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Installation of SPRINKLER SYSTEMS



National Fire Protection Association

BATTERYMARCH PARK, QUINCY, MA 02169

NFPA

13

1989 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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NFPA 13

Installation of Sprinkler Systems

1989 Edition

Reference: 2-2.3.1, 2-2.3.2, 2-2.3.3, et al.

The Committee on Automatic Sprinklers notes the following errors in the 1989 edition of the Standard for the Installation of Sprinkler Systems, NFPA 13:

- 1. In paragraph 2-2.3.1, 6th line, change 2-2.3.2(a) to 2-2.4(a).
- 2. Renumber 2-2.3.2 as 2-2.4 with the heading of "Additional Requirements."
- 3. Renumber 2-2.3.3 to 2-2.4.1, 2-2.3.4 to 2-2.4.2, 2-2.3.5 to 2-2.4.3, 2-2.3.6 to 2-2.4.4, 2-2.3.7 to 2-2.4.5, and 2-2.3.8 to 2-2.4.6.
 - 4. In paragraph 3-3.8 change "(See 2-2.3.4)" to "(See 2-2.4.2)".
- 5. In Table 3-5.3.5.1(2) change "Schedule 10" to "Schedule 40". Also in Table 3-5.3.5.1(2), change "Schedule 40" to "Schedule 10".
- 6. In Table 3-5.3.5.1(3) add "†" to Diagrams D, E, F, G, H, and I. Also add a note to the bottom of the table, to read: "† For Wooden Beams Not Less Than 3 in. (76 mm)."
 - 7. In Table A-9-2.4 change "Drip" to "Drop" in the heading.

Issue Date: April 1989

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NFPA 13

Installation of Sprinkler Systems

1989 Edition

Reference: 3-3.4.1, 3-3.4.2, 3-3.5.2(b)

The Committee on Automatic Sprinklers notes the following errors in the 1989 edition of the Standard for the Installation of Sprinkler Systems, NFPA 13:

- 1. Delete 3-3.4.1 and 3-3.4.2 in their entirety. (These requirements are now covered in new 3-3.5, and these paragraphs should, therefore, have been deleted.)
- 2. In Figure 3-3.5.2(b), change "1 in. Close Nipple" to "Nipple (4 in. maximum length)." The revised Figure 3-3.5.2(b) is as follows:

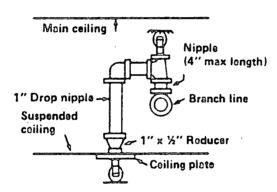


Figure 3-3.5.2(b) Sprinklers in Concealed Space and Below Ceiling.

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NFPA 13

Standard for the

Installation of Sprinkler Systems

1989 Edition

This edition of NFPA 13, Standard for the Installation of Sprinkler Systems, was prepared by the Technical Committee on Automatic Sprinklers, released by the Correlating Committee on Water Extinguishing Systems, and acted on by the National Fire Protection Association, Inc. at its Fall Meeting held November 14-17, 1988 in Nashville, Tennessee. It was issued by the Standards Council on January 13, 1989, with an effective date of February 6, 1989, and supersedes all previous editions.

The 1989 edition of this standard 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 as to 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, 1910, 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 complete 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, and 1986.

The 1989 edition has recognized some of the latest technology in the field of fire protection systems. Discussion of extra large orifice sprinklers and early suppression fast response sprinklers are but two of the many changes in this edition. Improved definitions of building construction types have been provided in order to permit the user to place sprinklers in their proper position.

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NFPA 13

Standard for the

Installation of Sprinkler Systems

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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 sprinkler systems and of 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 their appurtenances, the installation of fire pumps, the construction and installation of gravity and pressure tanks and towers.

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

1-2 Purpose. The purpose of this standard is to provide a reasonable degree of protection for life and property from fire through standardized installation requirements for sprinkler systems based upon sound engineering principles, test data, and field experience. The standard endeavors to continue the excellent record that has been established by standard sprinkler systems and meet the needs of changing technology. Nothing in this standard is intended to restrict new technologies or alternate arrangements, providing the level of safety prescribed by the 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 3-1.1.5, 4-1.1.3, and this one, allow the use of materials and devices not specifically designated by this standard, provided such use is within parameters established by testing and listing agencies. 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 is in complete accord with such listing requirements.

1-3* 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 or procedures, equipment or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

Authority Having Jurisdiction. The "authority having jurisdiction" is 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, 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 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."

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.

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.

Sprinkler System. A sprinkler system, for fire protection purposes, is 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 22, Water Tanks for Private Fire Protection; NFPA 20, Installation of Centrifugal Fire Pumps; and NFPA 24, Installation of Private Fire Service Mains and Their Appurtenances.

Standard. A document containing 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 Other Publications. A selected list of other publications related to the installation of sprinkler systems is published at the end of this standard.

1-5 Maintenance.

- 1-5.1* A sprinkler system installed under this standard shall be properly maintained for efficient service. The owner is responsible for the condition of the sprinkler system and shall use due diligence in keeping the system in good operating condition.
- 1-5.2 The installing contractor shall provide the owner with:
- (a) Instruction charts describing operation and proper maintenance of sprinkler devices.
- (b) Publication titled NFPA 13A, Recommended Practice for the Inspection, Testing and Maintenance of Sprinkler Systems.

1-6 Classification of Sprinkler Systems.

1-6.1 This standard covers automatic sprinkler systems of the types listed below, and systems of outside sprinklers for protection against exposure fires covered specifically in Chapter 6. Manually operated deluge systems, used for certain special hazard conditions, are not specifically covered in this standard but certain provisions of this standard will be found applicable.

Wet-Pipe Systems (See Section 5-1.)

Dry-Pipe Systems (See Section 5-2.)

Preaction Systems (See Section 5-3.)

Deluge Systems (See Section 5-3.)

Combined Dry-Pipe and Preaction Systems (See Section 5-4.)

Sprinkler Systems — Special Types. Special purpose systems employing departures from the requirements of this standard, such as special water supplies and reduced pipe sizing, shall be installed in accordance with their listing.

1-7 Classification of Occupancies.

1-7.1* 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.

1-7.2 Light Hazard Occupancies.

1-7.2.1* Light Hazard. 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.

1-7.3 Ordinary Hazard Occupancies.

- 1-7.3.1* 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.
- 1-7.3.2* Ordinary Hazard (Group 2). Occupancies or portions of other occupancies where quantity and combustibility of contents is moderate, stockpiles do not exceed 12 ft (3.7 m), and fires with moderate rate of heat release are expected.
- 1-7.3.3* Ordinary Hazard (Group 3). Occupancies or portions of other occupancies where quantity and/or combustibility of contents is high, and fires of high rate of heat release are expected.

1-7.4* Extra Hazard Occupancies.

- 1-7.4.1* Extra Hazard 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.
- 1-7.4.2 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 1-7.4.1 with little or no flammable or combustible liquids.

Extra Hazard (Group 2) includes occupancies described in 1-7.4.1 with moderate to substantial amounts of flammable or combustible liquids or where shielding of combustibles is extensive.

1-8* Design and Installation.

1-8.1 Devices and Materials.

- 1-8.1.1 Only new sprinklers shall be employed in the installation of sprinkler systems.
- 1-8.1.2* When a sprinkler system is installed, only approved materials and devices shall be used.
- **1-8.1.3** Sprinkler systems shall be designed for a maximum working pressure of 175 psi (12.1 bars).

Exception: Higher design pressures may be used when all system components are rated for pressures higher than 175 psi (12.1 bars).

1-8.1.3.1 Interior system components subject to pressure shall be designed for a working pressure not less than 175 psi (12.1 bars).

1-9* Working Plans.

- 1-9.1 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.
- 1-9.2* Working plans shall be drawn to an indicated scale, on sheets of uniform size, with a plan of each floor, made so that they can be easily duplicated, and shall show the following data:
 - (a) Name of owner and occupant
 - (b) Location, including street address
 - (c) Point of compass
 - (d) Ceiling construction
 - (e) Full height cross section
 - (f) Location of fire walls
 - (g) Location of partitions
 - (h) Occupancy of each area or room
- (i) Location and size of concealed spaces, closets, attics, and bathrooms [see 4-4.3 to 4-4.16 inclusive (except 4-4.5 and 4-4.6), and 4-4.19]
- (j) Any questionable small enclosures in which no sprinklers are to be installed
- (k) Size of city main in street, pressure, and whether dead-end or circulating and, if dead-end, direction and distance to nearest circulating main, city main test results, and elevation relative to the test hydrant (see B-2-1)
- (l) Other sources of water supply, with pressure or elevation
 - (m) Make, type, and nominal orifice size of sprinkler
- (n) Temperature rating and location of high-temperature sprinklers
 - (o) Total area protected by each system on each floor
 - (p) Number of sprinklers on each riser per floor
- (q) Make, type, model, and size of alarm or dry-pipe valve
- (r) Make, type, model, and size of preaction or deluge valve
 - (s) Kind and location of alarm bells
- (t) Total number of sprinklers on each dry-pipe system, preaction system, combined dry-pipe/preaction system, or deluge system
- (u) Approximate capacity in gallons of each dry-pipe system
 - (v) Pipe type and schedule of wall thickness
- (w) 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 line.
 - (x) Location and size of riser nipples
- (y) Type of fittings and joints and location of all welds and bends
- (z) Type and locations of hangers, sleeves, braces, and methods of securing sprinklers when applicable

- (aa) All control valves, check valves, drain pipes, and test connections
- (bb) Size and location of hand hose, hose outlets, and related equipment
- (cc) 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 top of the pipe is laid below grade
 - (dd) Provision for flushing (see 3-3.2)
- (ee) When the equipment is to be installed as an addition to an existing system enough of the existing system shall be indicated on the plans to make all conditions clear
- (ff) For hydraulically designed systems, the material to be included on the hydraulic data nameplate
 - (gg) Name and address of contractor
 - (hh) Method of protection for nonmetallic piping
- (ii) A graphical representation of the scale shall be provided on all plans.

1-10 Approval of Sprinkler Systems.

- 1-10.1 The installer shall perform all required acceptance tests (see Section 1-11), complete the Contractor's Material and Test Certificate(s) [see Figures 1-10.1(a) and 1-10.1(b)], and forward the certificate(s) to the authority having jurisdiction prior to asking for approval of the installation.
- 1-10.2 When the authority having jurisdiction desires to be present during the conduct of acceptance tests, the installer shall give advance notification of the time and date the testing will be performed.

1-11 Acceptance Tests.

1-11.1* Flushing of Piping. Underground mains and leadin connections to system risers shall be flushed thoroughly before connection is made to sprinkler piping, in order to remove foreign materials which may have entered the underground during the course of the installation or which may have been present in existing piping. The minimum rate of flow shall be not less than the water demand rate of the system which is determined by the system design, or not less than that necessary to provide a velocity of 10 ft per second (3 m/s), whichever is greater. For all systems the flushing operations shall be continued for a sufficient time to ensure thorough cleaning. When planning the flushing operations, consideration shall be given to disposal of the water issuing from the test outlets.

Exception: When the flow rate, as listed in Table 1-11.1, cannot be verified or met, supply piping shall be flushed at the maximum flow rate available to the system under fire conditions.

Table 1-11.1 Flow Required to Produce a Velocity of 10 Ft per Second (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

For SI Units: 1 in. = 25.4 mm; 1 gpm = 3.785 L/min.

CONTRACTOR'S MATERIAL & TEST CERTIFICATE FOR



certificate shall be f sentative's signatur cal ordinances.	illed out and e in no way p	signed by I prejudices a	both represe any claim ag	entatives. Copies sha ainst contractor for t	all be prep aulty mate	ared for appr rial, poor wo	oving au rkmansh	thorities, owners, ip, or failure to cor	and contra	ctor. It is undepproving auth	erstood th	e owner's i quirements	
ROPERTY NAME						•				DATE			
ROPERTY ADDRES	SS								·	L			
	ACCEPTI	ED BY APP	PROVING A	UTHORITIES (NAM	ES)								
	ADDRES	S							,				
PLANS	INSTALL	ATION CO	NFORMS T	O ACCEPTED PLAI	NS						O YES	□ NO	
			IS APPRO	VED							O YES	□ NO	
	IF NO, EX	XPLAIN DE	VIATIONS										
		ROL VALV		FIRE EQUIPMENT ARE AND MAINTEN							□ YES	O NO	
INSTRUCTIONS										•			
				WING BEEN LEFT (REMISES:					☐ YES	□ NO	
		SYSTEM COMPONENTS INSTRUCTIONS CARE AND MAINTENANCE INSTRUCTIONS									☐ YES ☐ YES		
	3.	3. NFPA 13A								□ YES	□ NO		
LOCATION OF SYSTEM	SUPPLIE	S BUILDIN	GS										
	MAKE			YEAR OF MODEL MANUFACTURE			ORIFICE QUANTITY			TEMPERATURE RATING			
SPRINKLERS							ļ		ļ				
													
PIPE AND FITTINGS	Type of F												
	<u> </u>							MA	AXIMUM T	IME TO OPE	RATE		
ALARM Valve	 	TYPE		ALARM DEVIC	E	Тмс	DEL	TH MI		EST CONNE	CONNECTION SEC.		
OR FLOW INDICATOR													
		MAKE	=	DRY VALVE S		RIAL NO.		Q. MAKE		Q.O.D. MODEL		RIAL NO.	
	L	TIME TO		 	<u> </u>		<u> </u>		TIME WATER		ALARM		
DRY PIPE		CONNE		PRESSURE	F	AIR PRESSURE	A	TRIP POINT IR PRESSURE	REACHED TEST OUTLET*			PERATED	
OPERATING TEST	14/21	MIN.	SEC.	PSI		PSI		PSI	MIN.	SEC.	YES	NO	
	Without Q.O.D.												
	With Q.O.D.												
	IF NO, EX	PLAIN	1	.1					·	-			

Figure 1-10.1(a) Contractor's Material and Test Certificate for Aboveground Piping.

OPERATION							
	() PNEUI	MATIC () ELECT	BIC F	HYDRAUI	IC		
PIPING SUPERVISE	D	□ NO	DETEC	TING MEDIA	A SUPERVISED		ON C
DOES VALVE OPER				ITROL STA		O YES C	ON C
IS THERE AN ACCE	SSIBLE PACILITY II	EACH CIRCOIT FO	A IESTING	IF NO, E	AFLAIIA		
	YES INO						
MAKE	MODEL						
107.512	1110022	YES	NO	YES	NO	MIN.	SEC.
HYDROSTATIC: Hydro of 150 psi (10.2 bars) fo shall be stopped.	static tests shall be n r two hours. Different	nade at not less than al dry-pipe valve clap	200 psi (13.6 ba pers shall be lef	ars) for two I t open durin	nours or 50 psi (3.4 bag test to prevent dame	ars) above static pressu age. All aboveground pi	ure in exces ping leakag
PNEUMATIC: Establish tanks at normal water k	40 psi (2.7 bars) air evel and air pressure	pressure and measu and measure air pres	re drop which si ssure drop whic	hall not exce h shall not e	ed 1-1/2 psi (0,1 bars xceed 1-1/2 psi (0,1 b	s) in 24 hours. Test pres pars) in 24 hours.	ssure
ALL PIPING HYDROS	TATICALLY TESTED	AT PSI	FOR	HRS.	IF NO, STATE REAS	ON	
				D 000000	NE OUEMON O	DILIN CILICATE OR	
							10
		NE, OR OTHER COI	NHOSIVE CHE	MICALS WE	HE NOT USED FOR	TESTING STSTEMS	JN.
		NEAR WATER		RESIDUA	L PRESSURE WITH	VALVE IN TEST	
			.				
							LER PIPING
			D NO I	OTHER			
LUSHED BY INSTALL	ER OF UNDER-						
BROUND SPRINKLER	PIPING	☐ YES	□ NO				
NUMBER USED L	OCATIONS					NUMBER R	EMOVED
WELDED BIRING	U AE6 U Y	10					
WELDED FIFING	U 169 U 1		IE VES				
DO YOU CERTIFY AS	THE SPRINKLER CO	ONTRACTOR THAT		CEDURES	COMPLY		
WITH THE REQUIREMENTS OF AT LEAST AWS D10.9, LEVEL AR-3							□ 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						O YES	□ NO
DO YOU CERTIFY TH	YOU CERTIFY THAT WELDING WAS CARRIED OUT IN COMPLIANCE WITH A						
RETRIEVED, THAT OF WELDING RESIDUE A	PENINGS IN PIPING RE REMOVED, AND	ARE SMOOTH, THA THAT THE INTERN	T SLAG AND O AL DIAMETERS	THER S OF		TI YES	□ NO
OO YOU CERTIFY THA	T YOU HAVE A COM	NTROL FEATURE TO	DENSURE THA	AT ALL			□ NO
		IF NO, EXPLAIN	٧				
_		1					
					-		
DATE LEFT IN SERVIC	E WITH ALL CONTR	IOL VALVES OFEN.					
NAME OF SPRINKLER	CONTRACTOR						
	<u> </u>	TES	TS WITNESSE	D BY	<u> </u>		
OR PROPERTY OWN	ER (SIGNED)		TITLE			DATE	
FOR SPRINKLER CON	TRACTOR (SIGNED)	TITLE			DATE	
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TYES TO NO DRAIN READING OF GAGE LOCATED NEAR WATER TEST SUPPLY TEST CONNECTION: PS SINDERGROUND MAINS AND LEAD IN CONNECTIONS TO SY. FERIFIED BY COPY OF THE U FORM NO. 85B TYES FLUSHED BY INSTALLER OF UNDER- BROUND SPRINKLER PIPING TYES NUMBER USED LOCATIONS WELDED PIPING TYES NO DO YOU CERTIFY AS THE SPRINKLER CONTRACTOR THAT WITH THE REQUIREMENTS OF AT LEAST AWS D10.9, LEVEL DO YOU CERTIFY THAT THE WELDING WAS PERFORMED BS COMPLIANCE WITH THE REQUIREMENTS OF AT LEAST AWS DO YOU CERTIFY THAT WELDING WAS CARRIED OUT IN CO DOCUMENTED QUALITY CONTROL PROCEDURE TO INSUR BETTIEVED. THAT OPENINGS IN PIPING ARE SMOOTH. THA WELDING RESIDUE ARE REMOVED, AND THAT THE INTERN PIPING ARE NOT PENETRATED DO YOU CERTIFY THAT YOU HAVE A CONTROL FEATURE TO CUTOUTS (DISCS) ARE RETRIEVED? NAME PLATE PROVIDED IF NO, EXPLAIN THES WAME OF SPRINKLER CONTRACTOR TES	MAKE MODEL DOES EACH CIRCUIT OPERATE SUPERVISION LOSS ALARM YES NO HYDROSTATIC; Hydrostatic tests shall be made at not less than 200 psi (13.6 bd of 150 psi (10.2 bars) for two hours. Differential dry-pipe valve clappers shall be lefshall be stopped. PNEUMATIC; Establish 40 psi (2.7 bars) air pressure and measure drop which stanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks at normal water level and air pressure and measure air pressure drop which altanks and and and and air pressure and measure air pressu	MAKE MODEL SOPERATIC CRUIT OPERATE DOES SUPERVISION LOSS ALARM OPERATIC YES NO YES HYDROSTATIC; Hydrostatic tests shall be made at not less than 200 psi (13.6 bars) for two hours. 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THAT WELL PROBLEM THAT ALL DISCS ARE HET REVED. THAT WELL PROBLEM THAT ALL DISCS ARE HET RIEVED. THAT WELL PROBLEM THAT ALL DISCS ARE HET RIEVED. THAT WELL PROBLEM THAT ALL DISCS ARE HET RIEVED. THAT WELL PROBLEM THAT ALL DISCS ARE HET RIEVED. THAT WELL PROBLEM THAT ALL DISCS ARE HET RIEVED. THAT WELL PROBLEM THAT ALL DISCS ARE HET RIEVED. THAT WELL PROBLEM THAT ALL DISCS ARE HET RIEVED. THAT ALL DISCS ARE RETRIEVED. THAT WELL PROBLEM THAT ALL DISCS ARE HET RIEVED. TH	MAKE MODEL DOES BACH CIRCUIT OPERATE SUPERVISION LOSS ALARM OPERATE VALVE RELEASE YES NO YES YES NO YES NO YES YES NO YES NO YES YES NO YES NO YES YES YES NO YES YES YES YES YES YES YES YE	MAKE MODEL SUPERVISION LOSS ALARM OPERATE DOES EACH CIRCUIT OPERATE SUPERVISION LOSS ALARM OPERATE RELEASE OPERATE RE SUPERVISION LOSS ALARM OPERATE RELEASE OPERATE RE YES NO MIN. HYDROSTATIC: Hydrostatic tests shall be made at not less than 200 psi (13.6 bars) for two hours. Differential dry-pipe valve dispors shall be left open during test to prevent damage. All aboveground pishall be stopped. HYDROSTATIC: Hydrostatic tests shall be made at not less than 200 psi (13.6 bars) for two hours. Differential dry-pipe valve dispors shall be left open during test to prevent damage. All aboveground pishall be stopped. HYDROSTATIC: Establish do psi (2.7 bars) at pressure and measure drop which shall not exceed 1-1/2 psi (0.1 bars) in 24 hours. Test presaure and resulted all pressure drop which shall not exceed 1-1/2 psi (0.1 bars) in 24 hours. Test pressure drop which shall not exceed 1-1/2 psi (0.1 bars) in 24 hours. Test pressure drop which shall not exceed 1-1/2 psi (0.1 bars) in 24 hours. Test pressure drop which shall not exceed 1-1/2 psi (0.1 bars) in 24 hours. Test pressure drop which shall not exceed 1-1/2 psi (0.1 bars) in 24 hours. Test pressure drop which shall not exceed 1-1/2 psi (0.1 bars) in 24 hours. 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Figure 1-10.1(a) (continued) Contractor's Material and Test Certificate for Aboveground Piping.

CONTRACTOR'S MATERIAL & TEST CERTIFICATE FOR NDERGROUND PIPING



						
PROCEDURE Upon completion of w system left in service	ork, inspection and tests shall be made by the contract before contractor's personnel finally leave the job.	or's representativ	e and witnesse	ed by an owner's representative. All defe	cts shall be	corrected ar
A certificate shall be fi resentative's signature local ordinances.	lled out and signed by both representatives. Copies sha in no way prejudices any claim against contractor for f	all be prepared to faulty material, po	or approving au oor workmansh	uthorities, owners, and contractor. It is un nip, or failure to comply with approving au	derstood th thority's re	ne owner's re quirements c
PROPERTY NAME				DATE		
PROPERTY ADDRES	s				-	
	ACCEPTED BY APPROVING AUTHORITIES (NAM	ES)				
	ADDRESS					
PLANS					-	
	INSTALLATION CONFORMS TO ACCEPTED PLAN EQUIPMENT USED IS APPROVED	NS		,	O YES	□ NO
	IF NO, STATE DEVIATIONS				□ YES	□ NO
	HAS PERSON IN CHARGE OF FIRE EQUIPMENT OF CONTROL VALVES AND CARE AND MAINTEN IF NO, EXPLAIN				O YES	□ NO
INSTRUCTIONS	HAVE COPIES OF APPROPRIATE INSTRUCTIONS BEEN LEFT ON PREMISES? IF NO, EXPLAIN	S AND CARE AN	D MAINTENA	NCE CHARTS	□ YES	□NO
LOCATION	SUPPLIES BUILDINGS					
	PIPE TYPES AND CLASS		TYPE JOINT		*	
	PIPE CONFORMS TO	STANDARD	l		O YES	□ NO
UNDERGROUND PIPES AND JOINTS	FITTINGS CONFORM TO IF NO, EXPLAIN	STANDARD			□ YES	D NO
	JOINTS NEEDING ANCHORAGE CLAMPED, STRA	APPED, OR BLO	CKED IN		O YES	□ NO
	ACCORDANCE WITH	STAN	DARD			
TEST DESCRIPTION	FLUSHING. Flow the required rate until water is cleablow-offs. Flush at flows not less than 390 GPM (147 Inch pipe, 2440 GPM (9235 L/min) for 10-inch pipe, a rates, obtain maximum available. HYDROSTATIC. Hydrostatic tests shall be made at excess of 150 psi (10.3 bars) for two hours. LEAKAGE. New pipe laid with rubber gasketed joint leakage at the joints shall not exceed 2 qts. per hr. (1 joints. If such leakage occurs at a few joints the instal leakage specified above may be increased by 1 fl oz section. If dry barrel hydrants are tested with the mail leakage is permitted for each hydrant.	6 L/min) for 4-ino and 3520 GPM (1 not less than 200 s shall, if the wor I.89 L/h) per 100 Illation shall be oc per in. valve diar	h pipe, 880 Gi 3323 L/min) fo psi (13.8 bars kmanship is sa joints irrespect insidered unsa neter per hr. (3	PM (3331 L/min) for 6-inch pipe, 1560 GF or 12-inch pipe. When supply cannot prod is for two hours or 50 psi (3.4 bars) above tilsfactory, have little or no leakage at the tilve of pipe diameter. The leakage shall b tilsfactory and necessary repairs made. T 30 mL/25 mm/h) for each metal seated va	M (5905 L uce stipula static pres joints. The e distribute he amount lve isolatin	/min) for 8- ted flow sure in armount of d over all of allowable g the test
	NEW UNDERGROUND PIPING FLUSHED ACCORD BY (COMPANY) IF NO, EXPLAIN	DING TO		STANDARD	☐ YES	⊡ NO
ı	HOW FLUSHING FLOW WAS OBTAINED D PUBLIC WATER D TANK OR RESERVOIF	R OFIRI	PUMP	THROUGH WHAT TYPE OPENING IT HYDRANT BUTT.	OPEN	PIPE
FLUSHING TESTS	LEAD-INS FLUSHED ACCORDING TO BY (COMPANY) IF NO, EXPLAIN			STANDARD	□ YE\$	□ NO
	HOW FLUSHING FLOW WAS OBTAINED	a cinc i	DI NAD	THROUGH WHAT TYPE OPENING		PEN PIPE
85B(10-88)	PRINTED IN USA	O FIRE I	OMIT	DY CONN. TO FLANGE & SPIGOT	UUI	(OVER)
(,						1

Figure 1-10.1(b) (continued) Contractor's Material and Test Certificate for Underground Piping.

HYDROSTATIC	ALL NEW UNDERGROUND	JOINTS C	JOINTS COVERED						
TEST	PSI	FOR	_ HOURS		O YE	S DNO			
	TOTAL AMOUNT OF LEAKA	IGE MEASURED							
LEAKAGE		GALS.	HOURS						
TEST	ALLOWABLE LEAKAGE			-					
		GALS.	HOURS	i .					
HYDRANTS	NUMBER INSTALLED	TYPE AND MAKE	Ē			ALL OPERATE S	ATISFACTORILY		
HYDRANIS						☐ YES	□ NO		
	WATER CONTROL VALVES	LEFT WIDE OPEN				☐ YES	□ NO		
CONTROL VALVES	III NO, OTATE NEASON								
VALVES	HOSE THREADS OF FIRE DEP	EPARTMENT CON ARTMENT ANSWE	NECTIONS AND HYD RING ALARM	RANTS INTERCHANGEAB	LE	☐ YES	□ NO		
	DATE LEFT IN SERVICE								
REMARKS									
	NAME OF INSTALLING CON	ITRACTOR							
	TESTS WITNESSED BY								
SIGNATURES	FOR PROPERTY OWNER (S	SIGNED)	TITLE			DATE			
	FOR INSTALLING CONTRA	CTOR (SIGNED)	TITLE	·, · · · · · · · · · · · · · · · · · ·		DATE			
ADDITIONAL EXPLAN	ATION AND NOTES								

Figure 1-10.1(b) (continued) Contractor's Material and Test Certificate for Underground Piping.

1-11.1.1 Provision shall be made for the disposal of water issuing from test outlets to avoid property damage.

1-11.2 Hydrostatic Tests.

1-11.2.1* All new systems including yard piping shall be hydrostatically tested at not less than 200 psi (13.8 bars) pressure for 2 hours, or at 50 psi (3.4 bars) in excess of the maximum pressure, when the maximum pressure to be maintained in the system is in excess of 150 psi (10.3 bars).

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

Exception: At seasons of the year that will not permit testing with water an interim test may be conducted with air pressure of at least 40 psi (2.8 bars) allowed to stand for 24 hours. The standard hydrostatic test shall be conducted when weather permits.

- 1-11.2.2* Permissible Leakage. The inside sprinkler piping shall be installed in such a manner that there will be no visible leakage when the system is subjected to the hydrostatic pressure test. Refer to NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances, for permissible leakage in underground piping. The amount of leakage shall be measured by pumping from a calibrated container.
- 1-11.2.3 Fire Department Connection. Piping between the check valve in the fire department inlet pipe and the outside connection shall be tested in the same manner as the balance of the system.

- 1-11.2.4 Corrosive Chemicals. Additives and corrosive chemicals, sodium silicate or derivatives of sodium silicate, brine or other corrosive chemicals shall not be used for testing systems or stopping leaks.
- 1-11.2.5 Test Blanks. Whenever a test blank is used it shall be of the self-indicating type. Test blanks shall have red painted lugs protruding beyond the flange in such a way as to clearly indicate their presence. The installer shall have all test blanks numbered so as to keep track of their use and assure their removal after the work is completed.

1-11.3 Test of Dry-Pipe Systems.

- 1-11.3.1 Differential Dry-Pipe Valves. The clapper of a differential type dry-pipe valve shall be held off its seat during any test in excess of 50 psi (3.4 bars) to prevent damaging the valve.
- 1-11.3.2 Air Test. In dry-pipe systems an air pressure of 40 psi (2.8 bars) shall be pumped up, allowed to stand 24 hours, and all leaks that allow a loss of pressure over 1½ psi (0.1 bar) for the 24 hours shall be stopped.
- 1-11.3.3 Operating Test of Dry-Pipe Valve. A working test of the dry-pipe valve alone and with a quick-opening device, if installed, shall be made before acceptance by opening the system test connection. Trip and water delivery times shall be measured from the time the inspector's test connection is opened and shall be recorded using the Contractor's Material and Test Certificate for Aboveground Piping.

- **1-11.4 Tests of Drainage Facilities.** Tests of drainage facilities shall be made while the control valve is wide open. The main drain valve shall be opened and remain open until the system pressure stabilizes. (*See 2-9.1.*)
- 1-11.5 Each pressure reducing valve shall be tested upon completion of the initial installation to ensure proper pressure reduction at both maximum and normal inlet pressures.
- 1-12 Operation of Sprinkler System Control Valves by Contractors. When work on a sprinkler system requires that a contractor operate a valve controlling water supplies to a sprinkler system, the contractor shall inform the owner so that the owner may follow the normal valve supervision procedure.
- 1-13 Units. Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). Two units (liter and bar), outside of but recognized by SI, are commonly used in international fire protection. These units are listed in Table 1-13 with conversion factors.

Table 1-13 Metric Units of Measurement

Name of Unit	Unit Symbol	Conversion Factor
liter	L	1 gal = 3.785 L
liter per minute per square meter	(L/min)/m ²	$1 \text{ gpm/ft}^2 = 40.746$ (L/min)/m ²
millimeter per minute	1 mm/min	$1 \text{ gpm/ft}^2 = 40.746 \text{ mm/min}$
cubic decimeter	dm³	$1 \text{ gal} = 3.785 \text{ dm}^3$
pascal	Pa	1 psi = 6894.757 Pa
bar	bar	1 psi = 0.0689 bar
bar	bar	$1 \text{ bar} = 10^5 \text{ Pa}$

For additional conversions and information see ASTM E380, Standard for Metric Practice.

- 1-13.1 If a value for measurement as given in this standard is followed by an equivalent value in other units, the first stated is to be regarded as the requirement. A given equivalent value may be approximate.
- 1-13.2 The conversion procedure for the SI units has been to multiply the quantity by the conversion factor and then round the result to the appropriate number of significant digits.

Chapter 2 Water Supplies

- **2-1* General Provisions.** Every automatic sprinkler system shall have at least one automatic water supply.
- $2\text{-}2^*$ Water Supply Requirements for Sprinkler Systems.

2-2.1 General.

2-2.1.1 Water supply requirement tables shall be used in determining the minimum water supply requirements for Light, Ordinary, and Extra Hazard Occupancies. Occupancy classification shall be determined from Section 1-7.

Exception No. 1: Water supply requirements for dwelling units protected by residential sprinklers shall be in accordance with 7-4.4 in wet systems only.

- Exception No. 2: The water supply requirements for ESFR and large-drop sprinkler systems shall be in accordance with Chapter 9.
- Exception No. 3: The water supply requirements for exposure protection systems shall be in accordance with Chapter 6.
- Exception No. 4: For hazard classifications other than those indicated, see appropriate NFPA standards for design criteria. When other NFPA standards have developed sprinkler system design criteria, they shall take precedence.
- (a) Table 2-2.1.1(a) shall be used to determine the minimum volume of water and pressure normally required for a pipe schedule sprinkler system. The table is to be used only with experienced judgment.
- (b) Table 2-2.1.1(b) shall be used to determine the minimum volume of water and pressure normally required for a hydraulically designed sprinkler system.
- **2-2.1.2** The following shall be used in applying Table 2-2.1.1(b).
- **2-2.1.3** The water supply for sprinklers only shall be calculated either from the area/density curves in Figure 2-2.1.1(b) in accordance with 2-2.2 or be based upon the room design method in accordance with 2-2.3.1 at the discretion of the designer.

2-2.2* Area/Density Method.

- 2-2.2.1 The water supply requirement for sprinklers only shall be calculated from the density curves in Figure 2-2.1.1(b). The calculations shall satisfy a single point on the appropriate design curve. It is not necessary to meet all points on the selected curve.
- 2-2.2.2 The densities and areas provided in Figure 2-2.1.1(b) are for use only with standard response sprinklers. For use of other types of sprinklers see 4-1.1.3.
- **2-2.2.3** For dry-pipe systems, increase the area of sprinkler operation by 30 percent without revising density.
- **2-2.2.4** When high-temperature sprinklers are used for Extra Hazard Occupancies, the area of sprinkler operation may be reduced by 25 percent without revising the density, but to not less than 2000 sq ft (186 m²).

2-2.3* Room Design Method.

- 2-2.3.1 The water supply requirements for sprinklers only shall be based upon the room which creates the greatest demand. The density selected shall be that from Figure 2-2.1.1(b) corresponding to the room size. If the room is smaller than the smallest area shown in the applicable curve in Figure 2-2.1.1(b) see 2-2.3.2(a). If the room is larger than the largest area shown in the applicable curve, use the density for the largest area shown for all sprinklers in the room. All rooms shall be enclosed with construction having a fire-resistance rating equal to the water supply duration indicated in Table 2-2.1.1(b) with minimum protection of openings as follows:
 - (a) Light Hazard—automatic or self-closing doors.

Occupancy Classification	Residual Pressure Required (see Note 1)	Acceptable Flow at Base of Riser (see Note 2)	Duration in Minutes
Light Hazard	15 psi	500-750 gpm (see Note 3)	30-60
Ordinary Hazard (Group 1)	15 psi or higher	700-1000 gpm	60-90
Ordinary Hazard (Group 2)	15 psi or higher	850-1500 gpm	60-90
Ordinary Hazard (Group 3)	Pressure and flow requirements for spi mined by authority having jurisdiction.	rinklers and hose streams to be deter-	60-120
High-Piled Storage (see 4-1.3.10)	Pressure and flow requirements for spi mined by authority having jurisdiction. (231C.)		
High-Rise Buildings	Pressure and flow requirements for spi mined by authority having jurisdiction.	rinklers and hose streams to be deter-	
Extra Hazard	Pressure and flow requirements for spr mined by authority having jurisdiction.		

For SI Units: 1 psi = 0.0689 bar; 1 gpm = 3.785 L/min.

Table 2-2.1.1(b) Table and Design Curves for Determining Density, Area of Sprinkler Operation, and Water Supply Requirements for Hydraulically Designed Sprinkler Systems

Minimum Water Supply Requirements

Hazard Classification	Sprinklers Only—gpm	Inside Hose—gpm	Total Combined Inside and Outside Hose—gpm	in
Light	See 2-2.1.3	0, 50, or 100	100	30
Ord.—Gp. 1	See 2-2.1.3	0, 50, or 100	250	60-90
Ord.—Gp. 2	See 2-2.1.3	0, 50, or 100	250	60-90
Ord.—Gp. 3	See 2-2.1.3	0, 50, or 100	500	60-120
Ex. Haz.—Gp. 1	See 2-2.1.3	0, 50, or 100	500	90-120
Ex. Haz.—Gp. 2	See 2-2.1.3	0, 50, or 100	1000	120

For SI Units: 1 gpm = 3.785 L/min.

Exception: When 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 selfclosing doors with appropriate fire-resistance ratings for the enclosure.
- 2-2.3.2* Regardless of which of the above methods is used, the following restrictions apply:

- (a) For areas of sprinkler operation less than 1500 sq ft (139 m²) used for Light and Ordinary Hazard Occupancies, the density for 1500 sq ft (139 m²) shall be used. For areas of sprinkler operation less than 2500 sq ft (232 m²) for Extra Hazard Occupancies, the density for 2500 sq ft (232 m²) shall be used.
- (b) For construction having unsprinklered combustible concealed spaces (as described in 4-4.4) the minimum area of sprinkler operation shall be 3000 sq ft (279 m²).

Exception No. 1: Combustible concealed spaces filled entirely with noncombustible insulation.

Exception No. 2: Light or Ordinary Hazard Occupancies where noncombustible ceilings are directly attached to the bottom of solid wood joists so as to create enclosed joist spaces, each less than 160 cu ft (4.8 m³) in volume.

- 2-2.3.3* When inside hose stations are planned or are required by other standards, a water allowance of 50 gpm (189 L/min) for a one hose station installation and 100 gpm (378 L/min) for a two or more hose station installation shall be added to the sprinkler requirements at the point of connection to the system at the pressure required by the sprinkler system design.
- **2-2.3.4** When hose valves for fire department use are attached to wet-pipe sprinkler system risers in accordance with 3-3.8, the water supply requirements shall be as follows:
- (a) For buildings protected in accordance with this standard, the water supply for sprinklers need not be added to standpipe demand as determined from NFPA 14, Standard for the Installation of Standpipe and Hose Systems.

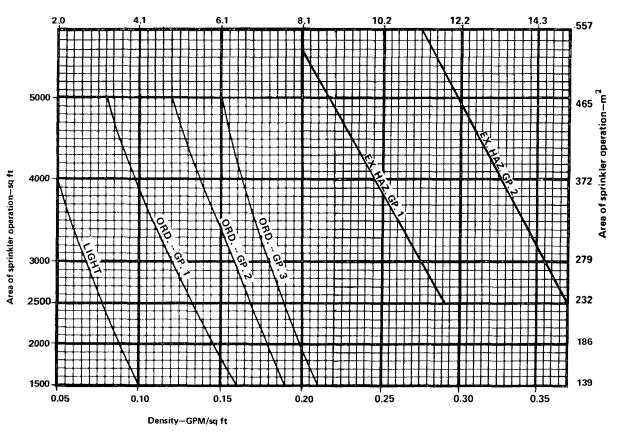
^{1.} The pressure required at the base of the sprinkler riser(s) is defined as the residual pressure required at the elevation of the highest sprinkler plus the pressure required to reach this elevation.

^{2.} The lower figure is the minimum flow including hose streams ordinarily acceptable for pipe schedule sprinkler systems. The higher flow should normally suffice for all cases under each group.

^{3.} The requirement may be reduced to 250 gpm if building area is limited by size compartmentation or if building (including roof) is noncombustible construction.

Density Curves

Density-(L/min) /m²



For SI Units: 1 sq ft = 0.0920 m^2 ; 1 gpm/sq ft = $40.746 \text{ (L/min)/m}^2$.

Figure 2-2.1.1(b).

Exception: When the sprinkler system demand, including hose stream allowance indicated in Table 2-2.1.1(b), exceeds the requirements of NFPA 14, Standard for the Installation of Standpipe and Hose Systems, the values in Table 2-2.1.1(b) shall be used.

- (b) For partially sprinklered buildings, the sprinkler demand, not including hose stream allowance, as indicated in Table 2-2.1.1(b) shall be added to the requirements given in NFPA 14, Standard for the Installation of Standpipe and Hose Systems.
- 2-2.3.5 Water demand of sprinklers installed in racks shall be added to the ceiling sprinkler water demand at the point of connection. Demands shall be balanced to the higher pressure.
- 2-2.3.6 Water allowance for outside hose shall be added to the sprinkler and inside hose requirement at the connection to the city water main, or at a yard hydrant, whichever is closer to the system riser.
- **2-2.3.7** The lower duration figures in Tables 2-2.1.1(a) and 2-2.1.1(b) are ordinarily acceptable where remote station waterflow alarm service or equivalent is provided.

- 2-2.3.8 When 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.
- 2-3 Connections to Water Works Systems.
- 2-3.1 Acceptability.
- 2-3.1.1* General. 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.
- **2-3.1.2 Meters.** Meters are not recommended for use on sprinkler systems; however, where required by other authorities, they shall be of an approved type.
- 2-3.2* Capacity. The connection and arrangement of underground supply piping shall be capable of supplying the volume as required in Table 2-2.1.1(a) or 2-2.1.1(b). Pipe size shall be at least as large as the system riser. (See NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.)

Exception: Unlined cast or ductile iron pipe shall not be less than 4 in. (102 mm) in size.

2-4 Gravity Tanks.

- **2-4.1** Acceptability. An elevated tank sized in accordance with Table 2-2.1.1(a) or 2-2.1.1(b) shall be an acceptable water supply source. (See NFPA 22. Standard for Water Tanks for Private Fire Protection.)
- **2-4.2 Capacity and Elevation.** The capacity and elevation of the tank and the arrangement of the underground supply piping shall provide the volume and pressure required by Table 2-2.1.1(a) or 2-2.1.1(b) designs.

2-5 Pumps.

- **2-5.1*** Acceptability. A single automatically controlled fire pump sized in accordance with Table 2-2.1.1(a) or 2-2.1.1(b) supplied under positive head shall be an acceptable water supply source. (See NFPA 20, Standard for the Installation of Centrifugal Fire Pumps.)
- 2-5.2* Supervision. When a single fire pump constitutes the sole sprinkler supply, it shall be provided with supervisory service from an approved central station, proprietary, remote station system or equivalent.

2-6 Pressure Tanks.

2-6.1 Acceptability.

- **2-6.1.1** A pressure tank sized in accordance with Table 2-2.1.1(a) or 2-2.1.1(b) is an acceptable water supply source. (See NFPA 22, Standard for Water Tanks for Private Fire Protection.)
- 2-6.1.2 Pressure tanks shall be provided with an approved means for automatically maintaining the required air pressure. When 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.
- 2-6.1.3 Pressure tanks shall not be used to supply other than sprinklers and hand hose attached to sprinkler piping.
- **2-6.2** Capacity. The required water capacity of a pressure tank shall be in accordance with 2-2.1.1 and shall include the extra capacity needed to fill dry-pipe or preaction systems when installed. The total volume shall be based on the water capacity, plus the air capacity required by 2-6.3.
- 2-6.3* Water Level and Air Pressure. Unless otherwise approved by the authority having jurisdiction, the pressure tank shall be kept two-thirds full of water, and an air pressure of at least 75 psi (5.2 bars) by the gage shall be maintained. When the bottom of the tank is located below the highest sprinklers served, the air pressure by the gage 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.

2-7 Fire Department Connections.

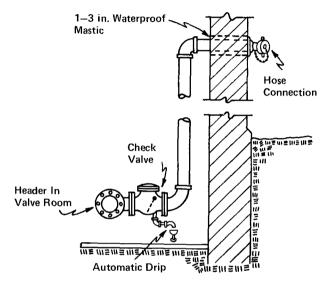
 $2-7.1^*$ A fire department connection shall be provided as described in this section.

Exception No. 1: The fire department connection may be omitted for systems having 20 sprinklers or less.

- Exception No. 2: When permission of the authority having jurisdiction has been obtained for its omission.
- 2-7.2* 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 serving one system riser may be as small as the system riser.

Exception No. 2: A single fire department hose connection may be piped to a 3-in. (76-mm) or smaller connection.



For SI Units: 1 in. = 25.4 mm.

Figure 2-7.1 Fire Department Connection.

- 2-7.3* Arrangement. (See 3-9.2.5 and 3-9.2.6.)
- 2-7.3.1 The fire department connection shall be made on the system side of a check valve in the water supply piping.
- 2-7.3.2 On wet-pipe systems with a single riser the connection shall be made on the system side of approved indicating, check, and alarm valves to the riser, unless the system is supplied by a fire department pumper connection in the yard. (See 3-9.2.6.)
- 2-7.3.3 On dry-pipe systems with a single riser the connection shall be made between the approved indicating valve and the dry-pipe valve, unless the system is supplied by a fire department pumper connection in the yard.
- 2-7.3.4 On systems with two or more risers, the connection shall be made on the system side of all shutoff valves controlling other water supplies, but on the supply side of the riser shutoff valves so that, with any one riser off, the connection will feed the remaining sprinklers, unless the sprinklers are supplied by a fire department pumper connection in the yard.
- 2-7.3.5 Fire department connections shall not be connected on the suction side of booster pumps.

2-7.3.6 Fire department connections to sprinkler systems shall be designated by a sign having raised letters at least 1 in. (25 mm) in size cast on plate or fitting reading for service designated: e.g. — "AUTOSPKR.," "OPENSPKR.," or "AUTOSPKR. and STANDPIPE."

2-7.4 Valves.

- 2-7.4.1 An approved check valve shall be installed in each fire department connection, located as near as practicable to the point where it joins the system.
- 2-7.4.2 There shall be no shutoff valve in the fire department connection.
- **2-7.5 Drainage.** The piping between the check valve and the outside hose coupling shall be equipped with an approved automatic drip.

2-7.6 Hose Connections.

2-7.6.1 The fire department connection(s) shall be internal threaded swivel fitting(s) having the NH standard thread, at least one of which shall be 2.5 — 7.5 NH standard thread, as specified in NFPA 1963, Standard for Screw Threads and Gaskets for Fire Hose Connections.

Exception: When local fire department connections do not conform to NFPA 1963, the authority having jurisdiction shall designate the connection to be used.

2-7.6.2 Hose connections shall be equipped with listed plugs or caps.

2-8 Arrangement of Water Supply Connections.

2-8.1 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.

2-8.2* 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.

2-9 Water Supply Test Connections and Gages.

2-9.1* Test Connections. Test connections, which may also be used as drain pipes, shall be provided at locations that will permit flow tests to be made to determine whether water supplies and connections are in order. Such test connections shall be not less than the sizes specified in 3-6.2 and equipped with a shutoff valve. They shall be so installed that the valve may be opened wide for a sufficient time to assure a proper test without causing water damage. (See 3-6.2 and 3-6.4.)

2-9.2 Gages.

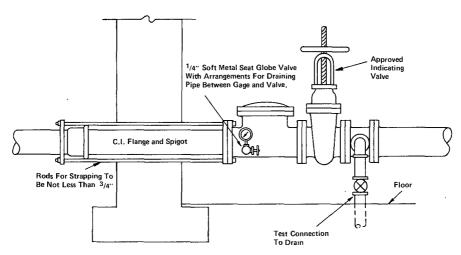
- 2-9.2.1 A pressure gage with a connection not smaller than ¼ in. (6.4 mm) shall be installed on the riser or feed main at or near each test connection. This gage connection shall be equipped with a shutoff valve and with provision for draining.
- 2-9.2.2 The required pressure gages shall be of an approved type 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.

Chapter 3 System Components

3-1 Piping.

3-1.1 Piping Specifications.

3-1.1.1 Pipe or tube used in sprinkler systems shall meet or exceed the standards in Table 3-1.1.1 or be in accordance with 3-1.1.2 through 3-1.1.6. Pipe and tube used in sprin-



For SI Units: 1 in. = 25.4 mm.

Figure 2-9.1 Water Supply Connection with Test Connection.

kler systems shall be designed to withstand a working pressure of not less than 175 psi (12.1 bars).

Table 3-1.1.1 Pipe or Tube Materials and Dimensions

1	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 ElecResistance 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
	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 3-1.1.7) according to ASTM standards.

- 3-1.1.2* When welded and seamless steel pipe listed in Table 3-1.1.1 is used and joined by welding as referenced in 3-7.2 or by roll grooved pipe and couplings as referenced in 3-7.3, 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; or as modified in 3-1.1.5, or as defined in 3-1.1.6.
- 3-1.1.3 When steel pipe listed in Table 3-1.1.1 is used and joined by threaded fittings referenced in 3-7.1 or by couplings 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).
- 3-1.1.4* Copper tube as specified in the standards listed in Table 3-1.1.1, used in sprinkler systems, shall have a wall thickness of Type K, L, or M.
- 3-1.1.5* Other types of pipe or tube may be used if investigated and listed for this service and installed in accordance with their listing limitations, including installation instructions. Pipe or tube shall not be listed for portions of an occupancy classification.
- **3-1.1.6** Whenever the word pipe is used in this standard it shall be understood to also mean tube.
- **3-1.1.7 Pipe Bending.** Bending of steel pipe (Schedule 40) and copper tube (Types K and L) may be accomplished

when bends are made in conformance with good installation practices and show no kinks, ripples, distortions, reduction 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.

3-2* Definitions. (See Figure A-3-2.)

Risers. The vertical pipes in a sprinkler system.

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

Feed Mains. Mains supplying risers or cross mains.

Cross Mains. Pipes directly supplying the lines in which the sprinklers are placed.

Branch Lines. Lines of pipe, from the point of attachment to the cross main (or similar connection) to the end sprinkler, in which the sprinklers are directly placed.

3-3 Special Provisions Applicable to Piping.

- 3-3.1 Rack Storage. For sprinklers in storage racks see NFPA 231C, Standard for Rack Storage of Materials.
- 3-3.2* 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 1¼-in. (33-mm) or larger pipe. All branch lines on gridded systems shall be arranged to facilitate flushing.
- 3-3.3 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.
- **3-3.4 Return Bends.** Return bends shall be used when 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.

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

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

- 3-3.4.1 In revamping existing systems, when it is not necessary to retain sprinklers in the concealed space, a nipple not exceeding 4 in. (102 mm) in length and of the same pipe thread size as the sprinkler being removed, may be used with 1-in. (25-mm) pipe and fittings for the other portions of the return bend to a single sprinkler in an area.
- 3-3.4.2 In revamping existing systems when it is necessary to retain sprinklers in the concealed space, the return bend shall be not less than 1 in. (25 mm) throughout to a single sprinkler in each area.

3-3.5 Piping to Sprinklers Below Ceilings.

3-3.5.1 In new installations expected to supply sprinklers below a ceiling, minimum 1 in. (25 mm) outlets shall be provided.

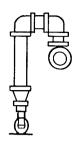


Figure 3-3.4 Return Bend Arrangement.

Exception: Hexagonal bushings may be utilized to accommodate the temporary sprinklers and are to be removed with the sprinklers.

3-3.5.2 In revamping existing systems, a nipple not exceeding 4 in. (102 mm) in length and of the same pipe thread size as the sprinkler being removed may be used. All other piping shall be 1 in. (25 mm) which supplies a single sprinkler in an area.

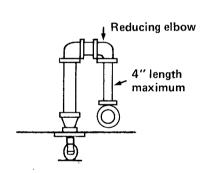


Figure 3-3.5.2(a) Nipple and Reducing Elbow Supplying Sprinkler Below Ceiling.

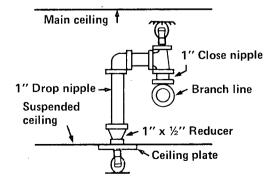


Figure 3-3.5.2(b) Sprinklers in Concealed Space and Below Ceiling.

- **3-3.6 Dry-Pipe Underground.** When necessary to place pipe that will be under air pressure underground, the pipe shall be protected against corrosion (*see 3-5.2*), or unprotected cast or ductile iron pipe may be used when joined with a gasketed joint listed for air service underground.
- 3-3.7* One and One-Half-Inch Hose Connections. One and one-half-inch [1½-in. (38-mm)] hose used for fire purposes only may 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 may be 2 in. (51 mm).

- (b) For piping serving a single hose station, pipe shall be minimum 1 in. (25 mm) for horizontal runs up to 20 ft (6.1 m), minimum 1½ 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).
- 3-3.8* Hose Connections for Fire Department Use. In buildings of Light or Ordinary Hazard Occupancy, 2½-in. (64-mm) hose valves for fire department use may be attached to wet-pipe sprinkler system risers. (See 2-2.3.4.) The following restrictions 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 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 2-7.

3-4 System Test Connections.

3-4.1 Wet Systems.

- 3-4.1.1* A test connection not less than 1 in. (25 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.
- **3-4.2* Dry-Pipe Systems.** A test connection not less than 1 in. (25 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-mm) shutoff valve and plug, at least one of which shall be brass. In lieu of a plug, a nipple and cap may be used.

- **3-4.3 Preaction Systems.** A test connection shall be used on a preaction system using supervisory air.
- **3-4.4 Deluge Systems.** A test connection is not required on a deluge system.

3-5* Protection of Piping.

3-5.1 Protection of Piping Against Freezing.

3-5.1.1 When portions of systems are subject to freezing and temperatures cannot be reliably maintained at or above 40°F (4°C) sprinklers shall be installed as a dry-pipe or preaction system.

Exception: Small unheated areas may be protected by antifreeze systems. (See Section 5-5.)

3-5.1.2* When 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).

3-5.2 Protection of Piping Against Corrosion.

- 3-5.2.1* When corrosive conditions are known to exist due to moisture or fumes from corrosive chemicals, or both, types of piping, fittings, and hangers that resist corrosion shall be used or a protective coating shall be applied to all unprotected exposed surfaces of the sprinkler system to resist corrosion. (See 3-11.4.)
- 3-5.2.2 When water supplies are known to have unusual corrosive properties and threaded or cut grooved steel pipe is to be used, wall thickness shall be in accordance with Schedule 30 [in sizes 8 in. (203 mm) or larger] or Schedule 40 [in sizes less than 8 in. (203 mm)].
- 3-5.2.3* Steel pipe, when exposed to weather, shall be externally galvanized or otherwise protected against corrosion.
- 3-5.2.4 When steel pipe is used underground as a connection from a system to sprinklers in a detached building, the pipe shall be protected against corrosion before being buried.

3-5.3 Protection of Piping Against Damage Where Subject to Earthquakes.

3-5.3.1* General. Sprinkler systems shall be protected to minimize or prevent pipe breakage where subject to earthquakes in accordance with the requirements of 3-5.3.

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.

- 3-5.3.2* Couplings. Listed flexible pipe couplings joining grooved end pipe shall be provided as flexure joints to allow individual sections of piping 3½ in. (89 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 may 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) At the ceiling of each story in multistory buildings.
- (c) On one side of concrete or masonry walls within 3 ft (0.9 m) of the wall surface.
 - (d)* At or near building expansion joints.
- (e) At the top of drops to hose lines, rack sprinklers, and mezzanines, regardless of pipe size.
- (f) At the top of drops exceeding 15 ft (4.6 m) in length to sprinklers or portions of systems, regardless of pipe size.
- **3-5.3.3*** Swing Joints. Swing joints assembled with flexible fittings shall be installed where sprinkler piping, regardless of size, crosses building seismic joints.
- **3-5.3.4* Clearance.** Clearance shall be provided around all piping extending through walls, floors, platforms, and foundations, including drains, fire department connections, and other auxiliary piping.
- (a) Minimum clearance on all sides shall be not less than 1 in. (25 mm) for pipes 1 in. (25 mm) through $3\frac{1}{2}$ in. (89 mm) and 2 in. (51 mm) for pipe sizes 4 in. (102 mm) and larger.

Exception No. 1: When 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 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 which is not required to have a fire-resistance rating.

Exception No. 3: No clearance is necessary if flexible couplings or swing joints are located within 1 ft (0.3 m) of each side of a wall.

(b) When required the clearance shall be filled with a flexible material such as mastic.

3-5.3.5 Sway Bracing.

3-5.3.5.1* Both lateral and longitudinal sway braces shall be sized and fastened such that the horizontal loads assigned to the braces in Table 3-5.3.5.1(1) do not exceed the allowable loads on the braces as shown in Table 3-5.3.5.1(2) and the allowable loads on fasteners as shown in Table 3-5.3.5.1(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 longi-

tudinal braces only, the brace may be connected to a tab welded to the pipe in conformance with 3-7.2.

Exception: In lieu of using Table 3-5.3.5.1(1), horizontal loads for braces may 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 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. For individual braces the slenderness ratio 1/r shall not exceed 200, where 1 is the length of the brace and r is the least radius of gyration, both in inches.

Table 3-5.3.5.1(1) Assigned Load Table (Based on half the weight of the water-filled pipe)

Spacing of Lateral Braces	Spacing of Longitudinal Braces**			Assigned Loa	nd for Pipe Size	to be Braced (lb)	
(ft)	(ft)	2	2 1/2	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

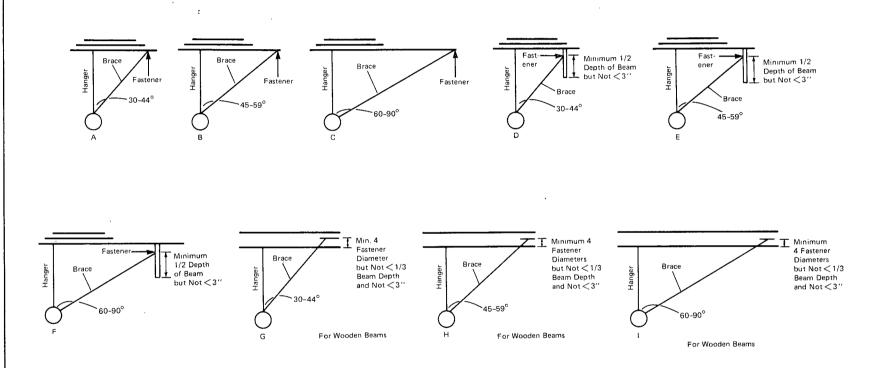
^{*}Permitted only under Exception No. 4 to 3-5.3.5.4.

Table 3-5.3.5.1(2)

Shape and Size	Least Radius of Gyration	Maximum Length for //r—200	Max 30° Angle From Vertical	imum Horizontal Load 45° Angle From Vertical	d (lb) 60° Angle From Vertical
Pipe (Schedule 10)	$=\frac{\sqrt{r_0^2+r_1^2}}{2}$				
1 in.	.42	7′0″	1767	2500	3061
1¼ in.	.54	9′0″	2393	3385	4145
1½ in.	.623	10′4″	2858	4043	4955
2 in.	.787	13′1″	3828	5414	6630
Pipe (Schedule 40)	$=\frac{\sqrt{r_0^2+r_1^2}}{2}$				
1 in.	.43	7'2"	1477	2090	2559
1¼ in.	.55	9'2"	1900	2687	3291
1½ in.	.634	10'7"	2194	3103	3800
2 in.	.802	13'4"	2771	3926	4803
Angles $1 \frac{1}{2} \times 1 \frac{1}{2} \times \frac{1}{4}$ $2 \times 2 \times \frac{1}{4}$ $2 \frac{1}{2} \times 2 \times \frac{1}{4}$ $2 \frac{1}{2} \times 2 \times \frac{1}{4}$ $2 \frac{1}{2} \times 2 \frac{1}{2} \times \frac{1}{4}$ $3 \times 2 \frac{1}{2} \times \frac{1}{4}$ $3 \times 3 \times \frac{1}{4}$.292	4'10"	2461	3481	4263
	.391	6'6"	3356	4746	5813
	.424	7'0"	3792	5363	6569
	.491	8'2"	4257	6021	7374
	.528	8'10"	4687	6628	8118
	.592	9'10"	5152	7286	8923
Rods	$=\frac{r}{2}$				
3/8	.094	1'6"	395	559	685
1/2	.125	2'6"	702	993	1217
5/8	.156	2'7"	1087	1537	1883
3/4	.188	3'1"	1580	2235	2737
7/8	.219	3'7"	2151	3043	3726
Flats	= 0.29 h (where h is smaller of two side dimensions)	1/2//	1110	1501	1024
$1\frac{1}{2} \times \frac{1}{4}$.0725	1'2"	1118	1581	1936
$2 \times \frac{1}{4}$.0725	1'2"	1789	2530	3098
$2 \times \frac{3}{8}$.109	1'9"	2683	3795	4648

^{**}If branch lines are provided with lateral bracing or hung with U-hooks bent out at least 10 degrees from vertical, half the assigned load may be used for longitudinal braces.

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.



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												
Length	3 304 32	B C D E 25 292 168 32	F G	H 1	A 366	В (D D	E	F 834	G —	H	<u>I</u>	A 410	В	C D	E	F 716	G	H	I —	A 487	В —	<u>C</u>	D	E	F 843	G —	H —	
Under Head		54 317 183 35 75 336 194 37												— 728 €	 53 27	- — 7 728		515		— 896	548 813	_	_	_	_	1122 1407	_	_	_
(inches)		82 342 196 38 				559 50	01 209	559	1192	395	556	687			97 40 23 41						971 1297	— 1365	 1223	— 685		1630 2244		 1359	1678

Table 3-5.3.5.1 (3) (Continued)

Through Bolts in Wood (load perpendicular to grain) Diameter of Bolt (in.)

				3/8						1/2						5/8						7/8	3		
Length of Bolt in Timber (in.)	1½ 2 2½ 3 35/8 5½	ABCE 300 370 460 480 460	D 173 214 266 277 268	F 519 641 796 831 797	G 150 185 230 240 230	H 211 261 324 338 324	I 261 322 400 417 400	ABCE 340 420 550 630 720 680	D 197 243 318 364 416 393	F 589 727 952 1091 1247 1177	G 170 210 275 315 360 340	H 239 296 387 444 507 479	I 296 365 478 548 626 591	ABCE 390 470 620 710 850 1020	D 225 272 358 410 491 590	F 675 814 1074 1229 1472 1766	G 195 235 310 355 425 510	H 275 331 437 500 599 718	I 339 409 539 617 739 887	ABCE 470 580 760 870 1050 1580	D 272 335 439 503 607 913	F 614 1004 1316 1506 1818 2736	G 235 290 380 435 525 790	H 331 408 535 613 739 1113	1 409 504 661 757 913 1374

Expansion Shields in Concrete Diameter of Bolt (in.)

		3/8	1/2	5/8	7/8
Min. Depth of Hole (in.)	2½ 3¼ 3¾ 4½	A B C D E F G H I 498 962 1173 678 962 962 925 1303 1609 — — — — — 925 1303 1609 — — — — — 925 1303 1609 — — — — — 925 1303 1609	A B C D E F G H I 1638 2306 2848 923 1782 2076 1200 1782 1597 1638 2306 2848 1638 2306 2848 1638 2306 2848	A B C D E F G H I — — — — — — 2080 2930 3617 — — — — — 2080 2930 3617 1480 2857 2637 1524 2857 2581 2080 2930 3617 — — — — — 2080 2930 3617	A B C D E F G H I — — — — — — 2970 4113 5078 — — — — — — 2970 4113 5078 — — — — — 2970 4113 5078 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 900 1200 1400 800 1200 1550 735 1035 1278	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		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.

- 3-5.3.5.2 Longitudinal sway bracing spaced at a maximum of 80 ft (24 m) on center shall be provided for feed and cross mains.
- 3-5.3.5.3* Tops of risers shall be secured against drifting in any direction, utilizing a four-way sway brace.
- **3-5.3.5.4** 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 may be omitted on pipes individually supported by rods less than 6 in. (152 mm) long.
- Exception No. 2: U-type hangers used to support the mains may be used to satisfy the requirements for lateral sway bracing provided the legs are bent out at least 10 degrees from the vertical.
- Exception No. 3: When flexible couplings are installed on mains other than as required in 3-5.3.2, 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: When building primary structural members exceed 40 ft (12 m) on center, lateral braces may be spaced up to 50 ft (15.2 m) on center.

- 3-5.3.5.5 Bracing shall be attached directly to feed and cross mains.
- **3-5.3.5.6** A length of pipe shall not be braced to sections of the building that will move differentially.
- 3-5.3.5.7 The last length of pipe at the end of a feed or cross main shall be provided with a lateral brace. Lateral braces may also act as longitudinal braces if they are within 24 in. (610 mm) of the center line of the piping braced longitudinally.
- 3-5.3.5.8 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-3-10.1) 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 3-5.3.5.4.

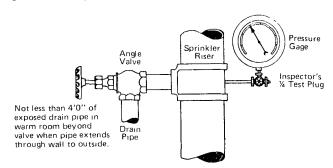
- **3-5.3.5.9** C-type clamps used to attach hangers to the building structure in areas subject to earthquakes shall be equipped with a retaining strap or other approved means to prevent movement. (See Figure A-3-10.1.)
- **3-5.3.5.10** C-type clamps, with or without retaining straps, shall not be used to attach braces to the building structure.

3-6 Drainage.

3-6.1 Pitching of Piping for Drainage.

- 3-6.1.1* All sprinkler pipe and fittings shall be so installed that the system may be drained.
- **3-6.1.2** On wet-pipe systems, sprinkler pipes may be installed level. Trapped piping shall be drained in accordance with 3-6.3.

- 3-6.1.3 On those portions of preaction systems subject to freezing and on dry-pipe systems, sprinkler pipe on branch lines shall be pitched at least ½-in. in 10 ft (4 mm/m) and the pipe of cross and feed mains shall be given a pitch of not less than ¼-in. in 10 ft (2 mm/m). A pitch of ¾ to 1-in. (19 to 25-mm) shall be provided for short branch lines and ½-in. in 10 ft (4 mm/m) for cross and feed mains in refrigerated areas and in buildings of light construction that may settle under heavy loads.
- **3-6.2** System, Main Drain, or Sectional Drain Connections. [See Figures 3-6.2 and A-3-4.1.1(b).]
- **3-6.2.1** 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 3-6.2 Drain Connection for System Riser.

3-6.2.2 Drain connections for systems supply risers and mains shall be sized as shown in Table 3-6.2.2.

Table 3-6.2.2

Riser or Main Size	Size of Drain Connection
Up to 2 in.	¾ in. or larger
$2\frac{1}{2}$ in., 3 in., $3\frac{1}{2}$ in.	1¼ in. or larger
4 in. and larger	2 in. only

- **3-6.2.3** Each interior sectional control valve shall be provided with a drain connection sized as shown in Table 3-6.2.2 so as to drain that portion of the system controlled by the sectional valve. These drains shall discharge either outside or to a drain connection.
- **3-6.2.4** The test valves required by 2-9.1 may be used as main drain valves.

3-6.3 Auxiliary Drains.

3-6.3.1 Auxiliary drains shall be provided when a change in piping direction prevents drainage of sections of branch lines or mains through the main drain valve.

3-6.3.2 Auxiliary Drains for Wet-Pipe Systems.

3-6.3.2.1 When the capacity of trapped sections of pipes is 5 gal (18.9 L) or less, the auxiliary drain shall consist of a nipple and cap or brass plug not less than ¾ in. (19 mm) in size.

Exception: Auxiliary drains are not required for piping that can be drained by removing a single pendent sprinkler.

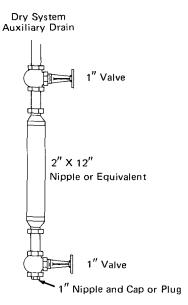
- 3-6.3.2.2 When the capacity of isolated trapped sections of pipe is more than 5 gal (18.9 L) and less than 50 gal (189 L), the auxiliary drain shall consist of a valve not smaller than ¾ in. (19 mm) in size and a plug, at least one of which shall be brass. In lieu of a plug, a nipple and cap may be used.
- 3-6.3.2.3* When the capacity of isolated trapped sections of pipe is 50 gal (189 L) or more, the auxiliary drain shall consist of a valve not smaller than 1 in. (25 mm), piped to an accessible location.
- **3-6.3.2.4** Tie-in drains are not required on wet-pipe systems.

3-6.3.3 Auxiliary Drains for Dry-Pipe Systems.

3-6.3.3.1 When capacity of trapped sections of pipe is 5 gal (18.9 L) or less, the auxiliary drain shall consist of a valve not smaller than ¾ in. (19 mm) and a plug, at least one of which shall be brass. In lieu of a plug, a nipple and cap may be used.

Exception: Auxiliary drains are not required for a drop nipple when installed in accordance with 5-2.2.

3-6.3.3.2 When capacity of isolated trapped sections of pipe is more than 5 gal (18.9 L), the auxiliary drain shall consist of two 1-in. (25-mm) valves, and one 2-in. by 12-in. (51-mm by 305-mm) condensate nipple or equivalent, accessibly located. (See Figure 3-6.3.3.)



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

Figure 3-6.3.3 Dry System Auxiliary Drain.

3-6.3.3.3* Tie-in drains shall be provided for multiple adjacent trapped branch lines and shall be a minimum of 1 in. (25 mm). Tie-in drain lines shall be pitched a minimum of ½ in. in 10 ft (4 mm/m).

3-6.3.4 Auxiliary Drains for Preaction Systems.

3-6.3.4.1 When trapped sections of pipe are in areas subject to freezing, auxiliary drains shall conform to 3-6.3.3.

3-6.3.4.2 When trapped sections of pipe are in areas not subject to freezing, auxiliary drains shall consist of a valve not smaller than ³/₄ in. (19 mm) and a plug, at least one of which shall be brass. In lieu of a plug, a nipple and cap may be used.

Exception: Auxiliary drains are not required for piping that can be drained by removing a single pendent sprinkler when capacity of the trapped sections of pipe is 5 gal (18.9 L) or less.

3-6.4 Discharge of Drain Valves.

- **3-6.4.1*** Direct interconnections shall not be made between sewers and sprinkler drains of systems supplied by public water. The drain discharge shall be in conformity with any health or water department regulations.
- **3-6.4.2** When drain pipes are buried underground, approved corrosion-resistant pipe shall be used.
- **3-6.4.3** Drain pipes shall not terminate in blind spaces under the building.
- **3-6.4.4** When exposed, drain pipes shall be fitted with a turned down elbow.
- **3-6.4.5*** Drain pipes shall be arranged so as not to expose any part of the sprinkler system to freezing conditions.

3-7 Joining of Pipe and Fittings.

3-7.1 Threaded Pipe and Fittings.

- 3-7.1.1 All threaded fittings and pipe shall have threads cut to ANSI/ASME standard B1.20.1. Care shall be taken that the pipe does not extend into the fitting sufficiently to reduce the waterway.
- 3-7.1.2* 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, unless a threaded assembly has been investigated for suitability in automatic sprinkler installations and listed for this service.
- 3-7.1.3 Joint compound or tape shall be applied to the threads of the pipe and not in the fitting.

3-7.2* Welded Piping.

- **3-7.2.1** 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.
- 3-7.2.2* Welding sections of sprinkler piping in place inside the building shall not be permitted. Sections of branch lines, cross mains, or risers may be shop welded.

Exception: Welding sections of sprinkler piping in place inside new buildings under construction may be permitted only when the construction is noncombustible and no combustible contents are present and when the welding process is performed in accordance with NFPA 51B, Standard for Fire Prevention in Use of Cutting and Welding Processes.

- 3-7.2.3 Welding procedures, welders, and welding machine operators shall be qualified as required by 3-7.2.11.
- 3-7.2.4 Fittings used to join pipe shall be listed fabricated fittings, or manufactured in accordance with Table 3-8.1.1. 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 when pipe ends are buttwelded.

3-7.2.5 No welding shall be performed if there is impingement of rain, snow, sleet, or high wind on the weld area of the pipe product.

3-7.2.6 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: Tabs may be welded to pipe for longitudinal earthquake braces only. (See 3-5.3.5.1.)

- 3-7.2.7 When reducing a pipe size in the run of a main, cross main, or branch, a reducing fitting designed for that purpose shall be used.
- 3-7.2.8 Torch cutting and welding shall not be permitted as a means of modifying or repairing sprinkler systems.
- **3-7.2.9** When welding is planned, a contractor shall specify the section to be shop welded on drawings and the type of fittings or formations to be used.
- **3-7.2.10** Sections of shop welded piping shall be joined by means of flanged or flexible gasketed joints or other approved fittings.

Exception: See 3-7.2.2.

3-7.2.11 Qualifications.

- **3-7.2.11.1** A welding procedure shall be prepared and qualified before any welding is done. Qualification of the welding procedure to be used and the performance of welders and welding operators is required and shall comply with the requirements of American Welding Society standard AWS D10.9, Level AR-3.
- 3-7.2.11.2 Contractors or fabricators shall be responsible for all welding they install. Each contractor or fabricator shall have an established written quality assurance proce-

dure related to control of the requirements of 3-7.2.6, available to the authority having jurisdiction.

- 3-7.2.11.3 Contractors or fabricators shall be responsible for qualifying any welding procedure that they intend to have used by personnel of their organization.
- **3-7.2.11.4** Contractors or fabricators shall be responsible for qualifying all of the welders and welding machine operators employed by them in compliance with the requirements of AWS D10.9, Level AR-3.

3-7.2.12 Records.

- 3-7.2.12.1 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.
- 3-7.2.12.2 Contractors or fabricators shall maintain certified records, which are 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.

3-7.3 Groove Joining Methods.

3-7.3.1 Pipe joined with mechanical grooved fittings shall be joined by a listed combination of fittings, gaskets, and grooves. When grooves are cut or rolled on the pipe they shall be dimensionally compatible with the fitting.

Exception: 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 fittings used with pipe having cut grooves.

- **3-7.3.2** Mechanical grooved couplings including gaskets used on dry-pipe systems shall be listed for dry-pipe service.
- 3-7.4* Brazed and Soldered Joints. Joints for the connection of copper tube shall be brazed.

Exception No. 1: Solder joints may be permitted for wetpipe systems in Light Hazard Occupancies where the temperature classification of the installed sprinklers is Ordinary or Intermediate.

Exception No. 2: Solder joints may be permitted for wetpipe systems in Ordinary Hazard (Group 1) Occupancies where the piping is concealed.

- 3-7.5 Other Types. Other types of joints shall be made or installed in accordance with the requirements of the listing for this service.
- **3-7.6 End Treatment.** After cutting, pipe ends shall have burrs and fins removed.
- 3-7.6.1 When using listed fittings, the pipe and its end treatment shall be in accordance with the manufacturer's installation instructions and the listing.

3-8 Fittings.

3-8.1 Types of Fittings.

3-8.1.1 Fittings used in sprinkler systems shall be of the materials listed in Table 3-8.1.1 or in accordance with

3-8.1.2. The chemical properties, physical properties, and dimensions of the materials listed in Table 3-8.1.1 shall be at least equivalent to the standards cited in the table. Fittings used in sprinkler systems shall be designed to withstand the working pressures involved, but not less than 175 psi (12.1 bars) cold water [125 psi (8.6 bars) saturated steam] pressure.

Table 3-8.1.1 Fittings Materials and Dimensions

Material 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 B 16.11
Copper Wrought Copper and Bronze Solder-Joint Pressure Fittings	ANSI B16.22
Cast Bronze Solder-Joint Pressure Fittings	ANSI B16.18

- 3-8.1.2* Other types of fittings may be used, but only those investigated and listed for this service.
- 3-8.1.2.1* When unique characteristics of a fitting, such as a tendency to rotate, require support in addition to that required in Section 3-10, restraint shall be provided in accordance with its listing.
- **3-8.1.3** Fittings used in sprinkler systems shall be extraheavy 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 may be used where pressures do not exceed 300 psi (20.7 bars).

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

Exception No. 3: Fittings may be used for system pressures up to the limits specified in listings by a testing laboratory.

3-8.1.4 When water pressures are 175 psi to 300 psi (12.1 to 20.7 bars), extra heavy valves shall be used in accordance with their pressure ratings.

- 3-8.1.5* When 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 5000 sq ft (465 m²).
- 3-8.2* 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 approved specifically for use in sprinkler systems. Unions, screwed or mechanical couplings, or flanges may be used to facilitate installation.
- **3-8.3 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 may be used 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 3-3.5.1 are acceptable.

3-9 Valves.

3-9.1 Types of Valves to Be Used.

3-9.1.1 All valves on connections to water supplies and in supply pipes to sprinklers shall be listed indicating valves, unless a nonindicating valve, such as an underground gate valve with approved roadway box complete with T-wrench, is accepted by the authority having jurisdiction.

Such valves shall not close in less than 5 seconds when operated at maximum possible speed from the fully open position. This is to avoid damage to piping by water hammer.

The following may not incorporate indicating devices as part of the valve, but the valve assembly described shall qualify as an indicating valve:

- (a) A listed underground gate valve equipped with a listed indicator post,
- (b) A listed water control valve assembly with a reliable position indication connected to a remote supervisory station.
- **3-9.1.2** Drain valves and test valves shall be of approved type of 175 psi (12.1 bars) cold water [125 psi (8.6 bars) saturated steam] pressure rating.
- **3-9.1.3** Check valves shall be listed and installed in a vertical or horizontal position in accordance with their listing.
- **3-9.1.4** When wafer type valves are used, the disc may extend beyond the end of the valve body. Valve discs shall not interfere with the operation of other system components.

3-9.2* Valves Controlling Sprinkler Systems.

- **3-9.2.1*** Each system shall be provided with a listed indicating valve so located as to control all sources of water supply except fire department connections.
- **3-9.2.2** At least one listed indicating valve shall be installed in each source of water supply except fire department connections.

connection.

- **3-9.2.3** 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) Locking valves open,
- (d) Sealing of valves and approved weekly recorded inspection when valves are located within fenced enclosures under the control of the owner.

Exception No. 1: Underground gate valves with roadway boxes need not be supervised.

Exception No. 2: For floor control valves in high-rise buildings; see 3-12.6; for circulating closed-loop systems, see 5-6.1.6.

3-9.2.4 When there is more than one source of water supply, a check valve shall be installed in each connection. Exception: When cushion tanks are used with automatic fire pumps, no check valve is required in the cushion tank

- **3-9.2.5*** A check valve shall be installed in each water supply connection if there is a fire department connection on the system.
- 3-9.2.6* When 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.
- **3-9.2.7** In a city connection serving as one source of supply, the city valve in the connection may serve as one of the required valves. A listed indicating valve or an indicator post valve shall be installed on the system side of the check valve. (See Figure A-3-9.2.5.)

Exception: When 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.

3-9.3 Pressure Reducing Valves.

- 3-9.3.1 In portions of systems where all components are not listed for pressure greater than 175 psi (12.1 bar) and the potential exists for normal (nonfire condition) water pressure in excess of 175, a listed pressure reducing valve shall be installed and set for an outlet pressure not exceeding 165 psi (11.4 bar) at the maximum inlet pressure.
- **3-9.3.2** Pressure gages shall be installed on the inlet and outlet sides of each pressure reducing valve.
- 3-9.3.3 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 bar).
- **3-9.3.4** A listed indicating valve shall be provided on the inlet side of each pressure reducing valve.

Exception: Where the pressure reducing valve meets the listing requirements for use as an indicating valve.

3-9.4* Identification of Valves. When there is more than one control valve, permanently marked identification signs indicating the portion of the system controlled by each valve shall be provided.

Embossed plastic tape, pencil, ink, crayon, etc., shall not be considered permanent markings. The sign shall be secured with noncorrosive wire, chain, or other means.

3-10 Hangers.

3-10.1* General. Type of hangers and installation methods shall be in accordance with the requirements of Section 3-10.

Exception: Hangers and installation methods certified by a registered professional engineer for the following:

- (a) 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 enough to support the sprinkler system.
 - (c) Ferrous materials are used for hanger components.

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

3-10.1.1 Hangers and their components shall be ferrous.

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

3-10.1.2 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.

- 3-10.1.3* Sprinkler piping or hangers shall not be used to support nonsystem components.
- 3-10.1.4 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.
- **3-10.1.5** Sprinkler piping shall be supported independently of the ceiling sheathing.

Exception: Toggle hangers shall be used only for the support of pipe 1½ in. (38 mm) or smaller in size under ceilings of hollow tile or metal lath and plaster.

- **3-10.1.6** When sprinkler piping is installed below ductwork, piping shall be substantially supported from the building structure or from the steel angles supporting the ductwork provided the angles conform to Tables 3-10.1.7(a) and 3-10.1.7(b).
- 3-10.1.7* 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 3-10.1.7(b) equals or exceeds the section modulus required in Table 3-10.1.7(a).

Any other sizes or shapes giving equal or greater section modulus will be acceptable. All angles are to be used with

Table 3-10.1.7(a) Section Modulus Required for Trapeze Members (in.3)

	Pipe Size													
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 .08	.09 .09	.09 .09	.09 .10	.10 .11	.11	.12 .13	.13 .15	.15 .18	.18 .22	.24 .30	.32 .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	.14 .15	.15 .15	.16 .16	.17 .18	.18 .21	.20 .22	.21 .25	.25	.30 .36	.40 .50	.54 .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 of water-filled pipe, plus 250 lb.

the longer leg vertical. The trapeze member shall be secured to prevent slippage. When a pipe is suspended from a pipe trapeze, ring, strap, or clevis, hangers of the size corresponding to the suspended pipe shall be used on both ends.

- 3-10.1.8 The size of hanger rods and fasteners required to support the steel angle iron or pipe indicated in Table 3-10.1.7(a) shall comply with 3-10.4.
- 3-10.1.9 Eye rods and ring hangers shall be secured with necessary lock washers to prevent lateral motion at the point of support.
- **3-10.1.10** Holes through concrete beams may also be considered as a substitute for hangers for the support of pipes.

3-10.1.11 Maximum Distance Between Hangers.

3-10.1.11.1* For steel pipe sizes $1\frac{1}{2}$ in. (38 mm) and larger, the maximum distance between hangers shall be 15 ft (4.5 m). For steel pipe sizes less than $1\frac{1}{2}$ in. (38 mm), the maximum distance between hangers shall be 12 ft (3.6 m).

Exception No. 1: Threaded lightweight steel pipe shall have a maximum distance between hangers not exceeding 12 ft (3.6 m) for pipe sizes 3 in. (76 mm) or less.

Exception No. 2: The maximum distance between hangers may be modified in accordance with other paragraphs of Section 3-10.

- 3-10.1.11.2* For copper tubes as specified in Table 3-1.1.1 the maximum distance between hangers shall not exceed that in Table 3-10.1.11.2.
- 3-10.1.12 When sprinkler piping is installed in storage racks as defined in NFPA 231C, Standard for Rack Storage of Materials, piping shall be substantially supported from the storage rack structure or building in accordance with all applicable provisions of Section 3-10.

3-10.2 Hangers in Concrete.

- **3-10.2.1** Listed inserts set in concrete may be installed for the support of hangers. Wood plugs shall not be used.
- 3-10.2.2 Listed expansion shields for supporting pipes under concrete construction may be used in a horizontal position in the sides of beams. In concrete having gravel or crushed stone aggregate, expansion shields may be used in the vertical position to support pipes 4 in. (102 mm) or less in diameter.
- 3-10.2.3 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 may be supported entirely by expansion shields in the vertical position, but spaced not over 10 ft (3 m) apart.
- **3-10.2.4** Expansion shields shall not be used in ceilings of gypsum or similar soft material. In cinder concrete, expan-

Table 3-10.1.7(b) Available Section Moduli of Common Trapeze Hangers

Pipe	Modulus		Aı	ngles		Mo	dulus
Schedule 10						_	
1 in.	.12	1 1/2	X	1 1/2	X	3/16	.10
1¼ in.	.19	2	X	2	X	1/8	.13
1½ in.	.26	2 2 2 2 2	X	1 1/2	X	3/16	.18
2 in.	.42	2	X	2	X	3/16	.19
21/2 in.	.69	2	X	2 2	X	1/4	.25
3 in.	1.04	21/2	X	1 1/2	X	3/16	.28
31/2 in.	1.38	21/2	X	2 2	X	3/16	.29
4 in.	1:76	2 2½	X	2	X	5/16	.30
5 in.	3.03	21/2	X	21/2	X	3/16	.30
6 in.	4.35	2 2½	X	2 2½	X	3/8	.35
		21/2	X	21/2	X	1/4	.39
Schedule 40		3 3 3	X	2	X	3/16	.41
•		3	X	21/2	X	3/16	.43
1 in.	.13	3	X	3	X	3/16	.44
1¼ in.	.23	21/2	X	21/2	X	5/16	.48
1½ in.	.33	3	X	2	X	1/4	.54
2 in.	.56	21/2	X	2	X	3/8	.55
2½ in.	1.06	21/2	X	21/2	X	3/8	.57
3 in.	1.72	3	X	3	\mathbf{X}	1/4	.58
31/2 in.	2.39	3	X	3	X	5/16	.71
4 in.	3.21	21/2	X	21/2	X	1/2	.72
5 in.	5.45	31/2	X	21/2	X	1/4	.75
6 in.	8.50	3	X	21/2	X	3/8	.81
		3	X	3	X	3/8	.83
		31/2	X	21/2	X	5/16	.93
		3	X	3	X	7/16	.95
		4	X	4	X	1/4	1.05
		3	X	3	X	1/2	1.07
		3 4 3 4 4	X	3	\mathbf{X}	5/16	1.23
		4	X	4	X	5/16	1.29
		4	X	3	X	3/8	1.46
		4	X	4	X	3/8	1.52
		5	X	31/2	X	5/16	1.94
		4	X	4	X	1/2	1.97
		4	X	4	X	5/8	2.40
		4	X	4	X	3/4	2.81
-		. 6	X	4	X	3/8	3.32
		6	X	4	X	1/2	4.33
	•.	6	X	4	X	3/4	6.25
		6	X	6	X	1	8.57

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

Table 3-10.1.11.2 Hanger Spacing for Copper Tube

Tube Size	Maximum Hanger Spacing
³ / ₄ in.—1 in.	8 ft
1 1/4 in.—1 1/2 in.	10 ft
2 in.—3 in.	12 ft
3½ in.—8 in.	15 ft

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

sion shields shall not be used except on branch lines where they shall alternate with through bolts or hangers attached to beams.

3-10.2.5 When 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 be not less than specified for the type of shield used.

3-10.2.6 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.

3-10.3 Powder-Driven Studs and Welding Studs.

3-10.3.1* Powder-driven studs, welding studs, and the tools used for installing these devices shall be listed by a testing laboratory and installed within the limits of pipe size, installation position, and construction material into which they are installed as expressed in individual listings or approvals.

3-10.3.2 The ability of concrete to hold the studs varies widely according to type of aggregate and quality of concrete, and it shall be established in each case by testing concrete on the job 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 2½-, 3-, or 3½-in. (64-, 76-, or 89-mm) pipe, and 1200 lb (545 kg) for 4- or 5-in. (102- or 127-mm) pipe.

3-10.3.3 When increaser couplings are used, they shall be attached directly to the powder-driven stud or welding stud.

3-10.3.4 Welded studs or other hanger parts shall not be attached by welding to steel less than U.S. Standard, 12 gage.

3-10.4 Rods and "U" Hooks.

3-10.4.1 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 3-10.4.1.

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

Table 3-10.4.1 Hanger Rod Sizes

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

For SI Units: 1 in. = 25.4 mm.

3-10.4.2 U-Hooks. The size of the rod material of U-hooks shall not be less than that given in Table 3-10.4.2. Drive screws shall be used only in a horizontal position as in the side of a beam in conjunction with U-hangers only.

Table 3-10.4.2 U-Hook Rod Sizes

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

For SI Units: 1 in. = 25.4 mm.

3-10.4.3 The size of the rod material for eye rods shall not be less than specified in Table 3-10.4.3.

Table 3-10.4.3 Eye Rod Sizes

Pipe Size	Diameter of Rod			
	With Bent Eye		With Welded Eye	
	in.	mm	in.	mm
Up to 4 in.	3/8	9.5	3/8	9.5
Up to 4 in. 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.

3-10.4.4 Threaded sections of rods shall not be formed or bent.

3-10.4.5 Screws. For ceiling flanges and U-hooks, screw dimensions shall not be less than those given in Table 3-10.4.5.

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 may 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 may be permitted with hangers spaced not over 10 ft (3 m) apart.

Table 3-10.4.5 Screw Dimension for Ceiling Flanges and U-Hooks

Pipe Size	2 Screw Flanges			
Up to 2 in.	Wood Screw No. 18 × 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 3/8 in. × 2 in.			
4 in., 5 in., 6 in.	Lag Screw $\frac{1}{2}$ in. \times 2 in.			
8 in.	Lag Screw % 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 $\frac{3}{8}$ in. \times $1\frac{1}{2}$ in.			
4 in., 5 in., 6 in.	Lag Screw $\frac{1}{2}$ in. \times 2 in.			
8 in.	Lag Screw % in. × 2 in.			
Pipe Size	U-Hooks			
Up to 2 in.	Drive Screw No. 16 × 2 in.			
2½ in., 3 in., 3½ in.	Lag Screw $\frac{3}{8}$ in. \times $\frac{2}{2}$ in.			
4 in., 5 in., 6 in.	Lag Screw ½ in. × 3 in.			

For SI Units: 1 in. = 25.4 mm.

3-10.4.6 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 3-10.4.6.

Table 3-10.4.6 Minimum Bolt or Lag Screw Sizes

	Size of Bolt or Lag Screw		Length of Lag Screw Used with Wood Beams	
Size of Pipe	in.	mm	in.	mm
Up to and in-	3/	0.5	21/	
cluding 2 in.	3/8	9.5 12.7	21/2	64 76
2½ to 6 in. (inclusive)	1/2		3	
8 in.	5/8	15.9	3	76

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

3-10.4.7 Wood screws shall not be driven. Nails are not acceptable for fastening hangers.

3-10.4.8 Screws in the side of a timber or joist shall be not less than $2\frac{1}{2}$ in. (64 mm) from the lower edge when supporting branch lines, and not less than 3 in. (76 mm) when supporting main lines. This shall not apply to 2-in. (51-mm) or thicker nailing strips resting on top of steel beams.

3-10.4.9 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 3-10.4.9.

Table 3-10.4.9 Minimum Plank Thicknesses and Beam or Joist Widths

	Nominal Plank Thickness		Nominal Width of Beam or Joist Face	
Pipe Size	in.	mm	in.	mm
Up to 2 in.	3	76	2	51
$2\frac{1}{2}$ in. to $3\frac{1}{2}$ in.	4	102	2	51
4 in. and 5 in.	4	102	3	76
6 in.	4	102	4	102

3-10.4.10 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 $\frac{1}{8}$ in. (3.2 mm) less in diameter than the root diameter of the lag screw thread.

3-10.5 Location of Hangers on Branch Lines. This subsection applies to the support of steel pipe or copper tube as specified in 3-1.1.1, subject to the provisions of 3-10.1.11.

3-10.5.1 On branch lines, there shall be not less than one hanger for each length of pipe.

Exception: Hangers may be located as provided in 3-10.5.2 to 3-10.5.5 inclusive.

3-10.5.2* When sprinklers are spaced less than 6 ft (1.8 m) apart, hangers may be spaced up to a maximum of 12 ft (3.7 m). (See Figure A-3-10.5.2.)

3-10.5.3 Starter lengths less than 6 ft (1.8 m) do not require a hanger, except on the end line of a side-feed system or where an intermediate cross main hanger has been omitted.

3-10.5.4 The distance between a hanger and the center line of an upright sprinkler shall not be less than 3 in. (76 mm).

3-10.5.5* 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. (25-mm) pipe or 48 in. (1219 mm) for 1½-in. (33-mm) or larger pipe. When either of these limits is exceeded, the pipe shall be extended beyond the end sprinkler and supported by an additional hanger. (See 3-8.1.2.1.)

Exception: 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. [See Figure A-3-10.5.5(a).]

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 clamps to and prevents upward movement of the piping. [See Figure A-3-10.5.5(a).]

3-10.5.6* 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. (See 3-8.1.2.1.)

Exception: When the maximum pressure at the sprinkler exceeds 100 psi 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 or drop nipple shall not exceed 12 in. (305 mm) for steel pipe and 6 in. (152 mm) for copper tube.

When the limits of unsupported armover lengths of 3-10.5.6 or this Exception are exceeded, the hanger closest to the sprinkler shall be of a type that prevents upward movement of the piping. [See Figure A-3-10.5.5(a).]

- **3-10.5.7** Wall mounted sidewall sprinklers shall be restrained to prevent movement.
- **3-10.6** Location of Hangers on Cross Mains. This subsection applies to the support of steel pipe only as specified in 3-1.1.1, subject to the provisions of 3-10.1.11. Intermediate hangers shall not be omitted for copper tube.
- 3-10.6.1* 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 may 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. [See Figure A-3-10.6.1(a).] Remaining branch line hangers shall be installed in accordance with 3-10.5.

Exception No. 2: In bays having three or more branch lines, either side or centerfeed, one (only) intermediate hanger may 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. [See Figures A-3-10.6.1(b) and A-3-10.6.1(c).] Remaining branch line hangers shall be installed in accordance with 3-10.5.

3-10.6.2 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 an ordinary hanger installed at this point, in which event an intermediate hanger may be omitted in accordance with 3-10.6.1, Exceptions No. 1 and No. 2.

3-10.7 Support of Risers.

3-10.7.1 Risers shall be supported by attachments directly to the riser or by hangers located on the horizontal connections close to the riser.

- 3-10.7.2 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 when flexible fittings are used. Where risers are supported from the ground, the ground support constitutes the first level or 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.
- 3-10.7.3 Sprinkler and tank 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.
- **3-10.7.4** Clamps supporting pipe by means of set screws shall not be used.

3-11 Sprinklers.

- **3-11.1 Types of Sprinklers.** Some of the commonly used sprinklers are as follows:
- (a) Upright Sprinklers. Sprinklers designed to be installed in such a way that the water spray is directed upwards against the deflector.
- (b) Pendent Sprinklers. Sprinklers designed to be installed in such a way that the water stream is directed downward against the deflector.
- (c) Sidewall Sprinklers. 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.
- (d) Extended Coverage Sidewall Sprinklers. Sprinklers with special extended, directional, discharge patterns.
- (e) Open Sprinklers. Sprinklers from which the actuating elements have been removed.
- (f) Corrosion-Resistant Sprinklers. Sprinklers with special coatings or platings to be used in an atmosphere that would corrode an uncoated sprinkler.
- (g) Nozzles. Devices for use in applications requiring special discharge patterns, directional spray, fine spray, or other unusual discharge characteristics.
- (h)* Dry-Pendent Sprinklers. Sprinklers for use in a pendent position in a dry-pipe system or a wet-pipe system with the seal in a heated area.
- (i)* Dry Upright Sprinklers. Sprinklers that are designed to be installed in an upright position, on a wet-pipe system, to extend into an unheated area with a seal in a heated area.
- (j) Ornamental Sprinklers. Sprinklers that have been painted or plated by the manufacturer.
- (k) Flush Sprinklers. Sprinklers in which all or part of the body, including the shank thread, is mounted above the lower plane of the ceiling.
- (l) Recessed Sprinklers. Sprinklers in which all or part of the body, other than the shank thread, is mounted within a recessed housing.
- (m) Concealed Sprinklers. Recessed sprinklers with cover plates.
- (n) Old-Style Sprinklers. Sprinklers that direct only 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.

- (o) Residential Sprinklers. Sprinklers that have been specifically listed for use in residential occupancies.
- (p) Intermediate Level Sprinklers. Sprinklers equipped with integral shields to protect their operating elements from the discharge of sprinklers installed at higher elevations.
- (q) Special Sprinklers. Sprinklers that have been tested and listed as prescribed in 4-1.1.3.
- (r) Quick-Response Sprinklers. A type of special sprinkler incorporating a fast-actuating heat-responsive element.
 - (s) Large-Drop Sprinklers: Listed large-drop sprinklers are characterized by a K factor between 11.0 and 11.5, and proven ability to meet prescribed penetration, cooling, and distribution criteria prescribed in large-drop sprinkler examination requirements. The deflector/discharge characteristics of large-drop sprinklers generate drops of such size and velocity as to enable effective penetration of the high-velocity fire plume.

3-11.2 Use of Sprinklers.

3-11.2.1* Only listed sprinklers shall be used and shall be installed in accordance with their listing.

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

- 3-11.2.2 Sprinklers shall not be altered in any respect or have any type of ornamentation or coating applied after shipment from the place of manufacture.
- **3-11.2.3** Sprinklers shall not be used for system working pressures exceeding 175 psi (12.1 bars).

Exception: Higher design pressures may be used when sprinklers are listed for those pressures.

3-11.2.4 Old-style sprinklers shall not be used in a new installation.

Exception No. 1: For installation under piers and wharves where construction features require an upward discharge to wet the underside of decks and structural members supporting the decks, a sprinkler that projects water upward to wet the overhead shall be used. This can be accomplished by using standard pendent sprinklers installed in an upright position or by the use of old-style sprinklers. See NFPA 307, Standard for the Construction and Fire Protection of Marine Terminals, Piers, and Wharves.

Exception No. 2: Old-style sprinklers shall be installed in fur storage vaults. See 4-4.16.3. Also see NFPA 81, Standard for Fur Storage, Furnigation and Cleaning.

Exception No. 3: Listed old-style sprinklers may be used when construction features or other special situations require unique water distribution.

3-11.2.5 Sidewall sprinklers shall be installed only in Light Hazard Occupancies.

Exception: Sidewall sprinklers specifically listed for use in Ordinary Hazard Occupancies.

3-11.2.6 Extended coverage sidewall sprinklers shall be installed only in accordance with their listing.

3-11.2.7 Open sprinklers may be used to protect special hazards, for protection against exposures, or in other special locations.

3-11.2.8 Escutcheon Plates.

- **3-11.2.8.1** When nonmetallic ceiling plates (escutcheons) are used they shall be listed.
- **3-11.2.8.2** Escutcheon plates used to create a recessed or flush type sprinkler shall be part of a listed sprinkler assembly.

3-11.2.9 Residential Sprinklers.

- 3-11.2.9.1* Residential sprinklers may be used in dwelling units 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 Mobile Homes. One-half inch or larger orifice residential sprinklers may be used in dry-pipe systems when the design area is in compliance with Chapter 2.
- 3-11.2.9.2 When residential sprinklers are installed within a compartment as defined in 7-4.4, all sprinklers shall be from the same manufacturer and have the same heat-response element including temperature rating.

3-11.3 Replacement of Sprinklers.

- **3-11.3.1** When sprinklers are replaced, the replacement sprinkler shall be of the same type, orifice, and temperature rating unless conditions require a different type sprinkler be installed. The replacement sprinkler shall then be of a type, orifice, and temperature rating to suit the new conditions.
- **3-11.3.2** Old-style sprinklers may be replaced with old-style sprinklers, or with the appropriate pendent or upright sprinkler.
- **3-11.3.3** Old-style sprinklers shall not be used to replace pendent or upright sprinklers.
- **3-11.3.4** Extreme care shall be exercised when replacing horizontal sidewall and extended coverage sidewall sprinklers to assure the correct replacement sprinkler is installed.
- 3-11.3.5 Sprinklers that have been painted or coated, except by the manufacturer, shall be replaced and shall not be cleaned by use of chemicals, abrasives, or other means. (See 3-11.9.2.)

3-11.4 Corrosion-Resistant, Wax-Coated, or Similar Sprinklers.

- 3-11.4.1* Listed corrosion-resistant or special coated sprinklers shall be installed in locations where chemicals, moisture, or other corrosive vapors sufficient to cause corrosion of such devices exist.
- **3-11.4.2** Care shall be taken in the handling and installation of wax-coated or similar sprinklers to avoid damaging the coating.
- **3-11.4.3** Corrosion-resistant coatings shall be applied only by the manufacturer of the sprinkler.

Exception: Any damage to the protective coating occurring

Table 3-11.5 Sprinkler Discharge Characteristics Identification

Nominal Orifice Size (in.) ¹	Orifice Type	K Factor ²	Percent of Nominal ½ in. Discharge	Thread Type	Pintle	Nominal Orifice Size Marked On Frame
1/4	Small	1.3-1.5	25	½ in. NPT	Yes	Yes
5/16	Small	1.8-2.0	33.3	½ in. NPT	Yes	Yes
3/8	Small	2.6-2.9	50	½ in. NPT	Yes	Yes
7/16	Small	4.0-4.4	75	½ in. NPT	Yes	Yes
1/2	Standard	5.3-5.8	100	½ in. NPT	No	No
17/32	Large	7.4-8.2	140	¾ in. NPT	No	No
	Ü			or 1/2 in. NPT	Yes	Yes
5/8	Extra Large	11.0-11.5	200	¾ in. NPT	Yes	Special Deflector

¹See A-3-11.5.2

²K factor is the constant in the formula $Q = K \sqrt{P}$

Where Q = Flow in gpm

P = Pressure in psi

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 none of the sprinkler will be exposed after installation has been completed.

3-11.5* Sprinkler Discharge Characteristics and Identifica-

3-11.5.1 Table 3-11.5 shows the K factor, relative discharge, and identification for sprinklers having different orifice sizes.

Exception: Special listed sprinklers may have pipe threads different from those shown in Table 3-11.5.

- 3-11.5.2 For Light Hazard Occupancies not requiring as much water as is discharged by a nominal ½-in. (12.7-mm) orifice sprinkler operating at 7 psi (0.5 bar), sprinklers having a smaller orifice may be used subject to the following restrictions:
- (a) The system shall be hydraulically calculated. (See Section 8-1.)
- (b) Small orifice sprinklers shall not be used on dry-pipe, preaction, or combined dry-pipe and preaction systems.

Exception: Outside sprinklers for protection from exposure fires installed in conformance with Chapter 6.

(c) An approved strainer shall be provided in the riser or feed main that supplies sprinklers having orifices smaller than $\frac{3}{8}$ in. (9.5 mm).

For SI Units: $Qm = Km \sqrt{Pm}$

Where Qm ≈ Flow in L/min

Pm = Pressure in bars

Km = 14 K

- 3-11.5.3 For locations or conditions requiring more water than is discharged by a nominal ½-in. (12.7-mm) orifice sprinkler, a sprinkler having a larger orifice may be used.
- 3-11.5.4 Sprinklers having orifice sizes exceeding ½ in. (12.7 mm) and having ½ in. NPT shall not be installed in new sprinkler systems.

$3-11.6^*$ Temperature Ratings, Classifications, and Color Coding.

3-11.6.1 The standard temperature ratings of automatic sprinklers are shown in Table 3-11.6.1. Automatic sprinklers shall have their frame arms colored in accordance with the color code designated in Table 3-11.6.1, with the following Exceptions:

Exception No. 1: The color identification for corrosionresistant sprinklers may be a dot on the top of the deflector, the color of the coating material, or colored frame arms.

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

3-11.6.2 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

Table 3-11.6.1 Temperature Ratings, Classifications, and Color Codings

Max. Ceiling Temp.		Temperature Rating		Temperature	Color	Glass Bulb
°F	°C	°F	°C	Classification	Code	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

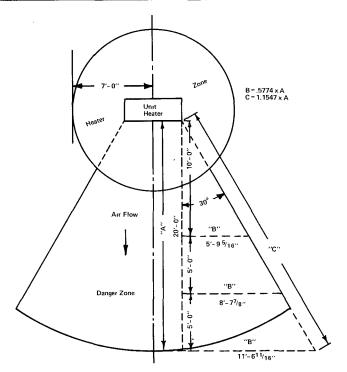
accordance with the maximum ceiling temperatures of Table 3-11.6.1 shall be used.

Exception No. 2: Intermediate and high-temperature sprinklers may 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 3-11.6.3 and 5-6.1.4.1.

Exception No. 4: When permitted or required by other NFPA standards.

- **3-11.6.3** The following practices shall be observed to provide sprinklers of other than ordinary temperature classification unless maximum expected temperatures are otherwise determined, or unless high-temperature sprinklers are used throughout [see Tables 3-11.6.3(a) and 3-11.6.3(b) and Figure 3-11.6.3(a)]:
- (a) Sprinklers near unit heaters. Sprinklers in the heater zone shall be high and sprinklers in the danger zone 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 intermediate temperature classification.
- (c) Sprinklers within 7 ft (2.1 m) of a low-pressure blowoff valve that discharges free in a large room shall be high temperature classification.
- (d) Sprinklers under glass or plastic skylights exposed to the direct rays of the sun shall be intermediate temperature classification.



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

Figure 3-11.6.3(a) Heater and Danger Zones at Unit Heaters.

Table 3-11.6.3(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	<u>-</u>
2. Unit Heater (a) Horizontal Discharge	·	Discharge Side: 7 ft 0 in. to 20 ft 0 in. radius pie-shaped cylinder [see Figure 3-11.6.3(a)] 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 3-11.6.3(a).]	_	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 3-11.6.3(b)	Datings	of Carialdore in	. Specified	Lacations
Table 4-11.6.3(b)	Ratinos	of Sprinklers in	i 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 con- cealed; insulated or uninsulated	Ventilated	Unventilated '		
Flat Roof: Metal, not concealed; insulated or uninsulated	Ventilated or unventilated	Note: For uninsulated roof, climate and occupancy may require 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.

- (e) Sprinklers in an unventilated concealed space under an uninsulated roof, or in an unventilated attic, shall be of intermediate temperature classification.
- (f) Sprinklers in unventilated show windows having high-powered electric lights near the ceiling shall be intermediate temperature classification.
- (g) For sprinklers protecting commercial-type cooking equipment and ventilation systems, temperature classifications of intermediate, high, or extra high shall be provided as determined by use of a temperature measuring device. (See 4-4.17.2.)
- **3-11.6.4** In case of change of occupancy involving temperature change, the sprinklers shall be changed accordingly.

3-11.7* Stock of Spare Sprinklers.

- 3-11.7.1 There shall be maintained on the premises a supply of spare sprinklers (never less than 6) so that any sprinklers that have operated or been damaged in any way may be promptly replaced. These sprinklers shall correspond to 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).
- **3-11.7.2** A special sprinkler wrench shall also be provided and kept in the cabinet, to be used in the removal and installation of sprinklers.
- **3-11.7.3** The stock of spare sprinklers shall be as follows:
- (a) For equipments not over 300 sprinklers, not less than 6 sprinklers.
- (b) For equipments 300 to 1,000 sprinklers, not less than 12 sprinklers.
- (c) For equipments above 1,000 sprinklers, not less than 24 sprinklers.
- (d) Stock of spare sprinklers shall include all types and ratings installed.
- 3-11.8* Guards and Shields. Sprinklers that are so located as to be subject to mechanical injury (in either the upright or the pendent position) shall be protected with listed guards.

3-11.9 Painting and Ornamental Finishes.

- 3-11.9.1* When the sprinkler piping is given any kind of coating, such as whitewash or paint, care shall be exercised to see that no automatic sprinklers are coated.
- 3-11.9.2* Sprinklers shall not be painted and any sprinklers that have been painted shall be replaced with new listed sprinklers of the same characteristics.

Exception: Factory-applied coatings to sprinkler frames for identifying sprinklers of different temperature ratings in accordance with 3-11.6.1.

3-11.9.3 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.

3-12 Sprinkler Alarms.

- **3-12.1 Definition.** A local alarm unit is an assembly of apparatus approved 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 minutes after such flow begins. For remote sprinkler waterflow alarm transmission see 3-12.7.1.
- **3-12.2* Where Required.** Local waterflow alarms shall be provided on all sprinkler systems having more than 20 sprinklers.

3-12.3 Waterflow Detecting Devices.

- **3-12.3.1 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.
- **3-12.3.2** 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, the actuating device of the alarms for the dry-pipe valve may be connected to the alarms on the wet-pipe system.
- 3-12.3.3* Preaction and Deluge Systems. In addition to the waterflow alarms required for systems having more than

20 sprinklers, all deluge and preaction systems shall be provided with listed alarm attachments actuated by the detection system.

3-12.3.4* Waterflow alarm indicators (paddle-type) shall not be installed in dry-pipe, preaction, or deluge systems.

3-12.4 Attachments — General.

- 3-12.4.1* An alarm unit shall include a listed mechanical alarm, horn, or siren, or a listed weatherproof electric gong, bell, horn, or siren.
- **3-12.4.2*** Outdoor mechanical or electrically operated bells shall be of weatherproof and guarded type.
- 3-12.4.3 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.
- 3-12.4.4 Alarm valves, 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.
- 3-12.4.5 A control valve shall be installed in connection with a pressure-type contactor or water-motor-operated alarm devices, and such valves shall be of the type that will clearly indicate whether they are open or closed and be so constructed that they may be locked or sealed in the open position. The control valve for the retarding chamber on alarm check valves of wet-pipe systems may be accepted as complying with this paragraph.
- 3-12.5* Attachments Mechanically Operated. For all types of sprinkler systems employing water-motor-operated alarms, an approved ¾-in. (19-mm) strainer shall be installed at the alarm outlet of the waterflow detecting device except that when 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. Water-motor-operated devices shall be protected from the weather, and shall be properly aligned and so installed as not to get out of adjustment. All piping to these devices shall be galvanized or brass or other approved corrosion-resistant material of a size not less than ¾ in. (19 mm).
- 3-12.6 Alarm Attachments High-rise Buildings. When a fire must be fought internally due to the height of a building, the following additional alarm supervision must be provided:
- (a) When 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 both locations.

Exception: When 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 or central station.

(b) A distinct trouble signal shall be provided to indicate a condition that will impair the satisfactory operation of the sprinkler system. This shall include but not be limited to monitoring 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.

3-12.7 Attachments — Electrically Operated.

- **3-12.7.1** Electrically operated alarm attachments forming part of an auxiliary, central station, proprietary, or remote station signaling system shall be installed in accordance with the following applicable NFPA standards:
- (a) NFPA 71, Standard for the Installation, Maintenance, and Use of Signaling Systems for Central Station Service,
- (b) NFPA 72B, Standard for the Installation, Maintenance, and Use of Auxiliary Protective Signaling Systems for Fire Alarm Service,
- (c) NFPA 72C, Standard for the Installation, Maintenance, and Use of Remote Station Protective Signaling Systems,
- (d) NFPA 72D, Standard for the Installation, Maintenance, and Use of Proprietary Protective Signaling Systems.
- 3-12.7.2* The circuits of electrical alarm attachments forming part of a local sprinkler waterflow alarm system need not be supervised.

Exception: If the local sprinkler waterflow alarm system is part of a required local fire alarm system, it shall be installed in accordance with NFPA 72A, Standard for the Installation, Maintenance, and Use of Local Protective Signaling Systems.

- **3-12.7.3** Waterflow detecting devices, including the associated alarm circuits, shall be tested by an actual waterflow through use of a test connection. (*See 3-12.8.*)
- **3-12.7.4** Outdoor electric alarm devices shall be of a type specifically listed for outdoor use, and the outdoor wiring shall be in approved conduit, properly protected from the entrance of water in addition to the requirements of 3-12.7.1 and 3-12.7.2.
- **3-12.8 Drains.** Drains from alarm devices shall be so arranged that there will be no danger of freezing, and so 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 3-6.4.)

Chapter 4 Spacing, Location, and Position of Sprinklers

4-1 General Information.

4-1.1* Basic Requirements.

- **4-1.1.1*** The basic requirements for spacing, location, and position of sprinklers are specified in this chapter and 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 optimize performance with respect to activation time and distribution,
 - (d) And as specified herein.
- Exception No. 1: See 4-4.3, 4-4.4, and 4-4.19.2 for locations from which sprinklers may be omitted.
- Exception No. 2: Special sprinklers may be installed in accordance with 4-1.1.3.
- Exception No. 3: When sprinklers are specifically tested and test results prove that deviations from clearance requirements to structural members offer no obstruction to spray discharge, they may be positioned and located accordingly.
- Exception No. 4: Clearance between sprinklers and ceilings may exceed the maximum specified in Sections 4-3 and 4-5.4 provided that, for the conditions of occupancy protected, tests or calculations show comparable sensitivity and performance of the sprinklers to those installed in conformance with Sections 4-3 and 4-5.4.
- **4-1.1.2** Residential sprinklers shall be installed in conformance with their listing and the positioning requirements of NFPA 13D, Standard for the Installation of Sprinkler Systems for One- and Two-Family Dwellings and Mobile Homes.
- 4-1.1.3 Special sprinklers may be installed with protection areas, locations, and distances between sprinklers differing from those specified in Sections 4-2 and 4-5 when found suitable for such use based on: fire tests related to the hazard category; tests to evaluate distribution, wetting of floors and walls, interference to distribution by structural elements; and tests to characterize response sensitivity, when installed in accordance with any special sprinkler listing limitation.
- Exception No. 1: No sprinkler shall be installed to protect an area greater than 400 sq ft (36 m²).
- Exception No. 2: Maximum area of coverage for individual extended coverage pendent and upright sprinklers shall be limited to areas having coverage with equal-sided dimensions.
- 4-1.2* 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.

4-1.3 Definitions.

4-1.3.1 Smooth Ceiling Construction. The term *smooth ceiling construction* as used in this standard includes:

- (a) Flat slab, pan-type reinforced concrete, concrete joist less than 3 ft (0.9 m) on centers.
- (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 centers.
- (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.
- (g) In (b) through (f) above, the roof and floor decks may be noncombustible or combustible. Item (b) would include standard mill construction.
 - (h) Suspended ceilings of noncombustible construction.
- (i) Suspended ceilings of combustible construction where there is a full complement of sprinklers in the space immediately above such a ceiling and the space is unfloored and unoccupied.
- (j) 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.
- (k) Combustible suspended ceilings arranged other than as specified under item (i).
- 4-1.3.2 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 centers and either supported on or framed into girders. [When supporting a wood plank deck, this includes semi-mill and panel construction, and when supporting (with steel framing) gypsum plank, steel deck, concrete, tile, or similar material, this would include much of the so-called noncombustible construction.]
- **4-1.3.3*** 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.
- 4-1.3.4 Panel Construction. The term panel construction as used in this standard includes ceiling panels formed by members capable of trapping heat to aid the operation of sprinklers and limited to a maximum of 300 sq ft (27.9 m²) in area. Beams spaced more than 7½ ft (2.3 m) apart and framed into girders qualify for panel construction provided the 300 sq ft (27.9 m²) area limitation is met.
- **4-1.3.5 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*.

- **4-1.3.6** 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.
- **4-1.3.7** 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 thickness 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.
- 4-1.3.8* 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 shall be fire-stopped 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 m²).
- **4-1.3.9 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, shall also be considered wood truss construction.
- **4-1.3.10 High-Piled Storage.** The term *high-piled storage* refers to solid piled, palletized, rack storage, bin box, and shelf storage in excess of 12 ft (3.7 m) in height. See 10-1.2 for availability of information for sprinkler protection of high-piled storage.
- 4-2 Spacing and Location of Upright and Pendent Sprinklers. (See also Sections 4-3 and 4-4.)
- 4-2.1 Distance Between Sprinklers, on the Branch Lines and Between the Branch Lines.
- **4-2.1.1** For Light Hazard Occupancies, the distance between sprinklers, either on branch lines or between branch lines, shall not exceed 15 ft (4.6 m).
- **4-2.1.2*** For Ordinary Hazard Occupancies, the distance between sprinklers, either on branch lines or between branch lines, shall not exceed 15 ft (4.6 m).
- **4-2.1.3** For Extra Hazard Occupancies, the distance between sprinklers, either on branch lines or between branch lines, shall not exceed 12 ft (3.7 m).
- **4-2.1.4** In areas used for high-piled storage (as defined in 4-1.3.10), the distance between sprinklers shall not exceed 12 ft (3.7 m).

Exception No 1: In bays 25 ft (7.6 m) wide, a spacing of 12 ft 6 in. (3.8 m) between sprinklers is permitted.

Exception No. 2: For systems hydraulically designed for densities below 0.25 gpm per sq ft [(10.2 L/min)/m²)] spacing between sprinklers to 15 ft (4.6 m) is permitted.

4-2.1.5 Distance from Walls.

4-2.1.5.1 The distance from walls to sprinklers shall not exceed one-half of the allowable distance between sprinklers.

Exception: For small rooms, see 4-4.19.

4-2.1.5.2 Sprinklers shall be located a minimum of 4 in. (102 mm) from a wall.

4-2.2* Protection Area Limitations.

4-2.2.1 System Areas. 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 m²)
Ordinary Hazard — 52,000 sq ft (4831 m²)
Extra Hazard — Pipe Schedule — 25,000 sq ft (2323 m²)
— Hydraulically Calculated — 40,000 sq ft (3716 m²)

Storage — High-piled storage (as defined in 4-1.3.10) and storage covered by other NFPA standards — 40,000 sq ft (3716 m²).

Exception: When 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 m²).

4-2.2.2 Light Hazard Occupancy.

4-2.2.2.1 Under smooth ceiling, beam and girder, and bar joist construction (as defined in 4-1.3.1, 4-1.3.2, and 4-1.3.3) the protection area per sprinkler shall not exceed 225 sq ft (20.9 m²).

Exception: The protection area per sprinkler for pipe schedule systems shall not exceed 200 sq ft (18.6 m²).

- 4-2.2.2.* Under exposed wood joist construction (as defined in 4-1.3.7) the protection area per sprinkler shall not exceed 130 sq ft (12.1 m²).
- 4-2.2.2.3 Under exposed composite wood joist and exposed parallel chord wood truss construction (as defined in 4-1.3.8 and 4-1.3.9 respectively) of 16 in. (406 mm) nominal depth or less and exposed pitch chord wood truss construction of any depth, the protection area per sprinkler shall not exceed 130 sq ft (12.1 m²).

Exception: For composite wood joist construction and exposed parallel wood chord construction with members spaced more than 3 ft (0.9 m) on centers, see 4-2.2.2.4.

- **4-2.2.2.4** For other types of construction the protection area per sprinkler shall not exceed 168 sq ft (15.6 m²).
- **.4-2.2.3 Ordinary Hazard Occupancy.** For all types of construction the protection area per sprinkler shall not exceed 130 sq ft (12.1 m²).

4-2.2.4 Extra Hazard Occupancy. The protection area per sprinkler shall not exceed 100 sq ft (9.3 m²) for any type of building construction. Sprinkler spacing may exceed 100 sq ft (9.3 m²) but shall not exceed 130 sq ft (12.1 m²) for densities below 0.25 gpm per sq ft [(10.2 L/min)/m²].

Exception: The protection area per sprinkler for pipe schedule systems shall not exceed 90 sq ft (8.4 m^2) .

- **4-2.2.5 High-Piled Storage.** In areas used for high-piled storage (as defined in 4-1.3.10) or for storage covered by other NFPA standards the protection area per sprinkler shall not exceed 100 sq ft (9.3 m²).
- Exception No. 1: Sprinkler protection areas may exceed 100 sq ft (9.3 m²) but shall not exceed 130 sq ft (12.1 m²) in systems hydraulically designed in accordance with NFPA 231, Standard for General Storage, and 231C, Standard for Rack Storage of Materials, for densities below 0.25 gpm per sq ft [(10.2 L/min)/m²].

Exception No. 2: Where protection areas are specifically indicated in the design criteria of other NFPA standards.

- **4-2.2.6 Special Conditions.** When other NFPA standards have developed more stringent sprinkler system spacing criteria, they shall take precedence when supported by valid fire tests.
- 4-2.3* Location of Sprinklers and Branch Lines with Respect to Structural Members.
- **4-2.3.1** Sprinklers may be located under beams, in bays, or both, in combination, but the locations must meet the provisions outlined in Sections 4-2.4 and 4-3.
- 4-2.3.2 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 bottom of the upper joist. (See Figure 4-2.3.2.) Sprinklers may be omitted from below the lower set of joists where at least 18 in. (457 mm) is maintained between sprinkler deflectors and tops of lower joists.

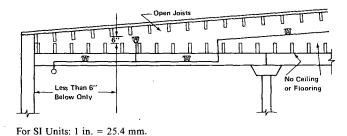


Figure 4-2.3.2 Arrangement of Sprinklers under Two Sets of Open Joists — No Sheathing on Lower Joists.

4-2.4 Clearance Between Sprinklers and Structural Members.

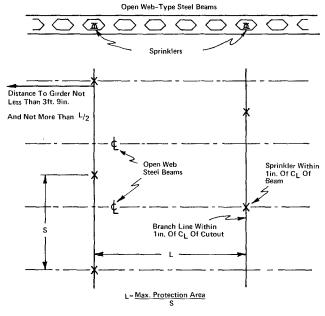
4-2.4.1 Trusses.

4-2.4.1.1 Sprinklers installed between the top and bottom chord members shall be located at least 2 ft (0.6 m) laterally from truss members (web or chord) that are more than 4 in.

(102 mm) wide, and at least 1 ft (0.3 m) laterally from truss members 4 in. (102 mm) or less in width. For trusses with steel webbing similar to bar joists, clearance from webs shall be in accordance with 4-2.4.5.

Exception: Sprinklers running through or above the trusses may be located on the center line of a truss provided chord members are not more than 8 in. (203 mm) wide, and the deflector is at least 6 in. (152 mm) above the chord member.

- 4-2.4.1.2 Where sprinklers are located laterally beside the chord members, clearances between the chord members and the sprinkler deflectors shall be in accordance with 4-2.4.6.
- **4-2.4.2 Girders.** When sprinkler lines are located perpendicular to and above girders, sprinklers shall be located at least 3 ft 9 in. (1.14 m) from girders except that they may be located directly above girders with the top flange not more than 8 in. (203 mm) wide, in which case the deflectors shall be at least 6 in. (152 mm) above the top of the girder.
- **4-2.4.3** When sprinkler deflectors are in accordance with Table 4-2.4.6, the girders may be disregarded in the spacing of the branch lines.
- **4-2.4.4 Open Web-Type Steel Beams.** (See Figure 4-2.4.4.) When branch lines are run across and through openings of open web-type steel beams, sprinklers may be spaced "bay and beam" provided:
- (a) The distance between sprinklers and between branch lines conforms to 4-2.1,



Open-Web Steel Beams, 21in. Deep, With Branch Line Through Beams

S= Spacing Of Sprinklers On Branch Lines L= Distance Between Branch Lines Lx S= Maximum Protected Area Per Sprinkler

For SI Units: 1 in. = 25.4 mm.

Figure 4-2.4.4 Location of Branch Lines and Sprinklers.

- (b) Sprinklers in the beam openings are located within 1 in. (25 mm) horizontally of the opening center line,
- (c) The branch line is located within 1 in. (25 mm) horizontally of the opening center line, and
 - (d) Sprinklers on alternate lines are staggered.
- 4-2.4.5 Bar Joists. Sprinklers shall be at least 3 in. (76 mm) laterally from web members of open bar joists which do not exceed ½ in. (13 mm) and at least 6 in. (152 mm) laterally from web members which do not exceed 1 in. (25 mm). When the dimensions of the web member exceed 1 in. (25 mm), see 4-2.4.1.
- **4-2.4.6* Beams.** Deflectors of sprinklers in bays shall be at sufficient distances from the beams, as shown in Table 4-2.4.6 and Figure 4-2.4.6, to avoid obstruction to the sprinkler discharge pattern. Otherwise the spacing of sprinklers on opposite sides of the beams shall be measured from the center line of the beam and the distance shall not exceed one-half of the allowable distance between sprinklers.

Table 4-2.4.6 Position of Deflector when Located above Bottom of Beam

Distance from Sprinkler to Side of Beam	Maximum Allowable Distance Deflector above Bottom of Beam				
Less than 1 ft	0 in.				
1 ft to less than 2 ft	1 in.				
2 ft to less than 2 ft 6 in	2 in.				
2 ft 6 in. to less than 3 ft	3 in.				
3 ft to less than 3 ft 6 in	4 in.				
3 ft 6 in. to less than 4 ft	6 in.				
4 ft to less than 4 ft 6 in	7 in.				
4 ft 6 in. to less than 5 ft	9 in.				
5 ft to less than 5 ft 6 in	11 in.				
5 ft 6 in. to less than 6 ft					

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

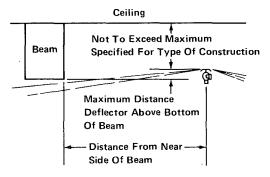


Figure 4-2.4.6 Position of Deflector, Upright, or Pendent Sprinkler When Located above Bottom of Beam.

4-2.4.7* Position of Deflectors. Deflectors of sprinklers shall be parallel to ceilings, roofs, or the incline of stairs, but when installed in the peak of a pitched roof they shall be horizontal. Low-pitched roofs having slopes not greater than 1 in. per ft (83 mm/m) may be considered level in the application of this rule, and sprinklers may be installed with deflectors horizontal.

4-2.5 Clear Space Below Sprinklers.

- **4-2.5.1** A minimum of 18 in. (457 mm) clearance shall be maintained between top of storage and ceiling sprinkler deflectors. For in-rack sprinklers, the clear space shall be in accordance with NFPA 231C, Standard for Rack Storage of Materials.
- **4-2.5.2*** The distance from sprinklers to privacy curtains, free-standing partitions, or room dividers shall be sufficient, as shown in Table 4-2.5.2 and Figure 4-2.5.2, to avoid obstruction to the sprinkler discharge pattern.

Table 4-2.5.2 Horizontal and Minimum Vertical Distances for Sprinklers

Horizontal Distance	Minimum Vertical Distance Below Deflector
6 in. or less	3 in.
More than 6 in. up to 9 in	4 in.
More than 9 in. up to 12 in	6 in.
More than 12 in. up to 15 in	
More than 15 in. up to 18 in	9½ in.
More than 18 in. up to 24 in	
More than 24 in. up to 30 in	
More than 30 in	

For SI Units: 1 in. = 25.4 mm.

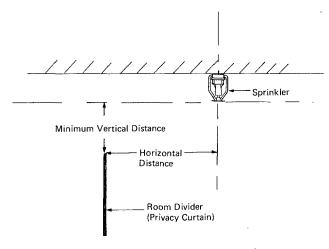


Figure 4-2.5.2 Standard Sprinkler Installed Near Privacy Curtains, Free-standing Partitions, or Room Dividers.

4-3 Position of Upright and Pendent Sprinklers.

4-3.1 Smooth Ceiling Construction (as defined in 4-1.3.1). Deflectors of sprinklers shall be located 1 to 10 in. (25 to 254 mm) below combustible ceilings or 1 to 12 in. (25 to 305 mm) below noncombustible ceilings. The operating elements of sprinklers shall be located below the ceiling.

Exception No. 1: Deflectors of sprinklers under beams shall be located 1 to 4 in. (25 to 102 mm) below beams, and not more than 14 in. (356 mm) below combustible ceilings or not more than 16 in. (406 mm) below noncombustible ceilings.

Exception No. 2: Special ceiling-type pendent sprinklers (concealed, recessed, and flush-types) may have the operating

element above the ceiling and the deflector located nearer to the ceiling when installed in accordance with their listing.

- 4-3.2 Beam and Girder Construction (as defined in 4-1.3.2).
- **4-3.2.1** Deflectors of sprinklers in bays shall be located 1 to 16 in. (25 to 406 mm) below combustible or noncombustible roof or floor decks.
- **4-3.2.2** Deflectors of sprinklers under beams shall be located 1 to 4 in. (25 to 102 mm) below beams and not more than 20 in. (508 mm) below combustible or noncombustible roof or floor decks.
- **4-3.2.3** Deflectors of sprinklers under concrete tee construction with stems spaced less than $7\frac{1}{2}$ ft (2.3 m) but more than 3 ft (0.9 m) on centers shall, regardless of the depth of the tee, be located at or above a plane 1 in. (25 mm) below the level of the bottom of the stems of the tees and comply with Table 4-2.4.6.
- **4-3.3** Open Bar Joist Construction (as defined in 4-1.3.3). Deflectors of sprinklers shall be located 1 to 10 in. (25 to 254 mm) below combustible roof or floor decks or not more than 12 in. (305 mm) below noncombustible roof or floor decks.
- **4-3.4 Panel Construction** (as defined in 4-1.3.4).
- **4-3.4.1** Deflectors of sprinklers in bays formed by members, such as beams framed into girders, resulting in panels up to 300 sq ft (27.9 m²) shall be located 1 to 18 in. (25 to 457 mm) below combustible or noncombustible roof or floor decks.
- **4-3.4.2** Deflectors of sprinklers under the members, such as under beams framed into girders, forming panels up to 300 sq ft (27.9 m²) shall be located 1 to 4 in. (25 to 102 mm) below such members and not more than 22 in. (559 mm) below combustible or noncombustible roof or floor decks.
- 4-3.5 Wood Joist Construction (as defined in 4-1.3.7). In exposed wood joists spaced 3 ft (0.9 m) or less on centers, deflectors of sprinklers shall be located 1 to 6 in. (25 to 152 mm) below the bottom of the joist. If exposed joists are spaced more than 3 ft (0.9 m) on centers, deflectors of sprinklers shall be located in accordance with 4-3.1 or 4-3.2.
- **4-3.6 Composite Wood Joist Construction** (as defined in 4-1.3.8). In exposed composite wood joist construction of 16 in. (406 mm) nominal depth or less, deflectors of sprinklers shall be located 1 to 6 in. (25 to 152 mm) below the bottom chord.
- **4-3.7 Wood Truss Construction** (as defined in 4-1.3.9). In exposed wood truss construction, sprinklers shall be located within the trusses and shall conform to 4-2.4.1, 4-2.4.5, and 4-3.1.

Exception: For wood truss construction with members 16 in. (406 mm) nominal depth or less, deflectors of sprinklers may be located 1 to 6 in. (25 to 152 mm) below the bottom chord.

4-3.8 Location Under Sheathed or Suspended Ceiling Under Any Type of Construction. The position of sprinklers under sheathed or suspended ceilings with any type of construction shall be the same as for smooth-ceiling construction. (See 4-3.1.)

- 4-4* Locations or Conditions Involving Special Consideration.
- **4-4.1 Combustible Form Board.** When roof or floor decks consist of poured gypsum or concrete on combustible form board supported on steel supports, the position of sprinkler deflectors shall be the same as for noncombustible construction as stated in Section 4-3. When combustible form board is located above suspended ceilings or in concealed spaces, see 4-4.4.1.
- **4-4.2 Metal Roof Decks.** When roof decks are metal with combustible adhesives or vapor seal, the position of sprinklers shall be the same as for combustible construction.
- **4-4.3 Spaces Under Ground Floors.** Sprinklers shall be installed in all spaces below combustible ground floors except that, by permission of the authority having jurisdiction, sprinklers may be omitted when all of the following conditions prevail:
- (a) The space is not accessible for storage purposes or entrance of unauthorized persons and is protected against accumulation of wind-borne debris;
- (b) The space contains no equipment such as steam pipes, electric wiring, shafting, or conveyors;
 - (c) The floor over the space is tight;
- (d) No combustible or flammable liquids or materials that under fire conditions may convert into combustible or flammable liquids are processed, handled, or stored on the floor above.

4-4.4 Concealed Spaces.

4-4.4.1* All concealed spaces enclosed wholly or partly by exposed combustible construction shall be protected by sprinklers.

Exception No. 1: 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 4-2.3.2.)

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

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

Exception No. 4: Spaces formed by ceilings attached directly to the underside of composite wood joist construction, provided the joist channels are fire-stopped into volumes each not exceeding 160 cu ft (4.53 m³) using materials equivalent to the joists.

Exception No. 5: Spaces entirely filled with noncombustible insulation.

Exception No. 6: In wood joist construction and composite wood joist construction with 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 fire-stopped into volumes each not exceeding 160 cu ft (4.53 m³) using materials equivalent to the joists.

Exception No. 7: Small spaces over rooms not exceeding 50 sq ft (4.6 m²) in area.

Exception No. 8: When 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: When the Btu content of the facing and substrate of insulation material does not exceed 1000 Btu per $sq\ ft\ (11\ 356\ kJ/m^2)$.

- **4-4.4.2** Sprinklers in concealed spaces having no access that will allow storage or other use may be installed on the basis of Light Hazard Occupancy.
- **4-4.4.3** When 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 two sprinklers in each joist channel, one on each side, adjacent to the heat-producing device. The temperature rating of the sprinklers shall be as prescribed in Table 3-11.6.1 and Figure 3-11.6.3(a).
- **4-4.4.4*** In concealed spaces having exposed combustible construction, or containing exposed combustibles, in localized areas, the combustibles shall be protected as follows:
- (a) If the exposed combustibles are in the vertical partitions or walls around all or a portion of the enclosure, a single row of sprinklers spaced not over 12 ft (3.7 m) apart nor more than 6 ft (1.8 m) from the inside of the partition may be installed to protect the surface. The first and last sprinklers in such a row shall not be over 5 ft (1.5 m) from the ends of the partitions.
- (b) If the exposed combustibles are in the horizontal plane, permission may be given to protect the area of the combustibles on a light hazard spacing and add a row of sprinklers not over 6 ft (1.8 m) outside the outline of the area and not over 12 ft (3.7 m) on center along the outline. When the outline returns to a wall or other obstruction, the last sprinkler shall not be over 6 ft (1.8 m) from a wall or obstruction.

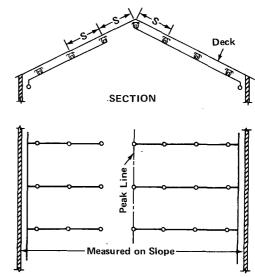
4-4.5 Spacing of Sprinklers Under Pitched Roofs.

- **4-4.5.1** Branch lines parallel to peaks of pitched roofs and sprinklers on lines perpendicular to peaks shall be spaced throughout the distance measured along the slope. This will place a row of sprinklers either in the peak or one-half the spacing down the slope from the peak.
- 4-4.5.2 Under saw-toothed roofs, the row of sprinklers at the highest elevation shall not be more than 3 ft (0.9 m) down the slope from the peak.
- **4-4.5.3** In 4-4.5.1 or 4-4.5.2, sprinklers in or near the peak shall have deflectors located not more than 3 ft (0.9 m) vertically down from the peak. [See Figures 4-4.5.3(a) and 4-4.5.3(b).]

Exception: In a steeply pitched roof the distance from the peak to the deflectors may be increased to maintain a horizontal clearance of not less than 2 ft (0.6 m) from other structural members. [See Figure 4-4.5.3(c).]

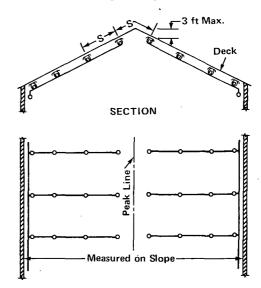
4-4.6 Spacing of Sprinklers Under Curved Roof Buildings.

4-4.6.1 When roofs are curved down to the floor line, the horizontal distance measured at the floor level from the sidewall or roof construction to the nearest sprinklers shall not be greater than one-half the allowable distance between sprinklers in the same direction.



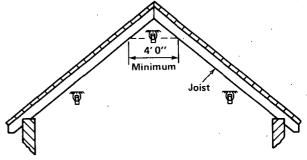
For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.

Figure 4-4.5.3(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 4-4.5.3(b) Sprinklers at Pitched Roofs; Branch Lines Run Up the Slope.



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

Figure 4-4.5.3(c) Desirable Horizontal Clearance for Sprinklers at Peak of Pitched Roof.

- **4-4.6.2** Deflectors of sprinklers shall be parallel with the curve of the roof or tilted slightly toward the peak of the roof. Deflectors of sprinklers shall be located as described for beam and girder construction or for the closest comparable type of ceiling construction.
- **4-4.6.3** When Extra Hazard Occupancy spacing of sprinklers is used under curved ceilings of other than fireresistive construction, as in aircraft storage or servicing areas, the spacing as projected on the floor shall be not wider than that required for Extra Hazard Occupancies, but in no case shall the spacing on the roof or ceiling be wider than that required for Ordinary Hazard Occupancies.
- 4-4.7 Elevators, Stairs, and Floor Openings.
- 4-4.7.1 Vertical Shafts.
- **4-4.7.1.1** One sprinkler shall be installed at the top of all shafts.
- **4-4.7.1.2*** When vertical shafts have combustible sides, one sprinkler shall be installed at each alternate floor level. When a shaft having combustible surfaces is trapped, an additional sprinkler shall be installed at the top of each trapped section.
- **4-4.7.1.3** When accessible shafts have noncombustible surfaces, one sprinkler shall be installed near the bottom.
- **4-4.7.1.4** When vertical openings are not protected by standard enclosures, sprinklers shall be so placed as to fully cover them. This necessitates placing sprinklers close to such openings at each floor level.

4-4.7.2* Stairways.

- **4-4.7.2.1** Stairways of combustible construction shall be sprinklered underneath, whether risers are open or not.
- **4-4.7.2.2** Stairways of noncombustible construction with combustible storage beneath shall be sprinklered.
- **4-4.7.2.3*** When moving stairways, staircases, or similar floor openings are unenclosed, the floor openings involved shall be protected by draft stops in combination with closely spaced sprinklers.

The draft stops shall be located immediately adjacent to the opening, shall be at least 18 in. (457 mm) deep, and shall be of substantially noncombustible 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 to form a water curtain. Sprinklers in this water curtain shall be hydraulically designed to provide a discharge of 3 gpm per lineal ft [(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 design area determined by 7-4.3.1. The water supply for these sprinklers shall be added to the water supply required for the area of operation in hydraulically designed systems or to the water supply required as determined in accordance with Table 2-2.1.1(a). Supplies shall be balanced to the higher pressure demand in either case. Sprinklers shall be nominal $\frac{1}{2}$ in., $\frac{7}{16}$ in., or $\frac{3}{8}$ in. orifice. When sprinklers are closer than 6 ft (1.8 m), cross baffles shall be provided in accordance with 4-4.18. When sprinklers in the normal 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.

Exception: Closely spaced sprinklers 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, when the openings have all horizontal dimensions between opposite edges of 20 ft (6 m) or greater, and an area of 1000 sq ft (93 m²) or greater.

- **4-4.7.2.4*** In noncombustible stair shafts, sprinklers shall be installed at the top and under the first landing above the lowest level. When the stair shaft serves two or more separate fire sections, sprinklers shall also be installed at each floor landing.
- **4-4.8* 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.
- 4-4.9* Exterior Canopies, Docks, and Platforms.
- **4-4.9.1** Sprinklers shall be installed under roofs or canopies over outside-loading platforms, docks, or other areas where combustibles are stored or handled.
- **4-4.9.2** Sprinklers shall be installed under exterior combustible roofs or canopies exceeding 4 ft (1.2 m) in width.

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

- **4-4.9.3** Sprinklers shall be installed under exterior docks and platforms of combustible construction unless such space is closed off and protected against accumulation of debris.
- **4-4.10*** Decks. Sprinklers shall be installed under decks and galleries over 4 ft (1.2 m) wide. Slatting of decks, walkways, or the use of open gratings as a substitute for such sprinklers is not acceptable. Sprinklers installed under open gratings shall be of the listed intermediate level type or shielded from the discharge of overhead sprinklers.
- **4-4.11 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 4-4.11(a).]

Exception No. 1: When vertical shelf dividers are incomplete and allow water distribution to adjacent aisles, sprinklers may be omitted in alternate aisles on each tier. When ventilation openings are also provided in tier floors, sprinklers shall be staggered vertically. [See Figure 4-4.11(b).]

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

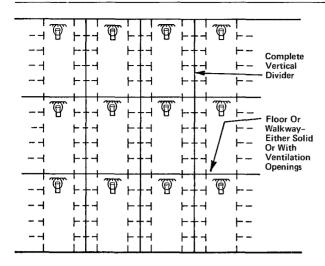


Figure 4-4.11(a) Sprinklers in Multitier Library Bookstacks.

- **4-4.12* Ducts.** Sprinklers shall be installed beneath ducts over 4 ft (1.2 m) wide unless ceiling sprinklers can be spaced in accordance with Table 4-2.4.6.
- **4-4.13 Electrical Equipment.** When sprinkler protection is provided in generator and transformer rooms, hoods or shields installed to protect important electrical equipment from water shall be noncombustible.
- 4-4.14* Open-Grid Ceilings. The following requirements are applicable to open-grid ceilings in which the openings are ¼ in. (6.4 mm) or larger in the least dimension, when the thickness or depth of the material does not exceed the least dimension of the openings, and when such openings constitute at least 70 percent of the area of the ceiling material. Other types of open-grid ceilings shall not be installed beneath sprinklers unless they are listed by a testing laboratory and are installed in accordance with the instructions contained in each package of the ceiling material. Ceilings made of highly flammable material may spread fire faster than sprinklers can control.
- (a) In Light Hazard Occupancies when spacing of either standard or old-style sprinklers is not wider than 10 by 10 ft (3 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. When spacing is wider than 10 by 10 ft (3 by 3 m) but not wider than 10 by 12 ft (3 by 3.7 m), a clearance of at least 24 in. (610 mm) shall be provided from standard sprinklers and at least 36 in. (914 mm) from old-style sprinklers. When spacing is wider than 10 by 12 ft (3 by 3.7 m), a clearance of at least 48 in. (1219 mm) shall be provided.
- (b) In Ordinary Hazard Occupancies, open-grid ceilings may be installed beneath sprinklers only where such use is approved by the authority having jurisdiction, and shall be installed beneath standard sprinklers only. When sprinkler spacing is not wider than 10 by 10 ft (3 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. When spacing is wider than 10 by 10 ft (3 by 3 m), a clearance of at least 36 in. (914 mm) shall be provided.

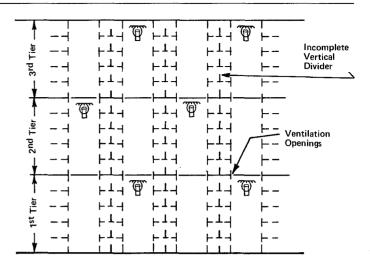


Figure 4-4.11(b) Sprinklers in Multitier Library Bookstacks.

4-4.15 Drop-out Ceilings.

4-4.15.1 Drop-out ceilings may be installed beneath sprinklers when ceilings are listed for that service and are installed in accordance with their listing. The authority having jurisdiction shall be consulted in all cases.

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

- **4-4.15.2** Drop-out ceilings shall not be considered ceilings within the context of this standard.
- **4-4.15.3*** Piping installed above drop-out ceilings shall not be considered concealed piping. (See 3-7.4, Exception No. 2.)
- **4-4.15.4*** Sprinklers shall not be installed beneath dropout ceilings.

4-4.16 Fur Vaults.

- **4-4.16.1** 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.
- **4-4.16.2** When sprinklers are spaced 5 ft (1.5 m) apart along the sprinkler branch lines, pipe sizes may be in accordance with the following schedule:

1	in.	4 sprinklers	2	in.	20 sprinklers
11/4	in.	6 sprinklers	21/2	in.	40 sprinklers
1 1/2	in.	10 sprinklers	3	in.	80 sprinklers

4-4.16.3 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.

NOTE: 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.

4-4.17 Commercial-type Cooking Equipment and Ventilation.

- **4-4.17.1** 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 for the Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooking Equipment.)
- **4-4.17.2** 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 when all cooking equipment is served by listed grease extractors.

4-4.17.3 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 3-5.1.)

Exception: Sprinklers or automatic spray nozzles may be omitted from a vertical riser located outside of a building provided the riser does not expose combustible material or 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).

- 4-4.17.4* 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 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.
- 4-4.17.5 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).
- 4-4.17.6 Sprinklers or automatic spray nozzles being used in duct, duct collar, and plenum areas shall be of the temperature classification extra high [325 to 375°F (163 to 191°C)] and have orifice sizes no less than ¼ in. (6.4 mm) and no more than ½ 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.

4-4.17.7 Access must be provided to all sprinklers or automatic spray nozzles for examination and replacement.

4-4.17.8 Cooking Equipment.

- **4-4.17.8.1** 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 4-4.17.1.
- **4-4.17.8.2** 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.
- **4-4.17.8.3** 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 protection. 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.
- **4-4.17.9*** A listed indicating valve shall be installed in the water supply line to the sprinklers and spray nozzles protecting the cooking and ventilating system.
- **4-4.17.10** An approved line strainer shall be installed in the main water supply preceding sprinklers or automatic spray nozzles having orifices smaller than $\frac{3}{8}$ in. (9.5 mm).
- **4-4.17.11** A system test connection shall be provided to verify proper operation of equipment specified in 4-4.17.8.3.
- **4-4.17.12** Sprinklers and automatic spray nozzles used for protecting commercial-type cooking equipment and ventilating systems shall be replaced annually.

Exception: When 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.

4-4.18 Baffles. Baffles (except for in-rack sprinklers, see NFPA 231C, Standard for Rack Storage of Materials) shall be installed whenever sprinklers are less than 6 ft (1.8 m) apart to prevent the sprinkler first opening from wetting adjacent sprinklers, thus delaying their operation. Baffles shall be located midway between sprinklers and arranged to baffle the actuating elements. Baffles may be of sheet metal about 8 in. (203 mm) wide and 6 in. (152 mm) high. The top of baffles shall extend 2 to 3 in. (51 to 76 mm) above the deflectors of upright sprinklers; and the bottom of baffles shall extend downward to a level at least even with the deflectors of pendent sprinklers.

Exception: Old-style sprinklers protecting fur storage vaults.

- **4-4.19 Small Rooms.** Rooms with smooth ceilings, and having floor areas not exceeding 800 sq ft (74.3 m²), of Light Hazard Occupancy classification.
- **4-4.19.1*** Within small rooms, sprinklers may be located not more than 9 ft (2.7 m) from any single wall; however, sprinkler spacing limitations of 4-2.1.1 and area limitations of 4-2.2.2.1 shall not be exceeded.

- **4-4.19.2** In hotels, sprinklers may be omitted from bathrooms not exceeding 55 sq ft (5.1 m²) with noncombustible plumbing fixtures and with walls and ceilings surfaced with noncombustible materials.
- 4-4.19.3 In hotel guest rooms, sprinkler installation may be omitted in clothes closets where the area does not exceed 24 sq ft (2.2 m²), the least dimension does not exceed 3 ft (0.9 m), and the walls and ceilings are surfaced with noncombustible or limited-combustible materials.
- 4-4.20 Theater 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; in all adjacent spaces and dressing rooms, storerooms, and workshops. When proscenium opening protection is required a deluge system shall be provided within 3 ft (0.9 m) of the stage side of the proscenium arch, with open sprinklers spaced up to a maximum of 6 ft (1.8 m) on center and designed to provide a discharge of 3 gpm/lineal ft [(37 L/min)/m] of water curtain, with no sprinkler discharging less than 15 gpm (56.8 L/min).

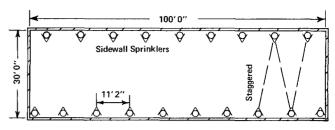
4-5* Spacing, Location, and Position of Sidewall Sprinklers. (See 3-11.2.5.)

4-5.1 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 deflector. Sidewall sprinklers shall not be installed back to back without being separated by a lintel or soffit.

4-5.2* Distance Between Sprinklers on Branch Lines.

4-5.2.1 Sidewall sprinklers shall be installed along the length of a single wall of rooms or bays not exceeding the width dimension specified in Table 4-5.2.1.

Exception: Sidewall sprinklers may be installed in Light Hazard Occupancies with smooth ceilings or in bays up to 30 ft (9 m) in width. When sidewall sprinklers are installed on two opposite walls or sides of bays, the spacing shall be as required in Section 4-5 with sprinklers regularly staggered. (See Figure 4-5.2.1.)



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

Figure 4-5.2.1 Spacing of Sidewall Sprinklers under Combustible Smooth Ceilings.

4-5.3 Protection Area Limitations for Light Hazard Occupancy.

4-5.3.1 With noncombustible smooth ceilings the protection area per sprinkler shall not exceed 196 sq ft (18.2 m²).

4-5.3.2 With combustible ceiling construction sheathed with plasterboard, metal, or wood lath and plaster forming a smooth ceiling, the protection area per sprinkler shall not exceed 168 sq ft (15.6 m²). (See Table 4-5.2.1.) When sheathing is combustible, such as wood, fiberboard, or other combustible material, the protection area per sprinkler shall not exceed 120 sq ft (11.1 m²).

Exception: Noncombustible smooth ceiling spacing is permitted beneath a noncombustible smooth ceiling located beneath any combustible concealed space. (See 4-4.4.1.)

4-5.4 Protection Area Limitations for Ordinary Hazard Occupancy.

4-5.4.1 With noncombustible smooth ceilings the protection area per sprinkler shall not exceed 100 sq ft (9.3 m²).

4-5.4.2 With combustible ceiling construction sheathed with plasterboard, metal, wood lath and plaster, wood fiberboard, or other combustible material forming a smooth ceiling, the protection area per sprinkler shall not exceed 80 sq ft (7.4 m²).

Table 4-5.2.1 Dimensions for Sidewall Sprinkler Installation

		Light Hazard Occupancy		Ordinary Hazard Occupancy		
	Combustible Construction with Combustible Sheathing	Combustible Construction Sheathed with Plaster- board, Metal, or Wood Lath and Plaster	Noncombustible Construction with Noncombustible Sheathing	Combustible Construction with Combustible Sheathing*	Noncombustible Smooth Ceiling	
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 (ft²)	120	168	196	80	100	

For SI Units: 1 ft = 0.3048 m.

*See 4-5.4.2

Exception: Noncombustible smooth ceiling spacing is permitted beneath a noncombustible smooth ceiling located beneath any combustible concealed space. (See 4-4.4.1.)

4-5.5 Position of Sidewall Sprinklers.

4-5.5.1* Sprinkler deflectors shall be at a distance from walls and ceilings not more than 6 in. (152 mm) or less than 4 in. (102 mm), unless special construction arrangements make a different position advisable for prompt operation and effective distribution.

Exception No. 1: Horizontal sidewall sprinklers may be positioned 6 to 12 in. (152 to 305 mm) below noncombustible ceilings when listed for these positions.

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

4-5.5.2 Where soffits are used for the installation of sidewall sprinklers, they shall not exceed an 8 in. (203 mm) projection from the wall.

Chapter 5 Types of Systems

5-1 Wet-Pipe Systems.

- 5-1.1* Definition. A 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 a fire.
- **5-1.2 Pressure Gages.** An approved pressure gage conforming to 2-9.2.2 shall be installed in each system riser. Pressure gages shall be installed above and below each alarm check valve when such devices are present.
- **5-1.3 Relief Valves.** A gridded wet-pipe system shall be provided with a relief valve not less than ½ in. (6.4 mm) in size set to operate at pressure 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 bar) in excess of the maximum system pressure.

Exception No. 2: When auxiliary air reservoirs are installed to absorb pressure increases.

5-2 Dry-Pipe Systems.

- 5-2.1* Definition. A 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.
- **5-2.2 Dry-Pendent Sprinklers.** Automatic sprinklers installed in the pendent position shall be of the listed drypendent type if installed in an area subject to freezing.

Exception: Pendent sprinklers installed on return bends are permitted when both the sprinklers and the return bends are located in a heated area.

5-2.3* Size of Systems.

5-2.3.1 Volume Limitations. Not more than 750-gal (2839 L) system capacity shall be controlled by one dry-pipe valve. Gridded dry-pipe systems shall not be installed.

Exception: Piping volume may 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.

5-2.4 Quick-Opening Devices.

5-2.4.1 Dry-pipe valves shall be provided with a listed quick-opening device when system capacity exceeds 500 gal (1893 L).

Exception: A quick-opening device shall not be required if the requirements of 5-2.3.1 Exception can be met without such a device.

- 5-2.4.2* 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.
- **5-2.4.3** A soft disc globe or angle valve shall be installed in the connection between the dry-pipe sprinkler riser and the quick-opening device.
- 5-2.4.4 A check valve shall be installed between the quickopening device and the intermediate chamber of the drypipe valve. If the quick-opening device requires pressure feedback from the intermediate chamber, a valve of the type that will clearly indicate whether it is opened or closed may be installed in place of that check valve. This valve shall be constructed so that it may be locked or sealed in the open position.
- 5-2.4.5 An approved antiflooding device shall be installed in the connection between the dry-pipe sprinkler riser and the quick-opening device, unless the particular quick-opening device has built-in antiflooding design features.

5-2.5* Location and Protection of Dry-Pipe Valve.

- 5-2.5.1 The dry-pipe valve and supply pipe shall be protected against freezing and mechanical injury.
- 5-2.5.2 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.
- **5-2.5.3** The supply for the sprinkler in the dry-pipe valve enclosure shall be from the dry side of the system.
- **5-2.5.4** Protection against accumulation of water above the clapper shall be provided for a low differential dry-pipe valve. This may be an automatic high water level signaling device or an automatic drain device.

5-2.6* Cold Storage Rooms.

5-2.6.1 Fittings for Inspection Purposes.

5-2.6.1.1 Fittings for inspection purposes shall be provided whenever a cross main connects to a riser or feed main. This may be accomplished by a blind flange on a fitting (tee or cross) in the riser or cross main or a flanged removable section 24 in. (610 mm) long in the feed main as shown in Figure 5-2.6.1(A). Such fittings in conjunction with the flushing connections specified in 3-3.2 would permit examination of the entire lengths of the cross mains. Branch lines may be examined by backing the pipe out of fittings.

5-2.6.1.2 Whenever feed mains change direction, facilities shall be provided for direct observation of every length of feed main within the refrigerated area. This may be accomplished by means of 2-in. (51-mm) capped nipples or blind flanges on fittings.

5-2.6.1.3 Fittings for inspection purposes shall be provided whenever a riser or feed main passes through a wall or floor from a warm room to a cold room. This may 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 5-2.6.1(B).

5-2.6.2 A local low air-pressure alarm shall be installed on sprinkler systems supplying freezer sections.

5-2.6.3 Piping in cold storage rooms shall be installed with pitch, as outlined in 3-6.1.3.

5-2.6.4 The air supply for dry-pipe systems in cold storage plants shall be taken from the freezers of lowest temperature or through a chemical dehydrator. Compressed nitrogen gas from cylinders may be used in place of air in dry-pipe systems to eliminate introducing moisture.

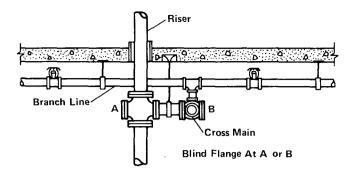
5-2.7 Air Pressure and Supply.

5-2.7.1 Maintenance of Air Pressure. Air or nitrogen pressure shall be maintained on dry-pipe systems throughout the year.

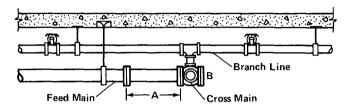
5-2.7.2* Air Supply. The compressed air supply shall be from a source available at all times and having a capacity capable of restoring normal air pressure in the system within 30 minutes, except for low differential dry-pipe systems where this time may be 60 minutes. Where low differential dry-pipe valves are used, the air supply shall be maintained automatically.

5-2.7.3 Air Filling Connection. The connection pipe from the air compressor shall not be less than ½ in. (13 mm) 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 renewable disc type shall be installed on the supply side of this check valve and shall remain closed unless filling the system.

5-2.7.4 Relief Valve. An approved 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 that should be carried in the system.



(a) Elevation At Riser And Cross Main

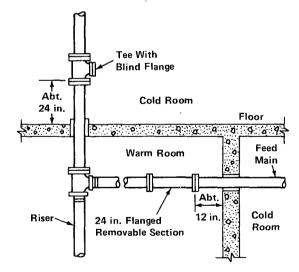


24 in. Flanged Removable Section At A or Blind Flange At B

(b) Elevation At Feed Main And Cross Main

For SI Units: 1 in. = 25.4 mm.

Figure 5-2.6.1(A) Fittings to Facilitate Examination of Feed Mains, Risers, and Cross Mains in Freezing Areas.

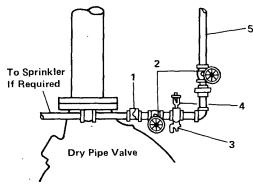


For SI Units: 1 in. = 25.4 mm.

Figure 5-2.6.1(B) Fittings in Feed Main or Riser Passing through Wall or Floor from Warm Room to Cold Room.

5-2.7.5 Shop Air Supply. When 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.



- 1. Check Valve
- 2. Control Valve (Renewable Disc Type)
- 3. Small Air Cock (Normally Open)
- 4. Relief Valve
- 5. Air Supply

Figure 5-2.7.5 Air Supply from Shop System.

- 5-2.7.6 Automatic Air Compressor. When 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 approved 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 water flow from one system to another.
- 5-2.7.7 Air Pressure to Be Carried. The air pressure to be carried shall be in accordance with the instruction sheet furnished with the dry-pipe valve, when available, 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 1-11.3.2.
- 5-2.7.8 When used, nitrogen shall be introduced through a pressure regulator set to maintain system pressure in accordance with 5-2.7.7.
- **5-2.8 Pressure Gages.** Approved pressure gages conforming to 2-9.2.2 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,
 - (c) At the air receiver,
- (d) In each independent pipe from air supply to dry-pipe system, and
 - (e) At exhausters and accelerators.

5-3 Preaction and Deluge Systems.

5-3.1 Definitions.

Preaction System. A system employing automatic sprinklers attached to a piping system containing air that may or

may not be under pressure, with a supplemental fire detection system installed in the same areas as the sprinklers. Actuation of the fire detection system (as from a fire) opens a valve that permits water to flow into the sprinkler piping system and to be discharged from any sprinklers that may be open.

Deluge System. A 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 fire 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.

- 5-3.2* Description. Preaction and deluge systems are normally without water in the system piping. The water supply is controlled by an automatic valve operated by means of fire detection devices and provided with manual means for operation that are independent of the sprinklers. Systems may have equipment of the types described in (a) through (f) below. (See 5-3.6.2.)
- (a) Automatic sprinklers with both sprinkler piping and fire detection devices automatically supervised.
- (b) Automatic sprinklers with sprinkler piping and fire detection devices not automatically supervised.
- (c) Open sprinklers with only fire detection devices automatically supervised.
- (d) Open sprinklers with fire detection devices not automatically supervised.
- (e) Combination of open and automatic sprinklers with fire detection devices automatically supervised.
- (f) Combination of open and automatic sprinklers with fire detection devices not automatically supervised.

5-3.3* General.

- 5-3.3.1 A supply of spare fusible elements for heatresponsive devices, not less than two of each temperature rating, shall be maintained on the premises for replacement purposes.
- 5-3.3.2 When hydraulic release systems are used, it is possible to water column the deluge valve or deluge-valve actuator if the heat-actuated devices (fixed temperature or rate-of-rise) are located at extreme heights above the valve. Refer to the manufacturer for height limitations of a specific deluge valve or deluge-valve actuator.
- 5-3.3. All new preaction or deluge systems shall be tested hydrostatically as specified in 1-11.2.1. In testing deluge systems, plugs shall be installed in fittings and replaced with open sprinklers after the test is completed, or automatic sprinklers may be installed and the operating parts removed after the test is completed.

5-3.4 Location and Protection of Preaction and Deluge Systems.

- 5-3.4.1 The preaction and deluge system water control valves and supply pipes shall be protected against freezing and mechanical injury.
- **5-3.4.2** Valve rooms shall be lighted and heated. The source of heat shall be of a permanently installed type.

- 5-3.4.3 Heat tape shall not be used in lieu of heated valve enclosure rooms to protect preaction and deluge valves and supply pipe against freezing.
- 5-3.5 Location and Spacing of Fire Detection Devices. Spacing of fire detection devices other than automatic sprinklers shall be in accordance with their listing by testing laboratories or in accordance with manufacturer's specifications. When automatic sprinklers are used as detectors, the distance between detectors and the area per detector shall not exceed the maximum permitted for suppression sprinklers as specified in 4-2.1 and 4-2.2; they shall be positioned in accordance with Section 4-3, but need not conform with the clearance requirements of 4-2.4. (See NFPA 72E, Standard on Automatic Fire Detectors.)

5-3.6 Preaction Systems.

- **5-3.6.1** All components of pneumatic, hydraulic, or electrical preaction systems shall be compatible.
- **5-3.6.2 Size of Systems.** Not more than 1,000 closed sprinklers shall be controlled by any one preaction valve.
- **5-3.6.3 Supervision.** Sprinkler piping and fire detection devices shall be automatically supervised when there are more than 20 sprinklers on the system.
- **5-3.6.4** For pipe schedules see Chapter 7 and Sections 8-2, 8-3, 8-4, and 8-5.
- **5-3.6.5 Pendent Sprinklers.** Automatic sprinklers on preaction systems installed in the pendent position shall be of the listed dry-pendent type if installed in an area subject to freezing.

Exception: Pendent sprinklers installed on return bends are permitted when both the sprinklers and the return bends are located in a heated area.

5-3.7* Deluge Systems. The fire detection devices or systems shall be automatically supervised when there are more than 20 sprinklers on the system.

5-3.8 Devices for Test Purposes and Testing Apparatus.

- 5-3.8.1 When fire detection devices installed in circuits are located where not readily accessible, an additional fire 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.
- 5-3.8.2 Testing apparatus capable of producing the heat or impulse necessary to operate any normal fire 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.
- **5-3.8.3 Pressure Gages.** Approved pressure gages conforming to 2-9.2.2 shall be installed as follows:
- (a) Above and below preaction valve and below deluge valve.
 - (b) On air supply to preaction and deluge valves.

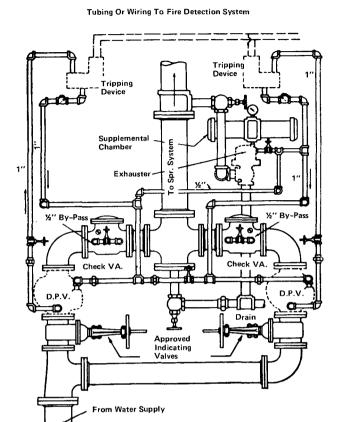
5-4 Combined Dry-Pipe and Preaction Systems.

5-4.1 General.

- 5-4.1.1* Definition. A combined dry-pipe and preaction sprinkler system is one employing automatic sprinklers attached to a piping system containing air under pressure with a supplemental fire detection system installed in the same areas as the sprinklers; operation of the fire detection system, as from a fire, actuates tripping devices that open dry-pipe valves simultaneously and without loss of air pressure in the system. Operation of the fire detection system also opens approved air exhaust valves at the end of the feed main, which facilitates the filling of the system with water, which usually precedes the opening of sprinklers. The fire detection system also serves as an automatic fire alarm system.
- 5-4.1.2 Combined automatic dry-pipe and preaction systems shall be so constructed that failure of the fire detection system shall not prevent the system from functioning as a conventional automatic dry-pipe system.
- 5-4.1.3 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 fire detection system from properly-functioning as an automatic fire alarm system.
- 5-4.1.4 Provisions shall be made for the manual operation of the fire detection system at locations requiring not more than 200 ft (61.0 m) of travel.
- **5-4.1.5** Except as indicated in 5-2.2, automatic sprinklers installed in the pendent position shall be of the approved dry-pendent type.

5-4.2 Dry-Pipe Valves in Combined Systems.

- 5-4.2.1 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 5-4.2.)
- 5-4.2.2 Each dry-pipe valve shall be provided with an approved tripping device actuated by the fire 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 a gate valve so that either dry-pipe valve can be shut off and worked on while the other remains in service.
- 5-4.2.3 The check valves between the dry-pipe valves and the common feed main shall be equipped with ½-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. A gate 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.
- **5-4.2.4** Each combined dry-pipe and preaction system shall be provided with approved quick-opening devices at the dry-pipe valves.



For SI Units: 1 in. = 25.4 mm.

Figure 5-4.2 Header for Combined Dry-Pipe and Preaction Sprinkler System, Standard Trimmings not Shown.

5-4.3* Air Exhaust ·Valves. One or more approved 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. (See Figure A-5-4.3.) 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.

5-4.4 Subdivision of System Using Check Valves.

5-4.4.1 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 1¹/₄-in. (33-mm) drain on the system side of each check valve supplemented by a drum drip.

5-4.4.2 Section drain lines and drum drips shall be located in heated areas or inside of thermostatically controlled electrically heated cabinets of sufficient size to enclose drain valves and drum drips for each section. Drum drips shall also be provided for all low points except that heated cabinets need not be required for systems of 20 sprinklers or less.

5-4.4.3 Air exhaust valves at the end of a feed main and associated check valves shall be protected against freezing.

5-4.5 Time Limitation. The sprinkler system shall be so constructed and the number of sprinkler heads 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 minutes.

5-4.6 System Test Connection. The end section shall have a system test connection as required for dry-pipe systems.

5-5 Antifreeze Systems.

5-5.1 Definition. An antifreeze system is one employing automatic sprinklers attached to a piping system containing an antifreeze solution and connected to a water supply. The antifreeze solution, followed by water, discharges immediately from sprinklers opened by a fire.

5-5.2* Where Used. The use of antifreeze solutions shall be in conformity with any state or local health regulations.

5-5.3 Antifreeze Solutions.

5-5.3.1 When sprinkler systems are supplied by public 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 5-5.3.1.

Table 5-5.3.1 Antifreeze Solutions to be Used if Public Water is Connected to Sprinklers

Material	Solution (by Volume)	Specific Gravity at 60°F (15.6°C)		ezing oint °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
-13	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%.

5-5.3.2 If public water is not connected to sprinklers, the commercially available materials indicated in Table 5-5.3.2 are suitable for use in antifreeze solutions.

5-5.3.3* 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. [See Figures 5-5.3.3(a) and (b).]

5-5.4* Arrangement of Supply Piping and Valves. All permitted antifreeze solutions are heavier than water. At the point of contact (interface) the heavier liquid will be below the lighter liquid in order to prevent diffusion of water into

Table 5-5.3.2 Antifreeze Solutions to be Used if Public Water is not Connected to Sprinklers

Material	Solution (by Volume)	Specific Gravity at 60°F (15.6°C)	P	ezing oint °C
Glycerine	If glycerine is	used, see Tabl	e 5-5.	3.1
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	2)
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	2)
Propylene Glycol If	propylene glyc	ol is used, see	Table	5-5.3.1
Calcium Chloride	Lb CaCl ₂ per			
80% "Flake"	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.

the unheated areas. In most cases, this necessitates the use of a 5-ft (1.5-m) drop pipe or U-loop as illustrated in Figure 5-5.4. The preferred arrangement is to have the sprinklers below the interface between the water and the antifreeze solution.

If sprinklers are above the interface, a check valve with a $\frac{1}{12}$ -in. (0.8-mm) hole in the clapper shall be provided in the U-loop. A water control valve and two small solution test valves shall be provided as illustrated in Figure 5-5.4. An acceptable arrangement of a filling cup is also shown.

Exception: When 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.

5-5.5* Testing. Before freezing weather each year, the solution in the entire system shall be emptied into convenient containers and brought to the proper specific gravity by adding concentrated liquid as needed. The resulting solution may be used to refill the system.

5-6 Automatic Sprinkler Systems with Nonfire Protection Connections.

5-6.1 Circulating Closed-Loop Systems.

5-6.1.1 Definition. A circulating closed loop is one with nonfire 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.

5-6.1.2 System Components.

5-6.1.2.1 Basic Principle. A circulating closed-loop system is primarily a sprinkler system, and all provisions of

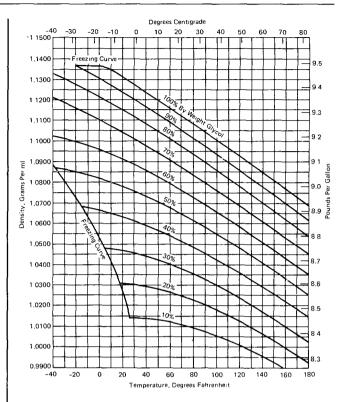


Figure 5-5.3.3(a) Densities of Aqueous Ethylene Glycol Solutions (percent by weight).

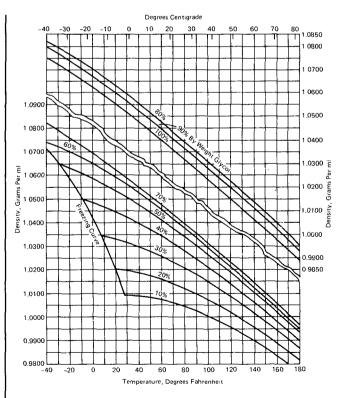
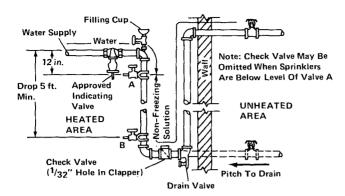


Figure 5-5.3.3(b) Densities of Aqueous Propylene Glycol Solutions (percent by weight).



NOTE: The ½32-in. (0.8-mm) hole in the check valve clapper is needed to allow for expansion of the solution during a temperature rise and thus prevent damage to sprinkler heads.

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

Figure 5-5.4 Arrangement of Supply Piping and Valves.

this standard such as control valves, area limitation of a system, alarms, fire department connections, sprinkler spacing, etc., are to be satisfied.

Exception: Items as specifically detailed within 5-6.1.

- **5-6.1.2.2** Piping, fittings, valves, and pipe hangers shall meet requirements specified in Chapter 3.
- **5-6.1.2.3** 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.

- **5-6.1.2.4** 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 luminaires shall be pressure rated at 175 or 300 psi (12.1 or 20.7 bars) (rupture pressure of 5 X rated water working pressure), to match the required rating of sprinkler system components.
- 5-6.1.2.5 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.
- **5-6.1.2.6** Auxiliary devices where hung from the building structure shall be supported independently from the sprinkler portion of the system, following recognized engineering practices.
- **5-6.1.3** 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:
- (a)* Water for sprinklers shall not be required to pass through heating or cooling equipment. At least one direct path shall exist for water flow 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.

5-6.1.4 Water Temperature.

- 5-6.1.4.1 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.
- 5-6.1.4.2 Minimum. Precaution shall be taken to ensure that temperatures below 40°F (4°C) will not be permitted.
- **5-6.1.5 Obstruction to Discharge.** Automatic sprinklers shall not be obstructed by auxiliary devices, piping, insulation, etc., from detecting fire or from proper distribution of water.
- **5-6.1.6 Valve Supervision.** Position of all valves controlling sprinkler system (post indicator, main gate, sectional control) shall be supervised open by one of the following methods:
- (a) Central station, proprietary, or remote station alarm service.
- (b) Local alarm service, which will cause the sounding of an audible signal at a constantly attended point.
- **5-6.1.7 Signs.** Caution signs shall be attached to all controlling sprinkler valves. 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 supply to auxiliary equipment. CAUTION: Automatic alarm will be sounded if this valve is closed."

5-6.1.8 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. When 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.

- **5-6.1.9 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.
- **5-6.1.9.1** 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).
- 5-6.1.10* Working Plans. Working plans shall be prepared and submitted in accordance with Section 1-9. Special symbols shall be used and explained for auxiliary piping, pumps, heat exchangers, valves, strainers, and the like, clearly distinguishing those 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.

5-6.1.11 Testing.

- **5-6.1.11.1** All sprinkler system and auxiliary system components shall be hydrostatically tested in accordance with 1-11.3.
- **5-6.1.11.2** Sprinkler system discharge tests shall be conducted using system test connections described in 3-4.1. Pressure gages 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.
- 5-6.1.12 Contractor's Material and Test Certificate. Additional information shall be appended to the Contractor's Material and Test Certificate as shown in Figures 1-10.1(a) and (b), as follows:
- (a) Certification that all auxiliary devices, such as heat pumps, circulating pumps, heat exchangers, radiators, and luminaires have a pressure rating of 175 or 300 psi (12.1 or 20.7 bars).
- (b) All components of sprinkler system and auxiliary system have been pressure tested as a composite system in accordance with 1-11.2, Hydrostatic Tests.
- (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.

Chapter 6 Outside Sprinklers for Protection Against Exposure Fires

6-1 Water Supply and Control.

6-1.1 Water Supply.

6-1.1.1* Sprinklers installed for protection against exposure fires shall be supplied from a standard water supply as outlined in Chapter 2.

- Exception: When approved, other supplies such as manual valves or pumps, or fire department connections, may be used.
- **6-1.1.2** When automatic systems of sprinklers are installed, water supplies shall be from an automatic source.
- **6-1.1.3** When the water supply feeds other fire protection appliances, it shall be capable of furnishing total demand for such appliances as well as the outside sprinkler demand.
- **6-1.1.4** When fire department connections are used for water supply, they shall be so located that they will not be affected by the exposing fire.

6-1.2 Control.

6-1.2.1 Each system of outside sprinklers shall have an independent control valve. When more than one system is required, the division between systems shall be vertical and not horizontal.

Exception: When more than six lines are installed, the systems shall be divided horizontally with independent risers.

- **6-1.2.2** Manually controlled open sprinklers shall be used only where constant supervision is present.
- **6-1.2.3** Sprinklers may be of the open or closed type. Closed sprinklers in areas subject to freezing shall be on dry-pipe systems conforming to Section 5-2 or antifreeze systems conforming to Section 5-5.
- **6-1.2.4*** Automatic systems of open sprinklers shall be controlled by the operation of fire detection devices designed for the specific application.

6-2 System Components.

6-2.1* Valves.

- **6-2.1.1** Control valves shall be of the listed indicating type and shall be distinctively marked by letters not less than ½ in. (13 mm) high to clearly explain their use.
- **6-2.1.2 Drain Valve.** Each system of outside sprinklers shall have a separate drain valve installed on the system side of each control valve. Drain valves shall be in accordance with 3-6.2, except that in no case shall valves be smaller than 1 in. (25.4 mm).
- 6-2.1.3 Check Valves. When sprinklers run 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. 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.
- 6-2.1.4 When 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.
- **6-2.2 Pipe and Fittings.** Approved corrosion-resistant pipe and fittings shall be used for the equipment as far back as the control valve on the water supply.

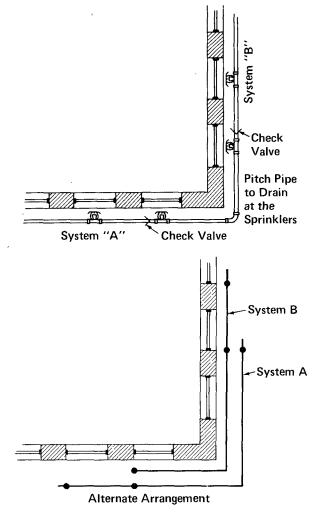


Figure 6-2.1.3 Arrangement of Check Valves.

- **6-2.3 Strainers.** An approved strainer shall be provided in the riser or feed main, which supplies sprinklers having orifices smaller than 3/8 in. (9.5 mm).
- **6-2.4 Gage Connections.** An approved pressure gage conforming to 2-9.2.2 shall be installed immediately below the control valve of each system.
- **6-3** Sprinklers.¹ Only sprinklers of such type as are approved for window, cornice, sidewall, or ridge pole service shall be installed for such use except where adequate coverage by use of other types of approved sprinklers and/or nozzles has been demonstrated. Sprinklers may be of small orifice [¼ in., 5/16 in., and 3/8 in. (6.4 mm, 7.9 mm, and 9.5 mm)] or large orifice [½ in., 5/8 in., and 3/4 in. (12.7 mm, 15.9 mm, and 19.1 mm)].

6-4 Piping System.

6-4.1* Pipe sizes of lines, risers, feed mains, and water supply shall be hydraulically calculated in accordance with

Chapter 7 to furnish a minimum of 7 psi (0.5 bars) at any sprinkler with all sprinklers facing the exposure operating, or pipe sizes shall be in accordance with 6-4.2 and 6-4.3.

6-4.2 Branch line sizes on pipe schedule systems shall be as follows:

Table 6-4.2 Maximum Number of Sprinklers Supplied on Line

C!		-	Orifi	ce Size—	In. (mm))	
Size of Pipe In.	1/4 (6.4)	^{3/16} (7.9)	³ / ₈ (9.5)	^{7/16} (11.1)	1½ (12.7)	⁵ / ₈ (15.9)	³ / ₄ (19.1)
1	4	3	2	2	1	1	1
1 1/4	8	6	4	3	2	2	1
1 1/2		9	6	4	3	3	2
2				5	4	4	3

For SI Units: 1 in. = 25.4 mm.

6-4.3 Risers and feed main sizes on pipe schedule systems shall be as follows for central feed risers:

Table 6-4.3 Maximum Number of Sprinklers— Riser or Feed Mains

Pipe Size	Number of Sprinklers						
	3/8 in. (9.5 mm) or smaller orifice						
11/2	6	3	2				
2	10	5	4				
21/2	18	9	7				
3	32	16	12				
31/2	48	24	17				
4	65	33	24				
5	120	60	43				
6		100	70				

For SI Units: 1 in. = 25.4 mm.

6-5 Testing and Flushing.

6-5.1 Tests.

6-5.1.1 All piping shall be tested hydrostatically as specified in 1-11.2.

6-5.1.2 Operating tests shall be made of the system when completed, except where such tests may risk water damage.

6-5.2 Flushing. Flushing shall be conducted in accordance with 1-11.1.

Chapter 7 Hydraulically Designed Sprinkler Systems

7-1 General.

7-1.1 Definition.

7-1.1.1 A hydraulically designed sprinkler system is one in which pipe sizes are selected on a pressure loss basis to provide a prescribed density, in gallons per minute per square foot [(L/min)/m²], distributed with a reasonable degree of uniformity over a specified area. This permits the selection of pipe sizes in accordance with the characteristics of the water supply available. The stipulated design density and area of application will vary with occupancy hazard.

¹For additional information on outside sprinklers see Appendix B-6-1.

- 7-1.1.2* The design basis for such a system or addition to an existing system supersedes the rules in the sprinkler 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. The size of pipe, number of sprinklers per br inch 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.
- 7-1.2* Nameplate Data. The instailer shall properly identify a hydraulically designed automatic sprinkler system by a permanently attached nameplate indicating the location(s) and the basis of design(s) [discharge density(ies) over designed area(s) of discharge, including gallons per minute and residual pressure demand at base of riser] and hose stream demand supplied by the sprinkler piping. Such nameplates shall be placed at the controlling alarm, drypipe, or preaction valve, for the system containing the hydraulically designed layout(s).

7-2 Information Required.

- 7-2.1 Basic Design Information. Basic design criteria for hydraulically designed sprinkler systems shall be obtained from this or other applicable standards. Where no standards exist, the authority having jurisdiction shall be consulted.
- 7-2.2 Sprinkler System Requirements. The following information shall be included when applicable:
 - (a) Area of water application, sq ft
- (b) Minimum rate of water application (density), gpm/sq ft
 - (c) Area per sprinkler, sq ft
 - (d) Allowance for inside hose and outside hydrants, gpm
 - (e) Allowance for in-rack sprinklers, gpm.
- 7-2.3* Water Supply Information. The following information shall be included: waterflow data with existing or proposed water supply, dead-end or circulating:
- (a) Location and elevation of static and residual test gage with relation to the riser reference point
 - (b) Flow location
 - (c) Static pressure, psi
 - (d) Residual pressure, psi
 - (e) Flow, gpm
 - (f) Date
 - (g) Time
 - (h) Test conducted by or information supplied by . . .

7-2.4 Information Required on the Drawings.

- 7-2.4.1 In addition to the requirements of Section 1-9, the drawings shall also contain the information mentioned in the remainder of 7-2.4.
- 7-2.4.2 Hydraulic Reference Points. Reference points may be shown by a number and/or letter designation and shall correspond with comparable reference points shown on the hydraulic calculation sheets.

- 7-2.4.3 Sprinklers. Description of sprinklers used.
- 7-2.4.4 System Design Criteria. 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 shall be included.
- **7-2.4.5** Actual Calculated Requirements. The total quantity of water and the pressure required shall be noted at a common reference point for each system.
- 7-2.4.6 Elevation Data. Relative elevations of sprinklers, junction points, and supply or reference points shall be noted.

7-3 Data Sheets and Abbreviations.

- 7-3.1 General. Hydraulic calculations shall be prepared on form sheets that include a summary sheet, detailed work sheets, and a graph sheet. (See copy of typical forms, Figures A-7-3.3 and A-7-3.4.)
- 7-3.2 Summary Sheet. The summary sheet shall contain the following information, when 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
- 2. Minimum rate of water application (density), gpm per sq ft
 - 3. Area per sprinkler, sq ft
- (i) Total water requirements as calculated including allowance for inside hose and outside hydrants
 - (j) Water supply information.
- 7-3.3* Detailed Work Sheets. Detailed work sheets (for sample work sheet, refer to Figure A-7-3.3) 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
 - (e) Pipe size
 - (f) Pipe lengths, center to center of fittings
 - (g) Equivalent pipe lengths for fitting and devices
 - (h) Friction loss in psi per ft of pipe
 - (i) Total friction loss between reference points
 - (j) In-rack sprinkler demand
 - (k) Elevation head in psi between reference points
 - (1) Required pressure in psi 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. [See Figure A-7-3.3(o).]
- 7-3.4* Graph Sheet. Water supply curves and system requirements, plus hose and in-rack sprinkler demand when applicable, shall be plotted on semi-logarithmic graph paper (Q^{1.85}) so as to present a graphic summary of the complete hydraulic calculation.
- 7-3.5 Abbreviations and Symbols. The following standard abbreviations and symbols shall be used on the calculation form:

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
$\hat{\mathbf{P_t}}$	Total pressure in psi at a point in a pipe
\mathbf{P}_{f}	Pressure loss due to friction between points indi- cated in location column
Pe	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
\mathbf{P}_{n}	Normal pressure in psi at a point in a pipe
E ["]	90° EII
EE	45° Ell
Lt.E	Long Turn Elbow
Cr	Cross
T	Tee — flow turned 90 degrees
GV	Gate Valve
BV	Butterfly Valve
Del V	Deluge Valve
ALV	Alarm 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

7-4 Calculation.

7-4.1 Formulas.

7-4.1.1 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 with C as the friction loss coefficient.

For SI Units:
$$P_m = 6.05 \times \frac{Q_m^{1.85}}{C^{1.85} d_m^{4.87}} \times 10.5$$

 P_m is the frictional resistance in bars per meter of pipe, Q_m is

the flow in L/min, and d_m is the actual internal diameter in mm with C as the friction loss coefficient.

7-4.1.2 Velocity Pressure Formula. Velocity pressure shall be determined on the basis of the formula

 $P_v = 0.001 123 Q^2/D^4$ $P_v = \text{velocity pressure psi.}$

where:

Q = flow in gpm.

D =the inside diameter in inches.

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

7-4.1.3 Normal pressure P_n shall be determined on the basis of the formula

$$\begin{array}{l} P_n \,=\, P_t \,-\, P_v \\ \text{where:} \\ P_t \,=\, total \; pressure \; in \; psi \; (bars) \\ P_v \,=\, velocity \; pressure \; in \; psi \; (bars) \end{array}$$

7-4.1.4 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.

7-4.2 Equivalent Pipe Lengths of Valves and Fittings.

7-4.2.1 Table 7-4.2 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 7-4.2, the increased friction loss shall be included in hydraulic calculations.

7-4.2.2 Use Table 7-4.2 with Hazen-Williams C = 120 only. For other values of C, the values in Table 7-4.2 shall be multiplied by the factors indicated below:

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

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

7-4.2.3 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.

7-4.3* Calculation Procedure.

7-4.3.1* For all systems the design area shall be the hydraulically most demanding based on the criteria of 2-2.1.3. When the design is based on area/density method, the calculation 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 used. This may include sprinklers on both sides of the cross main. Any fractional sprinkler shall be carried to the next higher whole sprinkler. When the design is based on the room design method, the calculation shall be based on the room that is the hydraulically most demanding.

Table 7-4.2	Equivalent	Pipe	Length Chart	
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Fittings and Valves				Fitti	ngs and	Valves E	xpressed	l in Equiv	alent Fe	et of Pi	pe.			
g	¾ in.	1 in.	1¼ in.	1½ in.	2 in.	2½ in.	3 in.	31/2 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 7-4.3.1.4.

Exception No. 1: Where the design area under consideration consists of a corridor protected by one row of sprinklers, the maximum number of sprinklers that need be calculated is 5, unless openings from the corridor are unprotected. (See 2-2.3.)

Exception No. 2: 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.

Exception No. 3: Where the design is based on the criteria of 2-2.3, including the Exceptions to that section, the above dimensional requirements do not apply.

Exception No. 4: Where the design area under consideration consists of a building service chute supplied by a separate riser, the maximum number of sprinklers that need be calculated is 3.

Exception No. 5: Residential sprinkler designs shall be in accordance with 7-4.4.

Exception No. 6: Designs for ESFR sprinklers shall be in accordance with Chapter 9.

7-4.3.1.1* 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.

- 7-4.3.1.2 System piping shall be hydraulically designed using design densities and areas of operation in accordance with Table 2-2.1.1(b) as required for the occupancies involved.
- (a)* The density shall be calculated on the basis of floor area. The area covered by any sprinkler for use in hydraulic design and calculations shall be determined as follows:
- 1. Along Branch Lines. Determine distance to next sprinkler (or to wall in case of end sprinkler on branch line) upstream and downstream. Choose larger of either twice (1) the distance to the wall, or (2) distance to the next sprinkler. Call this "S."

2. Between Branch Lines. Determine the perpendicular distance to sprinklers on branch lines (or to wall in case of the last branch line) on each side of the branch line on which the subject sprinkler is positioned. Choose the larger of (1) the larger distance to the sprinklers on the next branch line, or (2) in the case of the last branch line, twice the distance to the wall. Call this "L."

Exception: For sidewall sprinklers, L will be the distance to the wall opposite the sprinklers, or in the case where sprinklers are provided on two sides, half the distance between the two sides.

3. Design Area for Sprinkler = $S \times L$.

Exception: This does not apply to small rooms. (See 4-4.19.)

- (b)* When 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.
- (c) When sprinklers are installed above and below temporary obstructions such as overhead doors, the branch lines and the supply shall be calculated to supply the sprinklers both above and below the temporary obstruction.
- 7-4.3.1.3* 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). Begin calculations at the hydraulically most remote sprinkler. Discharge at each sprinkler shall be based on the calculated pressure at that sprinkler.
- **7-4.3.1.4** Calculate pipe friction loss in accordance with the Hazen-Williams formula with C values from Table 7-4.3.1.4.
- (a) Include pipe, fittings, and devices such as valves, meters, and strainers, and calculate elevation changes that affect the sprinkler discharge.
- (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 7-4.2.)
- (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 7-4.3.1.4 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 may recommend other C values.

- 7-4.3.1.5* Orifice plates or sprinklers of different orifice sizes shall not be used for balancing the system, except for special use such as exposure protection, small rooms or enclosures, or directional discharge. (See 4-4.19 for definition of small rooms.)
- 7-4.3.1.6 Sprinkler discharge in closets, washrooms, and similar small compartments requiring only one sprinkler may 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 Table 2-2.1.1(b).]

Exception: This shall not apply when areas of application are less than 1500 sq ft (140 m^2).

- 7-4.3.1.7 Where sprinklers are provided above and below permanent obstructions such as wide ducts, tables, etc., the water supply for one of the levels of sprinklers may be omitted from the hydraulic ceiling design calculations within the area of application. In any case, the most hydraulically demanding arrangement shall be calculated.
- 7-4.3.1.8* Velocity pressure (P_v) may or may not be included in the calculations at the discretion of the designer. If velocity pressures are used, they shall be used on both branch lines and cross mains where applicable.
- **7-4.3.2** Minimum operating pressure of any sprinkler shall be 7 psi (0.5 bar).

Exception: When higher minimum operating pressure for the desired application is specified in the listing of the sprinkler, it shall govern.

7-4.4 **Dwelling Units.** When residential sprinklers are used, design shall comply with this section.

- 7-4.4.1 Design Discharge. The system shall provide a discharge of not less than 18 gal/min (68 L/min) to any operating sprinkler and not less than 13 gal/min (49 L/min) per sprinkler to all operating sprinklers in the design area. Other discharge rates may be used in accordance with flow rates indicated in individual residential sprinkler listings.
- 7-4.4.2* Number of Design Sprinklers. The number of design sprinklers shall include all sprinklers within a compartment to a maximum of 4 sprinklers. When a compartment contains less than 4 sprinklers, the number of design sprinklers shall include all sprinklers in that compartment plus sprinklers in adjoining compartments to a total of 4 sprinklers. Adjoining corridors, if used in the calculations, shall be considered adjoining compartments solely for the purposes of these calculations. In all cases the design area shall include the 4 most hydraulically demanding sprinklers. (See Figure A-7-4.4.2.)
- 7-4.4.3 The definition of compartment for use in 7-4.4.2 to determine the number of design sprinklers is a space completely enclosed by walls and a ceiling. The compartment enclosure may have openings to an adjoining space if the openings have a minimum lintel depth of 8 in. (203 mm) from the ceiling.
- 7-4.4.4 Water Demand. The water demand for the dwelling unit shall be determined by multiplying the design discharge of 7-4.4.1 by the number of design sprinklers specified in 7-4.4.2.
- 7-4.4.5 Other Areas. When 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 all sections of this standard including appropriate water supply requirements of Table 2-2.1.1(b).

Chapter 8* Pipe Schedule Systems

8-1* General. The pipe schedule sizing provisions shall not apply to hydraulically designed systems. Sprinkler systems having sprinklers with orifices other than ½ in. (13 mm) nominal, or piping material other than that covered in Table 3-1.1.1, shall be hydraulically designed. (See Chapter 7.)

Exception: Exposure protection systems designed in accordance with Chapter 6.

- **8-1.1** The number of automatic sprinklers on a given pipe size on one floor shall not exceed the number given in Sections 8-2, 8-3, or 8-4 for a given occupancy.
- **8-1.2 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 Sections 8-2, 8-3, or 8-4.
- **8-1.3** 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 the pipe sizes,

and the feed mains or risers shall be of the size required for the total number of sprinklers.

8-2 Schedule for Light Hazard Occupancies.

8-2.1 Branch lines shall not exceed 8 sprinklers on either side of a cross main.

Exception: When more than 8 sprinklers on a branch line are necessary, lines may be increased to 9 sprinklers by making the two end lengths 1 in. (25.4 mm) and 1¼ in. (33 mm) respectively, and the sizes thereafter standard. Ten sprinklers may be placed on a branch line making the two 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.

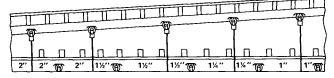
8-2.2 Pipe sizes shall be in accordance with Table 8-2.2.

Exception: Each area requiring more sprinklers than the number specified for 3½ in. (89 mm) pipe in Table 8-2.2 and without subdividing partitions (not necessarily fire walls) shall be supplied by mains or risers sized for Ordinary Hazard Occupancies.

Table 8-2.2 Light Hazard Pipe Schedules

Steel	Copper
1 in. 2 sprinklers 1¼ in. 3 sprinklers 1½ in. 5 sprinklers 2 in. 10 sprinklers 2½ in. 30 sprinklers 3 in. 60 sprinklers 3½ in. 100 sprinklers 4 in. See 4-2.2.1	1 in. 2 sprinklers 1 1/4 in. 3 sprinklers 1 1/2 in. 5 sprinklers 2 in. 12 sprinklers 2 ½ in. 40 sprinklers 3 in. 65 sprinklers 3 ½ in. 115 sprinklers 4 in. See 4-2.2.1

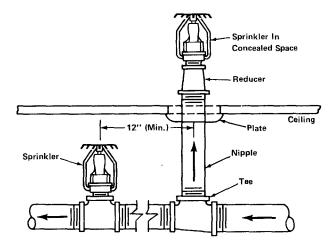
8-2.3 When sprinklers are installed above and below ceilings [see Figures 8-2.3(a), (b), and (c)] and such sprinklers are supplied from a common set of branch lines or separate branch lines from a common cross main, such branch lines shall not exceed 8 sprinklers above and 8 sprinklers below any ceiling on either side of the cross main. Pipe sizing up to and including 2½ in. (64 mm), shall be as shown in Table 8-2.3 utilizing the greatest number of sprinklers to be found on any two adjacent levels.



For SI Units: 1 in. = 25.4 mm.

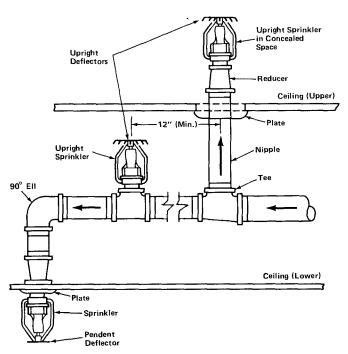
Figure 8-2.3(a) Arrangement of Branch Lines Supplying Sprinklers Above and Below a Ceiling.

8-2.3.1* When the total number of sprinklers above and below a ceiling exceeds the number specified in Table 8-2.3 for 2½-in. (64-mm) pipe, the pipe supplying such sprinklers shall be increased to 3 in. (76 mm) and sized thereafter according to the schedule shown in Table 8-2.2 for the number of sprinklers above or below a ceiling, whichever is larger.



For SI Units: 1 in. = 25.4 mm.

Figure 8-2.3(b) Sprinkler on Riser Nipple from Branch Line in Lower Fire Area.



For SI Units: 1 in. = 25.4 mm.

Figure 8-2.3(c) Arrangement of Branch Lines Supplying Sprinklers Above and Below Ceilings.

Table 8-2.3 Number of Sprinklers Above and Below a Ceiling

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

8-3 Schedule for Ordinary Hazard Occupancies.

8-3.1 Branch lines shall not exceed 8 sprinklers on either side of a cross main.

Exception: When more than 8 sprinklers on a branch line are necessary, lines may be increased to 9 sprinklers by making the two end lengths 1 in. (25.4 mm) and 1¼ in. (33 mm), respectively, and the sizes thereafter standard. Ten sprinklers may be placed on a branch line making the two 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.

8-3.2 Pipe sizes shall be in accordance with Table 8-3.2(a).

Table 8-3.2(a) Ordinary Hazard Pipe Schedule

Steel	Copper
1 in. 2 sprinklers 1¼ in. 3 sprinklers 1½ in. 5 sprinklers 2 in. 10 sprinklers 2½ in. 20 sprinklers 3 in. 40 sprinklers 3½ in. 65 sprinklers 4 in. 100 sprinklers 5 in. 160 sprinklers 6 in. .275 sprinklers 8 in. See 4-2.2.1 and 4-2.2.1 Exception	1 in. 2 sprinklers 11/4 in. 3 sprinklers 11/2 in. 5 sprinklers 2 in. 12 sprinklers 21/2 in. 25 sprinklers 3 in. 45 sprinklers 31/2 in. 75 sprinklers 4 in. 115 sprinklers 5 in. 180 sprinklers 6 in. 300 sprinklers 8 in. See 4-2.2.1 and 4-2.2.1 Exception

Exception: When 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 8-3.2(b).

Table 8-3.2(b) Number of Sprinklers— Greater than 12 ft Separations

Steel	Copper
2½ in	3 in

8-3.3 When 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 8-3.3 [see Figures 8-2.3(a), (b), and (c)] utilizing the greatest number of sprinklers to be found on any two adjacent levels.

Table 8-3.3 Number of Sprinklers Above and Below a Ceiling

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

8-3.3.1* When the total number of sprinklers above and below a ceiling exceeds the number specified in Table 8-3.3 for 3-in. (76-mm) pipe, the pipe supplying such sprinklers shall be increased to 3½ in. (89 mm) and sized thereafter according to the schedule shown in Table 8-2.2 or Table 8-3.2(a) for the number of sprinklers above or below a ceiling, whichever is larger.

Exception: When 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 8-3.2(b), taking into consideration the sprinklers protecting the occupied area only, or paragraph 8-3.3, whichever requires the greater size of pipe.

8-4 Schedule for Extra Hazard Occupancies. Branch lines shall not exceed 6 sprinklers on either side of a cross main. The number of sprinklers for a given pipe size shall be in accordance with Table 8-4.

Table 8-4 Extra Hazard Pipe Schedule

Steel	Соррег
1 in 1 sprinkler	1 in 1 sprinkler
1 ¹ / ₄ in	1 ¹ / ₄ in 2 sprinklers
1½ in 5 sprinklers	$1\frac{1}{2}$ in 5 sprinklers
2 in 8 sprinklers	2 in 8 sprinklers
2½ in 15 sprinklers	2½ in 20 sprinklers
3 in 27 sprinklers	3 in 30 sprinklers
3½ in 40 sprinklers	3½ in 45 sprinklers
4 in 55 sprinklers	4 in 65 sprinklers
5 in 90 sprinklers	5 in100 sprinklers
6 in	6 in170 sprinklers
8 in See 4-2.2.1	8 in See 4-2.2.1

8-5 Deluge Systems. Open sprinkler and deluge systems shall be hydraulically calculated according to applicable standards.

Exception: Open sprinklers for exposure protection installed in conformance with Chapter 6.

Chapter 9 Large-Drop and Early Suppression Fast Response (ESFR) Sprinklers

9-1 General.

9-1.1 Applications. This chapter provides requirements for the installation of large-drop and early suppression fast response (ESFR) sprinklers. Listed sprinklers other than large-drop and ESFR sprinklers are not covered by this chapter.

9-2 Large-Drop Sprinklers.

9-2.1* Definition. Large-Drop Sprinkler. A listed large-drop sprinkler is characterized by a K factor between 11.0 and 11.5; and proven ability to meet prescribed penetration, cooling, and distribution criteria prescribed in the large-drop sprinkler examination requirements. The deflector/discharge characteristics of the large-drop sprinkler generate large drops of such size and velocity as to enable effective penetration of the high-velocity fire plume.

9-2.2* Applicability.

- 9-2.2.1* Large-drop sprinklers are suitable for use with the hazards listed in Table A-9-2.4 and may be used in other specific hazard classifications and configurations only when proven by large-scale fire testing.
- 9-2.2.2 Requirements of this standard shall apply, except those portions dealing with subjects specifically addressed in this chapter.

9-2.3 Installation.

9-2.3.1 Operating Pressure.

- **9-2.3.1.1** Large-drop sprinkler systems shall be designed such that the minimum operating pressure is not less than 25 psi (1.7 bar), unless large-scale testing proves a lesser pressure to be adequate for a particular hazard.
- 9-2.3.1.2 For design purposes, 95 psi (6.5 bar) shall be the maximum discharge pressure used at the starting point of the hydraulic calculations.

9-2.3.2 Type of System.

- **9-2.3.2.1** Large-drop sprinkler systems shall be limited to wet-pipe or preaction systems.
- **9-2.3.2.2** Galvanized steel or copper pipe and fittings shall be used in preaction systems to avoid scale accumulation.

9-2.3.3 System Design.

- 9-2.3.3.1 Pipe shall be sized by hydraulic calculation.
- 9-2.3.3.2* The nominal diameter of branch line pipes (including riser nipples) shall be not less than $1\frac{1}{4}$ in. (33 mm) or greater than 2 in. (51 mm), except starter pieces, which may be $2\frac{1}{2}$ in. (64 mm).

Exception: When 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 center line of the pipe to the deflector. In lieu of this, sprinklers may be offset horizontally a minimum of 12 in. (305 mm).

9-2.3.4 Temperature Rating. Sprinkler temperature ratings shall be the same as 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 3-11.6.3.

9-2.3.5* Spacing.

- **9-2.3.5.1*** The area of coverage shall be limited to a minimum of 80 sq ft (7.4 m^2) and a maximum of 130 sq ft (12.18 m^2) .
- 9-2.3.5.2 The distance between branch lines and between sprinklers on the branch lines shall be limited to not more than 12 ft (3.7 m) nor less than 8 ft (2.4 m).

Exception: Under open wood joist construction, the maximum distance shall be limited to 10 ft (3.0 m).

- **9-2.3.6 Clear Space Below Sprinklers.** At least 36 in. (914 mm) shall be maintained between sprinkler deflectors and the top of storage.
- **9-2.3.7* Distance Below Ceiling.** Sprinklers shall be positioned so that the tops of deflectors are in conformance with Table 9-2.3.7.

Table 9-2.3.7 Minimum and Maximum Distance of Deflectors Below Ceiling for Various Construction Types

Construction Type ¹	Minimum Distance, In. (mm)	Maximum Distance, In. (mm)
Smooth ceiling and bar joist	6 (152)	8 (203)
Beam and girder	6 (152)	12 (305)
Panel up to 300 sq ft (27.9 m ²)	6 (152)	14 (358)
Open wood joist	1 (25) below bottom of joists	6 (152) below bottom of joists

¹See Chapter 4 for definitions of construction types.

9-2.3.8 Location of Sprinklers in Beam and Girder and Panel Construction.

- 9-2.3.8.1 Under beam and girder construction and under panel construction, the branch lines may run across the beams, but sprinklers shall be located in the bays and not under the beams.
- 9-2.3.8.2 The maximum distance of deflector above the bottom of beams shall be limited to the values specified in Chapter 4.

9-2.3.9* Obstructions in Piping.

- 9-2.3.9.1 Screens located in the inlet piping directly connected to rivers, lakes, ponds, reservoirs, uncovered tanks, and similar sources (see NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances) shall be cleaned and serviced at least annually and immediately after any work has been performed on nearby underground mains.
- 9-2.3.9.2* Visual and/or flushing investigations shall be conducted of all systems for foreign material, at intervals not exceeding five years.

9-2.3.10* Obstructions to Distribution.

9-2.3.10.1 Obstructions Located at the Ceiling. When sprinkler deflectors are located above the bottom of beams, girders, 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 deflectors does not exceed the value specified in Chapter 4.

9-2.3.10.2 Obstructions Located Below the Sprinklers.

9-2.3.10.2.1 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 9-2.3.10.2.1. (See Figure 9-2.3.10.2.1.)

Table 9-2.3.10.2.1 Position of Sprinklers in Relation to Obstructions 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)		
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)	

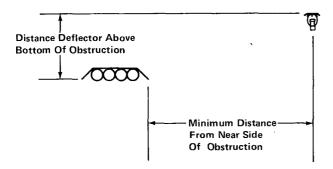


Figure 9-2.3.10.2.1 Position of Sprinklers in Relation to Obstructions Located Entirely below the Sprinklers.

(To be used with Table 9-2.3.10.2.1)

9-2.3.10.2.2 When 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 9-2.3.10.2.2.)

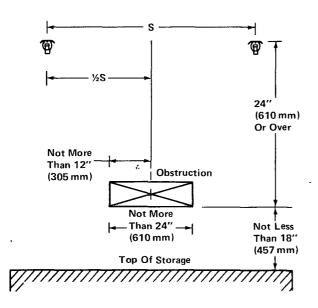


Figure 9-2.3.10.2.2 Position of Sprinklers in Relation to Obstructions Located 24 in. (610 mm) or more below Deflectors.

(b) The obstruction shall be limited to a maximum width of 24 in. (610 mm). (See Figure 9-2.3.10.2.2.)

Exception: When 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 9-2.3.10.2.2.)

Exception: When extensions 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 9-2.3.10.2.2.)

9-2.3.10.3 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 9-2.3.10.3.)
- (b) The obstruction shall be limited to a maximum width of 12 in. (305 mm). (See Figure 9-2.3.10.3.)
- (c) The obstruction shall be limited to a maximum extension of 6 in. (152 mm) to either side of the center line of the branch line. (See Figure 9-2.3.10.3.)

9-2.4* Protection Requirements.

9-2.4.1* Protection shall be provided as specified in Table A-9-2.4 or appropriate NFPA standards in terms of mini-

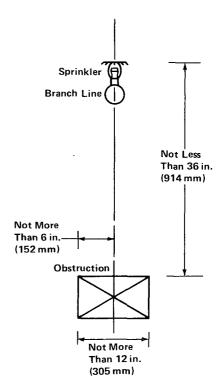


Figure 9-2.3.10.3 Position of Sprinklers in Relation to Obstructions Running Parallel to and Directly below Branch Lines.

mum operating pressure and the number of sprinklers to be included in the design area.

9-3 Early Suppression Fast Response (ESFR) Sprinklers.

9-3.1* Definition. Early Suppression Fast Response (ESFR) Sprinkler. A listed ESFR sprinkler is a thermosensitive device designed to react at a predetermined temperature by automatically releasing a stream of water and distributing it in a specified pattern and quantity over a designated area so as to provide early suppression of a fire when installed on the appropriate sprinkler piping.

9-3.2 Applicability.

- 9-3.2.1 ESFR sprinklers are suitable for use with the hazards listed in Table A-9-3.4.1 and may be used in other specific hazard classifications and configurations only when proven by large-scale or other suitable fire testing.
- 9-3.2.2 Requirements of this standard shall apply, except those portions dealing with subjects specifically addressed in this chapter.

9-3.3 Installation.

9-3.3.1 Construction.

- **9-3.3.1.1 Roof Construction.** ESFR sprinklers are suitable for use in buildings with the following types of roof construction:
 - (a) Smooth ceiling,
 - (b) Bar joist,
 - (c) Beam and girder,
 - (d) Panel.
- 9-3.3.1.2 Roof Slope. Roof slope cannot exceed ¼ in. per ft (21 mm/m).
- **9-3.3.2 Operating Pressure.** ESFR sprinkler systems shall be designed such that the minimum operating pressure is not less than 50 psi (3.4 bars).
- **9-3.3.3 System Type.** ESFR sprinkler systems shall be limited to wet-pipe systems only.
- **9-3.3.4 System Design.** Pipe shall be sized by hydraulic calculation to supply the most hydraulically remote 12 sprinklers, flowing 4 sprinklers on 3 branch lines.
- 9-3.3.5 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 3-11.6.3.

9-3.3.6* Spacing.

- **9-3.3.6.1** The protection area per sprinkler shall be limited to a minimum of 80 sq ft (7.4 m²) and a maximum of 100 sq ft (9.3 m²).
- 9-3.3.6.2 The distance between branch lines and between sprinklers on the branch lines shall be limited to not more than 12 ft (3.7 m) nor less than 8 ft (2.4 m).

9-3.3.7 Distances.

- **9-3.3.7.1 Clear Space Below Sprinklers.** At least 36 in. (914 mm) shall be maintained between sprinkler deflectors and the top of storage.
- 9-3.3.7.2 Distances Below Ceiling. Sprinklers shall be positioned so that deflectors are a maximum 14 in. (356 mm) and a minimum 6 in. (152 mm) below the ceiling.
- 9-3.3.8 Location of Sprinklers in Beam and Girder and Panel Construction. Under beam and girder construction and under panel construction, the branch lines may run across the beams, but sprinklers shall be located in the bays and not under the beams.

9-3.3.9 Obstruction in Piping.

- **9-3.3.9.1** Screens located in the inlet piping directly connected to rivers, lakes, ponds, reservoirs, uncovered tanks, and similar sources (see NFPA 24, Standard for Installation of Private Fire Service Mains and Their Appurtenances) shall be cleaned and serviced at least annually and after any work has been performed on fire protection water supply.
- 9-3.3.9.2 Visual and/or flushing investigations shall be conducted of all systems for foreign material at intervals not exceeding five years.

9-3.3.10 Obstruction to Distribution.

9-3.3.10.1 Obstructions Located at or Near the Ceiling. When sprinkler deflectors are located above the bottom of beams, girders, 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 Chapter 4.

9-3.3.10.2 Obstructions Located Entirely Below the Sprinklers.

9-3.3.10.2.1 Sprinklers shall be positioned with respect to any fluorescent lighting fixtures, ducts, or any other obstruction more than 12 in. (305 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 9-3.3.10.2.1. (See Figure 9-2.3.10.2.1.)

Table 9-3.3.10.2.1 Position of Sprinklers in Relation to Obstructions 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)

9-3.3.10.2.2 When the bottom of obstructions more than 12 in. (305 mm) wide is located below the sprinkler deflectors such that the deflector distances above obstructions specified in Table 9-3.3.10.2.1 are exceeded, install addi-

tional sprinklers beneath obstructions, and include such sprinklers in the water demand.

Exception No. 1: Obstructions up to 12 in. (305 mm) wide and located below a single sprinkler, but not below two or more adjacent sprinklers (including diagonally).

Exception No. 2: Continuous obstructions, such as utility piping or ductwork, up to 12 in. (305 mm) wide, offset by at least 24 in. (610 mm) from both the center line of sprinklers and the center line of any flue spaces for rack storage.

9-3.4 Protection Requirements.

- **9-3.4.1*** Occupancies. ESFR sprinklers may be used to protect the occupancies indicated in Table A-9-3.4.1. ESFR sprinklers cannot be used to protect rack storage with solid shelves or with solid, five-sided, open-top containers.
- 9-3.4.2 Hose Streams. Small hose stations shall be provided. Hose stream water demand is not required to be added to total water demand.
- **9-3.4.3 Water Supply Duration.** Water supply duration shall be at least 60 minutes.

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 shall be the current edition as of the date of the NFPA issuance of this document.
- 10-1.1 NFPA Publications. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.
- NFPA 13A-1987, Recommended Practice for the Inspection, Testing and Maintenance of Sprinkler Systems
- NFPA 13D-1989, Standard for the Installation of Sprinkler Systems for One- and Two-Family Dwellings and Mobile Homes
- NFPA 14-1986, Standard for the Installation of Standpipe and Hose Systems
- NFPA 20-1987, Standard for the Installation of Centrifugal Fire Pumps
- NFPA 22-1987, Standard for Water Tanks for Private Fire Protection
- NFPA 24-1987, Standard for the Installation of Private Fire Service Mains and Their Appurtenances
- NFPA 51B-1984, Standard for Fire Prevention in Use of Cutting and Welding Processes
- NFPA 71-1987, Standard for the Installation, Maintenance, and Use of Signaling Systems for Central Station Service
- NFPA 72A-1987, Standard for the Installation, Maintenance, and Use of Local Protective Signaling Systems for Guard's Tour, Fire Alarm, and Supervisory Service
- NFPA 72B-1986, Standard for the Installation, Maintenance, and Use of Auxiliary Protective Signaling Systems for Fire Alarm Service
- NFPA 72C-1986, Standard for the Installation, Maintenance, and Use of Remote Station Protective Signaling Systems

NFPA 72D-1986, Standard for the Installation, Maintenance, and Use of Proprietary Protective Signaling Systems

NFPA 72E-1987, Standard on Automatic Fire Detectors

NFPA 81-1986, Standard for Fur Storage, Fumigation and Cleaning

NFPA 96-1987, Standard for the Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooking Equipment

NFPA 220-1985, Standard on Types of Building Construction

NFPA 231-1987, Standard for General Storage

NFPA 231C-1986, Standard for Rack Storage of Materials NFPA 1963-1985, Standard for Screw Threads and Gaskets for Fire Hose Connections.

10-1.2 The following additional NFPA codes and standards contain specific sprinkler design criteria. (See 2-2.1.1 Exception No. 4 and A-2-1.)

NFPA 15-1985, Standard for Water Spray Fixed Systems for Fire Protection

NFPA 16-1986, Standard on Deluge Foam-Water Sprinkler and Foam-Water Spray Systems

NFPA 40-1988, Standard for the Storage and Handling of Cellulose Nitrate Motion Picture Film

NFPA 43A-1980, Code for the Storage of Liquid and Solid Oxidizing Materials

NFPA 45-1986, Standard on Fire Protection for Laboratories Using Chemicals

NFPA 101®-1988, Life Safety Code®

NFPA 214-1988, Standard on Water-Cooling Towers

NFPA 231-1987, Standard for General Storage

NFPA 231C-1986, Standard for Rack Storage of Materials

NFPA 231D-1986, Standard for Storage of Rubber Tires

NFPA 231F-1987, Standard for Storage of Roll Paper

NFPA 307-1985, Standard for Construction and Fire Protection of Marine Terminals, Piers, and Wharves

NFPA 409-1985, Standard on Aircraft Hangars

NFPA 423-1983, Standard for Construction and Protection of Aircraft Engine Test Facilities.

10-1.3 Other Codes and Standards.

10-1.3.1 ANSI Publications. American National Standards Institute, Inc., 1450 Broadway, New York, New York 10018.

ANSI B1.20.1-1983, Pipe Threads, General Purpose

ANSI B16.1-1975, Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800

ANSI B16.3-1985, Malleable Iron Threaded Fittings, Class 150 and 300

ANSI B16.4-1985, Cast Iron Threaded Fittings, Classes 125 and 250

ANSI B16.5-1981, Pipe Flanges and Flanged Fittings

ANSI B16.9-1986, Factory-Made Wrought Steel Buttwelding Fittings

ANSI B16.11-1980, Forged Steel Fittings, Socket-Welding and Threaded

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

ANSI B16.22-1980, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

ANSI B16.25-1986, Buttwelding Ends

ANSI B36.10M-1985, Welded and Seamless Wrought Steel Pipe.

10-1.3.2 ASTM Publications. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19105.

ASTM A53-1987, Standard Specification for Welded Pipe, Steel, Black and Hot-Dipped, Zinc-Coated and Seamless

ASTM A234-1987, Standard Specification for Piping Fittings of Wrought-Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures

ASTM A795-1985, Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use

ASTM B32-1987, Standard Specification for Solder Metal, 95-5 (Tin-Antimony-Grade 95TA)

ASTM B75-1986, Standard Specification for Seamless Cop-

ASTM B88-1986, Standard Specification for Seamless Copper Water Tube

ASTM B251-1987, Standard Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube

ASTM E380-1986, Standard for Metric Practice.

10-1.3.3 AWS Publications. American Welding Society. 2501 N.W. 7th Street, Miami, FL 33125.

AWS A5.8-1981, Specification for Brazing Filler Metal AWS D10.9-1980, Specification for Qualification of Welding Procedures and Welders for Piping and Tubing.

Appendix A

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

A-1-3 A sprinkler system is considered to have a single system riser control valve.

A-1-5.1 Impairments. Before shutting off a section of the fire service system to make sprinkler system connections, notify the authority having jurisdiction, plan the work carefully, and assemble all materials to enable completion in the shortest possible time. Work started on connections should be rushed to completion without interruption, and protection restored as promptly as possible. During the impairment, provide emergency hose lines, additional fire pails and extinguishers, and maintain extra watch service in the areas affected.

When changes involve shutting off water from any considerable number of sprinklers for more than a few hours, temporary water supply connections should be made to sprinkler systems so that reasonable protection can be maintained. In adding to old systems or revamping them, protection should be restored each night so far as possible. The members of the private fire brigade as well as public fire department should be notified as to conditions.

A-1-7.1 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 occupan-

A-1-7.2.1 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-1-7.3.1 Ordinary Hazard Occupancies (Group 1) include occupancies having conditions similar to:

Automobile parking garages

Bakeries

Beverage manufacturing

Canneries

Dairy products manufacturing and processing

Electronic plants

Glass and glass products manufacturing

Laundries

Restaurant service areas.

A-1-7.3.2 Ordinary Hazard Occupancies (Group 2) include occupancies having conditions similar to:

Cereal Mills

Chemical Plants — Ordinary

Cold Storage warehouses

Confectionery products

Distilleries

Horse Stables

Leather goods manufacturing

Libraries — large stack room areas

Machine shops

Metal working

Mercantiles

Printing and publishing

Textile manufacturing

Tobacco products manufacturing

Wood product assembly.

A-1-7.3.3 Ordinary Hazard Occupancies (Group 3) include occupancies having conditions similar to:

Feed Mills

Paper and pulp mills

Paper process plants

Piers and wharves

Repair garages

Tire manufacturing

Warehouses (having moderate to higher combustibility of content, such as paper, household furniture, paint, general storage, whiskey, etc.)¹

Wood machining.

When hazards in those buildings or portions of buildings of this occupancy group are severe, the authority having jurisdiction should be consulted for special rulings regarding water supplies, types of equipment, pipe sizes, types of sprinklers, and sprinkler spacing.

A-1-7.4 New installations protecting Extra Hazard Occupancies should be hydraulically designed where standards giving design criteria are available.

A-1-7.4.1 Extra Hazard Occupancies (Group 1) include occupancies having conditions similar to:

Combustible Hydraulic Fluid use areas

Die Casting

Metal Extruding

Plywood and particle board manufacturing

Printing [using inks with below 100°F (37.8°C)

flash points]

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

Mobile Home or Modular Building assemblies (where finished enclosure is present and has combustible interiors)

Open oil quenching

Solvent cleaning

Varnish and paint dipping.

A-1-8 Sprinkler Systems in Buildings Subject to Flood. When sprinkler systems are installed in buildings subject to recurring floods, the location of control valves, alarm devices, dry-pipe valves, pumps, compressors, power and fuel supplies should be such that system operation will be uninterrupted by high water.

A-1-8.1.2 Under special conditions used equipment may be reused by the original owner, subject to the approval of the authority having jurisdiction. Second-hand alarm valves, retarding chambers, circuit closers, water-motor alarms, dry-pipe valves, quick-opening devices, and other devices may be used as replacement equipment in existing systems subject to the approval of the authority having jurisdiction.

A-1-9 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. Any material deviation from approved plans will require permission of the authority having jurisdiction.

Preliminary layouts should show:

- (a) Name of owner and occupant
- (b) Location, including street address
- (c) Point of compass
- (d) Construction and occupancy of each building

NOTE: Date on special hazards should be submitted as they may require special rulings.

- (e) Building height in feet
- (f) If it is proposed to use a city main as a supply, whether the main is dead-end or circulating, size of the main and pressure in psi; and if dead-end, direction and distance to nearest circulating main
 - (g) Distance from nearest pumping station or reservoir
- (h) In cases where reliable up-to-date information is not available, a waterflow test of the city main should be conducted in accordance with B-2-1.1. (The preliminary plan should specify who conducted the test, date and time, the location of the hydrants where flow was taken, and where static and residual pressure readings were recorded; the size of main supplying these hydrants, and the results of the test, giving size and number of open hydrant butts flowed; also data covering minimum pressure in the connection with the city main should be included.)
- (i) Data covering waterworks systems in small towns in order to expedite the review of plans
- (j) Fire walls, fire doors, unprotected window openings, large unprotected floor openings, and blind spaces
- (k) Distance to and construction and occupancy of exposing buildings e.g., lumber yards, brick mercantiles, fire-resistive office buildings, etc.
- (1) Spacing of sprinklers, number of sprinklers in each story or fire area and total number of sprinklers, number of sprinklers on each riser and on each system by floors, total area protected by each system on each floor, total number of sprinklers on each dry-pipe system or preaction or deluge system and if extension to present equipment, number of sprinklers on riser per floor, sprinklers already installed
- (m) Capacities of dry-pipe systems with the bulk pipe included (see Table A-5-2.3), and if an extension is made to an existing dry-pipe system. The total capacity of the existing and also extended portion of the system
- (n) Weight or class, size, and material of any proposed underground pipe

¹ For high-piled storage as defined in 4-1.3.10, see Appendix C for separately published NFPA standards relating to water supply requirements, particularly NFPA 231, Standard for General Storage, and NFPA 231C, Standard for Rack Storage of Materials.

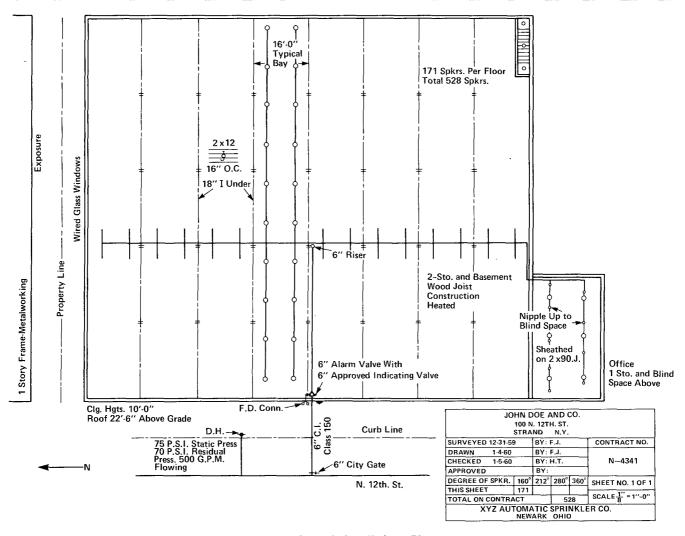


Figure A-1-9 Typical Preliminary Plan.

- (o) Whether property is located in a flood area requiring consideration in the design of sprinkler system
 - (p) Name and address of party submitting the layout.
- A-1-11.1 Underground mains and lead-in connections to system risers should be flushed through hydrants at dead ends of the system or through accessible aboveground flushing outlets allowing the water to run until clear. If water is supplied from more than one source or from a looped system, divisional valves should be closed to produce a high-velocity flow through each single line. The flows specified in Table 1-11.1 will produce a velocity of at least 10 ft/sec (3 m/s), which is necessary for cleaning the pipe and for lifting foreign material to an aboveground flushing outlet.
- A-1-11.2.1 Example. A sprinkler system has for its water supply a connection to a public water service main. A 100 psi (6.9 bar) rated pump is installed in the connection. With a maximum normal public water supply of 70 psi (4.8 bars)

at the low elevation point of the individual system or portion of the system being tested and a 120 psi (8.3 bars) pump (churn) pressure, the hydrostatic test pressure is 70 + 120 + 50 or 240 psi (16.5 bars).

Systems that have been modified or repaired to any appreciable extent should be hydrostatically tested at not less than 50 psi (3.4 bars) in excess of normal static pressure for 2 hours.

To reduce the possibility of serious water damage in case of a break, pressure may be maintained by a small pump, the main controlling gate meanwhile being kept shut during the test.

Polybutylene pipe will undergo expansion during initial pressurization. In this case a reduction in gage pressure may not necessarily indicate a leak. The pressure reduction should not exceed the manufacturer's specifications and listing criteria.

A-1-11.2.2 Valves isolating the section to be tested may not be "drop tight." When such leakage is suspected, test

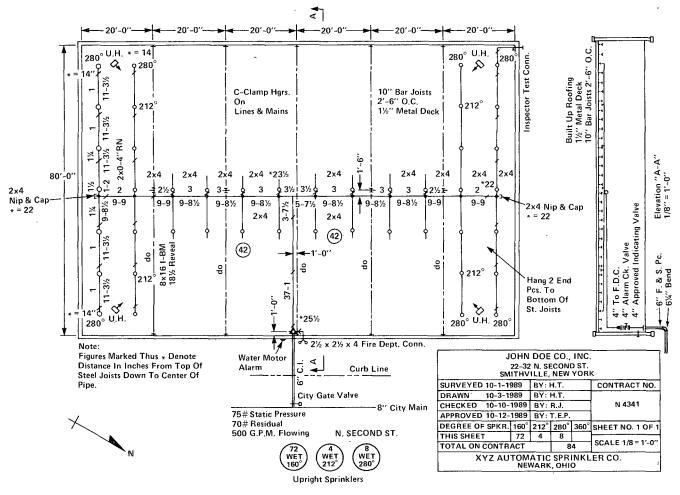


Figure A-1-9.2 Typical Working Plans.

blanks of the type recommended in 1-11.2.5 should be used in a manner that includes the valve in the section being tested.

A-2-1 Water supplies should have adequate pressure, capacity, and reliability.

The water supply needed for various occupancies, including Extra Hazard Occupancies, is determined by evaluating the number of sprinklers that may be expected to operate from any one fire plus quantities needed simultaneously for hose streams.

Determination of the water supply needed for Extra Hazard Occupancies will require special consideration of four factors: (1) area of sprinkler operation, (2) density of discharge, (3) required time of discharge, and (4) amount of water needed simultaneously for hose streams.

When the occupancy presents a possibility of intense fires requiring extra heavy discharge, this may be obtained by an increase in the pressure and volume of the water supply, by a closer spacing of sprinklers, by the use of larger pipe sizing, or by a combination of these methods. In such cases, consideration should be given to hydraulically designed systems. (See Chapter 7.)

When separately published standards on various subjects contain specific provisions for water supplies, these should be consulted. (See Chapter 10 for availability of standards.)

- A-2-2 The water supply requirement for sprinkler protection is determined by the number of sprinklers expected to operate in the event of fire. The primary factors affecting the number of sprinklers that might open are:
 - 1. Occupancy
 - 2. Combustibility of contents
 - 3. Area shielded from proper distribution of water
 - 4. Height of stock piles
 - 5. Combustibility of construction (ceilings and blind spaces)
 - 6. Ceiling heights and draft conditions
 - 7. Horizontal and vertical cutoffs

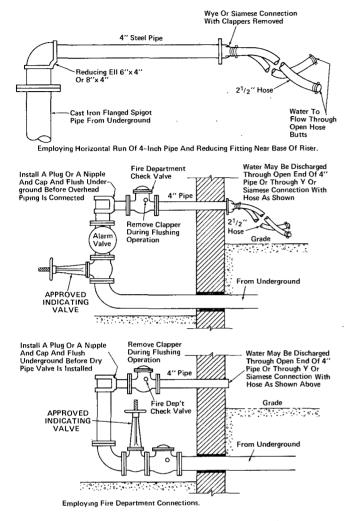


Figure A-1-11.1 Methods of Flushing Water Supply Connections.

- 8. Wet or dry sprinkler system
- 9. High water pressure
- 10. Housekeeping
- 11. Temperature rating of sprinklers
- 12. Waterflow alarm and response thereto.
- A-2-2.2 For occupancies with the potential for fast-spreading fire due to the presence of lint, combustible residue, combustible hydraulic fluids under high pressure with ignition sources nearby, etc., the minimum area of operation should encompass the entire area likely to be involved in such a fire.
- A-2-2.3 Corridors are rooms and should be considered as such. 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 four sprinklers and a smaller room has two

sprinklers but communicates through unprotected openings with three other rooms, each having two sprinklers, the smaller room and group of communicating spaces should also be calculated. Another example in which the room which creates the greatest demand is not the largest room would be where a large room is located near the system riser but a small room with the same hazard classification is located at the opposite end of the building or on an upper floor so as to produce a significantly higher demand.

- A-2-2.3.2 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-2-2.3.3 When considering the 100 gpm allowance for several hose stations, it is the intent of 2-2.3.3 to apply a 50 gpm allowance to each of the two most remote area connections to the sprinkler system, for an aggregate of 100 gpm.
- A-2-3.1.1 Care should be taken in making water tests to be used in designing or evaluating the capability of sprinkler systems. The water supply tested should be representative of the supply that may be available at the time of a fire. For example, testing of public water supplies should be done at times of normal demand on the system. Public water supplies are likely to fluctuate widely from season to season and even within a 24-hour period. Allowance should be made for seasonal or daily fluctuations, for drought conditions, for possibility of interruption by flood, or for ice conditions in winter. Testing of water supplies also normally used for industrial use should be done while water is being drawn for industrial use. The range of industrial-use demand should be taken into account.

Future changes in water supplies should be considered. For example a large, established, urban supply is not likely to change greatly within a few years. However, the supply in a growing suburban industrial park may deteriorate quite rapidly as greater numbers of plants draw more water.

- A-2-3.2 In private underground piping systems for buildings of other than Light Hazard Occupancy, any dead-end pipe supplying both sprinklers and hydrants should not be less than 8 in. (203 mm) in size. Also see NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.
- A-2-5.1 An automatically controlled vertical turbine pump taking suction from a reservoir, pond, lake, river, or well complies with 2-5.1.
- A-2-5.2 See sections dealing with sprinkler equipment supervisory and waterflow alarm services in NFPA 71, Standard for the Installation, Maintenance, and Use of Signaling Systems for Central Station Service; NFPA 72A, Standard for the Installation, Maintenance, and Use of Local Protective Signaling Systems for Guard's Tour Fire Alarm, and Supervisory Service; NFPA 72B, Standard for the Installation, Maintenance, and Use of Auxiliary Protective Signaling Systems for Fire Alarm Service; NFPA 72C, Standard for the Installation, Maintenance, and Use of Remote Station Protective Signaling Systems; or NFPA 72D, Standard for the Installation, Maintenance, and Use of Proprietary Protective Signaling Systems.

A-2-6.3 The air pressure to be carried and the proper proportion of air in the tank may be determined from the following formulas, in which,

P = Air pressure carried in pressure tank

A = Proportion of air in tank

H = Height of highest sprinkler above tank bottom

When tank is placed above highest sprinkler

$$P = \frac{30}{A} - 15.$$

A = $\frac{1}{3}$ then P = 90 - 15 = 75 lb per sq in. A = $\frac{1}{2}$ then P = 60 - 15 = 45 lb per sq in. A = $\frac{2}{3}$ then P = 45 - 15 = 30 lb per sq in.

When tank is below level of the highest sprinkler

$$P = \frac{30}{A} - 15 + \frac{0.434H}{A}$$

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

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

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

The respective air pressures above are calculated to ensure that the last water will leave the tank at a pressure of 15 psi (1.03 bars) when the base of the tank is on a level with the highest sprinkler, or at such additional pressure as is equivalent to a head corresponding to the distance between the base of the tank and the highest sprinkler when the latter is above the tank.

The final pressure required at the pressure tank for systems designed from Table 2-2.1.1(b) will normally be higher than the 15 psi (1.03 bars) anticipated in the previous paragraph. The following formula should be used to determine the tank pressure and ratio of air to water in hydraulically designed systems.

$$P_i = \frac{P_f + 15}{A} - 15$$

 P_i = Tank pressure

 P_f = Pressure required from hydraulic calculations

A = Proportion of air

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

$$P_{i} = \frac{75 + 15}{.5} - 15$$

$$P_i = 180 - 15 = 165 \text{ psi}$$

For SI Units: 1 ft = 0.3048 m; 1 psi = 0.0689 bar.

In this case the tank would be filled with 50 percent air and 50 percent water and the tank pressure would be 165 psi (11.4 bars). If the pressure is too high, the amount of air carried in the tank will have to be increased.

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

A-2-7.1 The fire department connection should be located not less than 18 in. (457 mm) and not more than 5 ft (1.5 m) above the level of the adjacent grade or access level.

A-2-7.2 For hydraulically designed sprinkler systems, the size of the fire department connection should be sufficient to supply the sprinkler water demand developed from Table 2-2.1.1(b).

A-2-7.3 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. When 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-2-8.2 When the system riser is close to an outside wall. underground fittings of proper length should be used in order to avoid pipe joints located in or under the wall. When the connection passes through the foundation wall below grade, a 1- to 3-in. (25- to 76-mm) clearance should be provided around the pipe and the clear space filled with asphalt mastic or similar flexible waterproofing material. (Also see Appendix B-3-1.)

A-2-9.1

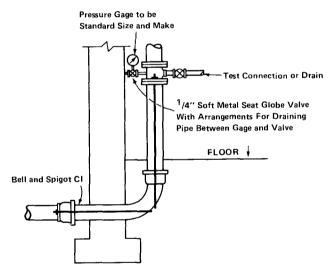


Figure A-2-9.1 Test Connection on Water Supply with Outside Control. (Also applicable to an interior riser.)

A-3-1.1.5 The investigation of pipe and tube other than that described in Table 3-1.1.1 should involve consideration of many factors:

- (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).

Table A-3-1.1.2 Steel Pipe Dimensions

Nominal				Schedu	le 10¹			Schedu	le 30			Schedu	ıle 40	
Pipe Size in.		tside meter (mm)		side meter (mm)	Wa Thiel in.			side meter (mm)	W Thiel in.	all kness (mm)		side meter (mm)		all kness (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)
21/2	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)
31/2	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 3-1.1.2.

Table A-3-1.1.4 Copper Tube Dimensions

Nominal				Туре	e K			Турс	e L		٠.	Туре	M	
Tube Size		tside		side		all		side		all		side		all
		meter		meter	Thic	kness		meter		kness		meter		kness
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)
21/2	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)
31/2	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)

(h) Physical characteristics related to integrity during earthquakes.

A-3-3.2 See page 74 for Figures A-3-3.2 (a) and (b). Also see NFPA 13A, Recommended Practice for the Inspection, Testing and Maintenance of Sprinkler Systems.

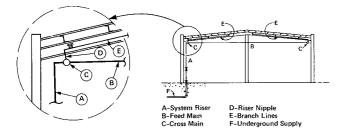


Figure A-3-2 Building Elevation Showing Parts of Sprinkler Piping System.

A-3-3.7 One and one-half (1½) in. hose connections for use in storage occupancies and other locations where standpipe systems are not required are covered by this standard. When 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-3-3.8 Combined automatic sprinkler and standpipe risers should not be interconnected by sprinkler system piping.

A-3-4.1.1 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. (See A-3-6.4.1.) In this event, the test

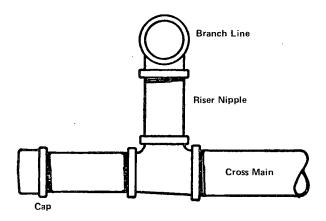


Figure A-3-3.2(a) Screw-type Cap.

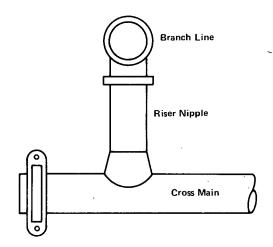
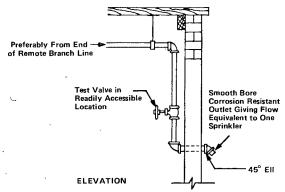


Figure A-3-3.2(b) Groove-type Cap.

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-3-4.1.1(a) and A-3-4.1.1(b).] The test valve should be located at an accessible point, and preferably not over 7 ft (2.1 m) above the floor. The control valve on the test connection should be located at a point not exposed to freezing.

A-3-5 Protection of Piping Against Damage Due to Impact. Sprinkler piping should be located so as to minimize the possibility of damage due to impact by mobile material handling equipment and other vehicles. For example, risers adjacent to structural columns and out of vehicle travel routes are generally safe, as are feed mains and cross mains shielded by heavy structural members such as girders.

A-3-5.1.2 In areas subject to freezing climates, when piping extends through an exterior wall, as for fire department connections, system test connection, or drains, a minimum of 4 ft (1.2 m) of pipe should be maintained between the wall and the section of piping containing water.



For SI Units: 1 ft = 0.3048 m. NOTE: Not Less Than 4ft (1.2 m) of Exposed Test Pipe in Warm Room Beyond Valve When Pipe Extends Through Wall to Outside.

Figure A-3-4.1.1(a) System Test Connection on Wet-Pipe System.

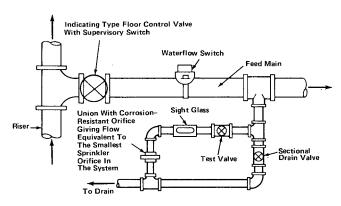
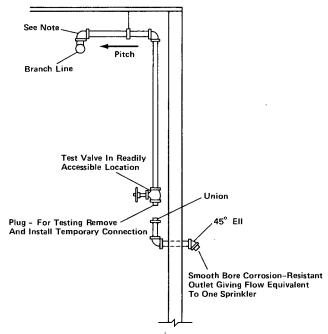
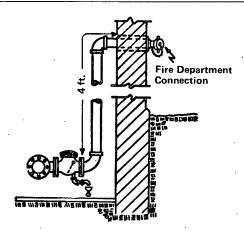


Figure A-3-4.1.1(b) Floor Control Valve.



NOTE: To minimize condensation of water in the drop to the test connection, provide a nipple-up off of the branch line.

Figure A-3-4.2 System Test Connection on Dry-Pipe System.



For SI Units: 1 ft=0.3048 m.

Figure A-3-5.1.2 Minimum Clearance to Avoid Freezing.

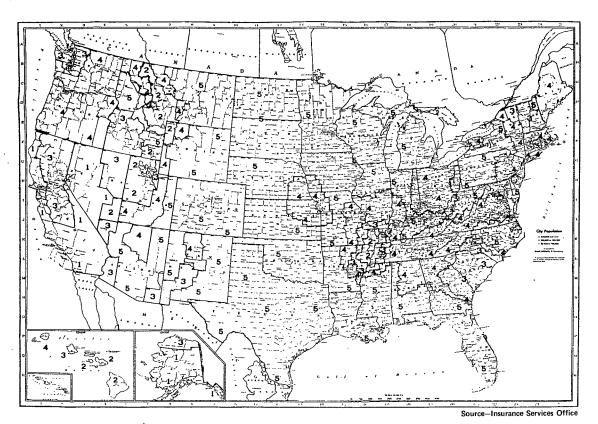
A-3-5.2.1 Types of locations where corrosive conditions may exist include bleacheries, dye houses, metalplating processes, animal pens, and certain chemical plants.

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 threaded ends of steel pipe should be painted.

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

- A-3-5.2.3 It is important when protected steel pipe (galvanized, dipped and wrapped, coated, etc.) is used that particular care is taken to see that all exposed threads, wrench marks, or abrasions that have penetrated through the protection be repaired, sealed, and/or properly coated.
- A-3-5.3.1 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.



EARTHQUAKE ZONES

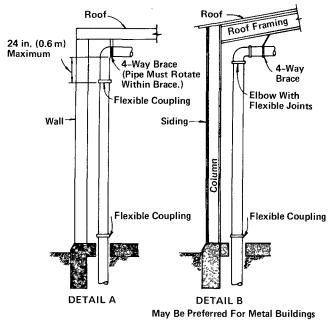
- 1-Maximum potential for earthquake damage
- 2-Reasonable potential

- 3—Slight potential
- 4 and 5-Earthquake protection not required

Figure A-3-5.3.1 Seismic Map.

Areas known to have a potential for earthquakes have been identified in building code and insurance maps. An example of such a map is shown in Figure A-3-5.3.1.

A-3-5.3.2 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 use of listed flexible couplings, by joining grooved end pipe at critical points, and by allowing clearances at walls and floors.



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-3-5.3.2(a) Riser Details.

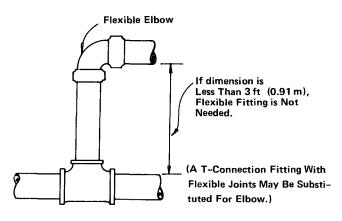


Figure A-3-5.3.2(b) Detail at Short Riser.

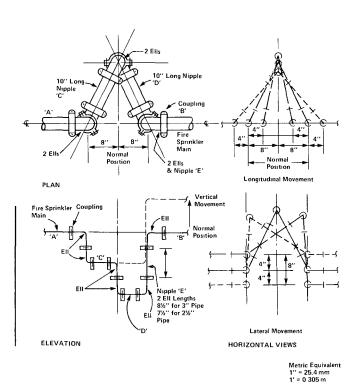
Tank or pump risers should be treated the same as sprinkler risers for their portion within a building. The discharge pipe of tanks on buildings should have a control valve above the roof line so any pipe break within the building can be controlled.

Piping 3 in. (76 mm) or smaller in size is pliable enough so that flexible couplings are not usually necessary. A flexible coupling is a mechanical coupling or fitting that permits some angular displacement, axial displacement, and rotation of the piping without failure of the pipe or fitting. "Rigid-type" mechanical couplings that do not permit movement at the grooved connections are not considered flexible couplings.

A-3-5.3.2(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 3-5.3.2(d) will suffice.

For seismic separation joints, considerably more flexibility is needed, particularly for piping above the first floor. The following figure shows a method of providing additional flexibility through the use of swing joints.

A-3-5.3.3 Plan and elevation views of a swing joint assembled with flexible elbows are shown in Figure A-3-5.3.3.



NOTE: The figure 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.

Figure A-3-5.3.3 Seismic Flexible Joint.

A seismic swing joint 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 earth-quakes. In lieu of calculations, permitted movement can be made at least twice the actual separations, at right angles to the separation as well as parallel to it.

A-3-5.3.4 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.

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

A-3-5.3.5.1 Sway Bracing.

Location of Bracing. [See Figure A-3-5.3.5.1(a).]

Two-way braces are either longitudinal or lateral depending on their orientation with the axis of the piping. [See Figures A-3-5.3.5.1(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, 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.

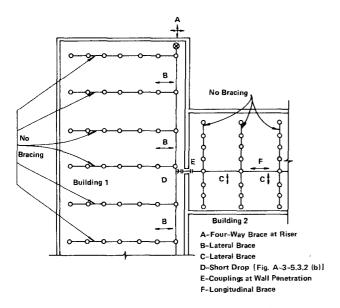


Figure A-3-5.3.5.1(a) Earthquake Protection for Sprinkler Piping.

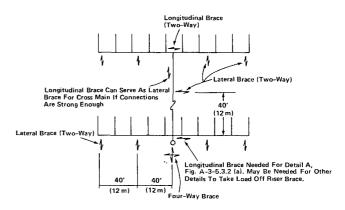


Figure A-3-5.3.5.1(b) Typical Location of Bracing on a Pipe Schedule System.

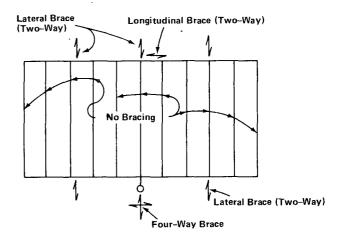


Figure A-3-5.3.5.1(c) Typical Location of Bracing on a Gridded System.

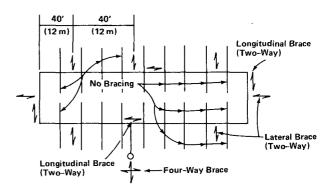


Figure A-3-5.3.5.1(d) Typical Location of Bracing on a Looped System.

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. When a branch line can pound against a piece of equipment, such as a space heater or a structural member, a lateral brace should be installed on the branch line to help prevent rupture.

A four-way brace is indicated at Location A. [Also see Figure A-3-5.3.2(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.

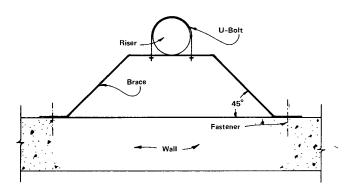


Figure A-3-5.3.5.1(e) Detail of Four-Way Brace at Riser.

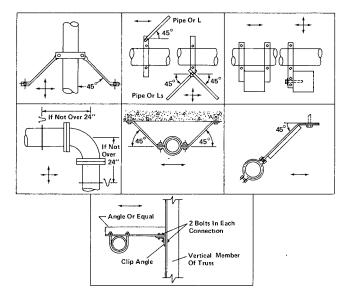


Figure A-3-5.3.5.1(f) Acceptable Types of Sway Bracing.

Figures A-3-5.3.5.1(b), (c), and (d) show typical locations of sway bracing for pipe schedule, gridded, and looped sprinkler systems.

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

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

The brace can be attached to the structural system directly through a leg of an angle or a flattened portion of pipe. Where dimensions are tight or some play must be allowed, a special fitting can be used. [See Figure A-3-5.3.5.1(b)]. 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, 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 3-5.3.5.1(2) 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.

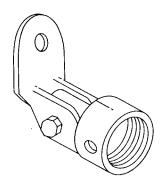


Figure A-3-5.3.5.1(g) Special Fitting.

- (c) Determine the total load tentatively applied to each brace in accordance with the examples shown in Figure A-3-5.3.5.1(h) and the following:
- 1. For the loads on lateral braces on cross mains, add one-half the weight of 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-3-5.3.5.1(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. [See examples 2, 3, 5, and 8 in Figure A-3-5.3.5.1(h).]
- 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-3-5.3.5.1(h).]

Use the information on weights of water-filled piping contained within Table A-3-5.3.5.1.

- (d) If the total expected loads are less than the maximums permitted in Table 3-5.3.5.1(2) 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 3-5.3.5.1(3). If not, again add additional braces or additional means of support.

Table A-3-5.3.5.1
Piping Weights for Determining Horizontal Load

Schedule 40 Pipe	Weight of Water-Filled Pipe (lb per ft)	½ Weight of Water-Filled Pipe (lb per ft)		
1	2.05	1.03		
1 1/4	2.93	1.47		
1 1/2	3.61	1.81		
2	5.13	2.57		
21/2	7.89	3.95		
3	10.82	5.41		
31/2	13.48	6.74		
	16.40	8.20		
4 5 6	23.47	11.74		
6	31.69	15.85		
8*	47.70	23.85		
Schedule 10 Pipe				
1 .	1.81	0.91		
11/4	2.52	1.26		
1 1/2	3.04	1.52		
2	4.22	2.11		
21/2	5.89	2.95		
3	7.94	3.97		
31/2	9.78	4.89		
4	11.78	5.89		
4 5 6	17.30	8.65		
6	23.03	11.52		
8	40.08	20.04		

^{*}Schedule 30

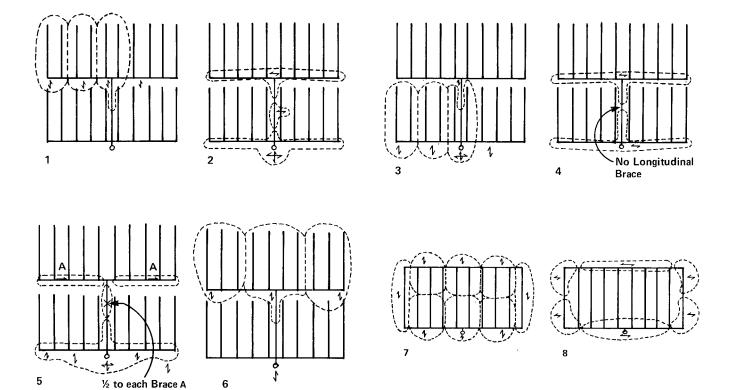


Figure A-3-5.3.5.1(h) Examples of Load Distribution to Bracing.

A-3-5.3.5.3 The four-way brace provided at the riser may also provide longitudinal and lateral bracing for adjacent mains.

A-3-6.1.1 All piping should be arranged where practicable to drain to the main drain valve.

A-3-6.3.2.3 An example of a suitable 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-3-6.3.3.3 The size of tie-in drain lines should be increased as necessary to provide efficient removal of trapped water. Consideration should be given to the volume of water trapped, elevation head available, and the time required to discharge water. Water or condensation or both that remains after initial drain down should not be permitted to collect since freezing may cause failure of the drain/system piping.

A-3-6.4.1 When possible, the main sprinkler riser drain should discharge outside the building at a point free from the possibility of causing water damage. When 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. When 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-3-6.4.5 When exterior ambient temperatures are subject to freezing [32°F (0°C) or less], at least 4 ft (1.2 m) of pipe should be installed beyond the valve, in a warm room.

A-3-7.1.2 Some steel piping material having lesser wall thickness than specified in 3-7.1.2 has been listed for use in sprinkler systems when 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 gages conforming to the Basic Dimensions of Ring Gages for USA (American) Standard Taper Pipe Threads, NPT, as per ANSI/ASME B1.20.1, Table 8.

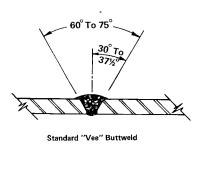
A-3-7.2.2 As used in this standard, shop in the term shop welded means either:

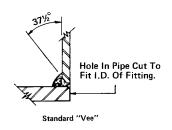
- (a) At the sprinkler contractor's or fabricator's premise.
- (b) An approved welding area at the building site.

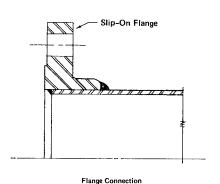
A-3-7.2.6(a) Listed, shaped, contoured nipples meet the definition of fabricated fittings.

A-3-7.4 The fire hazard of the brazing process should be suitably safeguarded.

Self-cleaning fluxes should not be used. Continued corrosive action after the soldering process is completed could result in leaks from the seats of sprinklers.







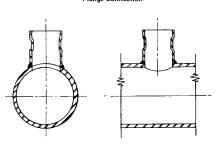


Figure A-3-7.2(a) Acceptable Weld Joints.

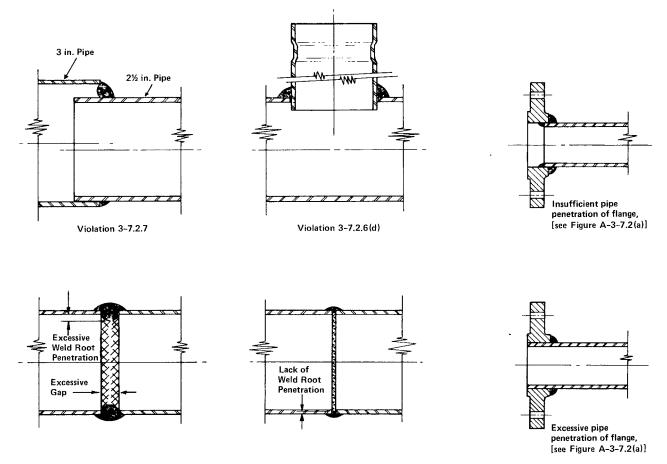


Figure A-3-7.2(b) Unacceptable Weld Joints.

A-3-8.1.2 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-3-8.1.2.1 Unless properly restrained, gravitational forces on unsupported nonvertical branches can cause the pipe to rotate out of position.

A-3-8.2 Approved flexible connections are permissible and encouraged for sprinkler installations in racks to reduce the possibility of physical damage. When flexible tubing is used it should be located so that it will be protected against mechanical injury.

A-3-9.2 See Figure A-3-9.2 on page 82.

A-3-9.2.1 A water supply connection should not extend into or through a building unless such connection is under the control of an outside listed indicating valve or an inside listed indicating valve located near the outside wall of the building.

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

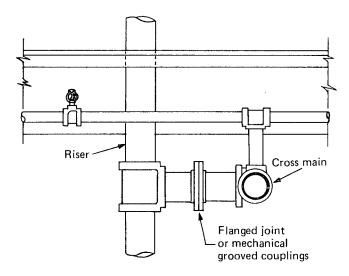


Figure A-3-8.1.5 One Arrangement of Flanged Joint at Sprinkler Riser.

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-3-9.2.5 Pits for underground valves, except those located at the base of a tank riser, are described in NFPA 24, Standard for Installation of Private Fire Service Mains and Their Appurtenances. For pits protecting valves located at the base of a tank riser, refer to NFPA 22, Standard for Water Tanks for Private Fire Protection.
- A-3-9.2.6 When 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 water supply connection immediately inside of the building; in case there is no outside control, the system indicating valve should be placed at the wall flange ahead of all fittings.
- A-3-9.4 All control, drain, and test connections should be provided with identification signs.
- A-3-10.1 Branch line hangers under metal decking may be attached by drilling or punching vertical members and using through bolts. The distance from the bottom of the bolt hole to the bottom of the vertical member should be not less than 3/8 in. (9.5 mm).

To take care of the thrust in a steeply pitched roof branch line, a clamp should be installed on the pipe just above the lowest hanger.

A-3-10.1.3 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.

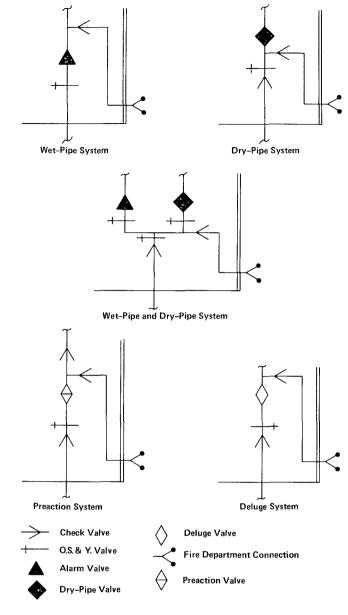


Figure A-3-9.2 Examples of Acceptable Valve Arrangements.

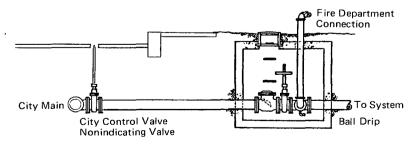


Figure A-3-9.2.5 Pit for Gate Valve, Check Valve, and Fire Department Connection.

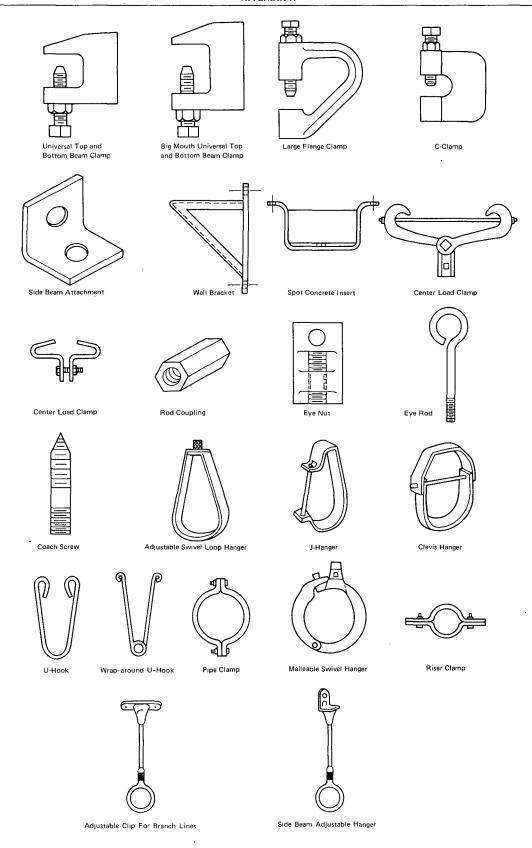
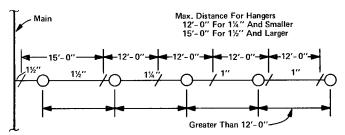


Figure A-3-10.1 Common Types of Acceptable Hangers.

A-3-10.1.7 Table 3-10.1.7(a) assumes that the load from 15 ft (5 m) of water-filled pipe, plus 250 lb (114 kg), is located at the midpoint of the span of the trapeze member, with a maximum allowable bending stress of 15 KSI (111 kg). If the load is applied at other than the midpoint, for the purpose of sizing the trapeze member, an equivalent length of trapeze may be used, derived from the formula

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

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

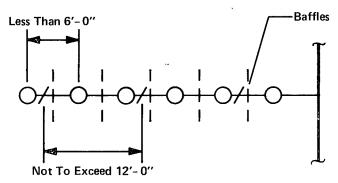


For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.

Figure A-3-10.1.11.1 Distance Between Hangers with Steel Pipe.

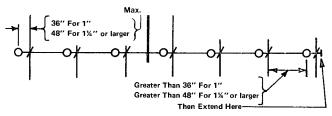
A-3-10.1.11.2 When copper tube is to be installed in moist areas or other environments conducive to galvanic corrosion, copper hangers or ferrous hangers with an insulating material should be used.

A-3-10.3.1 Powder-driven studs should not be used in steel of less than $\frac{3}{16}$ in. (4.8 mm) total thickness.



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

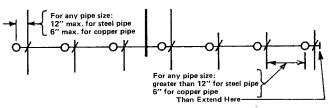
Figure A-3-10.5.2 Distance Between Hangers.



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

Figure A-3-10.5.5 Distance from Sprinkler to Hanger.

NOTE: For pendent sprinklers below a ceiling and exposed to maximum pressure greater than 100 psi, see Figure A-3-10.5.5 Exception.

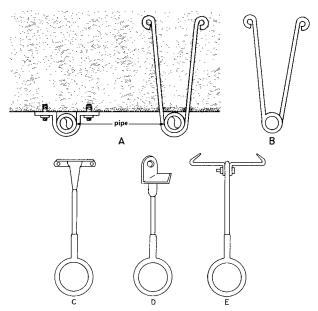


For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.

Figure A-3-10.5.5 Exception. 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.

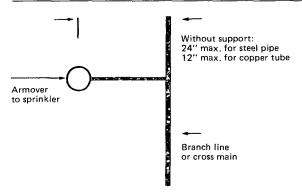
NOTE 1: The pendent sprinkler may be installed either directly in the fitting at the end of the line, or in a fitting at the bottom of a drop nipple.

NOTE 2: Hanger closest to sprinkler shall be of a type that clamps to and prevents upward movement of the pipe.



- 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

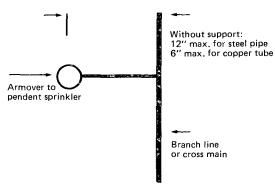
Figure A-3-10.5.5(a) Examples of Acceptable Hangers for End of Line (or Armover) Pendent Sprinklers.



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

Figure A-3-10.5.6 Maximum Length for Unsupported Armover.

NOTE: For a pendent sprinkler below a ceiling and exposed to maximum pressure greater than 100 psi, see Figure A-3-10.5.6 Exception.



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

Figure A-3-10.5.6 Exception. Maximum length of unsupported armover when the maximum pressure exceeds 100 psi (6.9 bars) and a branch line above a ceiling supplies pendent sprinklers below the ceiling.

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.

A-3-11.1(h) and (i) 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-3-11.2.1 Upright sprinklers should be installed with the frame parallel to the branch line pipe to reduce to minimum the obstruction of the discharge pattern.

A-3-11.2.9.1 The response and water distribution pattern of listed residential sprinklers have been shown by extensive fire testing to provide better control than conventional 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.

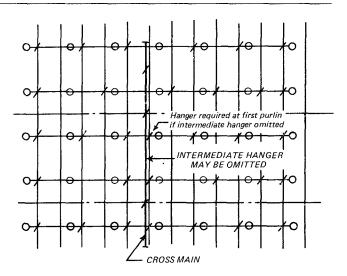


Figure A-3-10.6.1(a) Hangers on Cross Main.

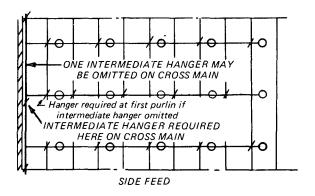


Figure A-3-10.6.1(b) Hanger Omission on Side Feed System.

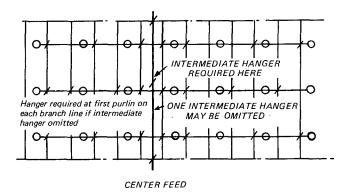


Figure A-3-10.6.1(c) Hangers on Cross Main — Center Feed System.

A-3-11.4.1 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-3-11.5 The following Table A-3-11.5 shows the nominal discharge capacities of approved sprinklers having a nominal ½-in. (13-mm) orifice at various pressures up to 100 psi (6.9 bars).

Table A-3-11.5 Nominal Discharge Capacities

Pressure at Sprinkler psi	Discharge gpm	Pressure at Sprinkler psi	Discharge gpm
10	18	35	34
15	22	50	41
20	25	75	50
25	28	100	58

For SI Units: 1 gpm = 3.785 L/min; 1 psi = 0.0689 bar.

A-3-11.6 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, which should be hung for several days in the questionable location, with the plant in operation.

When an occupancy hazard normally may be expected to produce a fast-developing fire or a rapid rate of heat release, the use of sprinklers of high temperature classification, as a means of limiting the total number of sprinklers that might open in a fire, is recommended. Since the number of sprinklers that might be expected to open will be reduced where the water pressure effective-in first operating sprinklers is at least 75 psi (5.2 bars) without the disadvantage of a potential increase in fire damage, this alternative should be given first consideration.

NOTE: Fire tests have shown that the number of sprinklers that might be expected to open, particularly under conditions where fast-developing fires may be expected, can be limited by the use of sprinklers of High Temperature Classification. This may be of advantage in reducing the number of sprinklers that would otherwise open outside the area directly involved in a fire and decrease the overall water demand. However, some increase in fire damage and fire temperatures may be expected when sprinklers of Intermediate or High Temperature Classification are used.

Some occupancies employ high-temperature fumigation processes requiring consideration in the selection of sprinkler temperature ratings.

A-3-11.7 For equipment aboard vessels or in isolated locations, a greater number of sprinklers should be provided to permit equipment to be put back into service promptly after a fire. When a great number of sprinklers are likely to be opened by a flash fire, a greater number of sprinklers should be provided.

A-3-11.8 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-3-11.9.1 When painting sprinkler piping or painting in areas near sprinklers, the sprinklers may be protected by covering them with a bag that should be removed immediately after the painting has been finished.

A-3-11.9.2 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-3-12.2 Central station, auxiliary, remote station, or proprietary protective signaling systems are a highly desirable supplement to local alarms, especially from a safety to life standpoint. (See 3-12.6.)

Identification Signs. Approved identification signs 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. (See Figure A-3-12.2.)



Figure A-3-12.2 Identification Sign.

A-3-12.3.3 A mechanical alarm (water motor gong) may also be required.

A-3-12.3.4 The surge of water when the valve trips may seriously damage the device.

A-3-12.4.1 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-3-12.4.2 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-3-12.5 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-3-12.7.2 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 shall be indicated by means of a conspicuous light located in the vicinity of the riser or alarm control panel. This light shall remain in operation during the entire period of the electrical circuit interruption.

A-4-1.1 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 of sprinklers (Section 4-2) and position of sprinklers (Section 4-3) are not exceeded.

All needless ceiling sheathing, hollow siding, tops of high shelving, partitions, or decks should be removed. Sheathing of paper and similar light flammable materials is particularly objectionable.

A-4-1.1.1 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 Installation of sprinklers throughout the premises is necessary for protection of life and property. In some cases partial sprinkler installations covering hazardous sections and other areas are specified in codes or standards or are required by authorities having jurisdiction for minimum protection to property or to provide opportunity for safe exit from the building.

When 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 adequate and designed with due 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 nonsprinklered area may overpower the partial sprinkler system.

When 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 spaced inside each adjacent room above the door opening. When 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-4-1.3.3 See Figures A-4-1.3.3(a) and (b) for examples of bar joist construction.

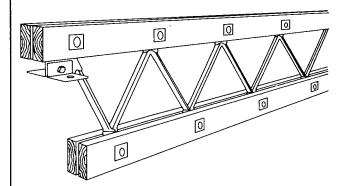


Figure A-4-1.3.3(a) Wood Bar Joist Construction.

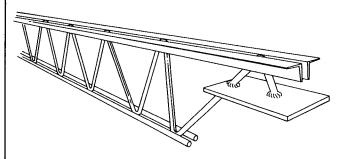


Figure A-4-1.3.3(b) Open-Web Bar Joist Construction.

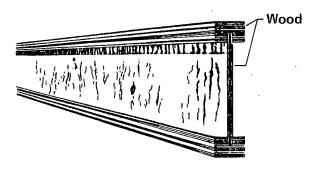


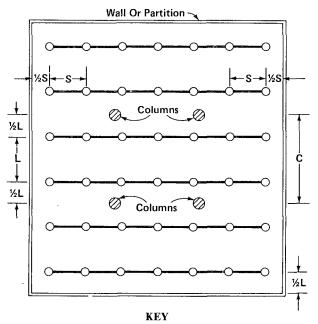
Figure A-4-1.3.8 Typical Composite Wood Joist Construction.

A-4-2.1.2 For examples of sprinkler layouts under smooth ceiling construction, refer to Figures A-4-2.1.2(a) and (b).

A-4-2.2 The protection area per sprinkler should be determined as follows:

1. Along Branch Lines. Determine distance to next sprinkler (or to wall in case of end sprinkler on branch line) upstream and downstream. Choose the larger of either twice

Flat Slab or Pan-Type Reinforced Concrete Maximum Spacing: 130 sq ft per Sprinkler $L \times S = 130$ or less



C = Column spacing.

L = Distance between branch lines, limit 15 ft.

S = Distance between sprinklers on branch lines, limit 15 ft.

Examples

С	L	S (Max)	C	L	S (Max)
21 ft 8 in. 24 ft 2 in.	10 ft 10 in. 12 ft 1 in.	12 ft 0 in. 10 ft 9 in.	21 ft 6 in.	10 ft 9 in.	12 ft 1 in.

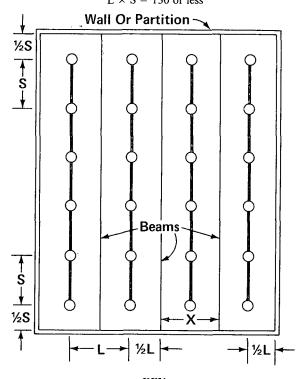
For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m; 1 ft² = 0.0929 m^2 .

Figure A-4-2.1.2(a) Layout of Sprinklers under Smooth Ceiling Construction — Ordinary Hazard Occupancy.

the distance to the wall or distance to the next sprinkler. Call this "S".

- 2. Between Branch Lines. Determine perpendicular distance to sprinkler on branch lines (or to wall in the case of the branch line) on each side of the branch line on which the subject sprinkler is positioned. Choose the larger of (1) the larger distance to the sprinklers on the next branch line, or (2) in the case of the last branch line, twice the distance to the wall. Call this, "L".
 - 3. Protection area of the sprinkler = $S \times L$.
- 4. This does not apply to any sprinkler located more than 7.5 ft (2.3 m) from any single wall in a small room. (See 4-4.19.)
- A-4-2.3 The arrangement of branch lines depends upon such construction features as the distance between girders or trusses, columns of mushroom-type reinforced concrete, and beams of standard mill construction. Each space or bay should usually be treated as a unit, installing the same number of branch lines uniformly in each space. When

Continuous Smooth Bays with Beams Supported on Columns Maximum Spacing: 130 sq ft per Sprinkler $L \times S = 130$ or less



KEY

L = Distance between branch lines, limit 15 ft.

S = Distance between sprinklers on branch lines, limit 15 ft.

X = Width of bay.

Examples

X	L	S (Max)	X	L	S (Max)
	10 ft 10 in. 12 ft 1 in.			10 ft 9 in.	12 ft 1 in.

For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m; 1 ft² = 0.0929 m².

Figure A-4-2.1.2(b) Layout of Sprinklers under Smooth Ceiling Construction — Ordinary Hazard Occupancy.

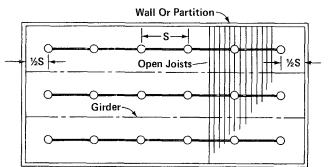
single branch lines will suffice, they should be placed midway in each bay or space. The arrangement of branch lines also depends upon the structural members available and suitable for the attachment of hangers, and upon the need for properly locating sprinkler deflectors in accordance with 4-2.4 and Section 4-3.

The direction in which branch lines are usually run in common types of ceiling construction and framing is shown in Table A-4-2.3.

A-4-2.4.6 Narrow Pocket. Girders, beams, or trusses forming narrow pockets of combustible construction along walls when of a depth that will obstruct the spray discharge pattern may require additional sprinklers.

A-4-2.4.7 On sprinkler lines larger than 2 in. (51 mm), consideration should be given to the distribution interfer-

Joists Above Girders or Framed into Girders; Branch Lines Uniformly Spaced Between Girders Maximum Spacing: 130 sq ft per Sprinkler $L \times S = 130$ or less



KEY

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 ft² = 0.0929 m².

Figure A-4-2.2.2.2 Layout of Sprinklers under Open Wood Joist Construction — Light and Ordinary Hazard Occupancies.

ence caused by the pipe, which can be minimized by installing sprinklers on riser nipples or installing sprinklers in the pendent position.

A-4-2.5.2 The distances given in Table 4-2.5.2 were determined through tests in which privacy curtains with either a solid fabric or close mesh ¼ in. (6.4 mm) top panel were

installed. For broader-mesh top panels [e.g., ½ in. (13 mm)] the obstruction of the sprinkler spray is not likely to be severe and the authority having jurisdiction may not need to apply the requirements in 4-2.5.2.

A-4-4 Special Occupancy Considerations.

- (a) Subject to the approval of the authority having jurisdiction, sprinklers may be omitted in rooms or areas where they are considered undesirable because of the nature of the contents, or in rooms or areas of noncombustible construction with wholly noncombustible contents and that are not exposed by other areas. Sprinklers should not be omitted from any room merely because it is damp or of fire-resistive construction.
- (b) It is not advisable to install sprinklers when the application of water, or of flame and water, to a room or area's contents may constitute a serious life or fire hazard, as in the manufacture or storage of quantities of aluminum powder, calcium carbide, calcium phosphide, metallic sodium and potassium, quicklime, magnesium powder, and sodium peroxide. The manufacture and storage of such materials should be confined to specially cut-off, unsprinklered rooms, or buildings of fire-resistive construction.
- A-4-4.4.1 Exceptions No. 1, 2, and 3 do not require sprinkler protection because it is not physically practical to install sprinklers in these spaces. To prevent the possibility of uncontrolled fire spread, consideration should be given in these unsprinklered concealed space situations by using other means such as Exceptions No. 5, 8, and 9.
- A-4-4.4. When there is a limited amount of combustibles available to burn and a limited prospect of fire propagation, sprinklers may not be required.

A-4-4.7.1.2 When practicable, sprinklers should be staggered at the alternate floor levels, particularly when only one sprinkler is installed at each floor level.

Table A-4-2.3 Common Branch Line Run Directions

Type of Ceiling	Location of Branch Lines
Smooth Continuous:	
Concrete mushroom	Either direction
Concrete pan-type or flat	Either direction
Sheathed (ceiling attached to bottom of beams, wood joists, or bar joists):	
Girders beneath sheathing	Across the beam or joists
No girders beneath sheathing	Whichever direction facilitates easy and proper hanging
Bays more than 7½ ft (2.3 m) wide:	
Formed by beams supported on columns	Parallel to beams
Formed by beams supported on girders or trusses	Either across beams or parallel to beams in the bays above girders or trusses
Supported directly on girders	Parallel to girders
Supported directly on trusses	Either direction, parallel to or through trusses
Beam and Girder:	
Wood or steel beams spaced 3 to 7½ ft (0.9 to 2.3 m) apart	Across beams
Open Bar Joist	Across the joists or trusses (either through or under them)
Open Joist (wood, steel, or concrete)	Across joists

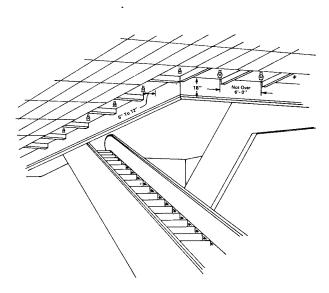
A-4-4.7.2 Floor or wall openings tending to create vertical or horizontal drafts, or other structural conditions that would delay the prompt operation of automatic sprinklers by preventing the banking up of the heated air from the fire, should be properly stopped in order to permit control of fire at any point by local sprinklers.

A-4-4.8 The installation of sprinklers at floor levels should be so arranged as to protect the sprinklers from mechanical injury, 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. (See also 4-1.2.) Sprinklers with special directional discharge characteristics may be advantageous.

A-4-4.9 Small loading docks, covered platforms, ducts, or similar small unheated areas may be protected by drypendent sprinklers extending through the wall from wet sprinkler piping in an adjacent heated area, as shown in Figure A-4-4.9.

Where possible, the 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.

A-4-4.10 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 employed, the area below should be sprinklered.



For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m. *Baffle (see 4-4.18).

Figure A-4-4.7.2.3 Sprinklers Around Escalators.

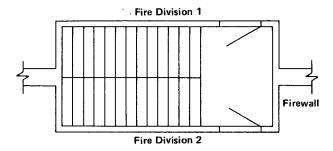


Figure A-4-4.7.2.4(a) Noncombustible Stair Shaft Serving Two Fire Sections.

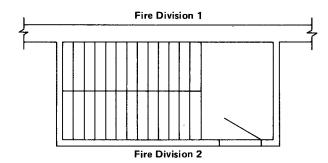


Figure A-4-4.7.2.4(b) Noncombustible Stair Shaft Serving One Fire Section.

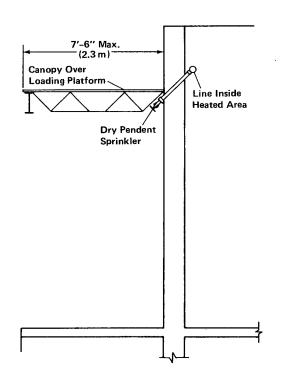
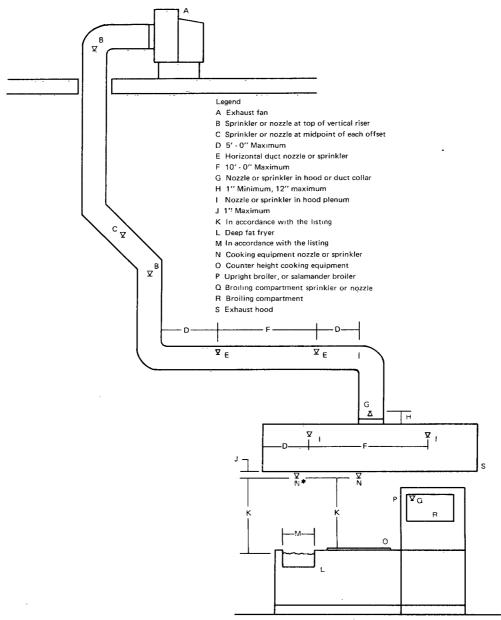


Figure A-4-4.9 Dry-Pendent Sprinklers for Protection of Covered Platforms, Shipping Docks, and Similar Areas.

- **A-4-4.12** For ducts less than 4 ft (1.2 m) wide that obstruct distribution from ceiling sprinklers, see B-4-2.3.
- **A-4-4.14** 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-4-4.15.3 Drop-out ceilings do not provide the required protection for soft-soldered copper joints or other piping that requires protection.
- **A-4-4.15.4** 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.



^{*}Listed for deep fat fryer protection.

Figure A-4-4.17.4 Typical Installation Showing Automatic Sprinklers or Automatic Spray Nozzles Being Used for the Protection of Commercial Cooking Equipment and Ventilation Systems.

A-4-4.17.9 The indicating control valve should be readily accessible and properly identified. (See 3-9.4.)

A-4-4.19.1 Examples of Sprinkler Spacing within Small Rooms. An example of sprinklers in small rooms for hydraulically designed and pipe schedule systems is shown in Figure A-4-4.19.1(a), and examples for hydraulically designed systems only are shown in Figures A-4-4.19.1(b), (c), and (d).

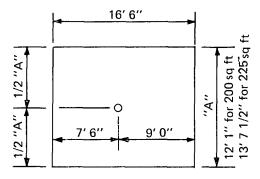
A-4-5 The installation of sidewall sprinklers other than beneath smooth ceilings will require special consideration. Beams or other ceiling obstructions interfere with proper distribution and, when present, sidewall sprinklers should be spaced with regard to such obstructions.

A-4-5.2 The protection area per sprinkler should be determined using the $S \times L = Protection$ Area rule as follows:

1. "S" — Determine distance to the next sprinkler (or to the wall, in 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.

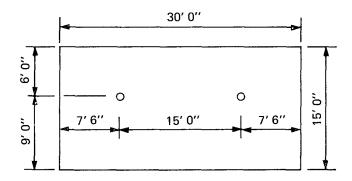
2. "L" — The distance to the opposite side of the room will be "L". Where sprinklers are provided on both sides of the room, "L" should be half the distance between the walls.

A-4-5.5.1 Sidewall sprinklers should be placed to receive heat from a fire and at the same time most effectively distribute the water discharged by them. This is likely to be particularly important when heavy decorative molding is encountered near the junction of walls and ceilings.



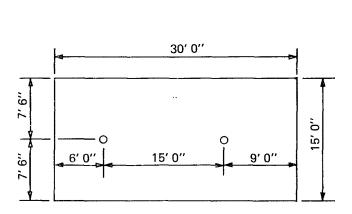
For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.

Figure A-4-4.19.1(a).

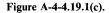


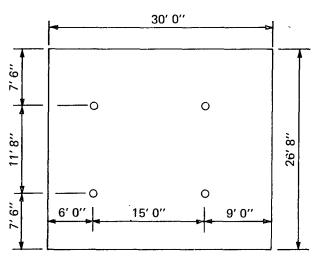
For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.

Figure A-4-4.19.1(b).



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





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

Figure A-4-4.19.1(d).

A-5-1.1 A dry-pipe, preaction, or deluge system may be supplied from a larger wet-pipe system, provided the water supply is adequate.

A-5-2.1 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.

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

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

A-5-2.3 The capacities of the various sizes of pipe given in Table A-5-2.3 are for convenience in calculating the capacity of a system.

Table A-5-2.3 Capacity of One Foot of Pipe (Based on actual internal pipe diameters)

Nominal	G	al	Nominal	Gal			
Diameter	Sch 40	Sch 10	Diameter	Sch 40	Sch 10		
³ / ₄ in.	0.028	_	3 in.	0.383	0.433		
1 in.	0.045	0.049	3½ in.	0.513	0.576		
1¼ in.	0.078	0.085	4 in.	0.660	0.740		
1½ in.	0.106	0.115	5 in.	1.040	1.144		
2 in.	0.174	0.190	6 in.	1.501	1.649^{1}		
2½ in.	0.248	0.283	8 in.	2.66^{3}	2.776^{2}		

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

A-5-2.4.2 In the case of dry-pipe valves having relatively small priming chambers and in which the normal quantity of priming water fills, or nearly fills, the entire priming chamber, the objective contemplated by this rule will be met by requiring connection of the quick-opening device at a point on the riser above the dry-pipe valve, which will provide a capacity measure between the normal priming level of the air chamber and the connection of 1½, 2, and 3 gal (5.7, 7.6, and 11.4 L) for 4-, 5-, and 6-in. (102-, 127-, and 152-mm) risers, respectively. Making the connection 24 in. (610 mm) above the normal priming water level will ordinarily provide this capacity.

A-5-2.5 The dry-pipe valve should be located in an accessible place near the sprinkler system it controls.

When exposed to cold, the dry-pipe valve should be located in an approved valve room or enclosure and, where this is not possible, in an underground pit acceptable to the authority having jurisdiction. The room should be of suffi-

cient size to give at least $2\frac{1}{2}$ ft (0.8 m) of free space at the sides and in front of, above and below, the dry-pipe valve or valves, and this room, if feasible, should not be built until the valve is in position.

Size of enclosure should be governed by the number and arrangement of dry-pipe valves, so as to give ready access to these devices.

A-5-2.6 Careful installation and maintenance, and some special arrangements of piping and devices as outlined in this section, are needed to avoid the formation of ice and frost inside piping in cold storage rooms that will be maintained at or below 32°F (0°C). Conditions are particularly favorable to condensation where pipes enter cold rooms from rooms having temperatures above freezing.

Whenever the opportunity offers, fittings such as those specified in 5-2.6.1 and illustrated in Figures 5-2.6.1(A) and 5-2.6.1(B), as well as flushing connections specified in 3-3.2, should be provided in existing systems.

When 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 which service such systems. NFPA 13A contains guidance in this matter.

- A-5-2.7.2 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-5-3.2 Preaction and deluge systems may also have outside sprinklers for protection against exposure fire.
- A-5-3.3 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.

When 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. When this combination is employed:

^{0.134} Wall Pipe

²0.188 Wall Pipe

³Schedule 30

- (a) Dry systems may be manifolded to a deluge valve, the protected area not exceeding 40,000 sq ft (3716 m²). The distance between valves should be as short as possible to minimize water hammer.
- (b) The dry-pipe valves should be pressurized to 50 psi (3.4 bars) to reduce the possibility of dry-pipe valve operation from water hammer.
- A-5-3.7 Deluge systems are usually applied to severe conditions of occupancy. In designing piping systems the pipe sizes should be calculated in accordance with the standard for hydraulically designed sprinkler systems as given in Chapter 7.

When 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 taper reducers may be used.

- A-5-4.1.1 When Installed. Combined dry-pipe and preaction systems may be installed when wet-pipe systems are impractical. They are 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.
- A-5-5.2 Antifreeze solutions may be used for maintaining automatic sprinkler protection in small unheated areas. Antifreeze solutions are recommended only for systems not exceeding 40 gallons (151 L).

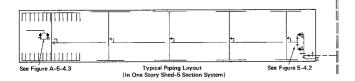
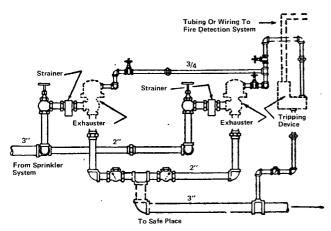


Figure A-5-4.1.1 Typical Piping Layout for Combined Dry-Pipe and Preaction Sprinkler System.



For SI Units: 1 in. = 25.4 mm.

Figure A-5-4.3 Arrangement of Air Exhaust Valves for Combined Dry-Pipe and Preaction Sprinkler System.

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

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.

A-5-5.3.3 Beyond certain limits, increased proportion of antifreeze does not lower the freezing point of solution. (See Figure A-5-5.3.3.) 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).

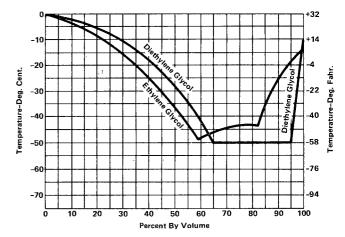


Figure A-5-5.3.3 Freezing Points of Water Solutions of Ethylene Glycol and Diethylene Glycol.

- A-5-5.4 To avoid leakage, the materials and workmanship should be excellent, the threads clean and sharp, and the joints tight. Use only metal-faced valves.
- A-5-5.5 Tests should be made by drawing a sample of the solution from valve B two or three times during the freezing season, especially if it has been necessary to drain the building sprinkler system for repairs, changes, etc. A small hydrometer should be used so that a small sample will be sufficient. When water appears at valve B or when the test sample indicates that the solution has become weakened, empty the entire system and recharge as previously described.
- A-5-6.1.3(a) Outlets should be provided at critical points on sprinkler system piping to accommodate attachment of pressure gages for test purposes.
- A-6-1.1.1 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 minutes.