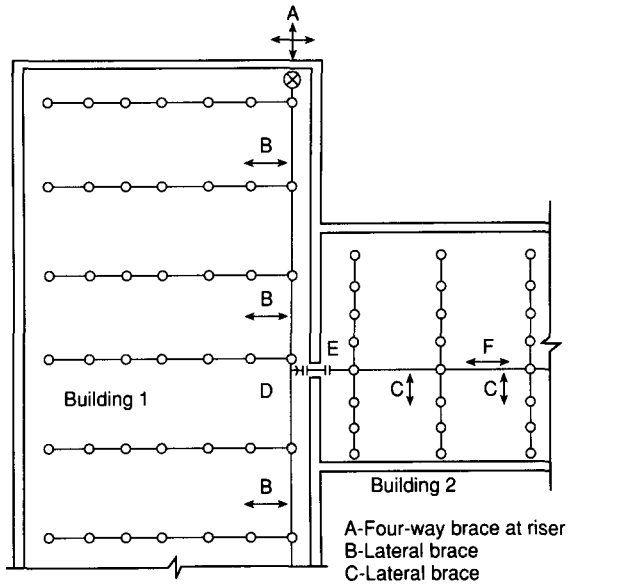


Figure A-4-6.4.3.5.2(a) Earthquake protection for sprinkler piping.

Figures A-4-6.4.3.5.2(b), (c), and (d) show typical locations of sway bracing.

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

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

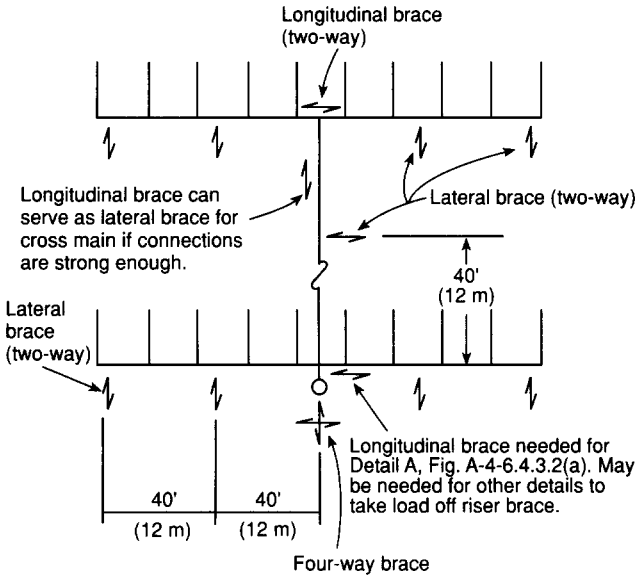


Figure A-4-6.4.3.5.2(b) Typical location of bracing on a tree system.

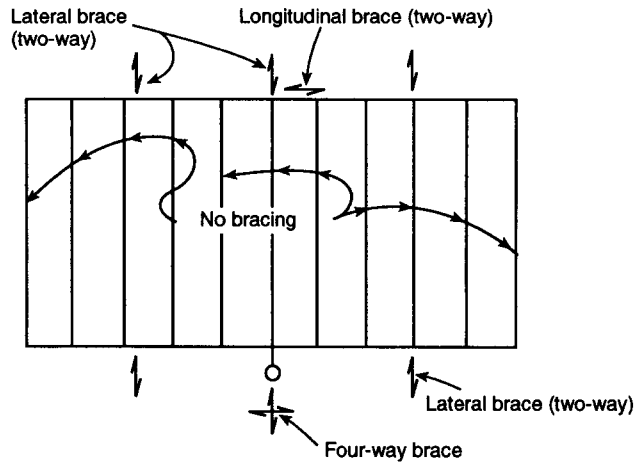


Figure A-4-6.4.3.5.2(c) Typical location of bracing on a gridded system.

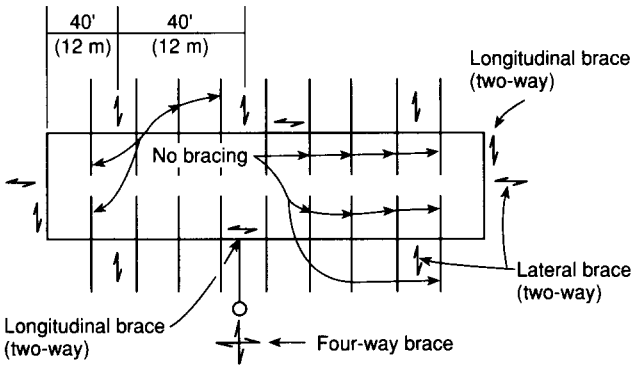


Figure A-4-6.4.3.5.2(d) Typical location of bracing on a looped system.

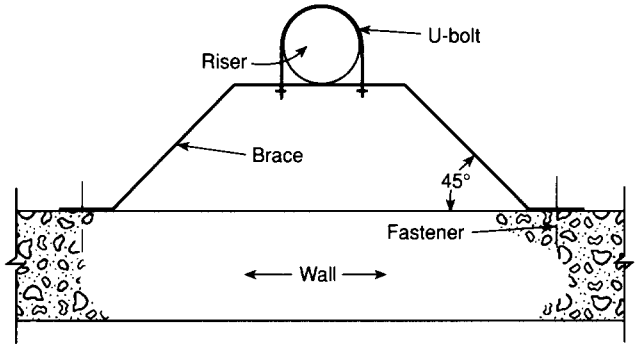


Figure A-4-6.4.3.5.2(e) Detail of four-way brace at riser.

The brace can be attached to the structural system directly through a leg of an angle or a flattened portion of pipe. Figures A-4-6.4.3.5.2(e) and (f) show acceptable connections. Where dimensions are tight or some play must be allowed, a special fitting can be used. [*See Figure A-4-6.4.3.5.2(g).*] This threads on an end of pipe. Rotation of the flat around the bolt allows play in the angle of the brace without sacrificing snugness.

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

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

(a) Based on the distance of mains from the structural members that will support the braces, choose brace shapes and sizes from Table 4-6.4.3.5.3 such that the maximum slenderness ratios l/r do not exceed 200. The angle of the braces from the vertical should be at least 30 degrees and preferably 45 degrees or more.

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

(c) Determine the total load tentatively applied to each brace in accordance with the examples shown in Figure A-4-6.4.3.5.2(h) and the following:

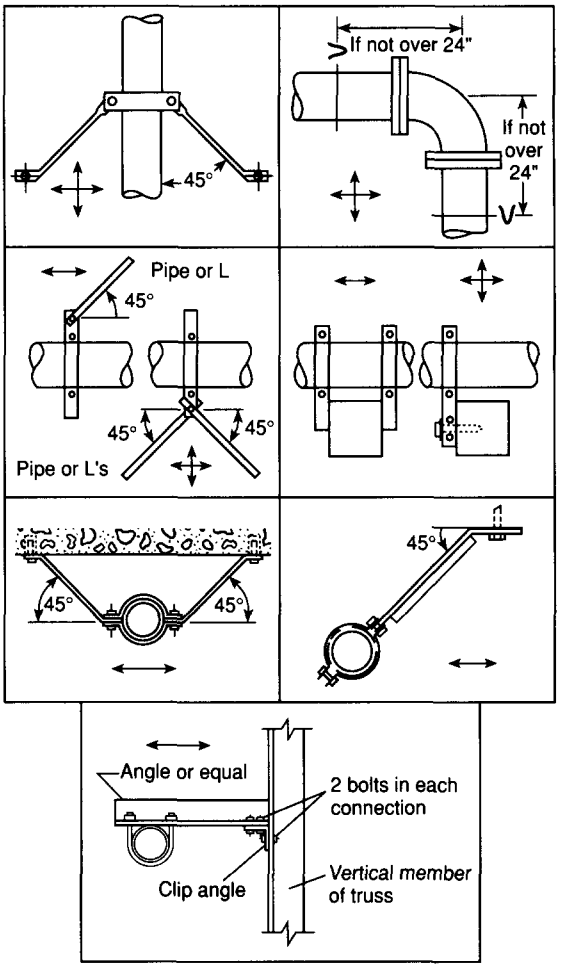


Figure A-4-6.4.3.5.2(f) Acceptable types of sway bracing.

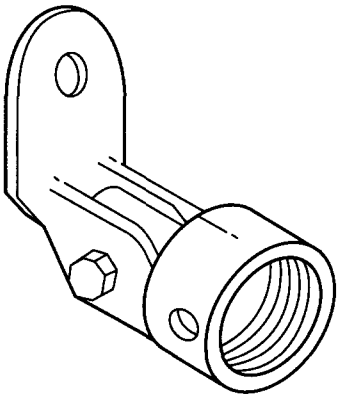


Figure A-4-6.4.3.5.2(g) Special fitting.

1. For the loads on lateral braces on cross mains, add one-half the weight of the branch to one-half the weight of the portion of the cross main within the zone of influence of the brace. [*See examples 1, 3, 6, and 7 in Figure A-4-6.4.3.5.2(h).*]

2. For the loads on longitudinal braces on cross mains, consider only one-half the weight of the cross mains and feed mains within the zone of influence. Branch lines need not be included if piping is provided with lateral sway bracing.

3. For the four-way brace at the riser, add the longitudinal and lateral loads within the zone of influence of the brace. [*See examples 2, 3, 4, 5, 7, and 8 in Figure A-4-6.4.3.5.2(h).*]

Use the information on weights of water-filled piping contained within Table A-4-6.4.3.5.2.

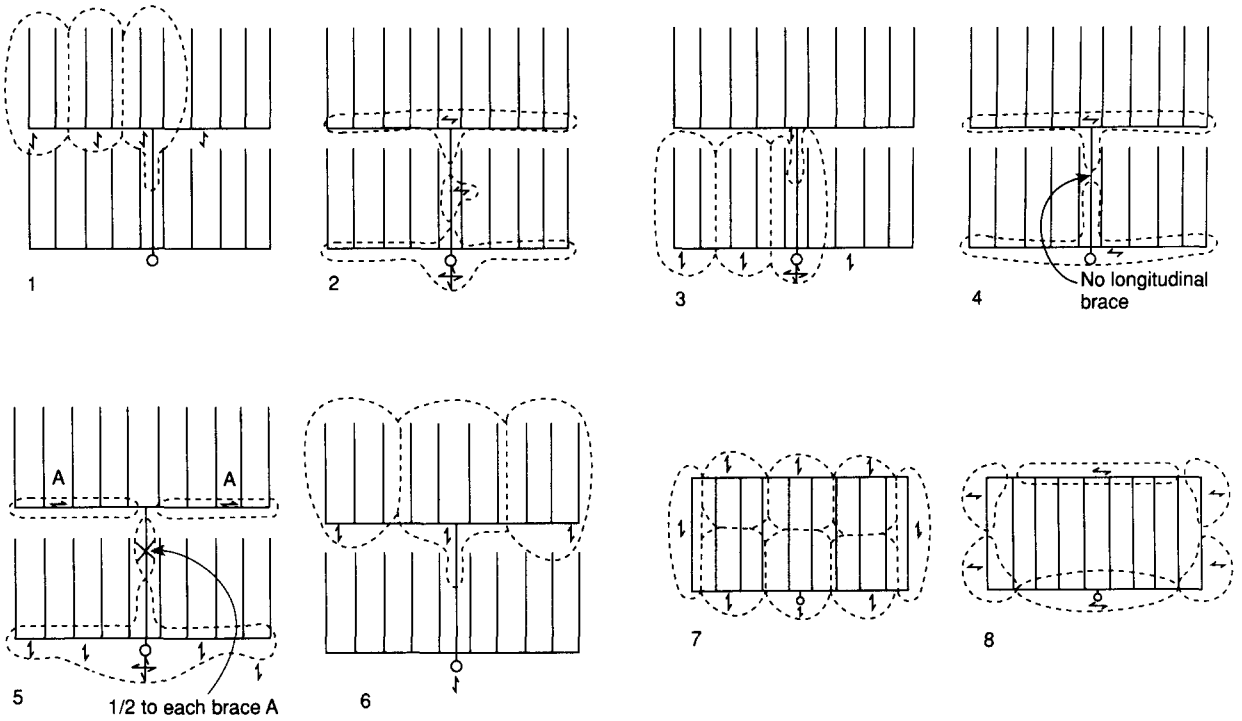


Figure A-4-6.4.3.5.2(h) Examples of load distribution to bracing.

(d) If the total expected loads are less than the maximums permitted in Table 4-6.4.3.5.3 for the particular brace and orientation, go on to step (e). If not, add additional braces to reduce the zones of influence of overloaded braces.

(e) Check that fasteners connecting the braces to structural supporting members are adequate to support the expected loads on the braces in accordance with Table 4-6.4.3.5.4. If not, again add additional braces or additional means of support.

A-4-6.4.3.5.6 The four-way brace provided at the riser may also provide longitudinal and lateral bracing for adjacent mains.

A-4-6.4.3.5.11 Wires used for piping restraints should be attached to the branch line with two tight turns around the pipe, and fastened with four tight turns within 1½ in. (37.5 mm), and should be attached to the structure in accordance with the details shown in Figures A-4-6.4.3.5.11(a) through (d) or other approved method.

A-4-6.4.3.5.11 Exception No. 3 The splayed seismic wire should be provided as close as possible to the hanger.

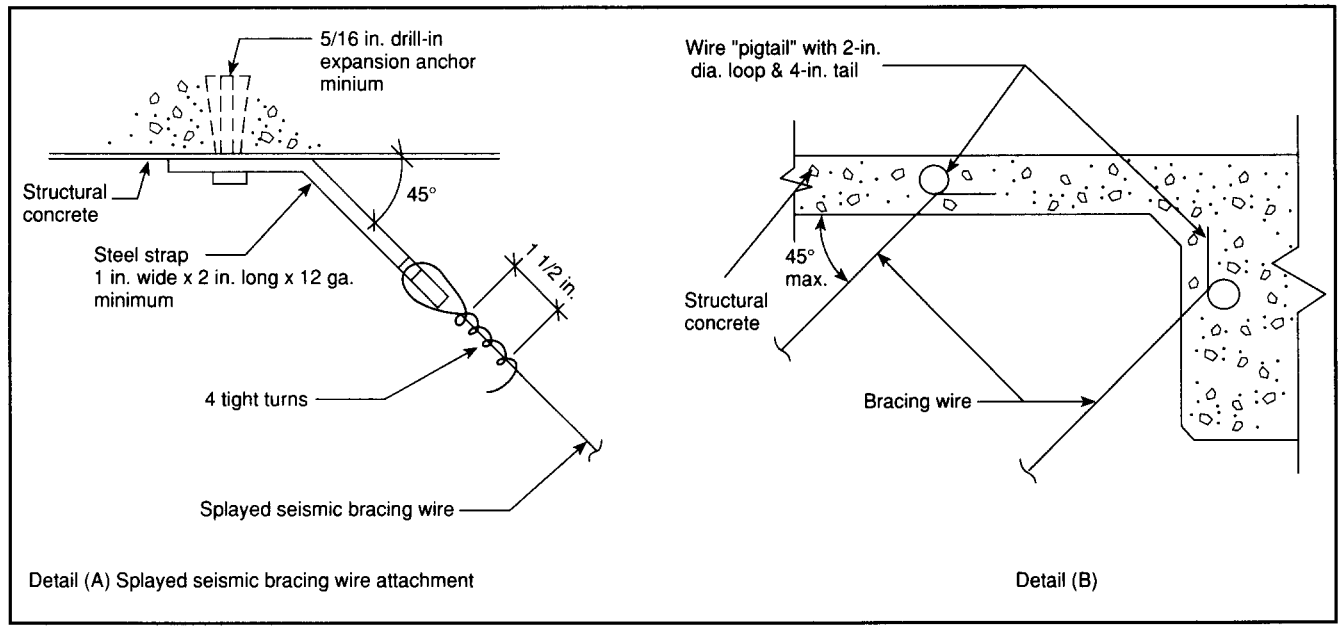
A-4-6.4.3.5.12 Such restraint may be provided by using the splayed seismic brace wire discussed in A-4-6.4.3.5.11 Exception No. 3.

A-4-7.1.1 Central station, auxiliary, remote station, or proprietary protective signaling systems are a highly desirable supplement to local alarms, especially from a safety to life standpoint. (*See 4-7.1.1.6.*)

Table A-4-6.4.3.5.2 Piping Weights for Determining Horizontal Load

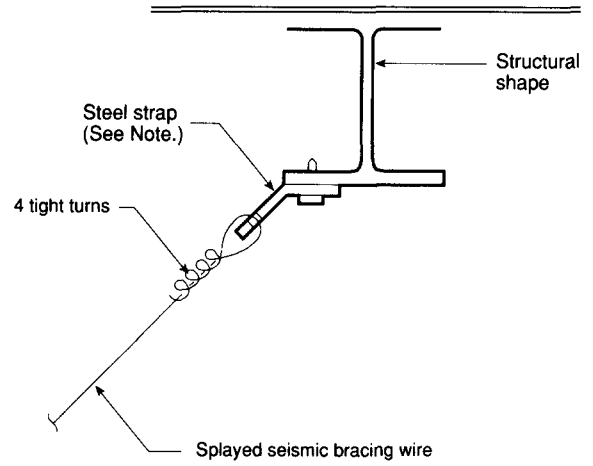
Schedule 40 Pipe (in.)	Weight of Water-Filled Pipe (lb per ft)	½ Weight of Water-Filled Pipe (lb per ft)
1	2.05	1.03
1¼	2.93	1.47
1½	3.61	1.81
2	5.13	2.57
2½	7.89	3.95
3	10.82	5.41
3½	13.48	6.74
4	16.40	8.20
5	23.47	11.74
6	31.69	15.85
8*	47.70	23.85
Schedule 10 Pipe (in.)		
1	1.81	0.91
1¼	2.52	1.26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

* Schedule 30
For SI Units: 1 in. = 25.4 mm; 1 lb = 0.45kg; 1 ft = 0.30 m.



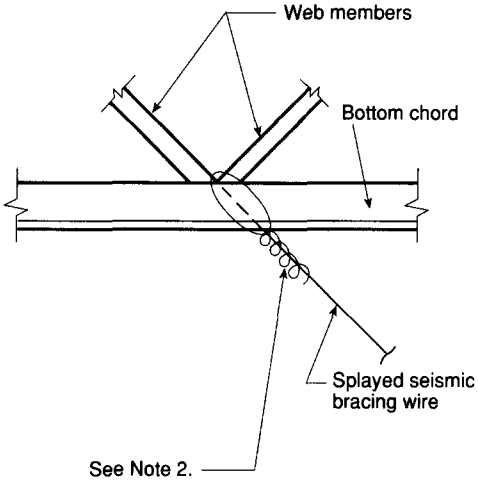
For SI Units: 1 in. = 25.4 mm.

Figure A-4-6.4.3.5.11(a) Wire attachment to cast-in-place concrete.



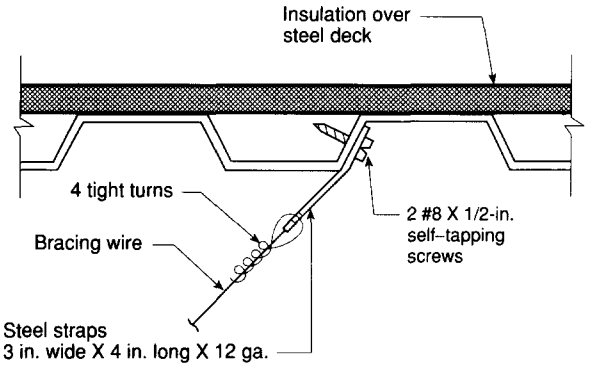
Note: See Figure A-4-6.4.3.5.11(a), Detail (B).

Detail (A) At steel beams



Note 1: Splay wires parallel to joist. Splay wires cannot be perpendicular to joist.
Note 2: See Figure A-4-6.4.3.5.11(a), Details (A) and (B).

Detail (B) At Open-Web Steel Joist

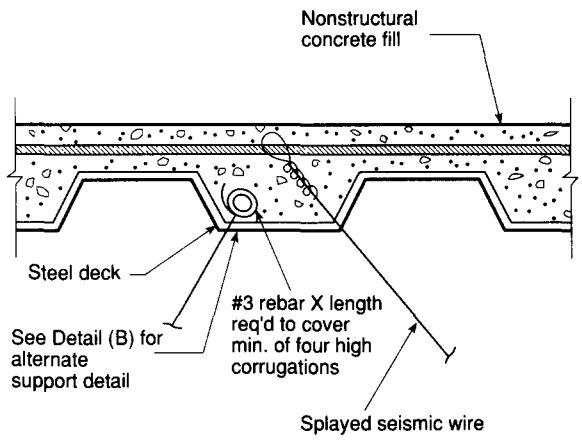


Note: If self-tapping screws are used with concrete fill, set screws before placing concrete.

Detail (C) At steel roof deck

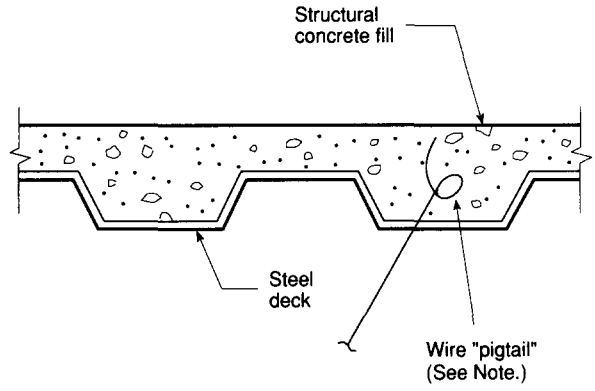
For SI Units: 1 in. = 25.4 mm.

Figure A-4-6.4.3.5.11(b) Acceptable details — wire connections to steel framing.



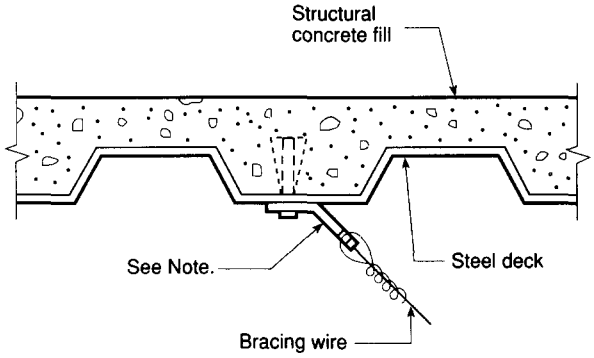
Note: Bracing wire detail similar.

Detail (A) At steel deck with insulating fill



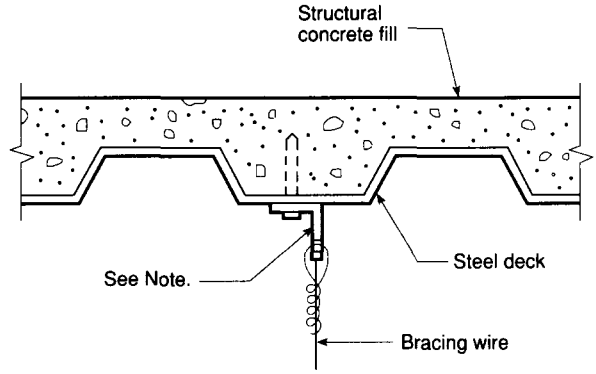
Note: See Figure A-4-6.4.3.5.11(a), Detail (B).

Detail (B) At steel deck with concrete fill



Note: See Figure A-4-6.4.3.5.11(a), Detail (B).

Detail (C) At steel deck with concrete fill

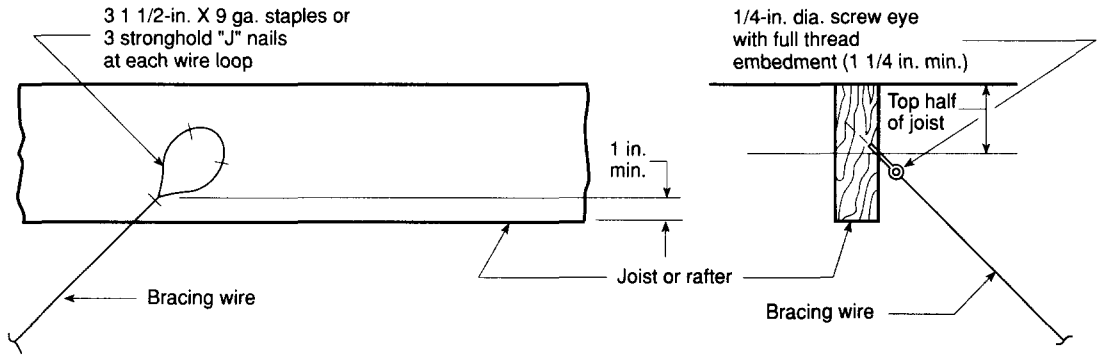


Note: See Figure A-4-6.4.3.5.11(a), Detail (A).

Detail (D) At steel deck with concrete fill

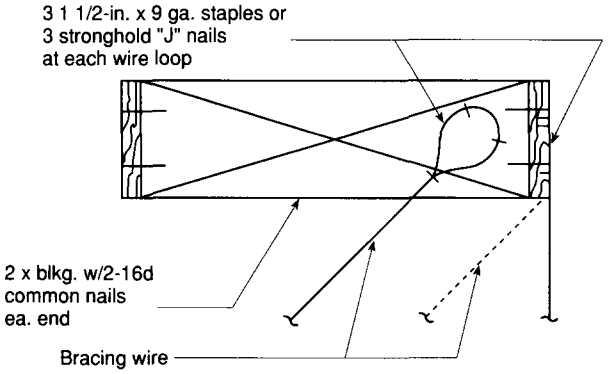
For SI Units: 1 in. = 25.4 mm.
Note: If self-tapping screws are used with concrete fill, set screws before placing concrete.

Figure A-4-6.4.3.5.11(c) Acceptable details — wire connections to steel framing.

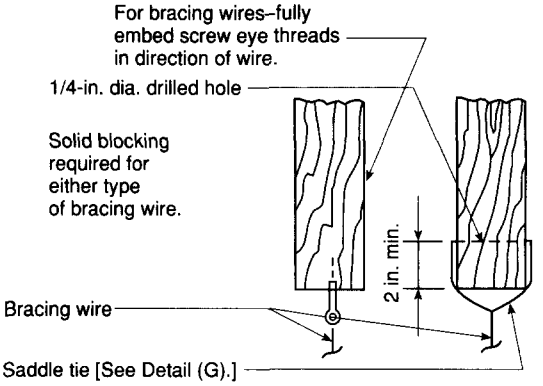


Detail (A) Wood joist or rafter

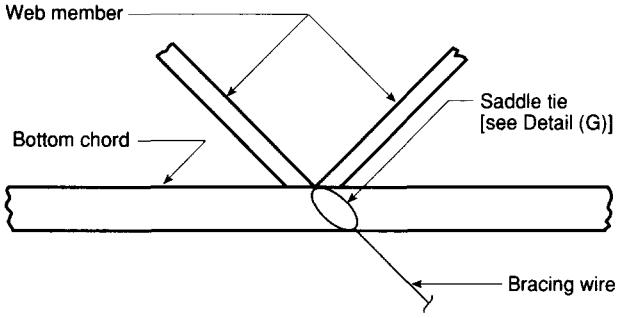
Detail (B) At wood joist or rafter



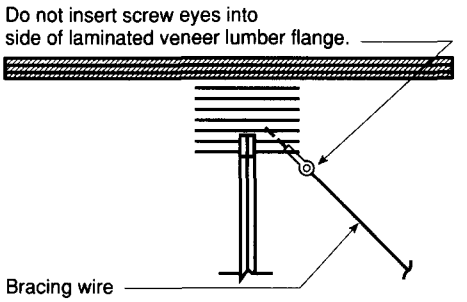
Detail (C) At wood joist or block



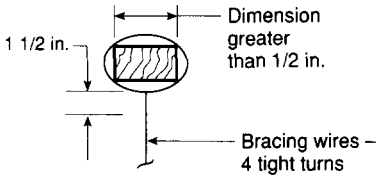
Detail (D) To bottom of joist



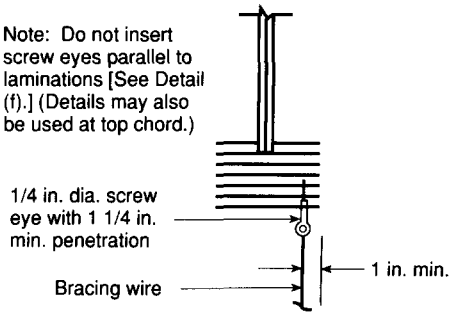
Detail (E) Bracing wire parallel to wood truss



Detail (F) Laminated veneer lumber upper flange



Detail (G) Typ. saddle tie



(H) Laminated veneer lumber lower flange

For SI Units: 1 in. = 25.4 mm.

Figure A-4-6.4.3.5.11(d) Acceptable details — wire connections to wood framing.

Identification Signs. Approved identification signs, as shown in Figure A-4-7.1.1, should be provided for outside alarm devices. The sign should be located near the device in a conspicuous position and should be worded as follows:

"SPRINKLER FIRE ALARM — WHEN BELL RINGS CALL FIRE DEPARTMENT OR POLICE."

Figure A-4-7.1.1 Identification sign.

A-4-7.1.1.5 Water-motor-operated devices should be located as near as practicable to the alarm valve, dry pipe valve, or other waterflow detecting device. The total length of the pipe to these devices should not exceed 75 ft (22.9 m), nor should the water-motor-operated device be located over 20 ft (6.1 m) above the alarm device or dry pipe valve.

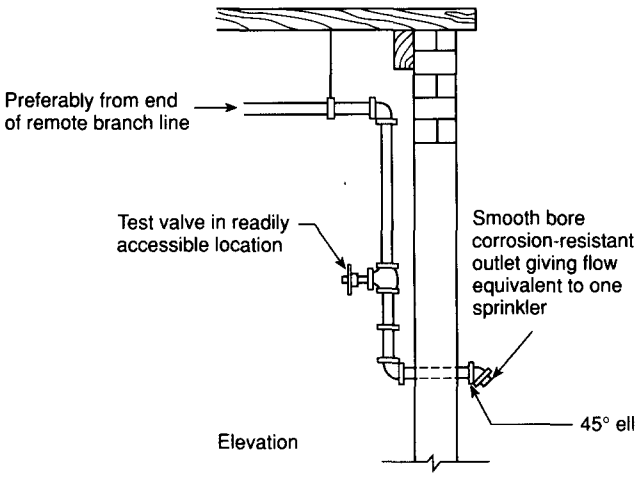
A-4-7.1.1.6 Monitoring should include but not be limited to control valves, building temperatures, fire pump power supplies and running conditions, and water tank levels and temperatures. Pressure supervision shall also be provided on pressure tanks.

A-4-7.2 The fire department connection should be located not less than 18 in. (457 mm) and not more than 4 ft (1.22 m) above the level of the adjacent grade or access level.

A-4-7.2.1 Fire department connections should be located and arranged so that hose lines can be readily and conveniently attached without interference from nearby objects including buildings, fences, posts, or other fire department connections. Where a hydrant is not available, other water supply sources such as a natural body of water, a tank, or reservoir should be utilized. The water authority should be consulted when a nonpotable water supply is proposed as a suction source for the fire department.

A-4-7.2.3 The check valve should be located to maximize accessibility and minimize freezing potential.

A-4-7.4.2 This test connection should be in the upper story, and the connection should preferably be piped from the end of the most remote branch line. The discharge should be at a point where it can be readily observed. In locations where it is not practical to terminate the test connection outside the building, the test connection may terminate into a drain capable of accepting full flow under system pressure. In this event, the test connection should be made using an approved sight test connection containing a smooth bore corrosion-resistant orifice giving a flow equivalent to one sprinkler simulating the least flow from an individual sprinkler in the system. [*See Figures A-4-7.4.2(a) and A-4-7.4.2(b).*] The test valve should be located at an accessible point and preferably not over 7 ft (2.1 m) above the floor. The control valve on the test connection should be located at a point not exposed to freezing.



For SI Units: 1 ft = 0.3048 m.
NOTE: Not less than 4 ft (1.2 m) of exposed test pipe in warm room beyond valve where pipe extends through wall to outside.

Figure A-4-7.4.2(a) System test connection on wet pipe system.

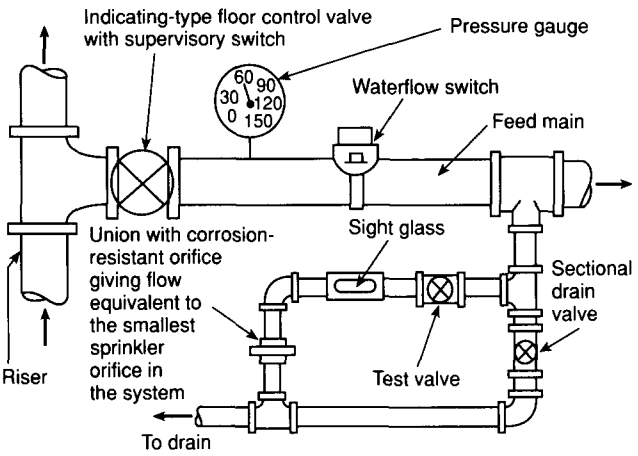
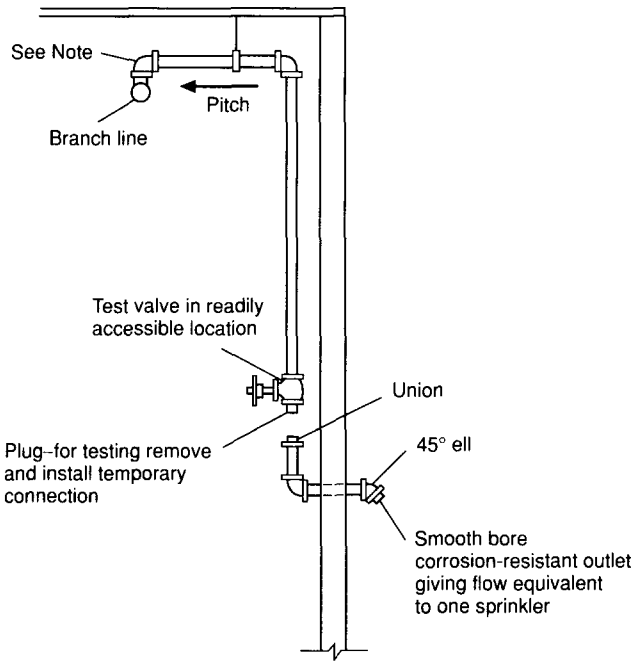


Figure A-4-7.4.2(b) Floor control valve.

A-4-7.4.3 See Figure A-4-7.4.3.

A-5-2.2.3 The additional pressure that is needed at the level of the water supply to account for sprinkler elevation is 0.433 psi per ft (9.8 kPa/m) of elevation above the water supply.

A-5-2.3.1.1 Appropriate area/density, other design criteria, and water supply requirements should be based on scientifically based engineering analyses that may include submitted fire testing, calculations, or results from appropriate computational models.



NOTE: To minimize condensation of water in the drop to the test connection, provide a nipple-up off of the branch line.

Figure A-4-7.4.3 System test connection on dry pipe system.

A-5-2.3.1.3(b) This section is included to compensate for possible delay in operation of sprinklers from fires in combustible concealed spaces found in wood frame, brick veneer, and ordinary construction.

A-5-2.3.1.3(b) Exception No. 2 Composite wood joists are not considered solid wood joists for the purposes of this section. Their web members are too thin and easily penetrated to adequately compartment a fire in an unsprinklered space.

A-5-2.3.1.3(b) Exception No. 3 This exception is intended to apply only when the exposed materials in the space are limited combustible materials or fire retardant treated wood as defined in NFPA 703, *Standard for Fire Retardant Impregnated Wood and Fire Retardant Coatings for Building Materials.*

A-5-2.3.2.2 Exception No. 1 It is not the intent of this exception to restrict the use of quick-response sprinklers in Extra Hazard Occupancies, but rather to indicate that the areas and densities shown in Figure 5-2.3 may not be appropriate for use with quick-response sprinklers in those environments due to a concern with water supplies.

A-5-2.3.3.1 This section allows for calculation of the sprinklers in the largest room, so long as the calculation produces the greatest hydraulic demand among selection of rooms and communicating spaces. For example, in a case where the largest room has 4 sprinklers and a smaller room has 2 sprinklers but communicates through unprotected openings with 3 other rooms, each having 2 sprinklers, the smaller room and group of communicating spaces should also be calculated.

Corridors are rooms and should be considered as such.

Walls may terminate at a substantial suspended ceiling and need not be extended to a rated floor slab above for this section to be applied.

A-5-3.2.2 See Figure A-5-3.2.2.

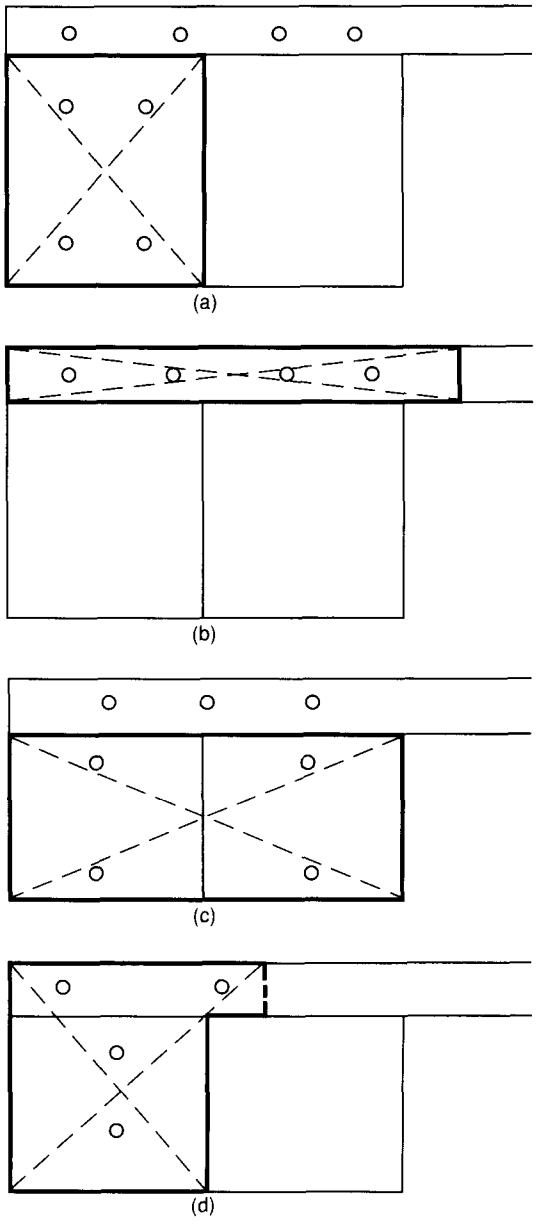


Figure A-5-3.2.2 Examples of design area for dwelling units. Calculate area indicated by heavy outline and X. Circle indicates sprinklers.

A-5-3.4 See Table A-5-3.4.

A-5-3.5 See Table A-5-3.5.

A-5-3.6.1 If the system is a deluge type, then all the sprinklers need to be calculated even if they are located on different building faces.

A-6-1 Preliminary layouts should be submitted for review to the authority having jurisdiction before any equipment is installed or remodeled in order to avoid error or subsequent misunderstanding. (*See Figure A-6-1.*) Any material deviation from approved plans will require permission of the authority having jurisdiction.

Table A-5-3.4 Large-Drop Sprinkler Data

Pressure and Number of Design Sprinklers Required for Various Hazards for Large-Drop Sprinklers

Hazard	Type of System	Minimum Operating Pressure,[1] psi (bar) 25 (1.7)	50 (3.4)	75 (5.2)	Hose Stream Demand gal/min (dm³/min)	Water Supply Duration, Hr
		Number Design Sprinklers				
Palletized[2] Storage						
Class I, II, and III commodities up to 25 ft (7.6 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	15	Note 4	Note 4	500 (1900)	2
	Dry	25	Note 4	Note 4		
Class IV commodities up to 20 ft (6.1 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	20	15	Note 4		
	Dry	Does not apply	Does not apply	Does not apply	500 (1900)	2
Unexpanded plastics up to 20 ft (6.1 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	25	15	Note 4		
	Dry	Does not apply	Does not apply	Does not apply	500 (1900)	2
Expanded plastics commodities up to 18 ft (5.5 m) with maximum 8 ft (2.4 m) clearance to ceiling	Wet	Does not apply	15	Note 4	500 (1900)	2
	Dry	Does not apply	Does not apply	Does not apply		
Idle wood pallets up to 20 ft (6.1 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	15	Note 4	Note 4		
	Dry	25	Note 4	Note 4	500 (1900)	1½
Solid Piled[2] Storage						
Class I, II, and III commodities up to 20 ft (6.1 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	15	Note 4	Note 4		
	Dry	25	Note 4	Note 4	500 (1900)	1½
Class IV commodities and unexpanded plastics up to 20 ft (6.1 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	Does not apply	15	Note 4		
	Dry	Does not apply	Does not apply	Does not apply	500 (1900)	1½
Double-Row Rack Storage[3] with Minimum 5.5 ft (1.7 m) Aisle Width and Multiple-Row Rack Storage with Minimum 8.0 ft (2.5 m) Aisle Width						
Class I and II commodities up to 25 ft (7.6 m) with maximum 5 ft (1.5 m) clearance to ceiling	Wet	20	Note 4	Note 4		
	Dry	30	Note 4	Note 4	500 (1900)	1½
Class I and II commodities up to 30 ft (9.2 m) with maximum 5 ft (1.5 m) clearance to ceiling	Wet	20 plus one level of in-rack sprinklers[5]	Note 4	Note 4		
	Dry	30 plus one level of in-rack sprinklers[5]	Note 4	Note 4	500 (1900)	1½
Class I, II, and III commodities up to 20 ft (6.1 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	15	Note 4	Note 4		
	Dry	25	Note 4	Note 4	500 (1900)	1½
Class I, II, and III commodities up to 25 ft (7.6 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	15 plus one level of in-rack sprinklers[5]	Note 4	Note 4		1½
	Dry	25 plus one level of in-rack sprinklers[5]	Note 4	Note 4	500 (1900)	
Class IV commodities up to 20 ft (6.1 m) with maximum 10 ft (3.0 m) clearance to ceiling	Wet	Does not apply	20	15		
	Dry	Does not apply	Does not apply	Does not apply	500 (1900)	2
Class IV commodities up to 25 ft (7.6 m) with maximum 10 ft clearance to ceiling	Wet	Does not apply	20 plus one level of in-rack sprinklers[5]	15 plus one level of in-rack sprinklers[5]		
	Dry	Does not apply	Does not apply	Does not apply	500 (1900)	2