Second Revision No. 1039-NFPA 13-2017 [Global Comment]

HBS-AAA

Update metric conversions in NFPA 13 to match that as shown on the attached list and pdf of NFPA 13.

Supplemental Information

File Name	Description	Approved
13-HBS_metrics.pdf	Metric conversions for hanging and bracing	✓
Metric_values_used_in_NFPA_13..docx	List of accepted metric conversions for NFPA 13.	✓

Submitter Information Verification

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Submittal Date: Fri Oct 06 13:29:50 EDT 2017

Committee Statement and Meeting Notes

Committee Statement: The metric conversions in the attached list are considered to be “soft” or approximate conversions and are intended to consider trade sizes for pipe and other materials and have been appropriately rounded with the number of significant digits taken into account. The intent of this list is to provide for consistent use of metric conversions throughout the standard with the understanding that it is acceptable for an engineer, authority having jurisdiction, designer or, installer to use an exact conversion rather than an approximate conversion as used in the standard when necessary.

The attached list has been reviewed by the NFPA 13 Metric Task Group.

Response Message:

16.15.2.1
In buildings of light or ordinary hazard occupancy, 2½ in. (65 mm) hose valves for fire department use shall be permitted to be attached to wet pipe sprinkler system risers.

16.15.2.2*
The following restrictions shall apply:
(1) Each connection from a standpipe that is part of a combined system to a sprinkler system shall have an individual control valve and check valve of the same size as the connection.

(2) The minimum size of the riser shall be 4 in. (100 mm) unless hydraulic calculations indicate that a smaller size riser will satisfy sprinkler and hose stream allowances.

(3) 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. *(For fire department connections serving standpipe and sprinkler systems, refer to Section 16.12.)*

16.16 Electrical Bonding and Grounding.

16.16.1
In no case shall sprinkler system piping be used for the grounding of electrical systems.

16.16.2*
The requirement of 16.16.1 shall not preclude the bonding of the sprinkler system piping to the lightning protection grounding system as required by NFPA 780 in those cases where lightning protection is provided for the structure.

16.17* Signs.
(Reserved)

Chapter 17 Installation Requirements for Hanging and Support of System Piping

17.1* General.

17.1.1
Unless the requirements of 17.1.2 are met, types of hangers shall be in accordance with the requirements of Section 9.1.

17.1.2
Hangers certified by a registered professional engineer to include all of the following shall be an acceptable alternative to the requirements of Section 9.1:
(1) Hangers shall be designed to support five times the weight of the water-filled pipe plus 250 lb (115 kg) at each point of piping support.

(2) These points of support shall be adequate to support the system.

(3) The spacing between hangers shall not exceed the value given for the type of pipe as indicated in Table 17.4.2.1(a) or Table 17.4.2.1(b).

(4) Hanger components shall be ferrous.

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

17.1.3 Support of Non-System Components.
17.1.3.1*
Sprinkler piping or hangers shall not be used to support non-system components.

17.1.3.2
Sprinkler piping shall be permitted to utilize shared support structures in accordance with 17.1.4.

17.1.4

Shared support structures shall be certified by a registered professional engineer in accordance with 17.1.2 and 17.1.4.

17.1.4.1*
The design of a shared support structure shall be based on either 17.1.4.1.1 or 17.1.4.1.2.

17.1.4.1.1
Sprinkler pipe and other distribution systems shall be permitted to be supported from a shared support structure designed to support five times the weight of water-filled sprinkler pipe and other supported distribution systems plus 250 lb (115 kg), based on the allowable ultimate stress.

17.1.4.1.2
Sprinkler pipe and other distribution systems shall be permitted to be supported from a shared support structure designed to support five times the weight of the water-filled sprinkler pipe plus 250 lb (115 kg), and one and one-half times the weight of all other supported distribution systems.

17.1.4.1.3
The building structure shall not be considered a shared support structure.

17.1.4.1.4*
The requirements of 17.1.4.1 shall not apply to 17.4.1.3.3.

17.1.4.1.5
Systems that are incompatible with the fire sprinkler systems based on vibration, thermal expansion and contraction, or other factors shall not share support structures.

17.1.5
Where water-based fire protection systems are required to be protected against damage from earthquakes, hangers shall also meet the requirements of 18.7.

17.1.6 Listing.

17.1.6.1*
Unless permitted by 17.1.6.2 or 17.1.6.3, the components of hanger assemblies that directly attach to the pipe, building structure, or racking structure shall be listed.

17.1.6.2*
Mild steel hanger rods and hangers formed from mild steel rods shall be permitted to be not listed.

17.1.6.3*
Fasteners as specified in 17.2.2, 17.2.3, and 17.2.4 shall be permitted to be not listed.

17.1.6.4
Other fasteners shall be permitted as part of a hanger assembly that has been tested, listed, and installed in accordance with the listing requirements.

17.1.7 Component Material.

17.1.7.1
Unless permitted by 17.1.7.2 or 17.1.7.3, hangers and their components shall be ferrous metal.

17.1.7.2
Nonferrous components that have been proven by fire tests to be adequate for the hazard application, that are listed for this purpose, and that are in compliance with the other requirements of this section shall be acceptable.

17.1.7.3
Holes through solid structural members shall be permitted to serve as hangers for the support of system piping, provided such holes are permitted by applicable building codes and the spacing and support provisions for hangers of this standard are satisfied.

17.2 Hanger Components.

17.2.1 Hanger Rods.

17.2.1.1
Unless the requirements of 17.2.1.2 are met, 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 17.2.1.1.

Table 17.2.1.1 Hanger Rod Sizes

Pipe Size		Diameter of Rod	
in.	**mm**	**in.**	**mm**
Up to and including 4	100	3⁄8	10
5	125	1⁄2	12
6	150		
8	200		
10	250	5⁄8	16
12	300		

17.2.1.2
Rods of smaller diameters than indicated in Table 17.2.1.1 shall be permitted where the hanger assembly has been tested and listed by a testing laboratory and installed within the limits of pipe sizes expressed in individual listings.

17.2.1.3
Where the pitch of the branch line is 6 in 12 or greater, a reduction in the lateral loading on branch line hanger rods shall be done by one of the following:

(1) *Second hanger installed in addition to the required main hangers

(2) Lateral sway brace assemblies on the mains

(3) Branch line hangers utilizing an articulating structural attachment

(4) Equivalent means providing support to the branch line hanger rods

17.2.1.4 U-Hooks.
The size of the rod material of U-hooks shall not be less than that given in Table 17.2.1.4.

Table 17.2.1.4 U-Hook Rod Sizes

Pipe Size		Hook Material Diameter	
in.	**mm**	**in.**	**mm**
Up to and including 2	50	5⁄16	8
2½ to 6	65 to 150	3⁄8	10
8	200	1⁄2	12

17.2.1.5 Eye Rods.

17.2.1.5.1
The size of the rod material for eye rods shall not be less than specified in Table 17.2.1.5.1.

Table 17.2.1.5.1 Eye Rod Sizes

Pipe Size		Diameter of Rod			
		With Bent Eye		With Welded Eye	
in.	mm	in.	mm	in.	mm
Up to and including 4	100	⅜	10	⅜	10
5	125	½	12	½	12
6	150	½	12	½	12
8	200	¾	20	½	12

17.2.1.5.2
Eye rods shall be secured with lock washers to prevent lateral motion.

17.2.1.5.3
Where eye rods are fastened to wood structural members, the eye rod shall be backed with a large flat washer bearing directly against the structural member, in addition to the lock washer.

17.2.1.6 Threaded Sections of Rods.
Threaded sections of rods shall not be formed or bent.

17.2.2* Fasteners in Concrete.

17.2.2.1
Unless prohibited by 17.2.2.2 or 17.2.2.3, the use of listed inserts set in concrete and listed post-installed anchors to support hangers shall be permitted for mains and branch lines.

17.2.2.2
Post-installed anchors shall not be used in cinder concrete, except for branch lines where the post-installed anchors are alternated with through-bolts or hangers attached to beams.

17.2.2.3
Post-installed anchors shall not be used in ceilings of gypsum or other similar soft material.

17.2.2.4
Unless the requirements of 17.2.2.5 are met, post-installed anchors shall be installed in a horizontal position in the sides of concrete beams.

17.2.2.5
Post-installed anchors shall be permitted to be installed in the vertical position under any of the following conditions:
(1) When used in concrete having gravel or crushed stone aggregate to support pipes 4 in. (100 mm) or less in diameter

(2) When post-installed anchors are alternated with hangers connected directly to the structural members, such as trusses and girders, or to the sides of concrete beams [to support pipe 5 in. (125 mm) or larger]

(3) When post-installed anchors are spaced not over 10 ft (3 m) apart [to support pipe 4 in. (100 mm) or larger]

17.2.2.6
Holes for post-installed anchors in the side of beams shall be above the centerline of the beam or above the bottom reinforcement steel rods.

17.2.2.7
Holes for post-installed anchors used in the vertical position shall be drilled to provide uniform contact with the shield over its entire circumference.

17.2.2.8
The depth of the post-installed anchor hole shall not be less than specified for the type of shield used.

17.2.2.9 Powder-Driven Studs.

17.2.2.9.1
Powder-driven studs, welding studs, and the tools used for installing these devices shall be listed.

17.2.2.9.2
Pipe size, installation position, and construction material into which they are installed shall be in accordance with individual listings.

17.2.2.9.3*
Representative samples of concrete into which studs are to be driven shall be tested to determine that the studs will hold a minimum load of 750 lb (340 kg) for 2 in. (50 mm) or smaller pipe; 1000 lb (454 kg) for 2½ in., 3 in., or 3½ in. (65 mm, 80 mm, or 90 mm) pipe; and 1200 lb (544 kg) for 4 in. or 5 in. (100 mm or 125 mm) pipe.

17.2.2.9.4
Increaser couplings shall be attached directly to the powder-driven studs.

17.2.2.10 Minimum Bolt or Rod Size for Concrete.

17.2.2.10.1
The size of a bolt or rod used with a hanger and installed through concrete shall not be less than specified in Table 17.2.2.10.1.

Table 17.2.2.10.1 Minimum Bolt or Rod Size for Concrete

Pipe Size		Size of Bolt or Rod	
in.	**mm**	**in.**	**mm**
Up to and including 4	100	⅜	10
5	125	½	12
6	150		
8	200		
10	250	⅝	16
12	300	¾	20

17.2.2.10.2
Holes for bolts or rods shall not exceed 1⁄16 in. (1.6 mm) greater than the diameter of the bolt or rod.

17.2.2.10.3
Bolts and rods shall be provided with flat washers and nuts.

17.2.3 Fasteners in Steel.

17.2.3.1*
Powder-driven studs, welding studs, and the tools used for installing these devices shall be listed.

17.2.3.2
Pipe size, installation position, and construction material into which they are installed shall be in accordance with individual listings.

17.2.3.3
Increaser couplings shall be attached directly to the powder-driven studs or welding studs.

17.2.3.4
Welding studs or other hanger parts shall not be attached by welding to steel less than U.S. Standard, 12 gauge (2.8 mm).

17.2.3.5 Minimum Bolt or Rod Size for Steel.

17.2.3.5.1
The size of a bolt or rod used with a hanger and installed through steel shall not be less than specified in Table 17.2.3.5.1.

Table 17.2.3.5.1 Minimum Bolt or Rod Size for Steel

Pipe Size		Size of Bolt or Rod	
in.	**mm**	**in.**	**mm**
Up to and including 4	100	3⁄8	10
5	125	1⁄2	12
6	150		
8	200		
10	250	5⁄8	15
12	300	3⁄4	20

17.2.3.5.2
Holes for bolts or rods shall not exceed 1⁄16 in. (1.6 mm) greater than the diameter of the bolt or rod.

17.2.3.5.3
Bolts and rods shall be provided with flat washers and nuts.

17.2.4 Fasteners in Wood.

17.2.4.1 Drive Screws.

17.2.4.1.1
Drive screws shall be used only in a horizontal position as in the side of a beam and only for 2 in. (50 mm) or smaller pipe.

17.2.4.1.2
Drive screws shall only be used in conjunction with hangers that require two points of attachments.

17.2.4.2 Ceiling Flanges and U-Hooks with Screws.

17.2.4.2.1
Unless the requirements of 17.2.4.2.2 or 17.2.4.2.3 are met, for ceiling flanges and U-hooks, screw dimensions shall not be less than those given in Table 17.2.4.2.1.

Table 17.2.4.2.1 Screw Dimensions for Ceiling Flanges and U-Hooks

Pipe Size		Two Screw Ceiling Flanges
in.	**mm**	
Up to and including 2	50	Wood screw No. 18 × 11⁄2 in. or Lag screw 5⁄16 in. × 11⁄2 in.
		Three Screw Ceiling Flanges
Up to and including 2	50	Wood screw No. 18 × 11⁄2 in.
21⁄2	65	Lag screw 3⁄8 in. × 2 in.
3	80	

Pipe Size		Two Screw Ceiling Flanges
in.	mm	
3½	90	
4	100	Lag screw ½ in. × 2 in.
5	125	
6	150	
8	200	Lag screw ⅝ in. × 2 in.
		Four Screw Ceiling Flanges
Up to and including 2	50	Wood screw No. 18 × 1½ in.
2½	65	Lag screw ⅜ in. × 1½ in.
3	80	
3½	90	
4	100	Lag screw ½ in. × 2 in.
5	125	
6	150	
8	200	Lag screw ⅝ in. × 2 in.
		U-Hooks
Up to and including 2	50	Drive screw No. 16 × 2 in.
2½	65	Lag screw ⅜ in. × 2½ in.
3	80	
3½	90	
4	100	Lag screw ½ in. × 3 in.
5	125	
6	150	
8	200	Lag screw ⅝ in. × 3 in.

17.2.4.2.2
When the thickness of planking and thickness of flange do not permit the use of screws 2 in. (50 mm) long, screws 1¾ in. (45 mm) long shall be permitted with hangers spaced not over 10 ft (3 m) apart.

17.2.4.2.3
When the thickness of beams or joists does not permit the use of screws 2½ in. (65 mm) long, screws 2 in. (50 mm) long shall be permitted with hangers spaced not over 10 ft (3 m) apart.

17.2.4.3 Bolts, Rods, or Lag Screws.

17.2.4.3.1
Unless the requirements of 17.2.4.3.2 are met, the size of bolt, rod, or lag screw used with a hanger and installed on the side of the beam shall not be less than specified in Table 17.2.4.3.1.

Table 17.2.4.3.1 Minimum Bolt, Rod, or Lag Screw Sizes for Side of Beam Installation

Pipe Size		Size of Bolt, Rod or Lag Screw		Length of Lag Screw Used with Wood Beams	
in.	mm	in.	mm	in.	mm
Up to and including 2	50	⅜	10	2½	65
2½ to 6 (inclusive)	65 to 150	½	12	3	75
8	200	⅝	16	3	75

17.2.4.3.2
Where the thickness of beams or joists does not permit the use of screws 2½ in. (65 mm) long, screws 2 in. (50 mm) long shall be permitted with hangers spaced not over 10 ft (3 m) apart.

17.2.4.3.3
All holes for lag screws shall be pre-drilled ⅛ in. (3 mm) less in diameter than the maximum root diameter of the lag screw thread.

17.2.4.3.4
Holes for bolts or rods shall not exceed 1⁄16 in. (1.6 mm) greater than the diameter of the bolt or rod.

17.2.4.3.5
Bolts and rods shall be provided with flat washers and nuts.

17.2.4.4 Wood Screws.
Wood screws shall be installed with a screwdriver.

17.2.4.5 Nails.
Nails shall not be acceptable for fastening hangers.

17.2.4.6 Screws in Side of Timber or Joists.

17.2.4.6.1
Screws in the side of a timber or joist shall be not less than 2½ in. (65 mm) from the lower edge where supporting pipe is up to and including nominal 2½ in. and not less than 3 in. (75 mm) where supporting pipe is greater than nominal 2½ in.

17.2.4.6.2
The requirements of 17.2.4.6.1 shall not apply to 2 in. (50 mm) or thicker nailing strips resting on top of steel beams.

17.2.4.7 Coach Screw Rods.

17.2.4.7.1 Minimum Coach Screw Rod Size.
The size of coach screw rods shall not be less than the requirements of Table 17.2.4.7.1.

Table 17.2.4.7.1 Minimum Coach Screw Rod Size

Pipe Size		Diameter of Rod		Minimum Penetration	
in.	mm	in.	mm	in.	mm
Up to and including 4	100	⅜	10	3	75
Larger than 4	100	NP	NP	NP	NP

NP: Not permitted.

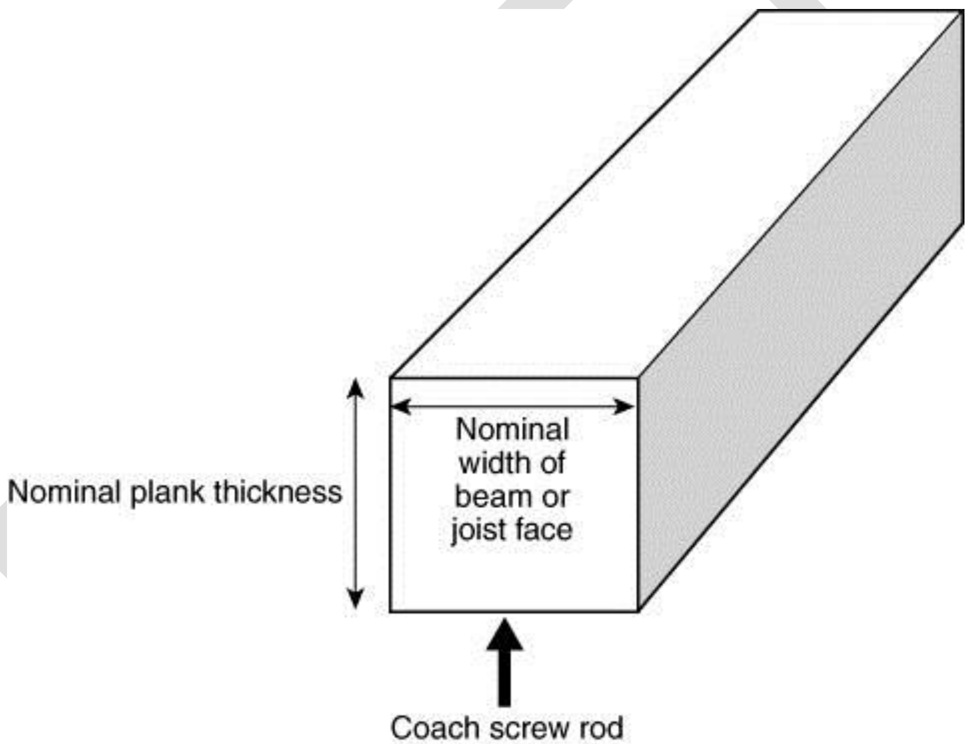
17.2.4.7.2

The minimum plank thickness and the minimum width of the lower face of beams or joists in which coach screw rods are used shall be not less than that specified in Table 17.2.4.7.2 and shown in Figure 17.2.4.7.2.

Table 17.2.4.7.2 Minimum Plank Thicknesses and Beam or Joist Widths

Pipe Size		Nominal Plank Thickness		Nominal Width of Beam or Joist Face	
in.	**mm**	**in.**	**mm**	**in.**	**mm**
Up to and including 2	50	3	75	2	50
2½	65	4	100	2	50
3	80				
3½	90				
4	100	4	100	3	75

Figure 17.2.4.7.2 Dimensions for Structural Members with Coach Screw Rods.



17.2.4.7.3
Coach screw rods shall not be used for support of pipes larger than 4 in. (100 mm) in diameter.

17.2.4.7.4
All holes for coach screw rods shall be predrilled ⅛ in. (3 mm) less in diameter than the maximum root diameter of the wood screw thread.

17.3* Trapeze Hangers.

17.3.1
For trapeze hangers, the minimum size of steel angle or pipe span between structural members shall be such that the section modulus required in Table 17.3.1(a**)** does not exceed the available section modulus of the trapeze member from Table 17.3.1(b) or Table 17.3.1(c).

Table 17.3.1(a) Section Modulus Required for Trapeze Members (in.^{3})

Nominal Diameter of Pipe Being Supported – Schedule 10 Steel												
Span (ft)	**1**	**1.25**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**5**	**6**	**8**	**10**
1.5	0.08	0.08	0.09	0.09	0.10	0.11	0.12	0.13	0.15	0.18	0.26	0.34
2.0	0.11	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.20	0.24	0.34	0.45
2.5	0.14	0.14	0.15	0.16	0.18	0.21	0.23	0.25	0.30	0.36	0.50	0.69
3.0	0.16	0.17	0.18	0.19	0.20	0.22	0.24	0.26	0.31	0.36	0.51	0.67
3.5	0.19	0.20	0.21	0.22	0.24	0.26	0.28	0.30	0.36	0.42	0.60	0.78
4.0	0.22	0.22	0.24	0.25	0.27	0.30	0.32	0.34	0.41	0.48	0.68	0.89
4.5	0.24	0.25	0.27	0.28	0.30	0.33	0.36	0.38	0.46	0.54	0.77	1.01
5.0	0.27	0.28	0.30	0.31	0.34	0.37	0.40	0.43	0.51	0.60	0.85	1.12
5.5	0.30	0.31	0.33	0.34	0.37	0.41	0.44	0.47	0.56	0.66	0.94	1.23
6.0	0.33	0.34	0.35	0.38	0.41	0.44	0.48	0.51	0.61	0.71	1.02	1.34
6.5	0.35	0.36	0.38	0.41	0.44	0.48	0.52	0.56	0.66	0.77	1.11	1.45
7.0	0.38	0.39	0.41	0.44	0.47	0.52	0.56	0.60	0.71	0.83	1.19	1.56
7.5	0.41	0.42	0.44	0.47	0.51	0.55	0.60	0.64	0.76	0.89	1.28	1.68
8.0	0.43	0.45	0.47	0.50	0.54	0.59	0.63	0.68	0.82	0.95	1.36	1.79
8.5	0.46	0.48	0.50	0.53	0.58	0.63	0.67	0.73	0.87	1.01	1.45	1.90
9.0	0.49	0.50	0.53	0.56	0.61	0.66	0.71	0.77	0.92	1.07	1.53	2.01
9.5	0.52	0.53	0.56	0.60	0.64	0.70	0.75	0.81	0.97	1.13	1.62	2.12
10.0	0.54	0.56	0.59	0.63	0.68	0.74	0.79	0.85	1.02	1.19	1.70	2.23
10.5	0.57	0.59	0.62	0.66	0.71	0.78	0.83	0.90	1.07	1.25	1.79	2.35
11.0	0.60	0.62	0.65	0.69	0.74	0.81	0.87	0.94	1.12	1.31	1.87	2.46
11.5	0.63	0.64	0.68	0.72	0.78	0.85	0.91	0.98	1.17	1.37	1.96	2.57
12.0	0.65	0.67	0.71	0.75	0.81	0.89	0.95	1.02	1.22	1.43	2.04	2.68
12.5	0.68	0.70	0.74	0.78	0.85	0.92	0.99	1.07	1.27	1.49	2.13	2.79
13.0	0.71	0.73	0.77	0.81	0.88	0.96	1.03	1.11	1.33	1.55	2.21	2.90
13.5	0.73	0.76	0.80	0.85	0.91	1.00	1.07	1.15	1.38	1.61	2.30	3.02
14.0	0.76	0.78	0.83	0.88	0.95	1.03	1.11	1.20	1.43	1.67	2.38	3.13
14.5	0.79	0.81	0.86	0.91	0.98	1.07	1.15	1.24	1.48	1.73	2.47	3.24
15.0	0.82	0.84	0.89	0.94	1.02	1.11	1.19	1.28	1.53	1.79	2.56	3.35
15.5	0.84	0.87	0.92	0.97	1.05	1.14	1.23	1.32	1.58	1.85	2.64	3.46
16.0	0.87	0.90	0.95	1.00	1.08	1.18	1.27	1.37	1.63	1.91	2.73	3.58
Nominal Diameter of Pipe Being Supported – Schedule 40 Steel												
Span (ft)	**1**	**1.25**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**5**	**6**	**8**	**10**
1.5	0.08	0.09	0.09	0.1	0.11	0.12	0.14	0.15	0.18	0.22	0.30	0.41

Nominal Diameter of Pipe Being Supported – Schedule 10 Steel												
Span (ft)	**1**	**1.25**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**5**	**6**	**8**	**10**
2.0	0.11	0.11	0.12	0.13	0.15	0.16	0.18	0.20	0.24	0.29	0.40	0.55
2.5	0.14	0.14	0.15	0.16	0.17	0.18	0.20	0.21	0.25	0.30	0.43	0.56
3.0	0.16	0.17	0.18	0.20	0.22	0.25	0.27	0.30	0.36	0.43	0.60	0.82
3.5	0.19	0.20	0.21	0.23	0.26	0.29	0.32	0.35	0.42	0.51	0.70	0.96
4.0	0.22	0.23	0.24	0.26	0.29	0.33	0.36	0.40	0.48	0.58	0.80	1.10
4.5	0.25	0.26	0.27	0.29	0.33	0.37	0.41	0.45	0.54	0.65	0.90	1.23
5.0	0.27	0.29	0.30	0.33	0.37	0.41	0.45	0.49	0.60	0.72	1.00	1.37
5.5	0.30	0.31	0.33	0.36	0.40	0.45	0.50	0.54	0.66	0.79	1.10	1.51
6.0	0.33	0.34	0.36	0.39	0.44	0.49	0.54	0.59	0.72	0.87	1.20	1.64
6.5	0.36	0.37	0.40	0.42	0.48	0.54	0.59	0.64	0.78	0.94	1.31	1.78
7.0	0.38	0.40	0.43	0.46	0.52	0.58	0.63	0.69	0.84	1.01	1.41	1.92
7.5	0.41	0.43	0.46	0.49	0.55	0.62	0.68	0.74	0.90	1.08	1.51	2.06
8.0	0.44	0.46	0.49	0.52	0.59	0.66	0.72	0.79	0.96	1.16	1.61	2.19
8.5	0.47	0.48	0.52	0.56	0.63	0.70	0.77	0.84	1.02	1.23	1.71	2.33
9.0	0.49	0.51	0.55	0.59	0.66	0.74	0.81	0.89	1.08	1.30	1.81	2.47
9.5	0.52	0.54	0.58	0.62	0.70	0.78	0.86	0.94	1.14	1.37	1.91	2.60
10.0	0.55	0.57	0.61	0.65	0.74	0.82	0.90	0.99	1.20	1.45	2.01	2.74
10.5	0.58	0.60	0.64	0.69	0.77	0.86	0.95	1.04	1.26	1.52	2.11	2.88
11.0	0.60	0.63	0.67	0.72	0.81	0.91	0.99	1.09	1.32	1.59	2.21	3.01
11.5	0.63	0.66	0.70	0.75	0.85	0.95	1.04	1.14	1.38	1.66	2.31	3.15
12.0	0.66	0.68	0.73	0.78	0.88	0.99	1.08	1.19	1.44	1.73	2.41	3.29
12.5	0.69	0.71	0.76	0.82	0.92	1.03	1.13	1.24	1.5	1.81	2.51	3.43
13.0	0.71	0.74	0.79	0.85	0.96	1.07	1.17	1.29	1.56	1.88	2.61	3.56
13.5	0.74	0.77	0.82	0.88	0.99	1.11	1.22	1.34	1.62	1.95	2.71	3.70
14.0	0.77	0.80	0.85	0.91	1.03	1.15	1.26	1.39	1.68	2.02	2.81	3.84
14.5	0.80	0.83	0.88	0.95	1.07	1.19	1.31	1.43	1.74	2.1	2.91	3.97
15.0	0.82	0.86	0.91	0.98	1.10	1.24	1.35	1.48	1.8	2.17	3.01	4.11
15.5	0.85	0.88	0.94	1.01	1.14	1.28	1.4	1.53	1.86	2.24	3.11	4.25
16.0	0.88	0.91	0.97	1.05	1.18	1.32	1.44	1.58	1.92	2.31	3.21	4.39

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

Note: The table is based on a maximum bending stress of 15 ksi and a midspan concentrated load from 15 ft (4.6 m) of water-filled pipe, plus 250 lb (114 kg).

Table 17.3.1(b) Available Section Modulus of Common Trapeze Hangers (in.^{3})

Pipe				
in.	mm	Modulus (in.^{3})	Angles (in.)	Modulus (in.^{3})
Schedule 10				
1	25	0.12	1½ × 1½ × 3⁄16	0.10
1¼	32	0.19	2 × 2 × 1⁄8	0.13
1½	40	0.26	2 × 1½ × 3⁄16	0.18
2	50	0.42	2 × 2 × 3⁄16	0.19
2½	65	0.69	2 × 2 × ¼	0.25
3	80	1.04	2½ × 1½ × 3⁄16	0.28
3½	90	1.38	2½ × 2 × 3⁄16	0.29
4	100	1.76	2 × 2 × 5⁄16	0.30
5	125	3.03	2½ × 2½ × 3⁄16	0.30
6	150	4.35	2 × 2 × 3⁄8	0.35
			2½ × 2½ × ¼	0.39
			3 × 2 × 3⁄16	0.41
Schedule 40				
1	25	0.13	3 × 2½ × 3⁄16	0.43
1¼	32	0.23	3 × 3 × 3⁄16	0.44
1½	40	0.33	2½ × 2½ × 5⁄16	0.48
2	50	0.56	3 × 2 × ¼	0.54
2½	65	1.06	2½ × 2 × 3⁄8	0.55
3	80	1.72	2½ × 2½ × 3⁄8	0.57
3½	90	2.39	3 × 3 × ¼	0.58
4	100	3.21	3 × 3 × 5⁄16	0.71
5	125	5.45	2½ × 2½ × ½	0.72
6	150	8.50	3½ × 2½ × ¼	0.75
			3 × 2½ × 3⁄8	0.81
			3 × 3 × 3⁄8	0.83
			3½ × 2½ × 5⁄16	0.93
			3 × 3 × 7⁄16	0.95
			4 × 4 × ¼	1.05
			3 × 3 × ½	1.07
			4 × 3 × 5⁄16	1.23
			4 × 4 × 5⁄16	1.29
			4 × 3 × 3⁄8	1.46

Pipe				
in.	mm	Modulus ($in.^3$)	Angles (in.)	Modulus ($in.^3$)
			4 ×4 × 3⁄8	1.52
			5 × 3½ × 5⁄16	1.94
			4 × 4 × ½	1.97
			4 × 4 × 5⁄8	2.40
			4 × 4 × ¾	2.81
			6 × 4 × 3⁄8	3.32
			6 × 4 × ½	4.33
			6 × 4 × ¾	6.25
			6 × 6 × 1	8.57

Table 17.3.1(c) Available Section Modulus of Common Trapeze Hangers (cm^3)

Pipe				
in.	mm	Modulus (cm^3)	Angles (mm)	Modulus (cm^3)
Schedule 10				
1	25	1.97	40 × 40 × 5	1.64
1¼	32	3.11	50 × 50 × 3	2.13
1½	40	4.26	50 × 40 × 5	2.95
2	50	6.88	50 × 50 × 5	3.11
2½	65	11.3	50 × 50 × 6	4.10
3	80	17.0	65 × 40 × 5	4.59
3½	90	22.6	65 × 50 × 5	4.75
4	100	28.8	50 × 50 × 8	4.92
5	125	49.7	65 × 65 × 5	4.92
6	150	71.3	50 × 50 × 10	5.74
			65 × 65 × 6	6.39
			80× 50 × 5	6.72
Schedule 40				
1	25	2.1	80 × 65 × 10	7.05
1¼	32	3.8	3 × 3 × 3⁄16	7.21
1½	40	5.4	65 × 65 × 8	7.87
2	50	9.2	3 × 2 × ¼	8.85
2½	65	17.4	65 × 50 × 10	9.01
3	80	28.2	65 × 65 × 10	9.34
3½	90	39.2	80 × 80 × 6	9.50

Pipe		Modulus (cm^3)	Angles (mm)	Modulus (cm^3)
in.	mm			
Schedule 10				
4	100	52.6	80 × 80 × 8	11.6
5	125	89.3	65 × 65 ×15	11.8
6	150	139.3	90 × 65 ×6	12.3
			80 × 65 × 10	13.3
			80 × 80 × 10	13.6
			90 × 65 × 8	15.2
			80 × 80 × 11	15.6
			100 × 100 × 6	17.2
			80 × 80 × 15	17.5
			100 × 80 × 8	20.2
			100 × 100 × 8	21.1
			100 × 80 × 10	23.9
			100 ×100 × 10	24.9
			125 × 90 × 8	31.8
			100 × 100 × 16	32.3
			100 × 100 × 8	39.3
			100 × 100 × 20	46.0
			150 × 100 × 10	54.4
			150 × 100 × 15	71.0
			150 × 100 × 20	102
			150 × 150 × 25	140

17.3.2
Any other sizes or shapes giving equal or greater section modulus shall be acceptable.

17.3.3
All angles shall be installed with the longer leg vertical.

17.3.4
The trapeze member shall be secured to prevent slippage.

17.3.5*
All components of each hanger assembly that attach to a trapeze member shall conform to **17.1.6** and be sized to support the suspended sprinkler pipe.

17.3.6
The ring, strap, or clevis installed on a pipe trapeze shall be manufactured to fit the pipe size of the trapeze member.

17.3.7
Holes for bolts or rods shall not exceed 1⁄16 in. (1.6 mm) greater than the diameter of the bolt or rod.

17.3.8

Bolts and rods shall be provided with flat washers and nuts.

17.3.9
Where angles are used for trapeze hangers and slotted holes are used, the slotted holes shall meet all of the following:

(1) The length of each slotted hole shall not exceed 3 in. (80 mm)

(2) The width of the slotted hole shall not exceed 1⁄16 in. (1.6 mm) greater than the bolt or rod diameter.

(3) The minimum distance between slotted holes shall be 3 in. (80 mm) edge to edge.

(4) The minimum distance from the end of the angle to the edge of the slotted hole shall be 3 in. (80 mm)

(5) The number of slots shall be limited to three per section of angle.

(6) The washer(s) required by 17.3.8 shall have a minimum thickness of one-half the thickness of the angle.

(7) Washers and nuts required by 17.3.8 shall be provided on both the top and bottom of the angle.

17.4* Installation of Pipe Hangers.

17.4.1 General.

17.4.1.1 Ceiling Sheathing.

17.4.1.1.1*
Unless the requirements of 17.4.1.1.2 are met, sprinkler piping shall be supported independently of the ceiling sheathing.

17.4.1.1.2
Toggle hangers shall be permitted only for the support of pipe 1½ in. (40 mm) or smaller in size under ceilings of hollow tile or metal lath and plaster.

17.4.1.2 Storage Racks.
Where sprinkler piping is installed in storage racks, piping shall be supported from the storage rack structure or building in accordance with all applicable provisions of Sections 17.4 and 9.3.

17.4.1.3* Building Structure.

17.4.1.3.1
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 (115 kg) applied at the point of hanging, except where permitted by 17.4.1.1.2, 17.4.1.3.3, and 17.4.1.4.1.

17.4.1.3.2
Trapeze hangers shall be used where necessary to transfer loads to appropriate structural members.

17.4.1.3.3* Flexible Sprinkler Hose Fittings.

17.4.1.3.3.1
Listed flexible sprinkler hose fittings and their anchoring components intended for use in installations connecting the sprinkler system piping to sprinklers shall be installed in accordance with the requirements of the listing, including any installation instructions.

17.4.1.3.3.2
When installed and supported by suspended ceilings, the ceiling shall meet ASTM C635, *Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-In Panel Ceilings*, and shall be installed in accordance with ASTM C636, *Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels*.

17.4.1.3.3.3*

Where flexible sprinkler hose fittings exceed 6 ft (1.8 m) in length and are supported by a suspended ceiling in accordance with 17.4.1.3.3.2, a hanger(s) attached to the structure shall be required to ensure that the maximum unsupported length does not exceed 6 ft (1.8 m).

17.4.1.3.3.4*
Where flexible sprinkler hose fittings are used to connect sprinklers to branch lines in suspended ceilings, a label limiting relocation of the sprinkler shall be provided on the anchoring component.

17.4.1.4 Metal Deck.

17.4.1.4.1*
Branch line hangers attached to metal deck shall be permitted only for the support of pipe 1 in. (25 mm) or smaller in size, by drilling or punching the vertical portion of the metal deck and using through bolts.

17.4.1.4.2
The distance from the bottom of the bolt hole to the bottom of the vertical member shall be not less than 3⁄8 in. (10 mm).

17.4.1.5
Where sprinkler piping is installed below ductwork, piping shall be supported from the building structure or from the ductwork supports, provided such supports are capable of handling both the load of the ductwork and the load specified in 17.4.1.3.1.

17.4.2* Maximum Distance Between Hangers.

17.4.2.1
The maximum distance between hangers shall not exceed that specified in Table 17.4.2.1(a) or Table 17.4.2.1(b), except where the provisions of 17.4.4 apply.

Table 17.4.2.1(a) Maximum Distance Between Hangers (ft-in.)

	Nominal Pipe Size (in.)											
	3⁄4	**1**	**1 1⁄4**	**1 1⁄2**	**2**	**2 1⁄2**	**3**	**3 1⁄2**	**4**	**5**	**6**	**8**
Steel pipe except threaded lightwall	NA	12-0	12-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0
Threaded lightwall steel pipe	NA	12-0	12-0	12-0	12-0	12-0	12-0	NA	NA	NA	NA	NA
Copper tube	8-0	8-0	10-0	10-0	12-0	12-0	12-0	15-0	15-0	15-0	15-0	15-0
CPVC	5-6	6-0	6-6	7-0	8-0	9-0	10-0	NA	NA	NA	NA	NA
Ductile-iron pipe	NA	NA	NA	NA	NA	NA	15-0	NA	15-0	NA	15-0	15-0

NA: Not applicable.

Table 17.4.2.1(b) Maximum Distance Between Hangers (m)

	Nominal Pipe Size (mm)											
	20	**25**	**32**	**40**	**50**	**65**	**80**	**90**	**100**	**125**	**150**	**200**
Steel pipe except threaded lightwall	NA	3.7	3.7	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Threaded lightwall steel pipe	NA	3.7	3.7	3.7	3.7	3.7	3.7	NA	NA	NA	NA	NA
Copper tube	2.4	2.4	3.0	3.0	3.7	3.7	3.7	4.6	4.6	4.6	4.6	4.6
CPVC	1.7	1.8	2.0	2.1	2.4	2.7	3.0	NA	NA	NA	NA	NA

	Nominal Pipe Size (mm)											
	20	**25**	**32**	**40**	**50**	**65**	**80**	**90**	**100**	**125**	**150**	**200**
Ductile-iron pipe	NA	NA	NA	NA	NA	NA	4.6	NA	4.6	NA	4.6	4.6

NA: Not applicable.

17.4.2.2
The maximum distance between hangers for listed nonmetallic pipe shall be modified as specified in the individual product listings.

17.4.3 Location of Hangers on Branch Lines.

17.4.3.1
Subsection 17.4.3 shall apply to the support of steel pipe or copper tube as specified in 7.3.1 and subject to the provisions of 17.4.2.

17.4.3.2* Minimum Number of Hangers.

17.4.3.2.1
Unless the requirements of 17.4.3.2.2 through 17.4.3.2.5 are met, there shall be not less than one hanger for each section of pipe.

17.4.3.2.2*
Unless the requirements of 17.4.3.2.3 are met, where sprinklers are spaced less than 6 ft (1.8 m) apart, hangers spaced up to a maximum of 12 ft (3.7 m) shall be permitted.

17.4.3.2.3
For welded or mechanical outlets on a continuous section of pipe, hanger spacing shall be according to Table 17.4.2.1(a) or Table 17.4.2.1(b).

17.4.3.2.4*
Starter lengths less than 6 ft (1.8 m) shall not require a hanger, unless on the end line of a sidefeed system or where an intermediate cross main hanger has been omitted.

17.4.3.2.5*
A single section of pipe shall not require a hanger when the cumulative distance between hangers on the branch line does not exceed the spacing required by Table 17.4.2.1(a) and Table 17.4.2.1(b).

17.4.3.3 Clearance to Hangers.
The distance between a hanger and the centerline of an upright sprinkler shall not be less than 3 in. (75 mm).

17.4.3.4* Unsupported Lengths.

17.4.3.4.1
For steel pipe, the unsupported horizontal length between the end sprinkler and the last hanger on the line shall not be greater than 36 in. (900 mm) for 1 in. (25 mm) pipe, 48 in. (1.2 m) for 1¼ in. (32 mm) pipe, and 60 in. (1.5 m) for 1½ in. (40 mm) or larger pipe.

17.4.3.4.2
For copper tube, the unsupported horizontal length between the end sprinkler and the last hanger on the line shall not be greater than 18 in. (450 mm) for 1 in. (25 mm) pipe, 24 in. (600 mm) for 1¼ in. (32 mm) pipe, and 30 in. (750 mm) for 1½ in. (40 mm) or larger pipe.

17.4.3.4.3
Where the limits of 17.4.3.4.1 and 17.4.3.4.2 are exceeded, the pipe shall be extended beyond the end sprinkler and shall be supported by an additional hanger.

17.4.3.4.4* Unsupported Length with Maximum Pressure Exceeding 100 psi (6.9 bar) and Branch Line Above Ceiling Supplying Sprinklers in Pendent Position Below Ceiling.

17.4.3.4.4.1
Where the maximum static or flowing pressure, whichever is greater at the sprinkler, applied other than through the fire department connection, exceeds 100 psi (6.9 bar) 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 restrains upward movement of the pipe.

17.4.3.4.4.2
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. (300 mm) for steel pipe or 6 in. (150 mm) for copper pipe.

17.4.3.4.4.3
When the limit of 17.4.3.4.4.2 is exceeded, the pipe shall be extended beyond the end sprinkler and supported by an additional hanger.

17.4.3.4.4.4
Unless flexible sprinkler hose fittings in accordance with 17.4.1.3.3.1 are used, the hanger closest to the sprinkler shall be of a type that restrains the upward movement of the pipe.

17.4.3.5* Unsupported Armover Length.

17.4.3.5.1
The cumulative horizontal length of an unsupported armover to a sprinkler, sprinkler drop, or sprig shall not exceed 24 in. (600 mm) for steel pipe or 12 in. (300 mm) for copper tube.

17.4.3.5.2* Unsupported Armover Length with Maximum Pressure Exceeding 100 psi (6.9 bar) and Branch Line Above Ceiling Supplying Sprinklers in Pendent Position Below Ceiling.

17.4.3.5.2.1
Where the maximum static or flowing pressure, whichever is greater at the sprinkler, applied other than through the fire department connection, exceeds 100 psi (6.9 bar) and a branch line above a ceiling supplies sprinklers in a pendent position below the ceiling, the cumulative horizontal length of an unsupported armover to a sprinkler or sprinkler drop shall not exceed 12 in. (300 mm) for steel pipe and 6 in. (150 mm) for copper tube.

17.4.3.5.2.2
Unless flexible sprinkler hose fittings in accordance with 17.4.1.3.3.1 are used, the hanger closest to the sprinkler shall be of a type that restrains upward movement of the pipe.

17.4.3.5.2.3
Where the armover exceeds the maximum unsupported length of 17.4.3.5.2.1, a hanger shall be installed so that the distance from the end sprinkler or drop nipple to the hanger is not greater than 12 in. (300 mm) for steel or 6 in. (150 mm) for copper, or the pipe shall be extended beyond the end sprinkler and shall be supported by an additional hanger.

17.4.3.6*
Wall-mounted sidewall sprinklers shall be restrained to prevent movement.

17.4.3.7 Sprigs.
Sprigs 4 ft (1.2 m) or longer shall be restrained against lateral movement.

17.4.4 Location of Hangers on Mains.

17.4.4.1
Unless any of the requirements of 17.4.4.2 through 17.4.4.7 are met, hangers for mains shall be in accordance with 17.4.2, between each branch line, or on each section of pipe, whichever is the lesser dimension.

17.4.4.2

For welded or mechanical outlets on a continuous section of pipe, hanger spacing shall be according to Table 17.4.2.1(a) or Table 17.4.2.1(b).

17.4.4.3
For cross mains in steel pipe systems in bays having two branch lines, the intermediate hanger shall be permitted to be omitted, provided that a hanger attached to a purlin is installed on each branch line located as near to the cross main as the location of the purlin permits.

17.4.4.3.1
The remaining branch line hangers shall be installed in accordance with 17.4.3.

17.4.4.4
For cross mains in steel pipe systems only in bays having three branch lines, either side or center feed, one (only) intermediate hanger shall be permitted to be omitted, provided that a hanger attached to a purlin is installed on each branch line located as near to the cross main as the location of the purlin permits.

17.4.4.4.1
The remaining branch line hangers shall be installed in accordance with 17.4.3.

17.4.4.5
For cross mains in steel pipe systems only in bays having four or more branch lines, either side or center feed, two intermediate hangers shall be permitted to be omitted, provided the maximum distance between hangers does not exceed the distances specified in 17.4.2 and a hanger attached to a purlin on each branch line is located as near to the cross main as the purlin permits.

17.4.4.6
The unsupported length of the end of a main shall be no greater than one half the maximum allowable hanger spacing per Table 17.4.2.1(a) and Table 17.4.2.1(b).

17.4.4.7
At the end of the main, intermediate trapeze hangers shall be installed unless the main is extended to the next framing member with a hanger installed at this point, in which event an intermediate hanger shall be permitted to be omitted in accordance with 17.4.4.3, 17.4.4.4, and 17.4.4.5.

17.4.4.8*
A single section of pipe shall not require a hanger when the cumulative distance between hangers on the main does not exceed the spacing required by Table 17.4.2.1(a) and Table 17.4.2.1(b).

17.4.4.9
The unsupported lengths of mains shall be in accordance with the distances in 9.2.3.4.

17.4.4.10
The unsupported length of the end of a main shall be no greater than one half the maximum allowable hanger spacing per Table 17.4.2.1(a) and Table 17.4.2.1(b).

17.4.5 Support of Risers.

17.4.5.1
Risers shall be supported by riser clamps or by hangers located on the horizontal connections within 24 in. (600 mm) of the centerline of the riser.

17.4.5.2
Riser clamps supporting risers by means of set screws shall not be used.

17.4.5.3*
Riser clamps anchored to walls using hanger rods in the horizontal position shall not be permitted to vertically support risers.

17.4.5.4 Multistory Buildings.

17.4.5.4.1

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.

17.4.5.4.2*

Supports above the lowest level shall also restrain the pipe to prevent movement by an upward thrust where flexible fittings are used.

17.4.5.4.3

Where risers are supported from the ground, the ground support shall constitute the first level of riser support.

17.4.5.4.4

Where risers are offset or do not rise from the ground, the first ceiling level above the offset shall constitute the first level of riser support.

17.4.5.5

Distance between supports for risers shall not exceed 25 ft (7.6 m).

17.5* Pipe Stands.

17.5.1 General.

17.5.1.1

Where pipe stands are used to support system piping, the requirements of 17.5 shall apply unless the requirements of 17.5.1.2 are met.

17.5.1.2

Pipe stands certified by a registered professional engineer to include all of the following shall be an acceptable alternative to the requirements of 17.5:

(1) Pipe stands shall be designed to support five times the weight of water-filled pipe plus 250 lb (115 kg) at each point of piping support.

(2) These points of support shall be adequate to support the system.

(3) The spacing between pipe stands shall not exceed the value given for the type of pipe as indicated in Table 17.4.2.1(a) or Table 17.4.2.1(b).

(4) Pipe stand components shall be ferrous.

(5) Detailed calculations shall be submitted, when required by the reviewing authority, showing stresses developed in the pipe stand, the system piping and fittings, and safety factors allowed.

17.5.1.3

Where water-based fire protection systems are required to be protected against damage from earthquakes, pipe stands shall also meet the requirements of 18.8.

17.5.2 Component Material.

17.5.2.1

Pipe stands and their components shall be ferrous unless permitted by 17.5.2.2.

17.5.2.2

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

17.5.3 Sizing.

17.5.3.1*

The maximum heights for pipe stands shall be in accordance with Table 17.5.3.1 unless the requirements of 17.5.3.2 are met.

Table 17.5.3.1 Maximum Pipe Stand Heights[a]

System Pipe Diameter[c]	Pipe Stand Diameter[b]					
	1½ in.	2 in.	2½ in.	3 in.	4 in.	6 in.
1½ in.	6.6 ft	9.4 ft	11.3 ft	13.8 ft	18.0 ft	26.8 ft
2 in.	4.4 ft	9.4 ft	11.3 ft	13.8 ft	18.0 ft	26.8 ft
2½ in.	—	8.1 ft	11.3 ft	13.8 ft	18.0 ft	26.8 ft
3 in.	—	5.2 ft	11.3 ft	13.8 ft	18.0 ft	26.8 ft
4 in. up to and including 8 in.	—	—	—	—	14.7 ft	26.8 ft

[a]For SI units, 1 in. = 25.4 mm; 1 ft = 0.305 m.

[b]Pipe stands are Schedule 40 pipe.

[c]System piping is assumed to be Schedule 40 (8 in. is Schedule 30).

17.5.3.2*
Pipe diameters up to and including 10 in. (200 mm) Schedule 40 are permitted to be supported by 2 in. (50 mm) diameter pipe stands when all of the following conditions are met:
(1) The maximum height shall be 4 ft (1.2 m), as measured from the base of the pipe stand to the centerline of the pipe being supported.

(2) *The pipe stand shall be axially loaded.

17.5.3.3
The distance between pipe stands shall not exceed the values in Table 17.4.2.1(a) or Table 17.4.2.1(b).

17.5.4 Pipe Stand Base.

17.5.4.1
The pipe stand base shall be secured by an approved method.

17.5.4.2*
Pipe stand base plates shall be threaded malleable iron flanges or welded steel flanges in accordance with Table 7.4.1.

17.5.4.2.1
Pipes stands installed in accordance with 17.5.3.2 shall be permitted to use a welded steel plate.

17.5.4.3*
Pipe stands shall be fastened to a concrete floor or footing using listed concrete anchors or other approved means.

17.5.4.4
A minimum of four anchors shall be used to attach the base plate to the floor.

17.5.4.4.1
Pipe stands installed in accordance with 17.5.3.2 shall be permitted to use a minimum of two anchors to attach the base plate to the floor.

17.5.4.5
The minimum diameter for the anchors shall be ½ in. for pipe stand diameters up to and including 3 in. and ⅝ in. for pipe stands 4 in. diameter and larger.

17.5.4.5.1
Where the pipe stand complies with 17.5.3.2, ⅜ in. anchors shall be permitted.

17.5.5 Attaching to System Piping.

17.5.5.1

Piping shall be attached to the pipe stand with U-bolts or equivalent attachment.

17.5.5.2*
Where a horizontal bracket is used to attach the system piping to the pipe stand, it shall not be more than 1 ft (0.3 m) as measured horizontally from the centerline of the pipe stand to the centerline of the supported pipe.

17.5.5.3
Horizontal support brackets shall be sized such that the section modulus required in Table 17.5.5.3 does not exceed the available section modulus from Table 17.3.1(b).

Table 17.5.5.3 Required Section Modulus for Pipe Stand Horizontal Support Arms (in.^{3})

Nominal Diameter of Pipe Being Supported (in.)	1	1 ¼	1 ½	2	2 ½	3	3 ½	4	5	6	8
Section Modulus – Schedule 10 Steel	0.22	0.23	0.24	0.25	0.30	0.36	0.42	0.49	0.66	0.85	1.40
Section Modulus – Schedule 40 Steel	0.22	0.24	0.24	0.27	0.36	0.45	0.54	0.63	0.86	1.13	1.64

For SI units, 1 in. = 25.4 mm.

Note: The table is based on the controlling section modulus determined for a concentrated load at a 1 ft (0.3 m) cantilever using: a) a maximum bending stress of 15 ksi (103 MPa) and a concentrated load equal to the weight of 15 ft (4.6 m) of water-filled pipe plus 250 lb (114 kg) b) a maximum bending stress of 28 ksi (193 MPa) and a concentrated load equal to five times the weight of 15 ft (4.6 m) of water-filled pipe plus 250 lb (114 kg)

17.5.6 Thrust.

17.5.6.1*
System piping shall be supported and restrained to restrict movement due to sprinkler/nozzle reaction and water surges.

17.5.6.2*
Where thrust forces are anticipated to be high, a pipe ring or clamp shall secure the system piping to the pipe stand.

17.5.7 Exterior Applications.

17.5.7.1
Where required, pipe stands used in exterior applications shall be made of galvanized steel or other suitable corrosion-resistant materials.

17.5.7.2
A welded, threaded, grooved, or other approved cap shall be securely attached to the top of the pipe stand.

17.6 Protection Criteria for Rack Storage of Group A Plastic Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

17.6.1 Control Mode Density/Area Sprinkler Protection Criteria for Single-, Double-, and Multiple-Row Racks for Group A Plastic Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

17.6.1.1 Storage 5 ft (1.5 m) or Less in Height.
For the storage of Group A plastics stored 5 ft (1.5 m) or less in height, the sprinkler design criteria for miscellaneous storage specified in Chapter 13 shall be used.

17.6.1.1.1
For storage 5 ft (1.5 m) or less in height that does not meet the definition of *Miscellaneous Storage* that is on solid shelf racks, in-rack sprinklers shall be provided in accordance with 17.1.5, and ceiling sprinkler protection shall be provided in accordance with Chapter 13.

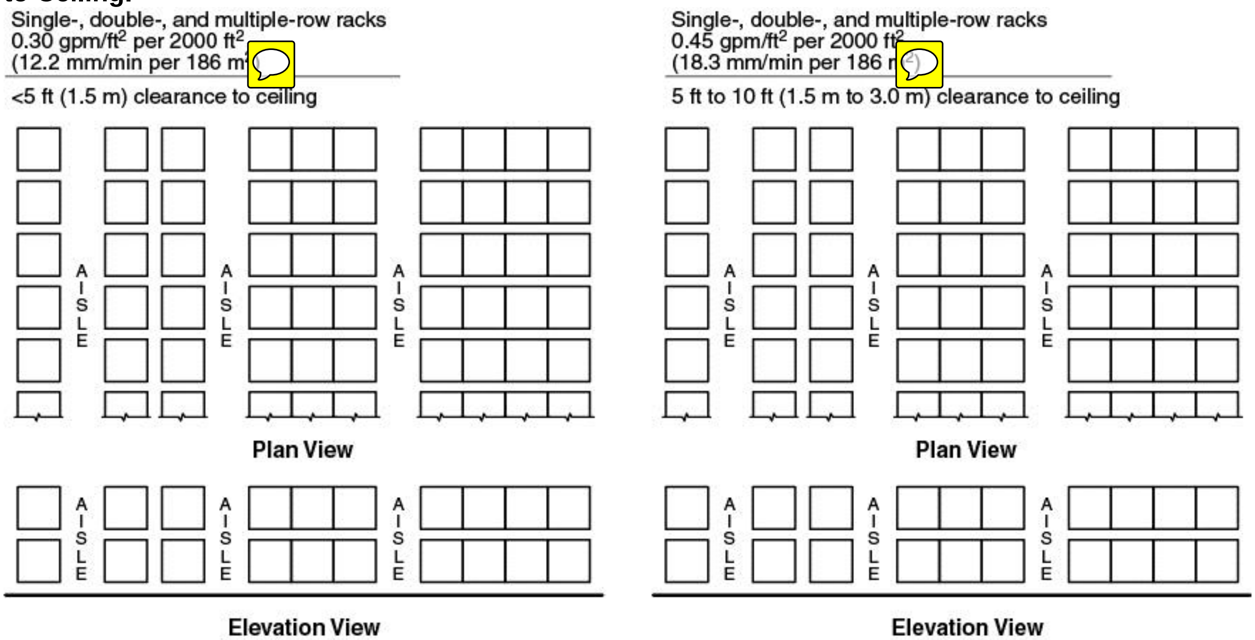
17.6.1.2 Ceiling Sprinkler Water Demand.

See Section C.22.

17.6.1.2.1

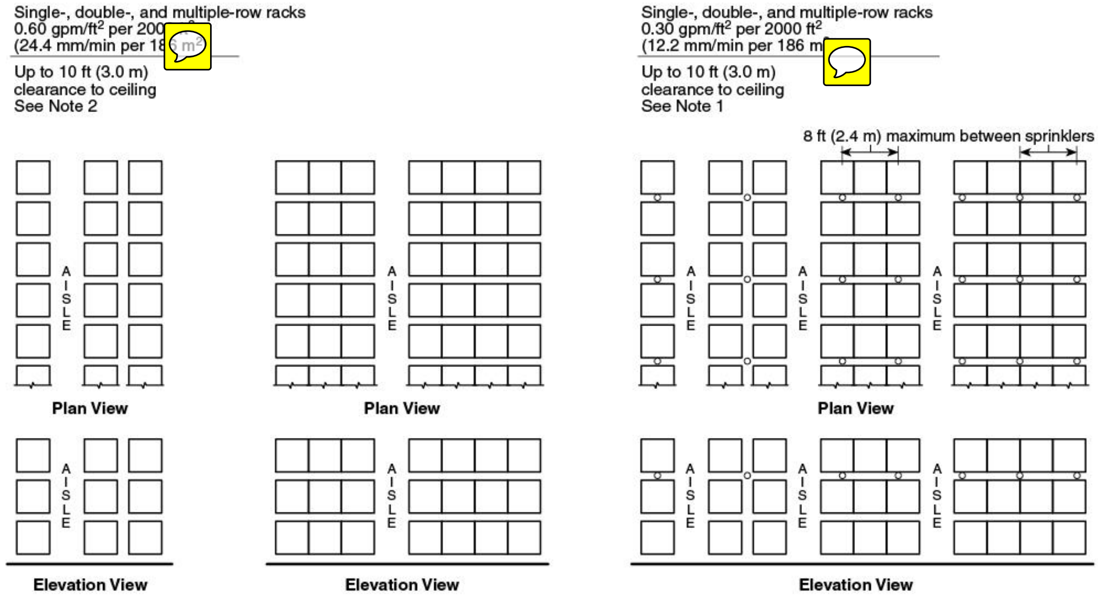
For Group A plastic commodities in cartons, encapsulated or nonencapsulated in single-, double-, and multiple-row racks and with a clearance to ceiling up to and including 10 ft. (3.0 m), ceiling sprinkler water demand in terms of density [gpm/ft^2 (mm/min)] and area of operation [ft^2 (m^2)] shall be selected from Figure 17.6.1.2.1(a) through Figure 17.6.1.2.1(f).

Figure 17.6.1.2.1(a) Storage 5 ft to 10 ft (1.5 m to 3.0 m) in Height with Up to 10 ft (3.0 m) Clearance to Ceiling.



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

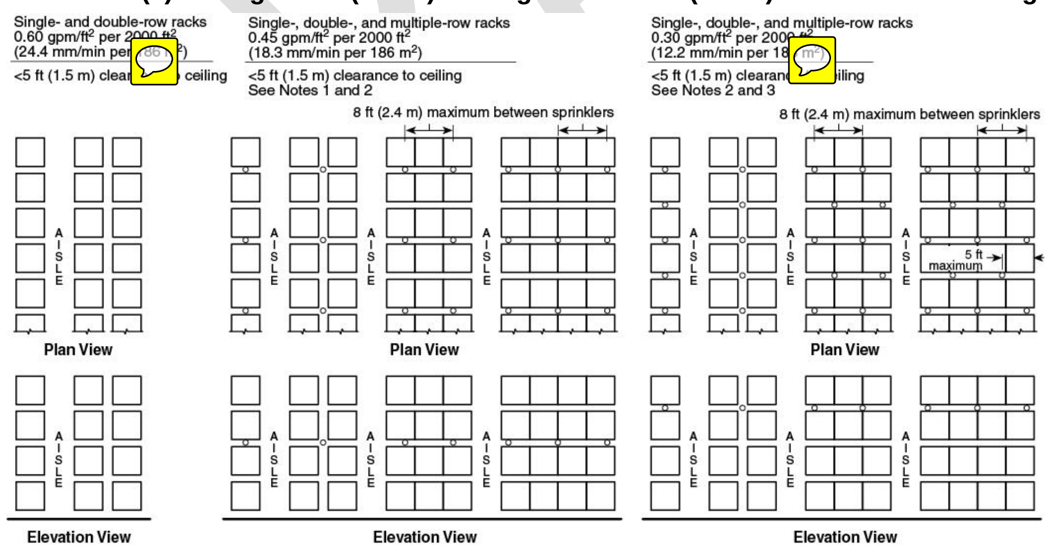
Figure 17.6.1.2.1(b) Storage 15 ft (4.6 m) in Height with Up to 10 ft (3.0 m) Clearance to Ceiling.



Notes:

1. Single level of in-rack sprinklers [K-5.6 (80) or K-8.0 (115) operating at 15 psi (1.0 bar) minimum] installed as indicated in the transverse flue spaces.
2. Where sprinklers listed for storage use are installed at the ceiling only and the ceiling height in the protected area does not exceed 22 ft (6.7 m) and a minimum clearance of 5 ft (1.5 m) and the storage height does not exceed 15 ft (4.6 m), the ceiling sprinkler discharge criteria shall be permitted to be reduced to 0.45 gpm/ft^2 per 2000 ft^2 (18.3 mm/min per 186 m^2).
3. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

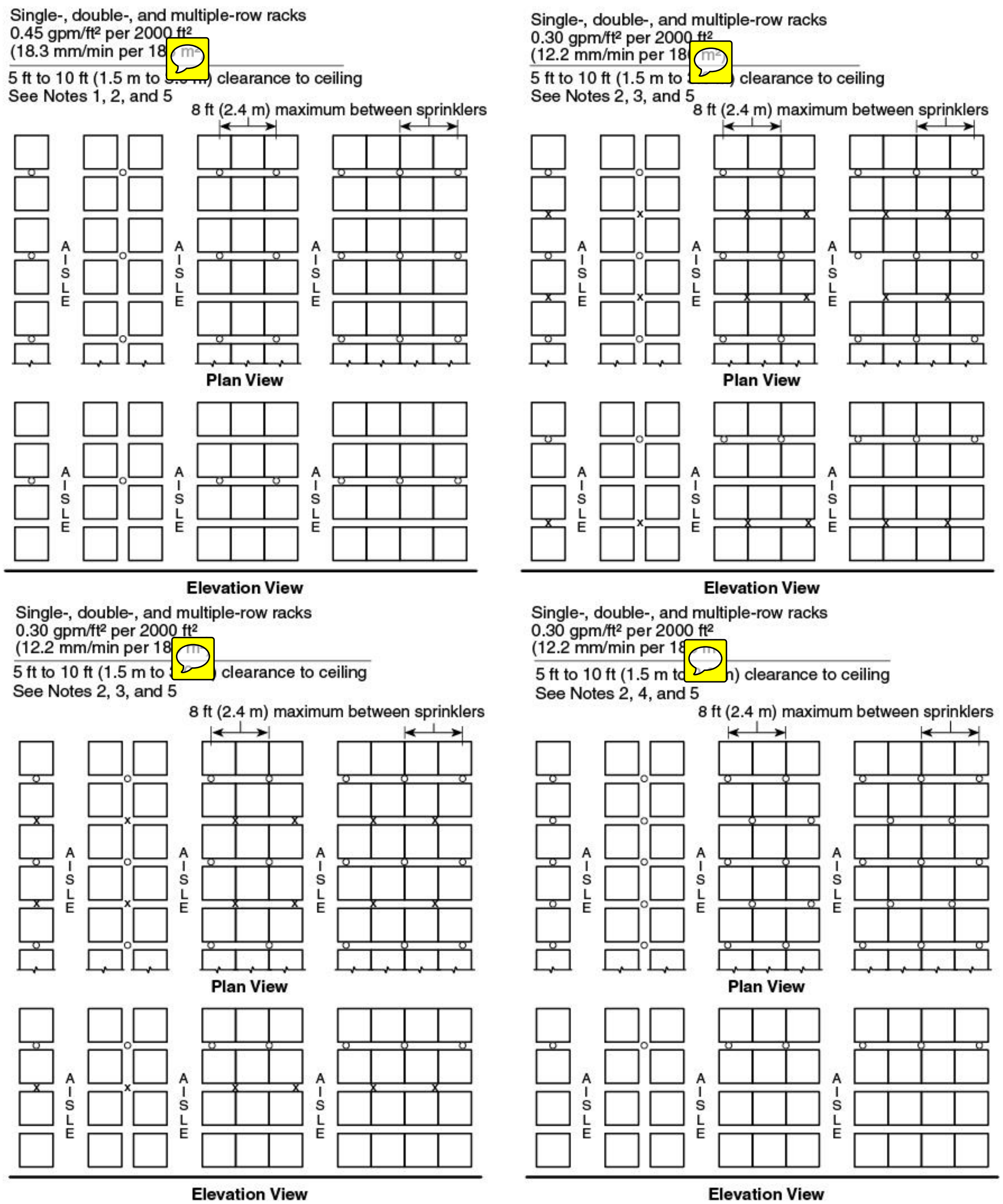
Figure 17.6.1.2.1(c) Storage 20 ft (6.1 m) in Height with <5 ft (1.5 m) Clearance to Ceiling.



Notes:

1. Single level of in-rack sprinklers [K-5.6 (80) or K-8.0 (115) operating at 15 psi (1.0 bar) minimum] installed as indicated in the transverse flue spaces.
2. Ceiling-only protection is not permitted for this storage configuration except where K-11.2 or larger spray sprinklers listed for storage use are installed. In-rack sprinklers are not required, provided the ceiling sprinkler discharge criterion is increased to 0.6 gpm/ft^2 (24 mm/min) over 2000 ft^2 (186 m^2).
3. Single level of in-rack sprinklers [K-8.0 (115) operating at 15 psi (1.0 bar) minimum or K-5.6 (80) operating at 30 psi (2.1 bar) minimum] installed on 4 ft to 5 ft (1.2 m to 1.5 m) spacings located, as indicated, in the longitudinal flue space at the intersection of every transverse flue space.
4. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

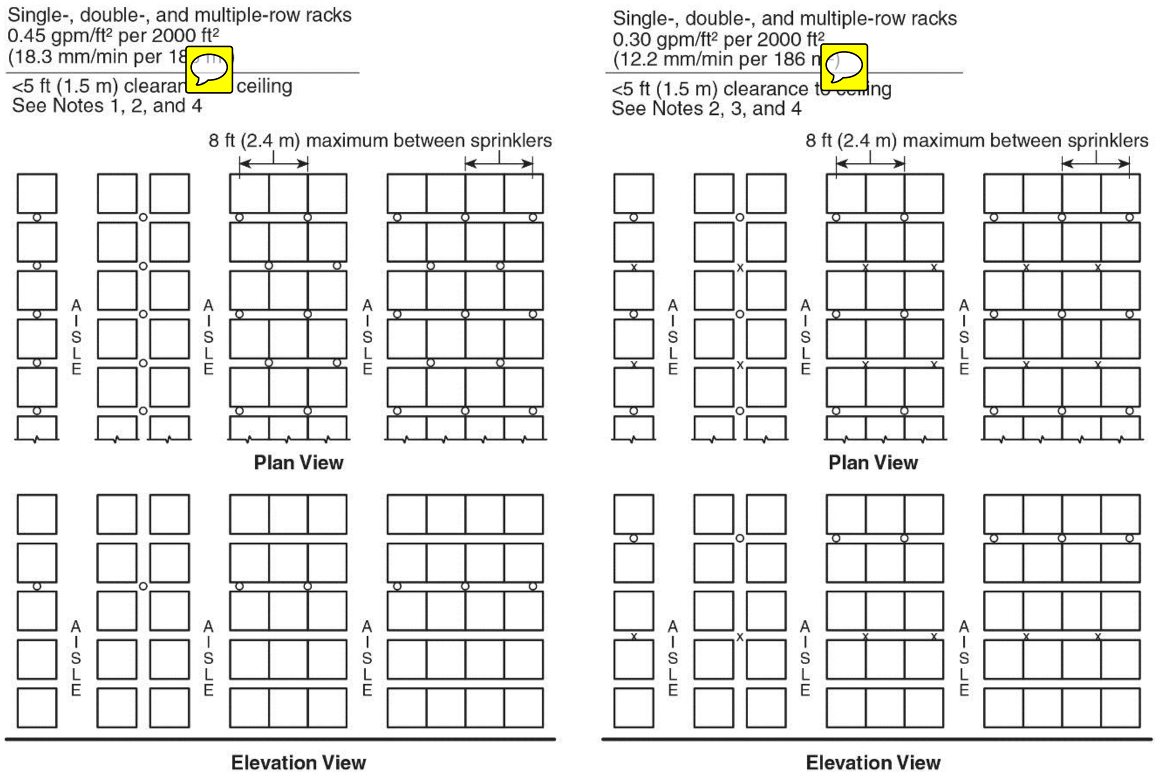
Figure 17.6.1.2.1(d) Storage 20 ft (6.1 m) in Height with 5 ft to 10 ft (1.5 m to 3.0 m) Clearance to Ceiling.



Notes:

1. Single level of in-rack sprinklers [K-5.6 (80) or K-8.0 (115) operating at 15 psi (1.0 bar) minimum] installed as indicated in the transverse flue spaces.
2. Ceiling-only protection shall not be permitted for this storage configuration except where K-11.2 or larger orifice spray sprinklers listed for storage use are installed. In-rack sprinklers shall not be required, provided the ceiling sprinkler discharge criterion is increased to 0.6 gpm/ft² (24.4 mm/min) over 2000 ft² (186 m²) and the ceiling height in the protected area does not exceed 27 ft (8.2 m).
3. Two levels of in-rack sprinklers [K-5.6 (80) or K-8.0 (115) operating at 15 psi (1.0 bar) minimum] installed as indicated and staggered in the transverse flue space.
4. Single level of in-rack sprinklers [K-8 (115) operating at 15 psi (1.0 bar) or K-5.6 (80) operating at 30 psi (2.1 bar) minimum] installed on 4 ft to 5 ft (1.2 m to 1.5 m) spacings located, as indicated, in the longitudinal flue space at the intersection of every transverse flue space.
5. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 17.6.1.2.1(e) Storage 25 ft (7.6 m) in Height with <5 ft (1.5 m) Clearance to Ceiling. ***(See Note 2.)***



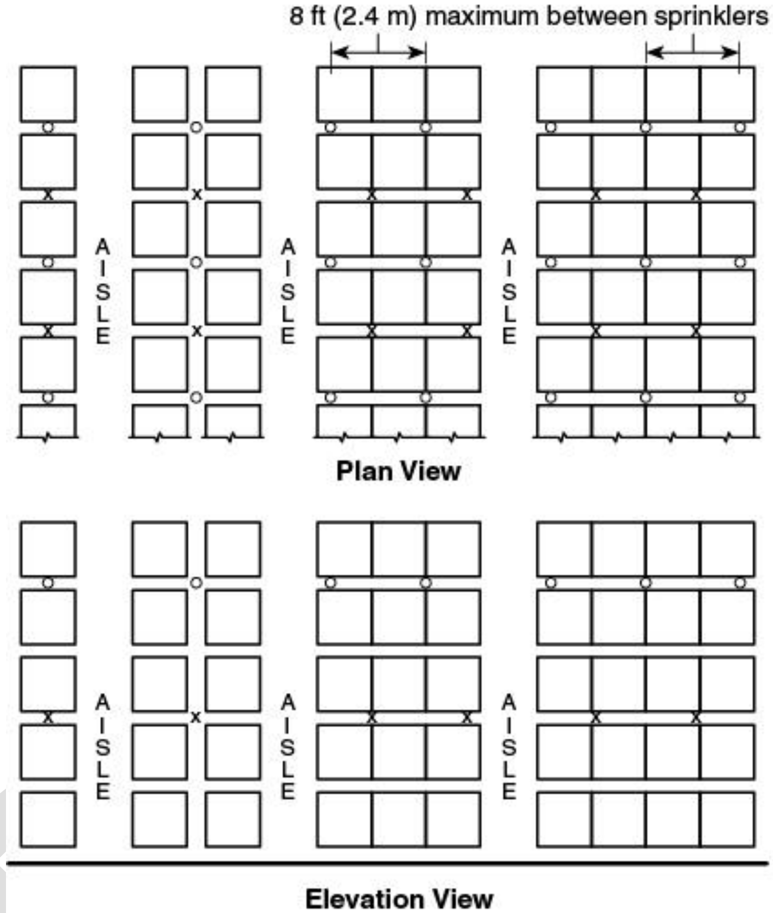
Notes:

1. Single level of in-rack sprinklers [K-8.0 (115) operating at 15 psi (1.0 bar) minimum or K-5.6 (80) operating at 30 psi (2.1 bar) minimum] installed on 4 ft to 5 ft (1.2 m to 1.5 m) spacings located, as indicated, in the longitudinal flue space at the intersection of every transverse flue space.
2. Ceiling-only protection shall not be permitted for this storage configuration except where K-16.8 spray sprinklers listed for storage use are installed. In-rack sprinklers shall not be required, provided the ceiling sprinkler discharge criterion is increased to 0.8 gpm/ft^2 (32.6 mm/min) over 2000 ft^2 (186 m^2) for wet systems and 4500 ft^2 (418 m^2) for dry systems and the ceiling height in the protected area does not exceed 30 ft (9.1 m).
3. Two levels of in-rack sprinklers [K-5.6 (80) or K-8.0 (115) operating at 15 psi (1.0 bar) minimum] installed as indicated and staggered in the transverse flue space.
4. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 17.6.1.2.1(f) Storage 25 ft (7.6 m) in Height with 5 ft to 10 ft (1.5 m to 3.0 m) Clearance to Ceiling. ***(See Note 2.)***

Single-, double-, and multiple-row racks
0.30 gpm/ft² per 2000 ft²
(12.2 mm/min per 186 m²)

5 ft to 10 ft (1.5 m to 3.0 m) clearance to ceiling
See Notes 1, 2, and 3



Notes:

1. Two levels of in-rack sprinklers [K-5.6 (80) or K-8.0 (115) operating at 15 psi (1.0 bar) minimum] installed on 8 ft to 10 ft (2.4 m to 3.0 m) spacings located as indicated and staggered in the transverse flue space.
2. Ceiling-only protection shall not be permitted for this storage configuration except where K-16.8 spray sprinklers listed for storage use are installed. In-rack sprinklers shall not be required, provided the ceiling sprinkler discharge criterion is increased to 0.8 gpm/ft² (32.6 mm/min) over 2000 ft² (186 m²) for wet systems and 4500 ft² (418 m²) for dry systems and the ceiling height in the protected area does not exceed 30 ft (9.1 m).
3. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

17.6.1.2.2
Linear interpolation of design densities and areas of application shall be permitted between storage heights with the same clearance to ceiling.

17.6.1.2.3
No interpolation between clearance to ceiling shall be permitted.

17.6.1.2.4
An option shall be selected from the appropriate Figure 17.6.1.2.1(a) through Figure 17.6.1.2.1(f) given the storage height and clearance being protected. The density/area criteria at the top of each option shall be applied to the ceiling sprinklers and the in-rack sprinklers shown in the option (if any) shall be provided. Options that do not show multiple-row racks in the figures shall not be permitted to protect multiple-row rack storage. Notes in each figure shall be permitted to clarify options or to present additional options not shown in the figures.

17.6.1.3
For storage of Group A plastics between 5 ft and 12 ft (1.5 m and 3.7 m) in height, the installation requirements for extra hazard systems shall apply.

17.6.1.4*
Exposed unexpanded Group A plastics protected with control mode density/area sprinklers shall be protected in accordance with one of the following:
(1) Maximum 10 ft (3.0 m) storage in a maximum 20 ft (6.1 m) high building with ceiling sprinklers designed for a minimum 0.8 gpm/ft^2 (32.6 mm/min) density over 2500 ft^2 (232 m^2) and no in-rack sprinklers required as shown in Figure 17.6.1.4(a)

(2) Maximum 10 ft (3.0 m) storage in a maximum 20 ft (6.1 m) high building with ceiling sprinklers designed for a minimum 0.45 gpm/ft^2 (18.3 mm/min) density over 2000 ft^2 (186 m^2) and one level of in-rack sprinklers required at alternate transverse flues as shown in Figure 17.6.1.4(b)

(3) Maximum 10 ft (3.0 m) storage in a maximum 20 ft (6.1 m) high building with ceiling sprinklers designed for a minimum 0.3 gpm/ft^2(12.2 mm/min) density over 2000 ft^2(186 m^2) and one level of in-rack sprinklers required in every transverse flue as shown in Figure 17.6.1.4(c)

(4) Maximum 15 ft (4.6 m) storage in a maximum 25 ft (7.6 m) high building with ceiling sprinklers designed for a minimum 0.45 gpm/ft^2(18.3 mm/min) density over 2000 ft^2(186 m^2) and one level of in-rack sprinklers required at alternate transverse flues as shown in Figure 17.6.1.4(d)

(5) Maximum 15 ft (4.6 m) storage in a maximum 25 ft (7.6 m) high building with ceiling sprinklers designed for a minimum 0.3 gpm/ft^2(12.2 mm/min) density over 2000 ft^2 (186 m^2) and one level of in-rack sprinklers required in every transverse flue as shown in Figure 17.6.1.4(e)

(6) Maximum 20 ft (6.1 m) storage in a maximum 25 ft (7.6 m) high building with ceiling sprinklers designed for a minimum 0.6 gpm/ft^2(24.4 mm/min) density over 2000 ft^2(186 m^2) and one level of in-rack sprinklers required at alternate transverse flues as shown in Figure 17.6.1.4(f)

(7) Maximum 20 ft (6.1 m) storage in a maximum 25 ft (7.6 m) high building with ceiling sprinklers designed for a minimum 0.45 gpm/ft^2(18.3 mm/min) density over 2000 ft^2(186 m^2) and one level of in-rack sprinklers required in every transverse flue as shown in Figure 17.6.1.4(g)

(8) Maximum 20 ft (6.1 m) storage in a maximum 30 ft (9.1 m) high building with ceiling sprinklers designed for a minimum 0.8 gpm/ft^2(32.6 mm/min) density over 1500 ft^2 (139 m^2) and one level of in-rack sprinklers required at alternate transverse flues as shown in Figure 17.6.1.4(h)

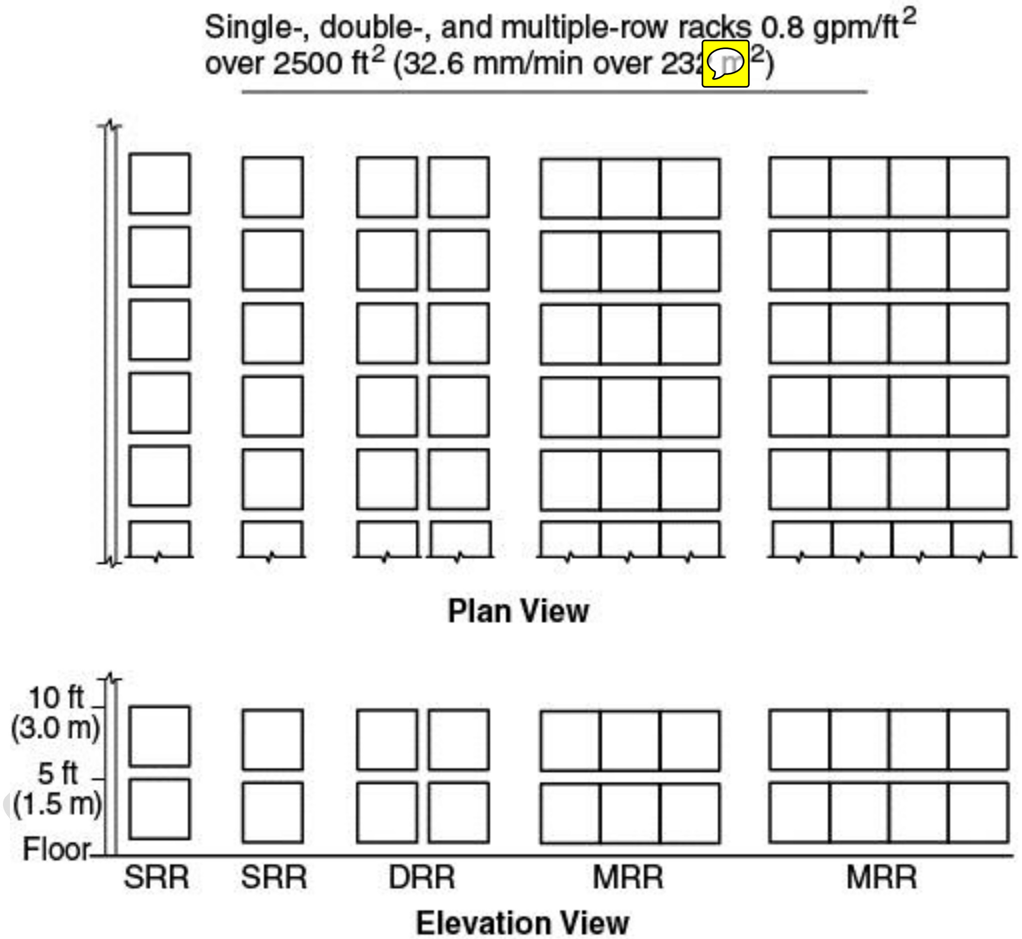
(9) Maximum 20 ft (6.1 m) storage in a maximum 30 ft (9.1 m) high building with ceiling sprinklers designed for a minimum 0.6 gpm/ft^2 (24.4 mm/min^2) density over 1500 ft^2 (139 m^2) and one level of in-rack sprinklers required in every transverse flue as shown in Figure 17.6.1.4(i)

(10) Maximum 20 ft (6.1 m) storage in a maximum 30 ft (9.1 m) high building with ceiling sprinklers designed for a minimum 0.3 gpm/ft^2(12.2 mm/min) density over 2000 ft^2 (186 m^2) and two levels of in-rack sprinklers required in every transverse flue as shown in Figure 17.6.1.4(j)

(11) Maximum 25 ft (7.6 m) storage in a maximum 35 ft (11 m) high building with ceiling sprinklers designed for a minimum 0.8 gpm/ft^2 (32.6 mm/min) density over 1500 ft^2 (139 m^2) and one level of in-rack sprinklers required in every transverse flue as shown in Figure 17.6.1.4(k)

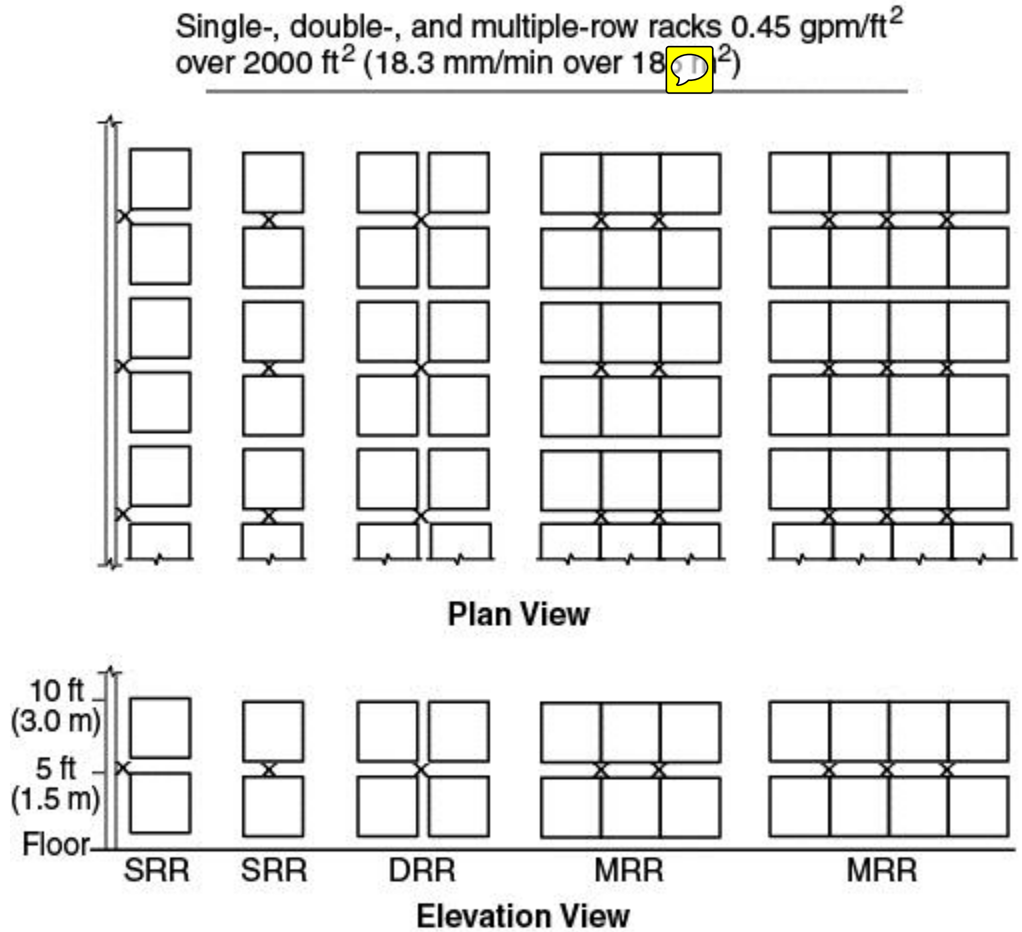
(12) Maximum 25 ft (7.6 m) storage in a maximum 35 ft (11 m) high building with ceiling sprinklers designed for a minimum 0.3 gpm/ft^2(12.2 mm/min) density over 2000 ft^2 (186 m^2) and two levels of in-rack sprinklers required in every transverse flue as shown in Figure 17.6.1.4(l)

Figure 17.6.1.4(a) Exposed Nonexpanded Group A Plastic Up to 10 ft (3.0 m) in Height in Up to a 20 ft (6.1 m) High Building with No In-Rack Sprinklers.



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 17.6.1.4(b) Exposed Nonexpanded Group A Plastic Up to 10 ft (3.0 m) in Height in Up to a 20 ft (6.1 m) High Building with One Level of In-Rack Sprinklers.



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 17.6.1.4(c) Exposed Nonexpanded Group A Plastics Up to 10 ft (3.0 m) in Height in Up to a 20 ft (6.1 m) High Building with One Level of Closely Spaced In-Rack Sprinklers.

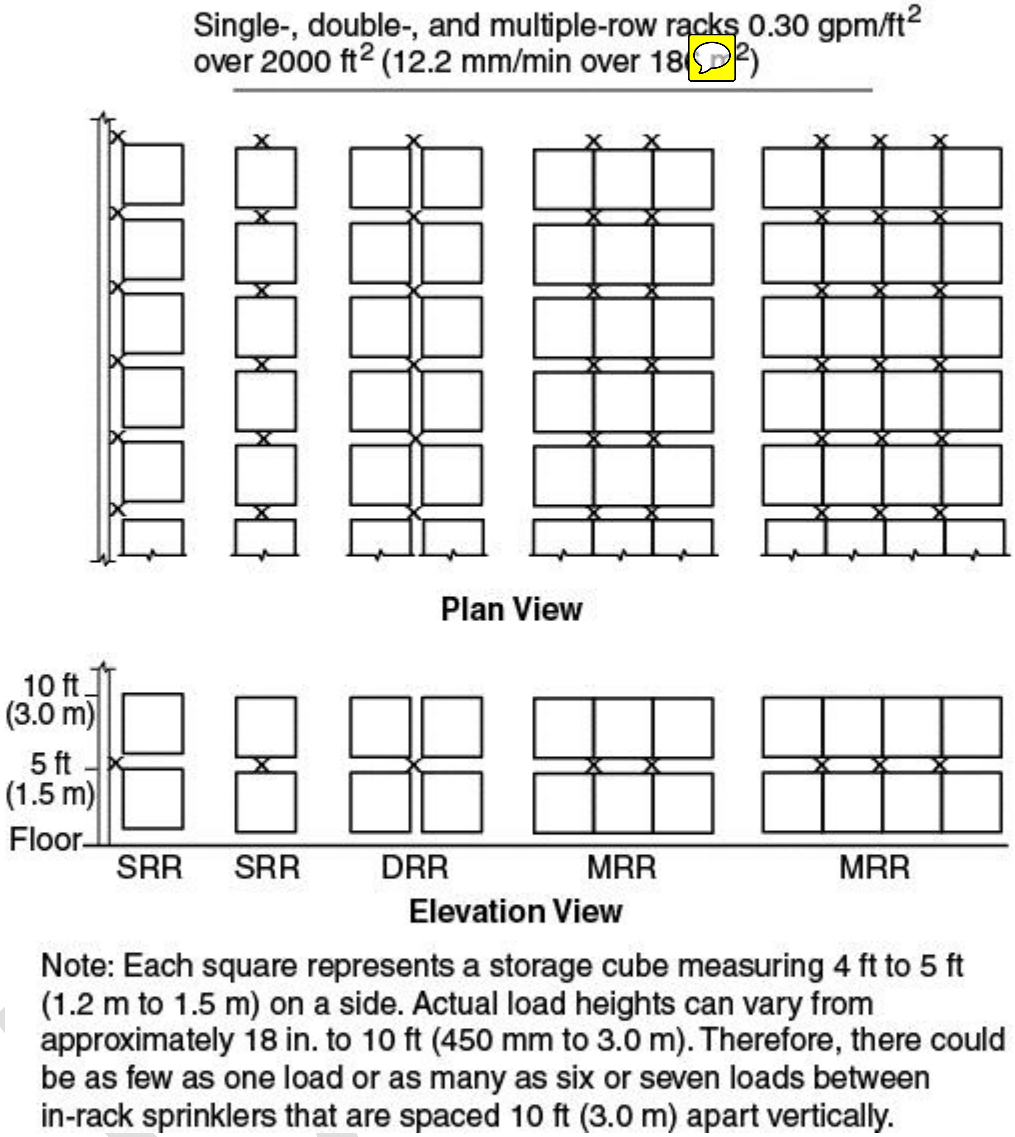


Figure 17.6.1.4(d) Exposed Nonexpanded Group A Plastics Up to 15 ft (4.6 m) in Height in Up to a 25 ft (7.6 m) High Building with One Level of In-Rack Sprinklers.

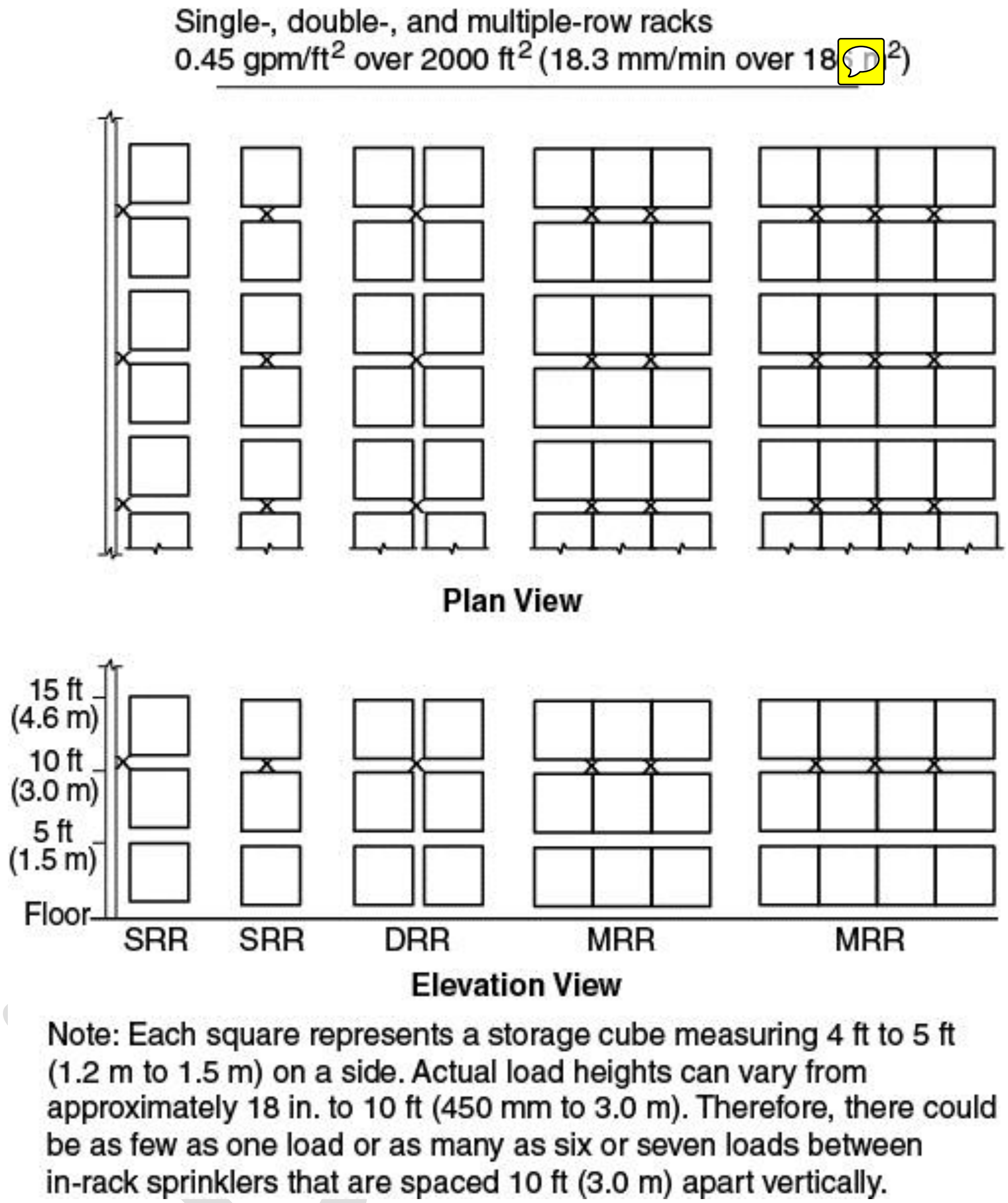
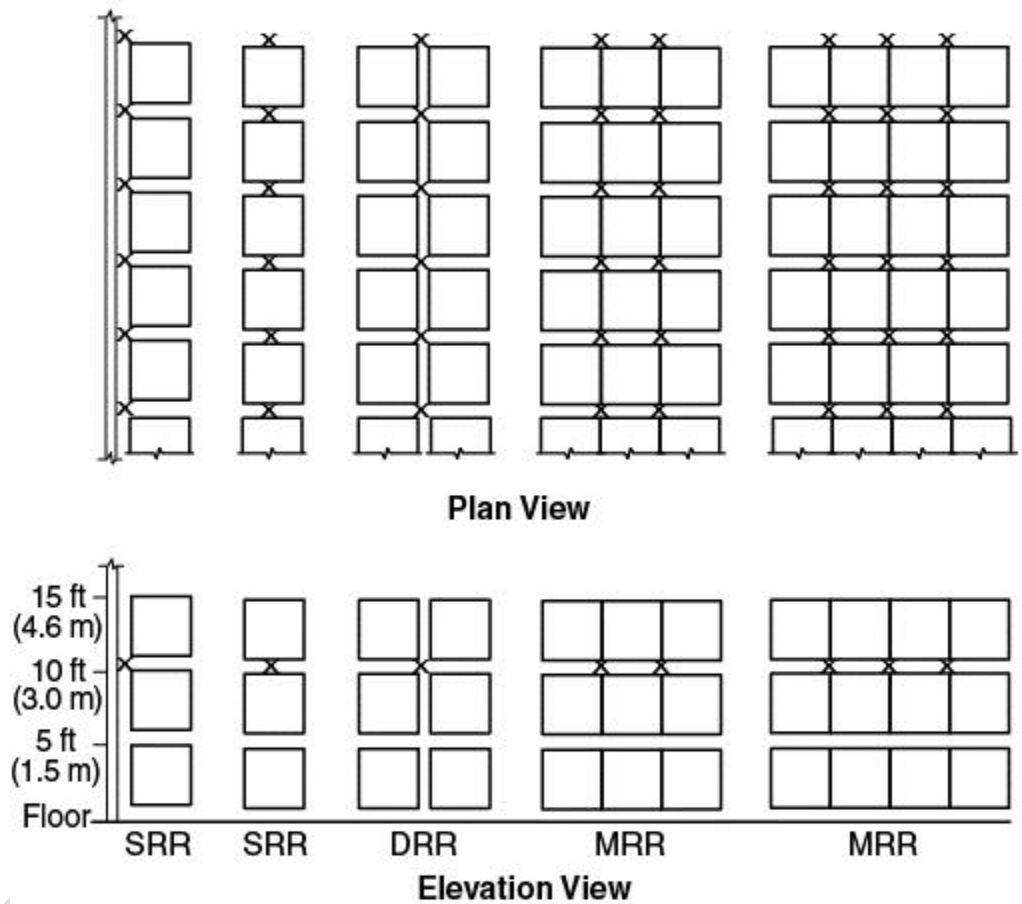


Figure 17.6.1.4(e) Exposed Nonexpanded Group A Plastics Up to 15 ft (4.6 m) in Height in Up to a 25 ft (7.6 m) High Building with One Level of Closely Spaced In-Rack Sprinklers.

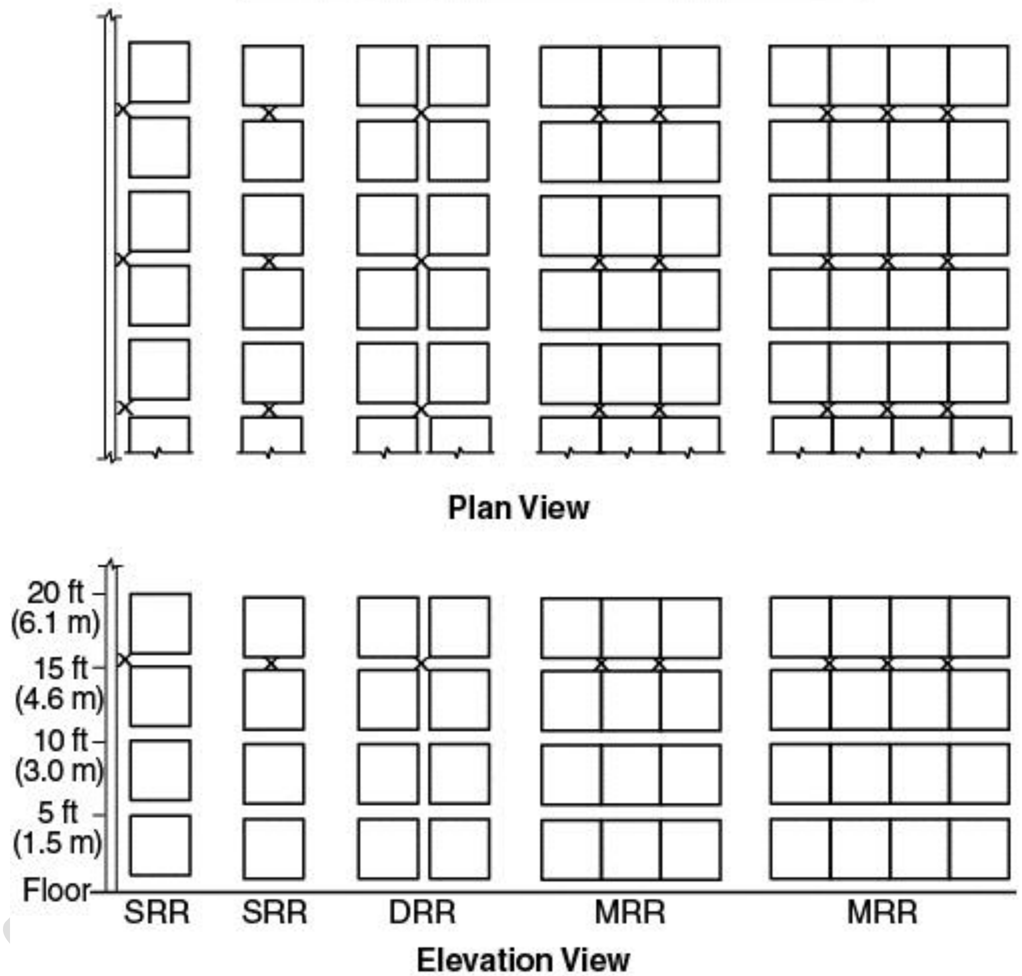
Single-, double-, and multiple-row racks
0.30 gpm/ft^2 over 2000 ft^2 (12.2 mm/min over 18[illegible]m^2)



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 17.6.1.4(f) Exposed Nonexpanded Group A Plastics Up to 20 ft (6.1 m) in Height in Up to a 25 ft (7.6 m) High Building with One Level of In-Rack Sprinklers.

Single-, double-, and multiple-row racks
0.60 gpm/ft^2 over 2000 ft^2 (24.4 mm/min over 186 m^2)



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 17.6.1.4(g) Exposed Nonexpanded Group A Plastics Up to 20 ft (6.1 m) in Height in Up to a 25 ft (7.6 m) High Building with One Level of Closely Spaced In-Rack Sprinklers.

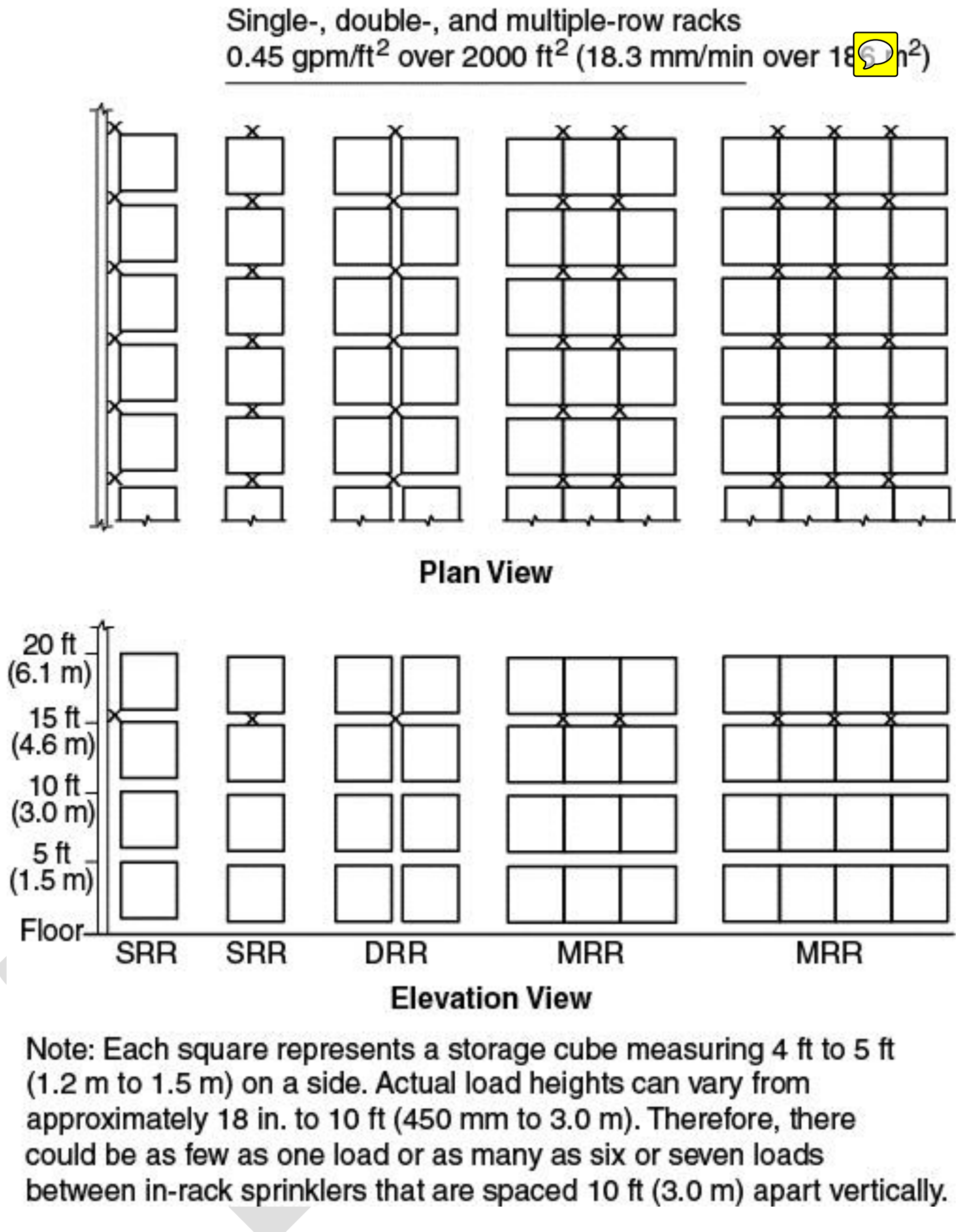


Figure 17.6.1.4(h) Exposed Nonexpanded Group A Plastics Up to 20 ft (6.1 m) in Height in Up to a 30 ft (9.1 m) High Building with One Level of In-Rack Sprinklers.

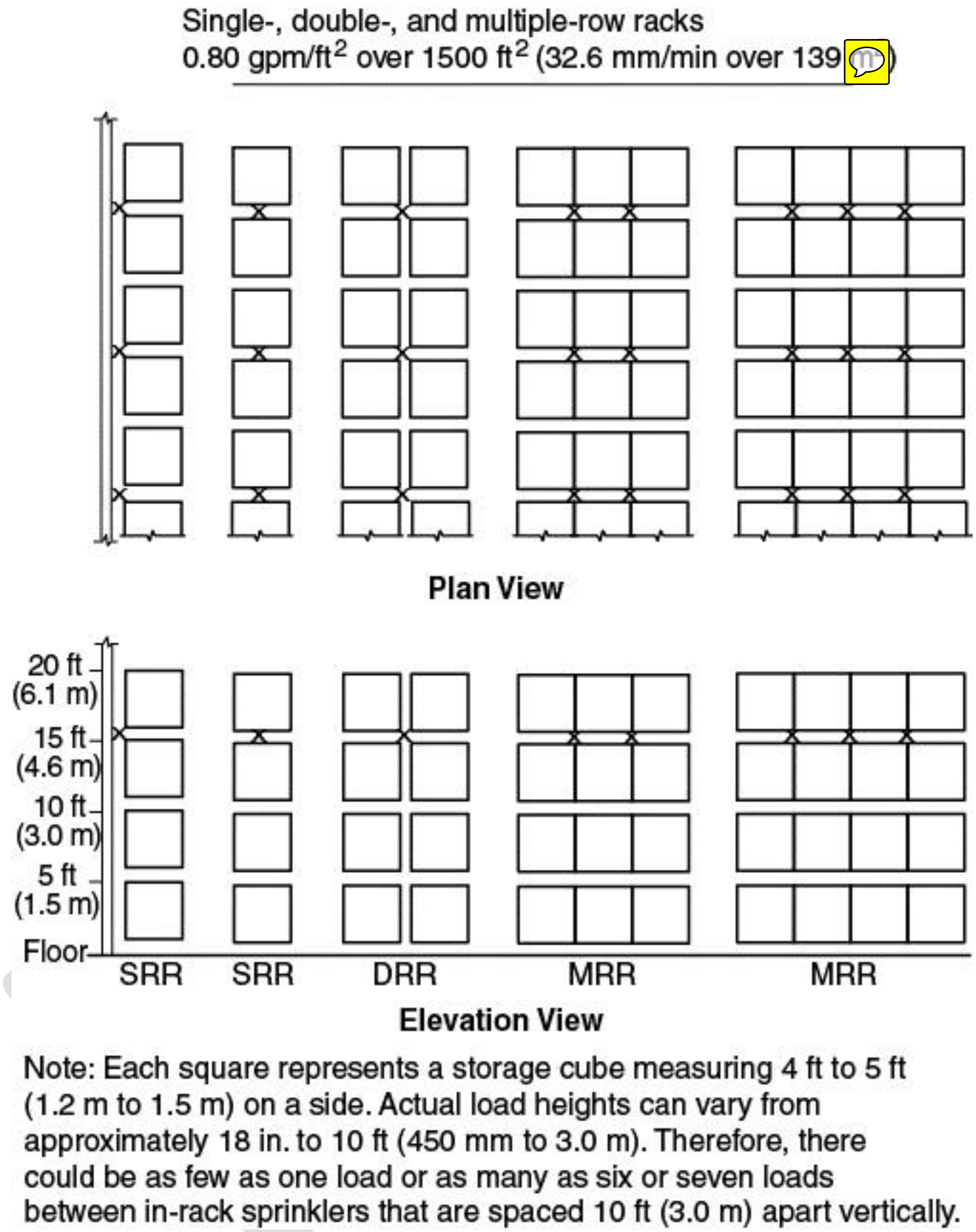
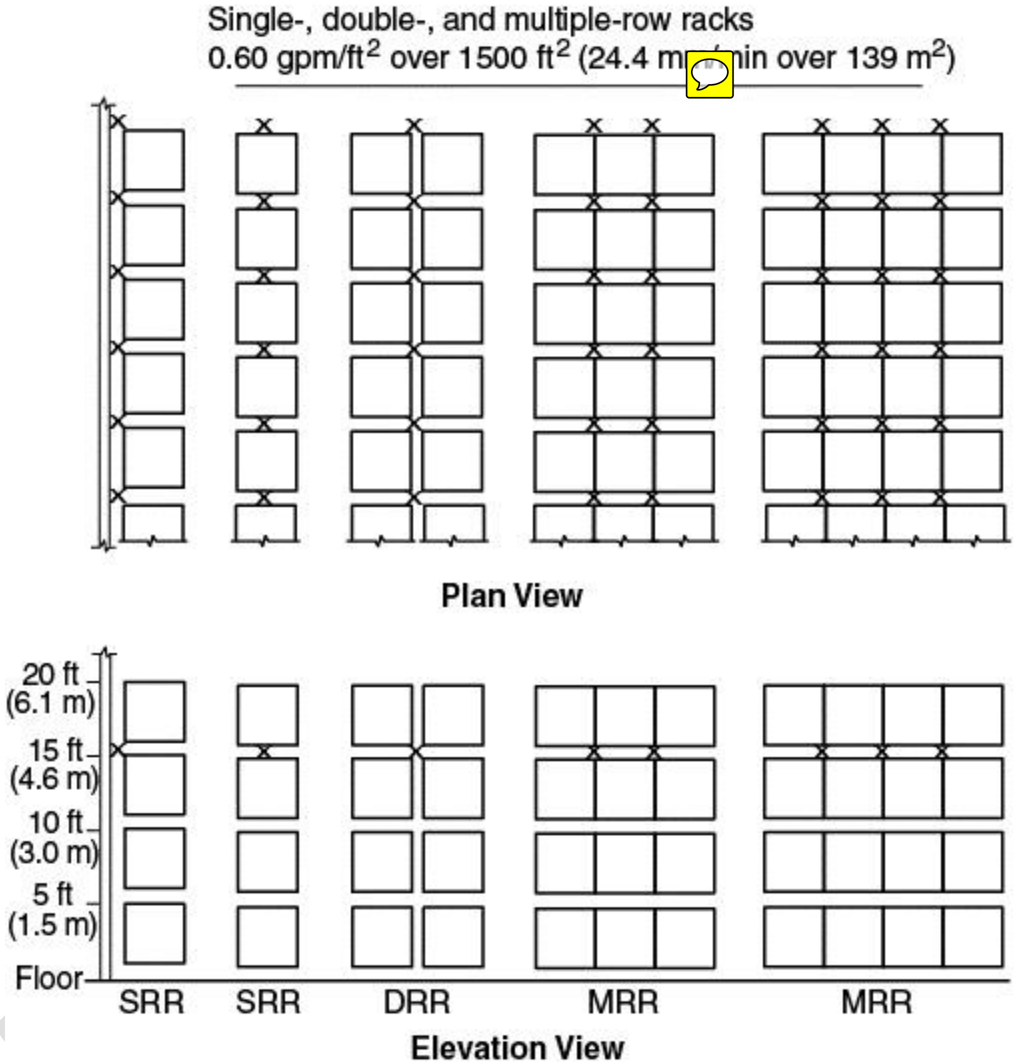


Figure 17.6.1.4(i) Exposed Nonexpanded Group A Plastics Up to 20 ft in (6.1 m) Height in Up to a 30 ft (9.1 m) High Building with One Level of Closely Spaced In-Rack Sprinklers.

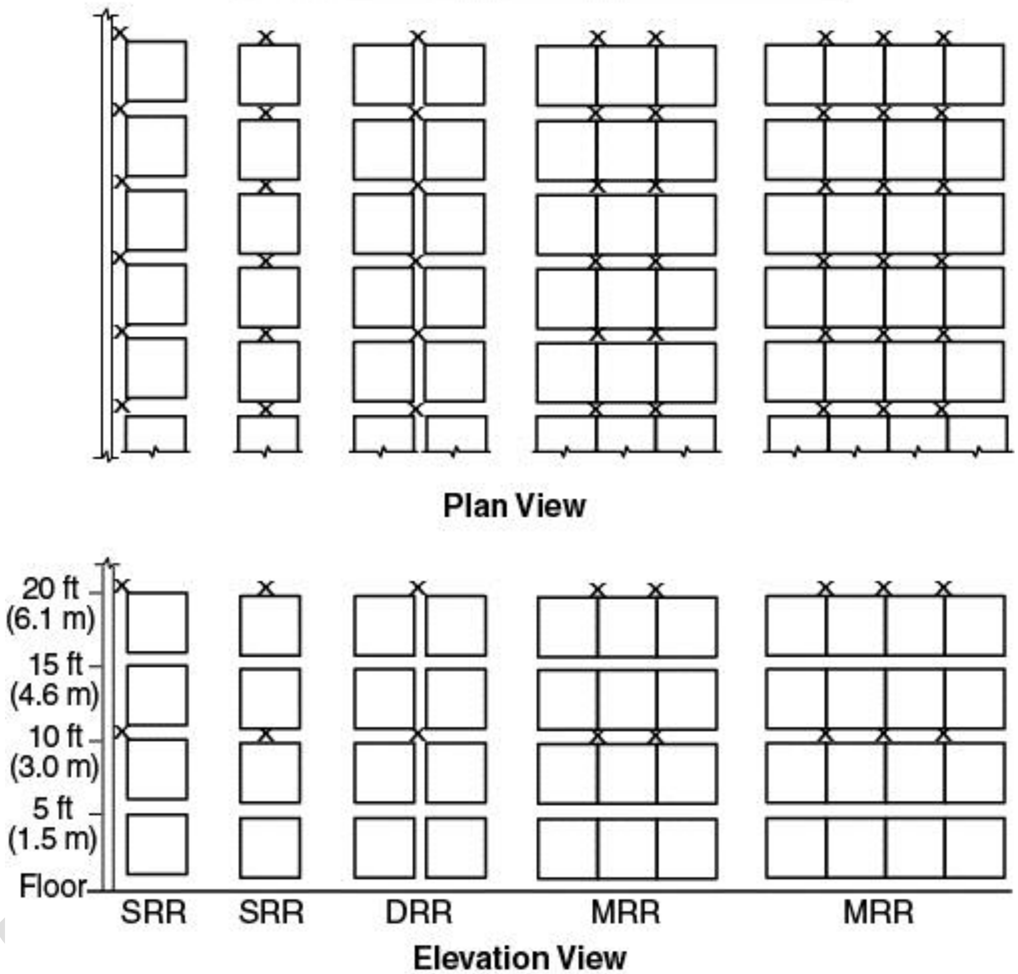


Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 17.6.1.4(j) Exposed Nonexpanded Group A Plastics Up to 20 ft (6.1 m) in Height in Up to a 30 ft (9.1 m) High Building with Two Levels of Closely Spaced In-Rack Sprinklers.

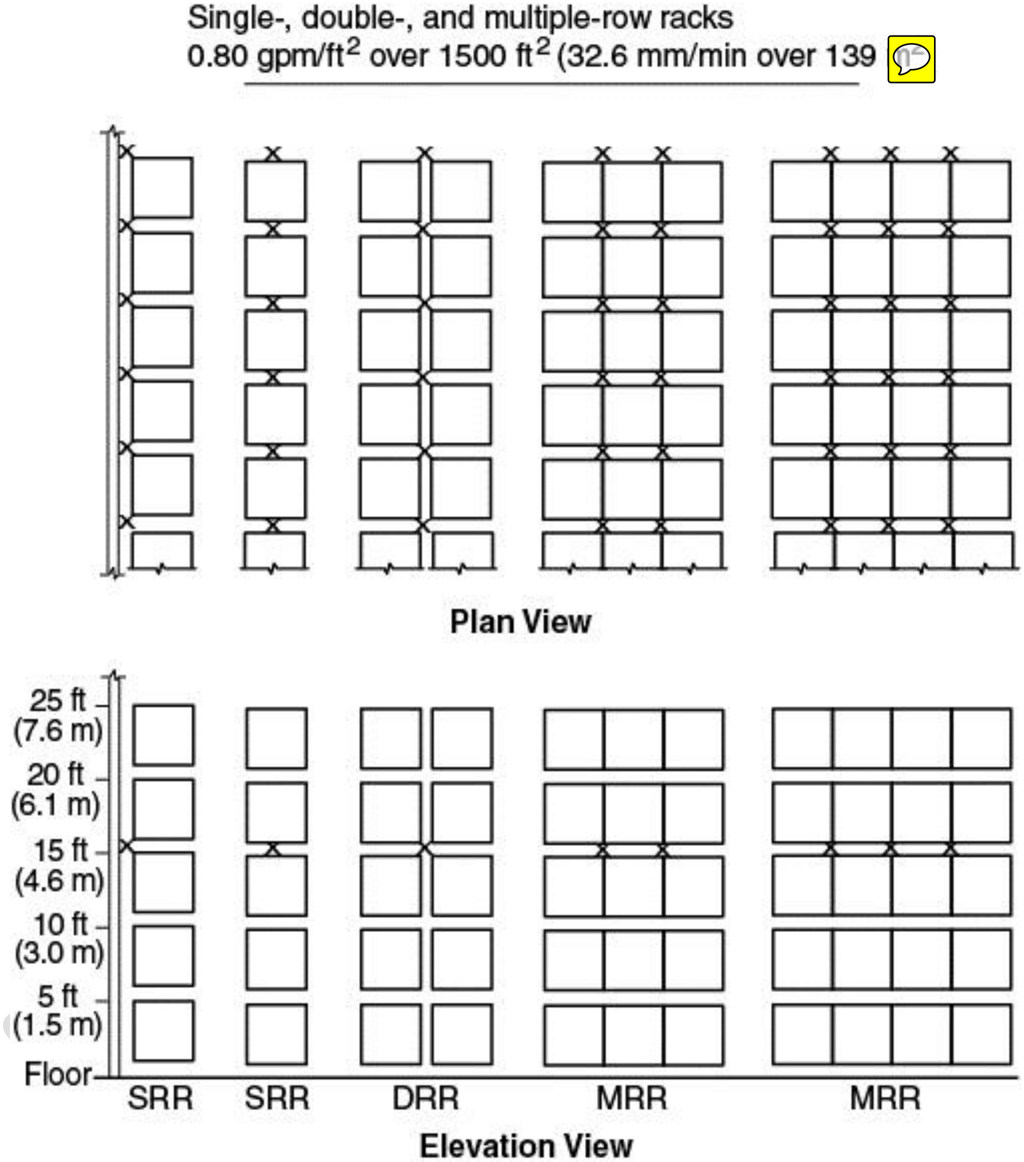
Single-, double-, and multiple-row racks

0.30 gpm/ft^2 over 2000 ft^2 (12.2 mm/min over 18[illegible]^2)



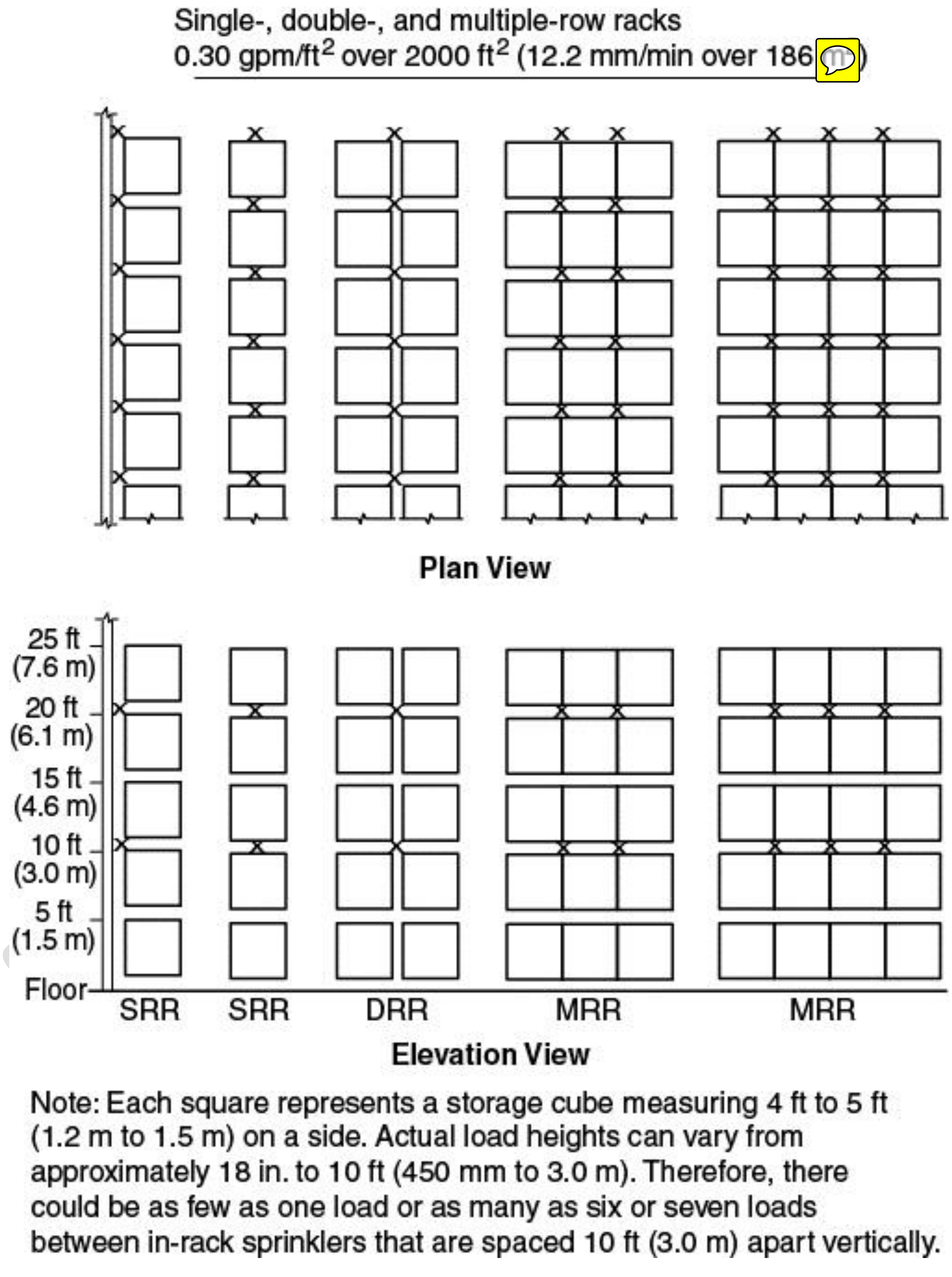
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 17.6.1.4(k) Exposed Nonexpanded Group A Plastics Up to 25 ft (7.6 m) in Height in Up to a 35 ft (10.7 m) High Building with One Level of Closely Spaced In-Rack Sprinklers.



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 17.6.1.4(l) Exposed Nonexpanded Group A Plastics Up to 25 ft (7.6 m) in Height in Up to a 35 ft (10.7 m) High Building with Two Levels of Closely Spaced In-Rack Sprinklers.



17.6.1.5 In-Rack Sprinkler Requirements Where Control Mode Density/Area Sprinklers Are Being Used at Ceiling.

17.6.1.5.1 In-Rack Sprinkler Clearance.
The minimum of 6 in. (150 mm) vertical clear space shall be maintained between the sprinkler deflectors and the top of a tier of storage.

(A)
Sprinkler discharge shall not be obstructed by horizontal rack members.

17.6.1.5.2
The spacing of in-rack sprinklers shall be in accordance with Figure 17.6.1.2.1(a) through Figure 17.6.1.2.1(f).

17.6.1.5.3
In-rack sprinklers shall be located at an intersection of transverse and longitudinal flues while not exceeding the maximum spacing rules.

17.6.1.5.4
Where distances between transverse flues exceed the maximum allowable distances, sprinklers shall be installed at the intersection of the transverse and longitudinal flues, and additional sprinklers shall be installed between transverse flues to meet the maximum distance rules.

17.6.1.5.5
Where no transverse flues exist, in-rack sprinklers shall not exceed the maximum spacing rules.

17.6.1.5.6 In-Rack Sprinkler Water Demand.
The water demand for sprinklers installed in racks shall be based on simultaneous operation of the most hydraulically remote sprinklers as follows:
(1) Eight sprinklers where only one level is installed in racks

(2) Fourteen sprinklers (seven on each top two levels) where more than one level is installed in racks

17.6.1.5.7 In-Rack Sprinkler Discharge Pressure.
Sprinklers in racks shall discharge at not less than 15 psi (1.0 bar) for all classes of commodities. *(See Section C.19.)*

17.6.2 CMSA Sprinklers for Rack Storage of Group A Plastic Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

17.6.2.1
Protection of single-, double-, and multiple-row rack storage for nonexpanded Group A plastic commodities shall be in accordance with Table 17.6.2.1.

Table 17.6.2.1 CMSA Sprinkler Design Criteria for Single-, Double-, and Multiple-Row Racks of Group A Plastic Commodities Stored Up and Including 25 ft (7.6 m) in Height

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
Single-, double-, and multiple-row racks (no open-top containers)	Cartoned nonexpanded plastics	20	6.1	25	7.6	11.2 (160) Upright	Wet	15	50	3.4
						16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
				30	9.1	11.2 (160) Upright	Wet Wet	30 20	50 75	3.4 5.2
						16.8 (240) Upright	Wet	15*	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
		25	7.6	30	9.1	11.2 (160) Upright	Wet	15 + 1 level of in-rack	50	3.4
		25	7.6	30	9.1	16.8 (240) Upright	Wet	15*	22	1.5
		25	7.6	30	9.1	19.6 (280) Pendent	Wet	15	16	1.1
		25	7.6	35	11	11.2 (160) Upright	Wet	30 + 1 level of in-rack	50	3.4
		25	7.6	35	11	11.2 (160) Upright	Wet	20 + 1 level of in-rack	75	5.2
		25	7.6	35	11	16.8 (240) Upright	Wet	30 + 1 level of in-rack	22	1.5
		25	7.6	35	11	16.8 (240) Upright	Wet	20 + 1 level of in-rack	35	2.4
		25	7.6	35	11	19.6 (280) Pendent	Wet	15	25	1.7
	Exposed nonexpanded plastics	20	6.1	25	7.6	11.2 (160) Upright	Wet	15	50	3.4
	Exposed nonexpanded plastics	20	6.1	25	7.6	16.8 (240) Upright	Wet	15	22	1.5
	Exposed nonexpanded plastics	20	6.1	30	9.1	11.2 (160) Upright	Wet	30	50	3.4
	Exposed nonexpanded plastics	20	6.1	30	9.1	11.2 (160) Upright	Wet	20	75	5.2
	Exposed nonexpanded plastics	20	6.1	30	9.1	16.8 (240) Upright	Wet	15*	22	1.5
	Exposed nonexpanded plastics	25	7.6	30	9.1	11.2 (160) Upright	Wet	15 + 1 level of in-rack	50	3.4
	Exposed nonexpanded plastics	25	7.6	30	9.1	16.8 (240) Upright	Wet	15*	22	1.5
	Exposed nonexpanded plastics	25	7.6	35	11	11.2 (160) Upright	Wet	30 + 1 level of in-rack	50	3.4
	Exposed nonexpanded plastics	25	7.6	35	11	11.2 (160) Upright	Wet	20 + 1 level of in-rack	75	5.2

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
						16.8 (240) Upright	Wet	30 + 1 level of in-rack	22	1.5
							Wet	20 + 1 level of in-rack	35	2.4

*Minimum 8 ft (2.4 m) aisle.

17.6.2.1.1
CMSA sprinklers shall not be permitted to protect storage on solid shelf racks unless the solid shelf racks are protected with in-rack sprinklers in accordance with 17.1.5.

17.6.2.1.1.1
Where solid shelves are used, in-rack sprinklers shall be installed in every level below the highest solid shelf.

17.6.2.2
Protection shall be provided as specified in Table 17.6.2.1 or appropriate NFPA standards in terms of minimum operating pressure and the number of sprinklers to be included in the design area.

17.6.2.3 Open Wood Joist Construction.

17.6.2.3.1
Where CMSA sprinklers are installed under open wood joist construction, firestopping in accordance with **17.6.2.3.2** shall be provided or the minimum operating pressure of the sprinklers shall be 50 psi (3.4 bar) for a K-11.2 (160) sprinkler or 22 psi (1.5 bar) for a K-16.8 (240) sprinkler.

17.6.2.3.2
Where each joist channel of open wood joist construction is fully firestopped to its full depth at intervals not exceeding 20 ft (6.1 m), the lower pressures specified in Table 17.6.2.1 shall be permitted to be used.

17.6.2.4 Preaction Systems.
For the purpose of using Table 17.6.2.1, preaction systems shall be classified as dry pipe systems.

17.6.2.5
Building steel shall not require special protection where Table 17.6.2.1 is applied as appropriate for the storage configuration.

17.6.2.6 In-Rack Sprinkler Requirements Where CMSA Sprinklers Are Used at Ceiling.

17.6.2.6.1
In-rack sprinklers shall be installed at the first tier level at or above one-half of the storage height.

17.6.2.6.2
The minimum of 6 in. (150 mm) vertical clear space shall be maintained between the sprinkler deflectors and the top of a tier of storage.

(A)
Sprinkler discharge shall not be obstructed by horizontal rack members.

17.6.2.6.3
In-rack sprinklers shall be located at an intersection of transverse and longitudinal flues.

17.6.2.6.4
The maximum horizontal distance between in-rack sprinklers shall be 5 ft (1.5 m).

17.6.2.6.5
Where distances between transverse flues exceed the maximum allowable distances, sprinklers shall be installed at the intersection of the transverse and longitudinal flues, and additional sprinklers shall be installed between transverse flues to meet the maximum distance rules.

17.6.2.6.6
Where no transverse flues exist, in-rack sprinklers shall not exceed the maximum spacing rules.

17.6.2.6.7 In-Rack Sprinkler Water Demand.
The water demand for sprinklers installed in racks shall be based on simultaneous operation of the most hydraulically remote eight sprinklers.

17.6.2.6.8 In-Rack Sprinkler Discharge Pressure.
Sprinklers in racks shall discharge at not less than 15 psi (1.0 bar) for all classes of commodities. *(See Section C.19.)*

17.6.3 Special Design for Rack Storage of Plastics Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

17.6.3.1 Slatted Shelves.

17.6.3.1.1
Slatted rack shelves shall be considered equivalent to solid rack shelves where the shelving is not considered open rack shelving or where the requirements of 17.6.3.1 are not met. *(See Section C.20.)*

17.6.3.1.2
A wet pipe system that is designed to provide a minimum of 0.6 gpm/ft² (24.4 mm/min) density over a minimum area of 2000 ft² (186 m²) or K-14.0 (200) ESFR sprinklers operating at a minimum of 50 psi (3.4 bar), K-16.8 (240) sprinklers operating at a minimum of 32 psi (2.2 bar), or K-25.2 (360) ESFR sprinklers operating at a minimum of 15 psi (1.0 bar) shall be permitted to protect single- and double-row racks with slatted rack shelving racks where all of the following conditions are met:

(1) Sprinklers shall be K-11.2 (160), K-14.0 (200), or K-16.8 (240) orifice spray sprinklers with a temperature rating of ordinary, intermediate, or high and shall be listed for storage occupancies or shall be K-14.0 (200), K-16.8 (240), or K-25.2 (360) ESFR.

(2) The protected commodities shall be limited to Class I through Class IV, Group B plastics, Group C plastics, cartoned (expanded and unexpanded) Group A plastics, and exposed (unexpanded) Group A plastics.

(3) Slats in slatted rack shelving shall be a minimum nominal 2 in. (50 mm) thick by maximum nominal 6 in. (150 mm) wide with the slats held in place by spacers that maintain a minimum 2 in. (50 mm) opening between each slat.

(4) Where K-11.2 (160), K-14.0 (200), or K-16.8 (240) orifice sprinklers are used, there shall be no slatted shelf levels in the rack above 12 ft (3.7 m). Open rack shelving using wire mesh shall be permitted for shelf levels above 12 ft (3.7 m).

(5) Transverse flue spaces at least 3 in. (75 mm) wide shall be provided at least every 10 ft (3.0 m) horizontally.

(6) Longitudinal flue spaces at least 6 in. (150 mm) wide shall be provided for double-row racks. Longitudinal flue spaces shall not be required when ESFR sprinklers are used.

(7) The aisle widths shall be at least 7½ ft (2.3 m).

(8) The maximum roof height shall be 27 ft (8.2 m) or 30 ft (9.1 m) where ESFR sprinklers are used.

(9) The maximum storage height shall be 20 ft (6.1 m).

(10) Solid plywood or similar materials shall not be placed on the slatted shelves so that they block the 2 in. (50 mm) spaces between slats, nor shall they be placed on the wire mesh shelves.

Chapter 18 Installation Requirements for Seismic Protection

18.1 Protection of Piping Against Damage Where Subject to Earthquakes.

18.1.1
Where water-based fire protection systems are required to be protected against damage from earthquakes, the requirements of Section 18.1 shall apply, unless the requirements of 18.1.2 are met.

18.1.2
Alternative methods of providing earthquake protection of sprinkler systems based on a 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 shall be permitted.

18.1.3 Obstructions to Sprinklers.
Braces and restraints shall not obstruct sprinklers and shall comply with the obstruction rules of Chapter 8.

18.2* Flexible Couplings.

18.2.1
Flexible couplings joining grooved end pipe shall be provided as flexure joints to allow individual sections of piping 2½ in. (65 mm) or larger to move differentially with the individual sections of the building to which it is attached.

18.2.2
Flexible couplings shall be arranged to coincide with structural separations within a building.

18.2.3
Systems having more flexible couplings than required by this section shall be provided with additional sway bracing as required in 18.5.5.9.

18.2.3.1
The flexible couplings shall be installed as follows:
(1)   *Within 24 in. (600 mm) of the top and bottom of all risers, unless the following provisions are met:
(a)   In risers less than 3 ft (900 mm) in length, flexible couplings shall be permitted to be omitted.

(b)   In risers 3 ft to 7 ft (900 mm to 2.1 m) length, one flexible coupling shall be adequate.

(2)   Within 12 in. (300 mm) above and within 24 in. (600 mm) below the floor in multistory buildings
(a)   In risers up to 7 ft in length terminating above the roof assembly or top landing, the flexible coupling shall not be required above the assembly.

(3)   On both sides of concrete or masonry walls within 1 ft (300 mm) of the wall surface, unless clearance is provided in accordance with 18.4

(4)   *Within 24 in. (600 mm) of building expansion joints

(5)   Within 24 in. (600 mm) of the top of drops exceeding 15 ft (4.6 m) in length to portions of systems supplying more than one sprinkler, regardless of pipe size

(6)   Within 24 in. (600 mm) above and 24 in. (600 mm) below any intermediate points of support for a riser or other vertical pipe

18.2.3.2
When the flexible coupling below the floor is above the tie-in main to the main supplying that floor, a flexible coupling shall be provided in accordance with one of the following:
(1)   *On the horizontal portion within 24 in. (600 mm) of the tie-in where the tie-in is horizontal

(2)   *On the vertical portion of the tie-in where the tie-in incorporates a riser

18.2.4* Flexible Couplings for Drops.
Flexible couplings for drops to hose lines, rack sprinklers, mezzanines, and free-standing structures shall be installed regardless of pipe sizes as follows:

(1) Within 24 in. (600 mm) of the top of the drop

(2) Within 24 in. (600 mm) above the uppermost drop support attachment, where drop supports are provided to the structure, rack, or mezzanine

(3) Within 24 in. (600 mm) above the bottom of the drop where no additional drop support is provided

18.3* Seismic Separation Assembly.

18.3.1
An approved seismic separation assembly shall be installed where sprinkler piping, regardless of size, crosses building seismic separation joints at ground level and above.

18.3.2
Seismic separation assemblies shall consist of flexible fittings or flexible piping so as to allow movement sufficient to accommodate closing of the separation, opening of the separation to twice its normal size, and movement relative to the separation in the other two dimensions in an amount equal to the separation distance.

18.3.3*
The seismic separation assembly shall include a four-way brace upstream and downstream within 6 ft (1.8 m) of the seismic separation assembly.

18.3.4
Bracing shall not be attached to the seismic separation assembly.

18.4* Clearance.

18.4.1
Clearance shall be provided around all piping extending through walls, floors, platforms, and foundations, including drains, fire department connections, and other auxiliary piping.

18.4.2
Unless any of the requirements of 18.4.3 through 18.4.7 or 18.4.10 are met, where pipe passes through holes in platforms, foundations, walls, or floors, the holes shall be sized such that the diameter of the holes is nominally 2 in. (50 mm) larger than the pipe for pipe 1 in. (25 mm) nominal to 3½ in. (90 mm) nominal and 4 in. (100 mm) larger than the pipe for pipe 4 in. (100 mm) nominal and larger.

18.4.3
Where clearance is provided by a pipe sleeve, a nominal diameter 2 in. (50 mm) larger than the nominal diameter of the pipe shall be acceptable for pipe sizes 1 in. (25 mm) through 3½ in. (90 mm), and the clearance provided by a pipe sleeve of nominal diameter 4 in. (100 mm) larger than the nominal diameter of the pipe shall be acceptable for pipe sizes 4 in. (100 mm) and larger.

18.4.4
No clearance shall be required for piping passing through gypsum board or equally frangible construction.

18.4.5
No clearance shall be required if flexible couplings are located within 1 ft (300 mm) of each side of a wall or if the requirements of 18.2.3.1(2) are met.

18.4.6
No clearance shall be required where horizontal piping passes perpendicularly through successive studs or joists that form a wall or floor/ceiling assembly.

18.4.7
No clearance shall be required where nonmetallic pipe has been demonstrated to have inherent flexibility equal to or greater than the minimum provided by flexible couplings located within 1 ft (300 mm) of each side of a wall, floor, platform, or foundation.

18.4.8
Where required, the clearance shall be filled with a flexible material that is compatible with the piping material.

18.4.9
The installed horizontal and upward vertical clearance between horizontal sprinkler piping and structural members not penetrated or used, collectively or independently, to support the piping shall be at least 2 in. (50 mm).

18.4.10*
No clearance shall be required where piping is supported by holes through structural members as permitted by 17.1.7.3.

18.4.11*
The installed clearance between a sprinkler and structural elements not used collectively or independently to support the sprinklers shall be at least 3 in. (75 mm).

18.4.11.1
Where sprinklers are installed using flexible sprinkler hose, clearance for the sprinkler shall not be required.

18.4.12
Clearance shall not be required for piping that is vertically supported by the bottom edge of holes through structural members as permitted by 17.1.7.3.

18.4.13
No horizontal clearance (tight fit) shall be provided for piping that is laterally supported by the side edges of holes through structural members.

18.4.13.1
Clearance shall be permitted where piping is secured to the structural member with an approved hanger or restraint.

18.5* Sway Bracing.

18.5.1 General.

18.5.1.1
The system piping shall be braced to resist both lateral and longitudinal horizontal seismic loads and to prevent vertical motion resulting from seismic loads.

18.5.1.2
The structural components to which bracing is attached shall be determined to be capable of resisting the added applied seismic loads.

18.5.1.3*
Horizontal loads on system piping shall be determined in accordance with 18.5.9.

18.5.1.4*
A shared support structure shall be permitted to support both the gravity loads addressed in 17.1.4.1 and the seismic loads addressed in 18.5.9.

18.5.1.4.1
When a shared support structure is used to support gravity and seismic loads, the structure shall be designed to support these loads for all pipe and distribution systems on the structure using either 18.5.9.3 or 18.5.9.4 with an importance factor, *Ip*, of 1.5 being applied to all of the distribution systems.

18.5.1.5*
If a shared support structure is used to support sprinkler pipe and other distribution systems per 17.1.4.1 and that structure does not provide seismic resistance as required in 18.5.1.4, the following shall be met:
(1) The sprinkler pipe shall be braced using the method in 18.5.6 with the zone of influence including the water-filled sprinkler pipe and all other distribution systems that are not independently equipped with seismic protection and attached to the shared support structure.

(2) The sprinkler sway bracing attachment shall be connected to the same building or structure as the shared support structure.

18.5.1.6
Bracing requirements of 18.5 shall not apply to drain piping downstream of the drain valve.

18.5.2 Listing.

18.5.2.1
Sway bracing assemblies shall be listed for a maximum load rating, unless the requirements of 18.5.2.2 are met.

18.5.2.2
Where sway bracing utilizing pipe, angles, flats, or rods as shown in Table 18.5.11.8(a), Table 18.5.11.8(b), and Table 18.5.11.8(c) is used, the components shall not require listing.

18.5.2.2.1
Bracing fittings and connections used with those specific materials shall be listed.

18.5.2.3*
The listed load rating shall be reduced as shown in Table 18.5.2.3 to determine the allowable load for installations where the brace is less than 90 degrees from vertical.

Table 18.5.2.3 Listed Horizontal Load Adjustment

Brace Angle Degrees from Vertical	Allowable Horizontal Load
30 to 44	Listed load rating divided by 2.000
45 to 59	Listed load rating divided by 1.414
60 to 89	Listed load rating divided by 1.155
90	Listed load rating

18.5.2.3.1*
Maximum allowable horizontal loads shall be determined by testing at angles of 30, 45, 60, and 90 degrees from vertical and confirmed to be equal to or greater than those calculated using 18.5.2.3.

18.5.2.3.2
For attachments to structures, additional tests shall be performed at 0 degrees.

18.5.3 Component Material.

18.5.3.1
Unless permitted by 18.5.3.2, components of sway brace assemblies shall be ferrous.

18.5.3.2
Nonferrous components that have been proven by fire tests to be adequate for the hazard application, that are listed for this purpose, and that are in compliance with the other requirements of this section shall be acceptable.

18.5.4 Sway Bracing Design.

18.5.4.1
Sway braces shall be designed to withstand forces in tension and compression, unless the requirements of 18.5.4.2 are met.

18.5.4.2*
Tension-only bracing systems shall be permitted for use where listed for this service and where installed in accordance with their listing limitations, including installation instructions.

18.5.4.3
For all braces, whether or not listed, the maximum allowable load shall be based on the weakest component of the brace with safety factors.

18.5.5 Lateral Sway Bracing.

18.5.5.1*

Lateral sway bracing shall be provided on all feed and cross mains regardless of size and all branch lines and other piping with a diameter of 2½ in. (65 mm) and larger.

18.5.5.1.1

Where branch lines are not provided with lateral sway bracing, they shall be provided with restraint in accordance with 18.6.

18.5.5.2*

The spacing between lateral sway braces shall be in accordance with either Table 18.5.5.2(a) through Table 18.5.5.2(l) or 18.5.5.3, based on the piping material of the sprinkler system.

Table 18.5.5.2(a) Maximum Load (F_{pw}) in Zone of Influence (lb), (F_y = 30 ksi) Schedule 10 Steel Pipe

Diameter of Pipe (in.) Being Braced	Lateral Sway Brace Spacing (ft)				
	20	**25**	**30**	**35**	**40**
1	111	89	73	63	52
1¼	176	141	116	99	83
1½	241	193	158	136	114
2	390	312	256	219	183
2½	641	513	420	360	301
3	966	773	633	543	454
3½	1281	1025	840	720	603
4	1634	1307	1071	918	769
5	2814	2251	1844	1581	1324
6 and larger*	4039	3231	2647	2269	1900

Note: ASTM A106 Grade B or ASTM A53 Grade B has an F_y = 35 ksi. An F_y = 30 ksi was used as a conservative value to account for differences in material properties as well as other operational stresses.

*Larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(b) Maximum Load (F_{pw}) in Zone of Influence (kg), (F_y = 207 N/mm^2) Schedule 10 Steel Pipe

Diameter of Pipe (mm) Being Braced	Lateral Sway Brace Spacing (m)				
	6.1	**7.6**	**9.1**	**10.7**	**12.2**
25	50	40	33	29	24
32	80	64	53	45	38
40	109	88	72	62	52
50	177	142	116	99	83
65	291	233	191	163	137
80	438	351	287	246	206
90	581	465	381	327	273
100	741	593	486	416	349
125	1276	1021	836	717	601

Diameter of Pipe (mm) Being Braced	Lateral Sway Brace Spacing (m)				
	6.1	7.6	9.1	10.7	12.2
150*	1832	1466	1201	1029	862

Note: ASTM A106 Grade B or ASTM A53 Grade B has an F_y = 241 N/mm^2. An F_y = 207 N/mm^2 was used also as a conservative value to account for differences in material properties as well as other operational stresses.

*Larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(c) Maximum Load (F_{pw}) in Zone of Influence (lb), (F_y= 30 ksi) Schedule 40 Steel Pipe

Diameter of Pipe (in.) Being Braced	Lateral Sway Brace Spacing (ft)				
	20	25	30	35	40
1	121	97	79	68	57
1¼	214	171	140	120	100
1½	306	245	201	172	144
2	520	416	341	292	245
2½	984	787	645	553	463
3	1597	1278	1047	897	751
3½	2219	1775	1455	1247	1044
4	2981	2385	1954	1675	1402
5	5061	4049	3317	2843	2381
6 and larger*	7893	6314	5173	4434	3713

Note: ASTM A106 Grade B or ASTM A53 Grade B has an F_y = 35 ksi. An F_y = 30 ksi was used as a conservative value to account for differences in material properties as well as other operational stresses.

*Larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(d) Maximum Load (F_{pw}) in Zone of Influence (kg), (F_y = 207 N/mm^2) Schedule 40 Steel Pipe

Diameter of Pipe (in.) Being Braced	Lateral Sway Brace Spacing (m)				
	6.1	7.6	9.1	10.7	12.2
25	55	44	36	31	26
32	97	78	63	54	45
40	139	111	91	78	65
50	236	189	155	132	111
65	446	357	293	251	210
80	724	580	475	407	341
90	1007	805	660	566	474
100	1352	1082	886	760	636
125	2296	1837	1505	1290	1080
150*	3580	2864	2346	2011	1684

Note: ASTM A106 Grade B or ASTM A53 Grade B has an F_y = 241 N/mm^2. An F_y = 207 N/mm^2 was used also as a conservative value to account for differences in material properties as well as other operational stresses.

*Larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(e) Maximum Load (F_{pw}) in Zone of Influence (lb), (F_y = 30 ksi) Schedule 5 Steel Pipe

Diameter of Pipe (in.) Being Braced	Lateral Sway Brace Spacing (ft)				
	20	25	30	35	40
1	71	56	46	40	33
1¼	116	93	76	65	55
1½	154	124	101	87	73
2	246	197	161	138	116
2½	459	367	301	258	216
3	691	552	453	388	325
3½	910	728	597	511	428
4*	1160	928	760	652	546

Note: ASTM A106 Grade B or ASTM A53 Grade B has an F_y = 35 ksi. An F_y = 30 ksi was used as a conservative value to account for differences in material properties as well as other operational stresses.

*Larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(f) Maximum Load (F_{pw}) in Zone of Influence (kg), (F_y = 207 N/mm^2) Schedule 5 Steel Pipe

Diameter of Pipe (mm) Being Braced	Lateral Sway Brace Spacing (m)				
	6.1	7.6	9.1	10.7	12.2
25	32	25	21	18	15
32	53	42	34	29	25
40	70	56	46	39	33
50	112	89	73	63	53
65	208	166	137	117	98
80	313	250	205	176	147
90	413	330	271	232	194
100*	526	421	345	296	248

Note: ASTM A106 Grade B or ASTM A53 Grade B has an F_y = 241 N/mm^2. An F_y = 207 N/mm^2 was used also as a conservative value to account for differences in material properties as well as other operational stresses.

*Larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(g) Maximum Load (F_{pw}) in Zone of Influence (lb), (F_y = 8 ksi) CPVC Pipe

Diameter of Pipe (in.) Being Braced	Lateral Sway Brace Spacing (ft)				
	20	25	30	35	40
¾	15	12	10	8	7

Diameter of Pipe (in.) Being Braced	Lateral Sway Brace Spacing (ft)				
	20	25	30	35	40
1	28	22	18	15	13
1¼	56	45	37	30	26
1½	83	67	55	45	39
2	161	129	105	87	76
2½	286	229	188	154	135
3	516	413	338	278	243

Table 18.5.5.2(h) Maximum Load (F_{pw}) in Zone of Influence (kg), (F_y = 55 N/mm²) CPVC Pipe

Diameter of Pipe (in.) Being Braced	Lateral Sway Brace Spacing (m)				
	6.1	7.6	9.1	10.7	12.2
20	7	5	5	4	3
25	13	10	8	7	6
32	25	20	17	14	12
40	38	30	25	20	18
50	73	59	48	39	34
65	130	104	85	70	61
80	234	187	153	126	110

Table 18.5.5.2(i) Maximum Load (F_{pw}) in Zone of Influence (lb), (F_y = 30 ksi) Type M Copper Tube (with Soldered Joints)

Diameter of Pipe (in.) Being Braced	Lateral Sway Brace Spacing (ft)				
	20	25	30	35	40
¾	16	13	10	9	8
1	29	24	19	16	14
1¼	53	42	35	28	25
1½	86	69	56	46	41
2*	180	144	118	97	85

*Larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(j) Maximum Load (F_{pw}) in Zone of Influence (kg), (F_y = 3207 N/mm²) Type M Copper Tube (with Soldered Joints)

Diameter of Pipe (in.) Being Braced	Lateral Sway Brace Spacing (m)				
	6.1	7.6	9.1	10.7	12.2
20	7.3	5.9	5	4.1	3.6
25	13.2	10.9	8.6	7.3	6.4
32	24	19.1	15.9	12.7	11.3
40	39	31.3	25.4	20.9	18.6
50*	81.6	65.3	53	44	38.6

*Larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(k) Maximum Load (F_{pw}) in Zone of Influence (lb), (F_y = 9 ksi) Type M Copper Tube (with Brazed Joints)

Lateral Sway Spacing (ft)					
Diameter of Pipe (in.) Being Braced	**20**	**25**	**30**	**35**	**40**
¾	6	5	4	3	3
1	11	9	7	6	5
1¼	20	16	13	12	10
1½	33	27	22	19	16
2*	70	56	46	39	33

*Larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(l) Maximum Load (F_{pw}) in Zone of Influence (lb), (F_y = 9 ksi) Red Brass Pipe (with Brazed Joints)

Lateral Sway Spacing (ft)					
Diameter of Pipe (in.) Being Braced	**20**	**25**	**30**	**35**	**40**
¾	34	27	22	19	16
1	61	49	40	35	29
1¼	116	93	76	65	55
1½	161	129	105	90	76
2*	272	218	178	153	128

*Larger diameter pipe can be used when justified by engineering analysis.

18.5.5.2.1
Specially listed nonstandard pipe shall be permitted using the values in Table 18.5.5.2(e) and Table 18.5.5.2(f) or with values provided by the manufacturer.

18.5.5.2.2
Spacing shall not exceed a maximum interval of 40 ft (12 m) on center.

18.5.5.2.3
The maximum permissible load in the zone of influence of a sway brace shall not exceed the values given in Table 18.5.5.2(a) through Table 18.5.5.2(l) or the values calculated in accordance with 18.5.5.3.

18.5.5.2.4
When determining permissible loads in accordance with 18.5.5.2 or 18.5.5.2.1 on a main with varying sizes, the allowable load shall be based on the smallest pipe size within the zone of influence.

18.5.5.3
The maximum load (F_{pw}) in the zone of influence for specially listed pipe shall be calculated. *(See Annex **E**.)*

18.5.5.4
The requirements of 18.5.5.1 shall not apply to 2½ in. (65 mm) starter pieces that do not exceed 12 ft (3.7 m) in length.

18.5.5.5
The distance between the last brace and the end of the pipe shall not exceed 6 ft (1.8 m).

18.5.5.6

Where there is a change in direction of the piping, the cumulative distance between consecutive lateral sway braces shall not exceed the maximum permitted distance in accordance with 18.5.5.2.2.

18.5.5.7
The last length of pipe at the end of a feed or cross main shall be provided with a lateral brace.

18.5.5.8
Lateral braces shall be allowed to act as longitudinal braces if they are within 24 in. (600 mm) of the centerline of the piping braced longitudinally and the lateral brace is on a pipe of equal or greater size than the pipe being braced longitudinally.

18.5.5.9
Where flexible couplings are installed on mains other than as required in 18.2, a lateral brace shall be provided within 24 in. (600 mm) of every other coupling, including flexible couplings at grooved fittings, but not more than 40 ft (12 m) on center.

18.5.5.10*
The lateral sway bracing required by 18.5.5 shall be permitted to be omitted when 18.5.5.10.1 for branch lines or 18.5.5.10.2 for mains is met.

18.5.5.10.1
Branch lines shall comply with the following:
(1) *The branch lines shall be individually supported within 6 in. (150 mm) of the structure, measured between the top of the pipe and the point of attachment to the building structure.

(2) At least 75 percent of all the hangers on the branch line shall meet the requirements of 18.5.5.10.1(1).

(3) Consecutive hangers on the branch line shall not be permitted to exceed the limitation in 18.5.5.10.1(1).

18.5.5.10.2
Mains shall comply with all the following:
(1) *The main piping shall be individually supported within 6 in. (150 mm) of the structure, measured between the top of the pipe and the point of attachment to the building structure.

(2) At least 75 percent of all the hangers on the main shall meet the requirements of 18.5.5.10.2(1).

(3) Consecutive hangers on the main shall not be permitted to exceed the limitation in 18.5.5.10.2(1)

(4) The seismic coefficient (C_p) shall not exceed 0.5.

(5) The nominal pipe diameter shall not exceed 6 in. (152 mm) for feed mains and 4 in. (102 mm) for cross mains.

(6) Hangers shall not be omitted in accordance with 17.4.4.3, 17.4.4.4, or 17.4.4.5.

18.5.5.10.3
Branch lines permitted to omit lateral sway bracing by 18.5.5.10 shall not be omitted from load calculations for the mains serving them in 18.5.9.6.

18.5.5.11
The lateral sway bracing required by18.5.5 shall be permitted to be omitted when 18.5.5.11.1 for branch lines or 18.5.5.11.2 for mains is met.

18.5.5.11.1
Branch lines shall comply with the following:
(1) The branch lines shall be individually supported by wraparound u-hooks or u-hooks arranged to keep pipe tight to the underside of the structural element provided the legs are bent out at least 30 degrees from the vertical and the maximum length of each leg and the rod size satisfies the conditions of Table 18.5.11.8(a), Table 18.5.11.8(b), and Table 18.5.11.8(c).

(2) At least 75 percent of all the hangers on the branch line shall meet the requirements of 18.5.5.11.2(1).

(3) Consecutive hangers on the branch line shall not be permitted to exceed the limitation in 18.5.5.11.2(1).

18.5.5.11.2
Mains shall comply with all the following:

(1) The main piping shall be individually supported by wraparound u-hooks or u-hooks arranged to keep pipe tight to the underside of the structural element provided the legs are bent out at least 30 degrees from the vertical and the maximum length of each leg and rod size satisfies the conditions of Table 18.5.11.8(a), Table 18.5.11.8(b), and Table 18.5.11.8(c).

(2) At least 75 percent of all the hangers on the main shall meet the requirements of 18.5.5.11.2(1).

(3) Consecutive hangers on the main shall not be permitted to exceed the limitation in 18.5.5.11.2(1).

(4) The seismic coefficient (C_p) shall not exceed 0.5.

(5) The nominal pipe diameter shall not exceed 6 in. (152 mm) for feed mains and 4 in. (102 mm) for cross mains.

(6) Hangers shall not be omitted in accordance with 17.4.4.3, 17.4.4.4, or 17.4.4.5.

18.5.6 Longitudinal Sway Bracing.

18.5.6.1
Longitudinal sway bracing spaced at a maximum of 80 ft (24 m) on center shall be provided for feed and cross mains.

18.5.6.2
Longitudinal braces shall be allowed to act as lateral braces if they are within 24 in. (600 mm) of the centerline of the piping braced laterally.

18.5.6.3
The distance between the last brace and the end of the pipe or a change in direction shall not exceed 40 ft (12 m).

18.5.7 Pipe with Change(s) in Direction.

18.5.7.1
Each run of pipe between changes in direction shall be provided with both lateral and longitudinal bracing, unless the requirements of 18.5.7.2 are met.

18.5.7.2*
Pipe runs less than 12 ft (3.7 m) in length shall be permitted to be supported by the braces on adjacent runs of pipe.

18.5.8 Sway Bracing of Risers.

18.5.8.1*
Tops of risers exceeding 3 ft (900 mm) in length shall be provided with a four-way brace.

18.5.8.2
Riser nipples shall be permitted to omit the four-way brace required by 18.5.8.1.

18.5.8.3
When a four-way brace at the top of a riser is attached on the horizontal piping, it shall be within 24 in. (600 mm) of the centerline of the riser and the loads for that brace shall include both the vertical and horizontal pipe.

18.5.8.4
Distance between four-way braces for risers shall not exceed 25 ft (7.6 m).

18.5.8.5
Four-way bracing shall not be required where risers penetrate intermediate floors in multistory buildings where the clearance does not exceed the limits of 18.4.

18.5.9* Horizontal Seismic Loads.

18.5.9.1*
The horizontal seismic load for the braces shall be as determined in 18.5.9.6 or 18.5.9.7, or as required by the authority having jurisdiction.

18.5.9.2
The weight of the system being braced (W_p) shall be taken as 1.15 times the weight of the water-filled piping. *(See A.18.5.9.1.)*

18.5.9.3
The horizontal force, F_{pw}, acting on the brace shall be taken as $F_{pw} = C_p W_p$, where C_p is the seismic coefficient selected in Table 18.5.9.3 utilizing the short period response parameter, S_s.

Table 18.5.9.3 Seismic Coefficient Table

S_S	C_p	S_S	C_p
0.33 or less	0.35	2.2	1.03
0.4	0.38	2.3	1.07
0.5	0.4	2.4	1.12
0.6	0.42	2.5	1.17
0.7	0.42	2.6	1.21
0.8	0.44	2.7	1.26
0.9	0.48	2.8	1.31
1	0.51	2.9	1.35
1.1	0.54	3	1.4
1.2	0.57	3.1	1.45
1.3	0.61	3.2	1.49
1.4	0.65	3.3	1.54
1.5	0.7	3.4	1.59
1.6	0.75	3.5	1.63
1.7	0.79	3.6	1.68
1.8	0.84	3.7	1.73
1.9	0.89	3.8	1.77
2	0.93	3.9	1.82
2.1	0.98	4	1.87

18.5.9.3.1
The value of S_s used in Table 18.5.9.3 shall be obtained from the authority having jurisdiction or from seismic hazard maps.

18.5.9.3.2*
Linear interpolation shall be permitted to be used for intermediate values of S_s.

18.5.9.4*
The horizontal force, F_{pw}, acting on the brace shall be permitted to be determined in accordance with Section 13.3.1 of SEI/ASCE 7, *Minimum Design Loads of Buildings and Other Structures*, multiplied by 0.7 to convert to allowable stress design (ASD).

18.5.9.5*
Where data for determining C_p are not available, the horizontal seismic force acting on the braces shall be determined as specified in 18.5.9.3 with $C_p = 0.5$.

18.5.9.6*
The zone of influence for lateral braces shall include all branch lines, drops, sprigs, and mains tributary to the brace, except branch lines that are provided with longitudinal bracing or as prohibited by 18.5.9.6.1.

18.5.9.6.1*
When riser nipples are provided in systems requiring seismic protection, they shall satisfy the following equation, unless one of the following conditions is met:

(1) Where riser nipples are 4 ft (1.2 m) or less in length and C_p is 0.50 or less

(2) Where riser nipples are 3 ft (900 mm) or less in length and C_p is less than 0.67

(3) Where riser nipples are 2 ft (600 mm) in length or less and C_p is less than is 1.0

$$\frac{\left(H_r \cdot W_p \cdot C_p\right)}{S} \geq F_y$$

[18.3.5.9.6.1]

where:

H_r = length of riser nipple piping (in inches)

W_p = tributary weight (in pounds) for the branch line or portion of branch line within the zone of influence including the riser nipple

C_p = seismic coefficient

S = sectional modulus of the riser nipple pipe

F_y = allowable yield strength of 30,000 psi (2070 bar) for steel, 30,000 psi for copper (soldered), 8000 psi (550 bar) for CPVC

18.5.9.6.2
If the calculated value is equal to or greater than the yield strength of the riser nipple, the longitudinal seismic load of each line shall be evaluated individually, and branch lines shall be provided with longitudinal sway bracing per 18.5.6.

18.5.9.7
The zone of influence for longitudinal braces shall include all mains tributary to the brace.

18.5.10 Net Vertical Reaction Forces.
Where the horizontal seismic loads used exceed 0.5 W_p and the brace angle is less than 45 degrees from vertical or where the horizontal seismic load exceeds 1.0 W_p and the brace angle is less than 60 degrees from vertical, the braces shall be arranged to resist the net vertical reaction produced by the horizontal load.

18.5.11* Sway Brace Installation.

18.5.11.1*
Bracing shall be attached directly to the system pipe.

18.5.11.2
Sway bracing shall be tight.

18.5.11.3
For individual braces, the slenderness ratio *(l/r)* shall not exceed 300, where *l* is the length of the brace and *r* is the least radius of gyration.

18.5.11.4
Where threaded pipe is used as part of a sway brace assembly, it shall not be less than Schedule 30.

18.5.11.5
All parts and fittings of a brace shall lie in a straight line to avoid eccentric loadings on fittings and fasteners.

18.5.11.6
For longitudinal braces only, the brace shall be permitted to be connected to a tab welded to the pipe in conformance to 7.5.2.

18.5.11.7
For tension-only braces, two tension-only brace components opposing each other must be installed at each lateral or longitudinal brace location.

18.5.11.8
The loads determined in 18.5.9 shall not exceed the lesser of the maximum allowable loads provided in Table 18.5.11.8(a), Table 18.5.11.8(b), and Table 18.5.11.8(c)and the manufacturer's certified maximum allowable horizontal loads for brace angles of 30 to 44 degrees, 45 to 59 degrees, 60 to 89 degrees, or 90 degrees.

Table 18.5.11.8(a) Maximum Horizontal Loads for Sway Braces with *l/r* = 100 for Steel Braces with F_y = 36 ksi

Brace Shape and Size (in.)		Area (in.^{2})	Least Radius of Gyration *(r)* (in.)	Maximum Length for *l/r* = 100		Maximum Horizontal Load (lb)		
						Brace Angle		
				ft	in.	30° to 44° Angle from Vertical	45° to 59° Angle from Vertical	60° to 90° Angle from Vertical
Pipe Schedule 40	1	0.494	0.421	3	6	3,150	4,455	5,456
	1¼	0.669	0.540	4	6	4,266	6,033	7,389
	1½	0.799	0.623	5	2	5,095	7,206	8,825
	2	1.07	0.787	6	6	6,823	9,650	11,818

Brace Shape and Size (in.)		Area (in.^{2})	Least Radius of Gyration *(r)* (in.)	Maximum Length for *l*/*r* = 100		Maximum Horizontal Load (lb)		
						Brace Angle		
				ft	in.	30° to 44° Angle from Vertical	45° to 59° Angle from Vertical	60° to 90° Angle from Vertical
Angles	1½ × 1½ × ¼	0.688	0.292	2	5	4,387	6,205	7,599
	2 × 2 × ¼	0.938	0.391	3	3	5,982	8,459	10,360
	2½ × 2 × ¼	1.06	0.424	3	6	6,760	9,560	11,708
	2½ × 2½ × ¼	1.19	0.491	4	1	7,589	10,732	13,144
	3 × 2½ × ¼	1.31	0.528	4	4	8,354	11,814	14,469
	3 × 3 × ¼	1.44	0.592	4	11	9,183	12,987	15,905
Rods (all thread)	⅜	0.07	0.075	0	7	446	631	773
	½	0.129	0.101	0	10	823	1,163	1,425
	⅝	0.207	0.128	1	0	1,320	1,867	2,286
	¾	0.309	0.157	1	3	1,970	2,787	3,413
	⅞	0.429	0.185	1	6	2,736	3,869	4,738
Rods (threaded at ends only)	⅜	0.11	0.094	0	9	701	992	1,215
	½	0.196	0.125	1	0	1,250	1,768	2,165
	⅝	0.307	0.156	1	3	1,958	2,769	3,391
	¾	0.442	0.188	1	6	2,819	3,986	4,882
	⅞	0.601	0.219	1	9	3,833	5,420	6,638
Flats	1½ × ¼	0.375	0.0722	0	7	2,391	3,382	4,142
	2 × ¼	0.5	0.0722	0	7	3,189	4,509	5,523
	2 × ⅜	0.75	0.1082	0	10	4,783	6,764	8,284

Table 18.5.11.8(b) Maximum Horizontal Loads for Sway Braces with *l*/*r* = 200 for Steel Braces with F_y = 36 ksi

Brace Shape and Size (in.)		Area (in.^{2})	Least Radius of Gyration *(r)* (in.)	Maximum Length for *l/r* = 200		Maximum Horizontal Load (lb) Brace Angle		
				ft	in.	30° to 44° Angle from Vertical	45° to 59° Angle from Vertical	60° to 90° Angle from Vertical
Pipe Schedule 40	1	0.494	0.421	7	0	926	1310	1604
	1¼	0.669	0.540	9	0	1254	1774	2173
	1½	0.799	0.623	10	4	1498	2119	2595
	2	1.07	0.787	13	1	2006	2837	3475
Angles	1½ × 1½ × ¼	0.688	0.292	4	10	1290	1824	2234
	2 × 2 × ¼	0.938	0.391	6	6	1759	2487	3046
	2½ × 2 × ¼	1.06	0.424	7	0	1988	2811	3442
	2½ × 2½ × ¼	1.19	0.491	8	2	2231	3155	3865
	3 × 2½ × ¼	1.31	0.528	8	9	2456	3474	4254
	3 × 3 × ¼	1.44	0.592	9	10	2700	3818	4677
Rods (all thread)	⅜	0.07	0.075	1	2	131	186	227
	½	0.129	0.101	1	8	242	342	419
	⅝	0.207	0.128	2	1	388	549	672
	¾	0.309	0.157	2	7	579	819	1004
	⅞	0.429	0.185	3	0	804	1138	1393
Rods (threaded at ends only)	⅜	0.11	0.094	1	6	206	292	357
	½	0.196	0.125	2	0	368	520	637
	⅝	0.307	0.156	2	7	576	814	997
	¾	0.442	0.188	3	1	829	1172	1435
	⅞	0.601	0.219	3	7	1127	1594	1952
Flats	1½ × ¼	0.375	0.0722	1	2	703	994	1218
	2 × ¼	0.5	0.0722	1	2	938	1326	1624
	2 × ⅜	0.75	0.1082	1	9	1406	1989	2436

Table 18.5.11.8(c) Maximum Horizontal Loads for Sway Braces with *l/r* = 300 for Steel Braces with F_y = 36 ksi

Brace Shape and Size (in.)		Area (in.²)	Least Radius of Gyration *(r)* (in.)	Maximum Length for *l/r* = 300		Maximum Horizontal Load (lb)		
						Brace Angle		
				ft	in.	30° to 44° Angle from Vertical	45° to 59° Angle from Vertical	60° to 90° Angle from Vertical
Pipe Schedule 40	1	0.494	0.421	10	6	412	582	713
	1¼	0.669	0.540	13	6	558	788	966
	1½	0.799	0.623	15	6	666	942	1153
	2	1.07	0.787	19	8	892	1261	1544
Angles	1½ × 1½ × ¼	0.688	0.292	7	3	573	811	993
	2 × 2 × ¼	0.938	0.391	9	9	782	1105	1354
	2½ × 2 × ¼	1.06	0.424	10	7	883	1249	1530
	2½ × 2½ × ¼	1.19	0.491	12	3	992	1402	1718
	3 × 2½ × ¼	1.31	0.528	13	2	1092	1544	1891
	3 × 3 × ¼	1.44	0.592	14	9	1200	1697	2078
Rods (all thread)	⅜	0.07	0.075	1	10	58	82	101
	½	0.129	0.101	2	6	108	152	186
	⅝	0.207	0.128	3	2	173	244	299
	¾	0.309	0.157	3	11	258	364	446
	⅞	0.429	0.185	4	7	358	506	619
Rods (threaded at ends only)	⅜	0.11	0.094	2	4	92	130	159
	½	0.196	0.125	3	1	163	231	283
	⅝	0.307	0.156	3	10	256	362	443
	¾	0.442	0.188	4	8	368	521	638
	⅞	0.601	0.219	5	5	501	708	867
Flats	1½ × ¼	0.375	0.0722	1	9	313	442	541
	2 × ¼	0.5	0.0722	1	9	417	589	722

Brace Shape and Size (in.)	Area (in.^{2})	Least Radius of Gyration *(r)* (in.)	Maximum Length for *l*/*r* = 300		Maximum Horizontal Load (lb)		
					Brace Angle		
			ft	in.	30° to 44° Angle from Vertical	45° to 59° Angle from Vertical	60° to 90° Angle from Vertical
2 × 3⁄8	0.75	0.1082	2	8	625	884	1083

Table 18.5.11.8(d) Maximum Horizontal Loads for Sway Braces with *l*/*r* = 100 for Steel Braces with F_y = 248 N/mm^2

Brace Shape and Size (mm)		Area (mm^2)	Least Radius of Gyration *(r)* mm)	Maximum Length for *l*/*r* = 100		Maximum Horizontal Load (kg)		
						Brace Angle		
				meters	mm	30° to 44° Angle from Vertical	45° to 59° Angle from Vertical	60° to 90° Angle from Vertical
Pipe Schedule 40	25	318.7	11	1.0	150	1,429	2,021	2,475
	32	431.6	14	1.2	150	1.935	2,737	3,352
	40	515.5	16	1.5	50	2,311	3,269	4,003
	50	690.3	20	1.8	150	3,095	4,377	5,361
Angles	40 × 40 × 6	443.9	7	0.6	125	1,990	2,815	3,447
	50 × 50 × 6	605.2	10	1.0	75	2,713	3,837	4,699
	65 × 50 × 6	683.9	11	1.0	150	3,066	4,336	5,311
	65 × 65 × 6	767.7	12	1.2	25	3,442	4,868	5,962

Brace Shape and Size (mm)		Area (mm^2)	Least Radius of Gyration *(r)* mm)	Maximum Length for *l/r* = 100		Maximum Horizontal Load (kg)		
						Brace Angle		
				meters	mm	30° to 44° Angle from Vertical	45° to 59° Angle from Vertical	60° to 90° Angle from Vertical
	80 × 65 × 6	845.2	13	1.2	100	3,789	5,359	6,563
	80 × 80 × 6	929.0	15	1.2	275	4,165	5,891	7,214
Rods (all thread)	10	45.2	2	0.0	175	202	286	351
	15	83.2	3	0.0	250	373	528	646
	16	133.5	3	0.3	0	599	847	1,037
	20	199.4	4	0.3	75	894	1,264	1,548
	22	276.8	5	0.3	150	1,241	1,755	2,149
Rods (threaded at ends only)	10	71.0	2	0.0	225	318	450	551
	15	126.5	3	0.3	0	567	802	982
	16	198.1	4	0.3	75	888	1,256	1,538
	20	285.2	5	0.3	150	1,279	1,808	2,214
	22	387.7	5	0.3	225	1,739	2,458	3,011
Flats	40 × 6	241.9	2	0.0	175	1,085	1,534	1,879
	50 × 6	322.6	2	0.0	175	1,447	2,045	2,505
	50 × 10	483.9	3	0.0	250	2,170	3,068	3,758

Table 18.5.11.8(e) Maximum Horizontal Loads for Sway Braces with *l/r* = 200 for Steel Braces with F_y = 248 N/mm²

Brace Shape and Size (mm)		Area (mm²)	Least Radius of Gyration *(r)* mm)	Maximum Length for *l/r* = 200		Maximum Horizontal Load (kg)		
						Brace Angle		
				meters	mm	30° to 44° Angle from Vertical	45° to 59° Angle from Vertical	60° to 90° Angle from Vertical
Pipe Schedule 40	25	318.7	11	2.1	0	420	594	728
	32	431.6	14	2.7	0	569	805	986
	40	515.5	16	3	100	679	961	1177
	50	690.3	20	4.0	25	910	1287	1576
Angles	40 × 40 × 6	443.9	7	1.2	250	585	827	1013
	50 × 50 × 6	605.2	10	1.8	150	798	1128	1382
	65 × 50 × 6	683.9	11	2.1	0	902	1275	1561
	65 × 65 × 6	767.7	12	2.4	50	1012	1431	1753
	80 × 65 × 6	845.2	13	2.4	225	1114	1576	1930
	80 × 80 × 6	929.0	15	2.7	250	1225	1732	2121
Rods (all thread)	10	45.2	2	0.3	50	59	84	103
	15	83.2	3	0.3	200	110	155	190
	16	133.5	3	0.6	25	176	249	305
	20	199.4	4	0.6	175	263	371	455
	22	276.8	5	0.9	0	365	516	632
Rods (threaded at ends only)	10	71.0	2	0.3	150	93	132	162
	15	126.5	3	0.6	0	167	236	289
	16	198.1	4	0.6	175	261	369	452
	20	285.2	5	0.9	25	376	532	651
	22	387.7	5	0.9	175	511	723	885
Flats	40 × 6	241.9	2	0.3	50	319	451	552

Brace Shape and Size (mm)		Area (mm^2)	Least Radius of Gyration *(r)* mm)	Maximum Length for ***l/r*** = 200		Maximum Horizontal Load (kg)		
						Brace Angle		
				meters	mm	30° to 44° Angle from Vertical	45° to 59° Angle from Vertical	60° to 90° Angle from Vertical
	50 × 6	322.6	2	0.3	50	425	601	737
	50 × 10	483.9	3	0.3	225	638	902	1105

Table 18.5.11.8(f) Maximum Horizontal Loads for Sway Braces with *l/r* = 300 for Steel Braces with F_y = 248 N/mm²

Brace Shape and Size (mm)		Area (mm^2)	Least Radius of Gyration *(r)* mm)	Maximum Length for ***l/r*** = 300		Maximum Horizontal Load (kg)		
						Brace Angle		
				meters	mm	30° to 44° Angle from Vertical	45° to 59° Angle from Vertical	60° to 90° Angle from Vertical
Pipe Schedule 40	25	318.7	10.5	3	150	187	264	323
	32	431.6	13.5	4	150	253	357	438
	40	515.5	15.6	4.6	150	302	427	523
	50	690.3	19.7	5.8	200	405	572	700
Angles	40 × 40 × 6	443.9	7.3	2.1	75	260	368	450
	50 × 50 × 6	605.2	9.8	2.7	225	355	501	614
	65 × 50 × 6	683.9	10.6	3	175	401	567	694
	65 × 65 × 6	767.7	12.3	3.7	75	450	636	779
	80 × 65 × 6	845.2	13.2	4	50	495	700	858
	80 × 80 × 6	929.0	14.8	4.3	225	544	770	943

Brace Shape and Size (mm)		Area (mm^2)	Least Radius of Gyration *(r)* mm)	Maximum Length for *l/r* = 300		Maximum Horizontal Load (kg)		
						Brace Angle		
				meters	mm	30° to 44° Angle from Vertical	45° to 59° Angle from Vertical	60° to 90° Angle from Vertical
Rods (all thread)	10	45.2	1.9	0.3	250	26	37	46
	15	83.2	2.5	0.6	150	49	69	84
	16	133.5	3.2	0.9	50	79	111	136
	20	199.4	3.9	0.9	275	117	165	202
	22	276.8	4.6	1.2	175	162	230	281
Rods (threaded at ends only)	10	71.0	2.4	0.6	100	42	59	72
	15	126.5	3.1	0.9	25	74	105	128
	16	198.1	3.9	0.9	250	116	164	201
	20	285.2	4.7	1.2	200	167	236	289
	22	387.7	5.5	1.5	125	227	321	393
Flats	40 × 6	241.9	1.8	0.3	225	142	200	245
	50 × 6	322.6	1.8	0.3	225	189	267	327
	50 × 10	483.9	2.7	0.6	200	283	401	491

18.5.11.9*

Other pipe schedules and materials not specifically included in Table 18.5.11.8(a), Table 18.5.11.8(b), and Table 18.5.11.8(c) shall be permitted to be used if certified by a registered professional engineer to support the loads determined in accordance with the criteria in the tables.

18.5.11.9.1

Calculations shall be submitted where required by the authority having jurisdiction.

18.5.11.10

C-type clamps including beam and large flange clamps, with or without restraining straps, shall not be used to attach braces to the building structure.

18.5.11.11

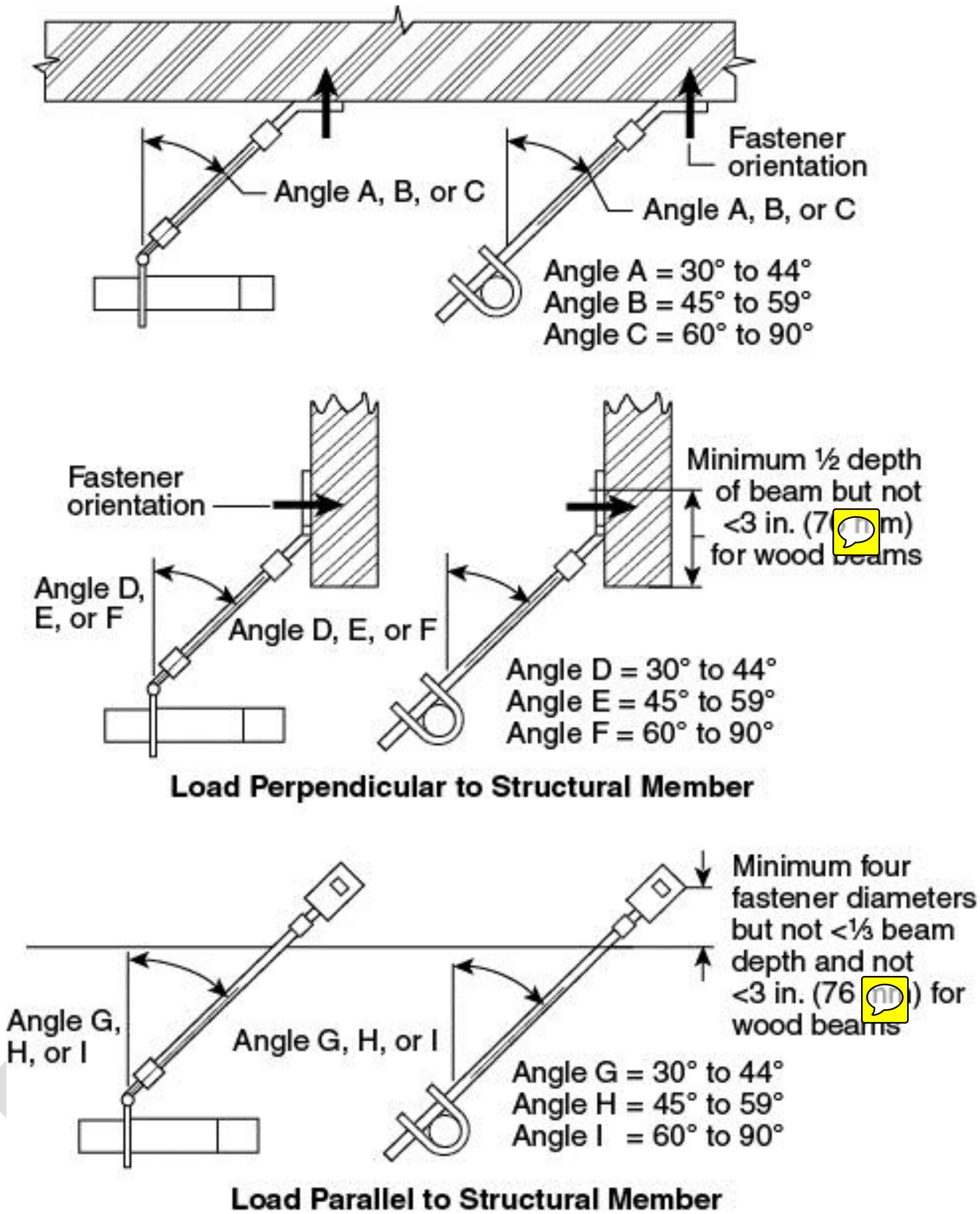
Powder-driven fasteners shall not be used to attach braces to the building structure, unless they are specifically listed for service in resisting lateral loads in areas subject to earthquakes.

18.5.12* Fasteners.

18.5.12.1

The designated angle category for the fastener(s) used in the sway brace installation shall be determined in accordance with Figure 18.5.12.1.

Figure 18.5.12.1 Designation of Angle Category Based on Angle of Sway Brace and Fastener Orientation.



18.5.12.2*

For individual fasteners, unless alternative allowable loads are determined and certified by a registered professional engineer, the loads determined in **18.5.9** shall not exceed the allowable loads provided in Table 18.5.12.2(a) through Table 18.5.12.2(i) or 18.5.12.7.

Table 18.5.12.2(a) Maximum Load for Wedge Anchors in 3000 psi (207 bar) Lightweight Cracked Concrete on Metal Deck

Wedge Anchors in 3000 psi Lightweight Cracked Concrete on Metal Deck (lb)										
Diameter (in.)	Embedment (in.)	A	B	C	D	E	F	G	H	I
		***Pr** ≤2.0*	***Pr** ≤1.1*	***Pr** ≤0.7*	***Pr** ≤1.2*	***Pr** ≤1.1*	***Pr** ≤1.1*	***Pr** ≤1.4*	***Pr** ≤0.9*	***Pr** ≤0.8*
⅜	2	117	184	246	—	—	—	—	—	—

Wedge Anchors in 3000 psi Lightweight Cracked Concrete on Metal Deck (lb)										
½	2⅜	164	257	344	—	—	—	—	—	—
⅝	3⅛	214	326	424	—	—	—	—	—	—
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		2.1–3.5	**1.2–1.8**	**0.8–1.0**	**1.3–1.7**	**1.2–1.8**	**1.2–2.0**	**1.5–1.9**	**1.0–1.3**	**0.9–1.1**
⅜	2	69	127	196	—	—	—	—	—	—
½	2⅜	97	178	274	—	—	—	—	—	—
⅝	3⅛	133	232	346	—	—	—	—	—	—
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		3.6–5.0	**1.9–2.5**	**1.1–1.3**	**1.8–2.2**	**1.9–2.5**	**2.1–2.9**	**2.0–2.4**	**1.4–1.7**	**1.2–1.4**
⅜	2	48	97	163	—	—	—	—	—	—
½	2⅜	67	136	228	—	—	—	—	—	—
⅝	3⅛	93	179	292	—	—	—	—	—	—
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		5.1–6.5	**2.6–3.2**	**1.4–1.6**	**2.3–2.7**	**2.6–3.2**	**3.0–3.8**	**2.5–2.9**	**1.8–2.1**	**1.5–1.7**
⅜	2	36	75	139	—	—	—	—	—	—
½	2⅜	51	106	196	—	—	—	—	—	—
⅝	3⅛	71	146	252	—	—	—	—	—	—

**Pr* = Prying Factor Range. (Refer to Annex for additional information.)

1 lb = 0.45 kg

Table 18.5.12.2(b) Maximum Load for Wedge Anchors in 3000 psi (207 bar) Lightweight Cracked Concrete

Wedge Anchors in 3000 psi Lightweight Cracked Concrete (lb)										
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr*	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		≤2.0	**≤1.1**	**≤0.7**	**≤1.2**	**≤1.1**	**≤1.1**	**≤1.4**	**≤0.9**	**≤0.8**
⅜	2	102	144	175	101	144	184	87	128	152
½	2⅜	140	196	238	137	196	251	118	174	207
⅝	3¼	222	308	372	215	308	397	220	272	323
¾	4⅛	327	469	580	336	469	586	289	426	504
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		2.1–3.5	**1.2–1.8**	**0.8–1.0**	**1.3–1.7**	**1.2–1.8**	**1.2–2.0**	**1.5–1.9**	**1.0–1.3**	**0.9–1.1**
⅜	2	69	109	150	87	109	121	76	110	133

Wedge Anchors in 3000 psi Lightweight Cracked Concrete (lb)										
½	2⅜	94	149	205	119	149	166	104	150	181
⅝	3¼	151	237	322	187	237	265	201	236	285
¾	4⅛	217	351	492	286	351	380	252	362	436
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		3.6–5.0	**1.9–2.5**	**1.1–1.3**	**1.8–2.2**	**1.9–2.5**	**2.1–2.9**	**2.0–2.4**	**1.4–1.7**	**1.2–1.4**
⅜	2	52	88	132	76	88	90	68	97	118
½	2⅜	71	121	180	104	121	124	93	132	161
⅝	3¼	114	192	284	165	192	198	185	208	254
¾	4⅛	162	280	427	249	280	281	223	315	385
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		5.1–6.5	**2.6–3.2**	**1.4–1.6**	**2.3–2.7**	**2.6–3.2**	**3.0–3.8**	**2.5–2.9**	**1.8–2.1**	**1.5–1.7**
⅜	2	41	74	117	68	74	70	61	86	106
½	2⅜	56	101	160	93	101	97	84	118	145
⅝	3¼	91	161	253	148	161	157	172	186	230
¾	4⅛	124	233	378	221	233	214	200	279	344

**Pr* = Prying Factor Range. (Refer to Annex for additional information.)

1 lb = 0.45 kg

Table 18.5.12.2(c) Maximum Load for Wedge Anchors in 3000 psi (207 bar) Normal Weight Cracked Concrete

Wedge Anchors in 3000 psi Normal Weight Cracked Concrete (lb)										
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr*	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		≤2.0	**≤1.1**	**≤0.7**	**≤1.2**	**≤1.1**	**≤1.1**	**≤1.4**	**≤0.9**	**≤0.8**
⅜	2	171	240	292	169	240	307	145	214	254
½	3⅝	412	567	682	394	567	735	340	498	592
⅝	3⅞	480	668	809	468	668	859	479	591	703
¾	4⅛	545	780	965	559	780	976	482	709	839
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		2.1–3.5	**1.2–1.8**	**0.8–1.0**	**1.3–1.7**	**1.2–1.8**	**1.2–2.0**	**1.5–1.9**	**1.0–1.3**	**0.9–1.1**
⅜	2	116	183	252	146	183	203	128	184	223
½	3⅝	282	438	592	344	438	493	302	434	523
⅝	3⅞	327	512	699	406	512	571	438	512	618
¾	4⅛	363	584	819	477	584	634	420	604	727

Wedge Anchors in 3000 psi Normal Weight Cracked Concrete (lb)										
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		3.6–5.0	**1.9–2.5**	**1.1–1.3**	**1.8–2.2**	**1.9–2.5**	**2.1–2.9**	**2.0–2.4**	**1.4–1.7**	**1.2–1.4**
⅜	2	87	148	221	128	148	152	114	162	198
½	3⅝	214	357	523	305	357	371	271	384	469
⅝	3⅞	247	415	615	359	415	428	404	452	551
¾	4⅛	271	467	712	416	467	468	371	526	641
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		5.1–6.5	**2.6–3.2**	**1.4–1.6**	**2.3–2.7**	**2.6–3.2**	**3.0–3.8**	**2.5–2.9**	**1.8–2.1**	**1.5–1.7**
⅜	2	69	124	197	115	124	118	103	145	178
½	3⅝	173	301	469	274	301	296	247	345	425
⅝	3⅞	197	349	549	321	349	337	374	404	498
¾	4⅛	208	389	629	369	389	357	333	465	573

**Pr* = Prying Factor Range. (Refer to Annex for additional information.)

1 lb = 0.45 kg

Table 18.5.12.2(d) Maximum Load for Wedge Anchors in 4000 psi (276 bar) Normal Weight Cracked Concrete

Wedge Anchors in 4000 psi Normal Weight Cracked Concrete (lb)										
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr*	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		≤2.0	**≤1.1**	**≤0.7**	**≤1.2**	**≤1.1**	**≤1.1**	**≤1.4**	**≤0.9**	**≤0.8**
⅜	2	200	282	344	199	282	359	171	251	299
½	3⅝	430	607	742	430	607	770	370	544	645
⅝	3⅞	532	729	872	505	729	950	511	636	758
¾	4⅛	630	903	1117	647	903	1129	558	821	971
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		2.1–3.5	**1.2–1.8**	**0.8–1.0**	**1.3–1.7**	**1.2–1.8**	**1.2–2.0**	**1.5–1.9**	**1.0–1.3**	**0.9–1.1**
⅜	2	135	214	295	171	214	236	150	216	261
½	3⅝	289	460	636	370	460	506	325	467	563
⅝	3⅞	367	566	760	442	566	642	470	557	672
¾	4⅛	419	676	948	552	676	733	486	699	841
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		3.6–5.0	**1.9–2.5**	**1.1–1.3**	**1.8–2.2**	**1.9–2.5**	**2.1–2.9**	**2.0–2.4**	**1.4–1.7**	**1.2–1.4**

Wedge Anchors in 4000 psi Normal Weight Cracked Concrete (lb)										
⅜	2	101	172	258	150	172	176	134	190	232
½	3⅝	218	370	556	325	370	377	290	410	500
⅝	3⅞	280	463	674	393	463	484	435	494	603
¾	4⅛	313	540	824	481	540	541	430	608	741
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		5.1–6.5	**2.6–3.2**	**1.4–1.6**	**2.3–2.7**	**2.6–3.2**	**3.0–3.8**	**2.5–2.9**	**1.8–2.1**	**1.5–1.7**
⅜	2	79	144	230	134	144	137	121	169	209
½	3⅝	170	310	494	289	310	292	261	365	449
⅝	3⅞	226	391	605	354	391	389	406	445	547
¾	4⅛	241	449	728	427	449	413	386	538	663

**Pr* = Prying Factor Range. (Refer to Annex for additional information.)

1 lb = 0.45 kg

Table 18.5.12.2(e) Maximum Load for Wedge Anchors in 6000 psi (414 bar) Normal Weight Cracked Concrete

Wedge Anchors in 6000 psi Normal Weight Cracked Concrete (lb)										
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr*	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		≤2.0	**≤1.1**	**≤0.7**	**≤1.2**	**≤1.1**	**≤1.1**	**≤1.4**	**≤0.9**	**≤0.8**
⅜	2¼	254	354	428	199	354	585	213	313	372
½	3⅝	527	744	910	418	744	1227	454	667	791
⅝	3⅞	652	893	1069	504	893	1481	626	780	928
¾	4⅛	772	1106	1369	622	1106	1819	684	1005	1190
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		2.1–3.5	**1.2–1.8**	**0.8–1.0**	**1.3–1.7**	**1.2–1.8**	**1.2–2.0**	**1.5–1.9**	**1.0–1.3**	**0.9–1.1**
⅜	2¼	172	271	370	215	271	302	188	271	327
½	3⅝	355	564	780	453	564	621	399	573	690
⅝	3⅞	450	694	932	542	694	786	576	682	823
¾	4⅛	514	828	1162	676	828	898	595	856	1030
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		3.6–5.0	**1.9–2.5**	**1.1–1.3**	**1.8–2.2**	**1.9–2.5**	**2.1–2.9**	**2.0–2.4**	**1.4–1.7**	**1.2–1.4**
⅜	2¼	130	219	325	189	219	226	169	239	292
½	3⅝	267	454	682	398	454	462	355	502	613
⅝	3⅞	343	567	826	481	567	593	534	606	739

Wedge Anchors in 6000 psi Normal Weight Cracked Concrete (lb)										
¾	4⅛	384	662	1009	590	662	663	527	745	909
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		5.1–6.5	**2.6–3.2**	**1.4–1.6**	**2.3–2.7**	**2.6–3.2**	**3.0–3.8**	**2.5–2.9**	**1.8–2.1**	**1.5–1.7**
⅜	2¼	103	184	290	170	184	178	153	214	263
½	3⅝	209	380	606	355	380	358	320	447	551
⅝	3⅞	277	480	741	433	480	476	497	545	671
¾	4⅛	295	551	892	523	551	506	473	660	813

**Pr* = Prying Factor Range. (Refer to Annex for additional information.)

1 lb = 0.45 kg

Table 18.5.12.2(f) Maximum Load for Undercut Anchors in 3000 psi (207 bar) Normal Weight Cracked Concrete

Undercut Anchors in 3000 psi Normal Weight Cracked Concrete (lb)										
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr*	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		≤2.0	**≤1.1**	**≤0.7**	**≤1.2**	**≤1.1**	**≤1.1**	**≤1.4**	**≤0.9**	**≤0.8**
⅜	4⅜	501	638	726	420	638	889	362	525	630
½	7	700	911	1051	608	911	1245	525	761	912
⅝	9½	1106	1535	1855	1074	1535	1975	1098	1356	1612
¾	12	1701	2404	2946	1707	2404	3041	1472	2161	2561
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		2.1–3.5	**1.2–1.8**	**0.8–1.0**	**1.3–1.7**	**1.2–1.8**	**1.2–2.0**	**1.5–1.9**	**1.0–1.3**	**0.9–1.1**
⅜	4⅜	368	526	658	381	526	643	333	477	578
½	7	505	738	942	547	738	882	479	685	829
⅝	9½	754	1179	1604	933	1179	1318	1005	1177	1419
¾	12	1143	1819	2520	1468	1819	1996	1291	1854	2233
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***
		3.6–5.0	**1.9–2.5**	**1.1–1.3**	**1.8–2.2**	**1.9–2.5**	**2.1–2.9**	**2.0–2.4**	**1.4–1.7**	**1.2–1.4**
⅜	4⅜	291	447	601	350	447	504	309	437	534
½	7	395	620	854	497	620	683	440	622	760
⅝	9½	572	957	1413	825	957	989	927	1039	1268
¾	12	860	1463	2202	1287	1463	1486	1149	1624	1980
Diameter (in.)	**Embedment (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
		Pr	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***	***Pr***

Undercut Anchors in 3000 psi Normal Weight Cracked Concrete (lb)										
		5.1–6.5	2.6–3.2	1.4–1.6	2.3–2.7	2.6–3.2	3.0–3.8	2.5–2.9	1.8–2.1	1.5–1.7
3⁄8	4 3⁄8	241	389	554	323	389	414	287	403	496
1⁄2	7	324	535	780	455	535	557	407	570	701
5⁄8	9 1⁄2	456	806	1263	739	806	781	859	931	1145
3⁄4	12	670	1223	1955	1146	1223	1147	1035	1444	1778

**Pr* = Prying Factor Range. (Refer to Annex for additional information.)

1 lb = 0.45 kg

Table 18.5.12.2(g) Maximum Load for Connections to Steel Using Unfinished Steel Bolts

Connections to Steel (Values Assume Bolt Perpendicular to Mounting Surface																	
Diameter of Unfinished Steel Bolt (in.)																	
1⁄4									3⁄8								
A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
400	500	600	300	500	650	325	458	565	900	1200	1400	800	1200	1550	735	1035	1278
Diameter of Unfinished Steel Bolt (in.)																	
1⁄2									5⁄8								
A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
1600	2050	2550	1450	2050	2850	1300	1830	2260	2500	3300	3950	2250	3300	4400	2045	2880	3557

Table 18.5.12.2(h) Maximum Load for Through-Bolts in Sawn Lumber or Glue-Laminated Timbers

Through-Bolts in Sawn Lumber or Glue-Laminated Timbers (Load Perpendicular to Grain)																												
		Bolt Diameter (in.)																										
		1⁄2									5⁄8									3⁄4								
		A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
Length of Bolt in Timber (in.)	1 1⁄2	115	165	200	135	230	395	130	215	310	135	190	235	155	270	460	155	255	380	155	220	270	180	310	530	170	300	450
	2 1⁄2	140	200	240	160	280	480	165	275	410	160	225	280	185	320	550	190	320	495	180	255	310	205	360	615	215	365	575
	3 1⁄2	175	250	305	200	350	600	200	330	485	200	285	345	230	400	685	235	405	635	220	310	380	255	440	755	260	455	730
	5 1⁄2	—	—	—	—	—	—	—	—	—	280	395	485	325	560	960	315	515	735	310	440	535	360	620	1065	360	610	925

Note: Wood fastener maximum capacity values are based on the 2001 National Design Specifications (NDS) for wood with a specific gravity of 0.35. Values for other types of wood can be obtained by multiplying the above values by the factors in Table 9.3.5.12.2(j).

Table 18.5.12.2(i) Maximum Load for Lag Screws and Lag Bolts in Wood

Lag Screws and Lag Bolts in Wood (Load Perpendicular to Grain — Holes Predrilled Using Good Practice)																												
		Lag Bolt Diameter (in.)																										
		½									⅝									¾								
		A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
Length of Bolt in Timber (in.)	3½	165	190	200	170	220	310	80	120	170	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4½	180	200	200	175	235	350	80	120	170	300	355	380	315	400	550	145	230	325	—	—	—	—	—	—	—	—	—
	5½	190	200	200	175	245	380	80	120	170	320	370	380	320	420	610	145	230	325	435	525	555	425	550	775	195	320	460
	6½	195	205	200	175	250	400	80	120	170	340	375	380	325	435	650	145	230	325	465	540	555	430	570	840	195	320	460

Note: Wood fastener maximum capacity values are based on the 2001 National Design Specifications (NDS) for wood with a specific gravity of 0.35. Values for other types of wood can be obtained by multiplying the above values by the factors in Table 9.3.5.12.2(j).

Table 18.5.12.2(j) Factors for Wood Based on Specific Gravity

Specific Gravity of Wood	Multiplier
0.36 thru 0.49	1.17
0.50 thru 0.65	1.25
0.66 thru 0.73	1.50

18.5.12.3*

The type of fasteners used to secure the bracing assembly to the structure shall be limited to those shown in Table 18.5.12.2(a) through Table 18.5.12.2(i) or to listed devices.

18.5.12.4*

For connections to wood, through-bolts with washers on each end shall be used, unless the requirements of 18.5.12.5 are met.

18.5.12.5

Where it is not practical to install through-bolts due to the thickness of the wood member in excess of 12 in. (300 mm) or inaccessibility, lag screws shall be permitted and holes shall be pre-drilled ⅛ in. (3 mm) smaller than the maximum root diameter of the lag screw.

18.5.12.6

Holes for through-bolts and similar listed attachments shall be 1⁄16 in. (1.6 mm) greater than the diameter of the bolt.

18.5.12.6.1

The requirements of 18.5.12 shall not apply to other fastening methods, which shall be acceptable for use if certified by a registered professional engineer to support the loads determined in accordance with the criteria in 18.5.9.

18.5.12.6.2

Calculations shall be submitted where required by the authority having jurisdiction.

18.5.12.7 Concrete Anchors.

18.5.12.7.1*
Concrete anchors shall be prequalified for seismic applications in accordance with ACI 355.2, *Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary*, and installed in accordance with the manufacturer's instructions.

18.5.12.7.2
Unless the requirements of 18.5.12.7.3 are met, concrete anchors shall be based on concrete strength, anchor type, designated angle category A through I, prying factor (*Pr*) range, and allowable maximum load.

(A)
Sway brace manufacturers shall provide prying factors (*Pr*) based on geometry of the structure attachment fitting and the designated angle category A through I as shown in Figure 18.5.12.1.

(B)
Where the prying factor for the fitting is unknown, the largest prying factor range in Table 18.5.12.2(a) through Table 18.5.12.2(f) for the concrete strength and designated angle category A through I shall be used.

18.5.12.7.3
The allowable maximum load shall be permitted to be calculated.

(A)
Allowable concrete anchor loads shall be permitted to be determined using approved software that considers the effects of prying for concrete anchors.

(B)
Anchors shall be seismically prequalified per 18.5.12.7.1.

(C)
Allowable maximum loads shall be based on the anchor capacities given in approved evaluation service reports, where the calculation of ASD allowable shear and tension values are determined in accordance with Chapter 17 of ACI 318, *Building Code Requirements for Structural Concrete and Commentary,* and include the effects of prying, brace angle, and the over strength factor (Ω=2.0).

(D)*
The shear and tension values determined in 18.5.12.7.3(C) using Chapter 17 of ACI 318, *Building Code Requirements for Structural Concrete and Commentary,* shall be multiplied by 0.43.

18.5.12.7.4
Concrete anchors shall be acceptable for use where designed in accordance with the requirements of the building code and certified by a registered professional engineer.

18.5.13 Braces to Buildings with Differential Movement.
A length of pipe shall not be braced to sections of the building that will move differentially.

18.6 Restraint of Branch Lines.

18.6.1*
Restraint is considered a lesser degree of resisting loads than bracing and shall be provided by use of one of the following:

(1) Listed sway brace assembly

(2) Wraparound U-hook satisfying the requirements of 18.5.5.11

(3) No. 12, 440 lb (200 kg) wire installed at least 45 degrees from the vertical plane and anchored on both sides of the pipe

(4) CPVC hangers listed to provide restraint

(5) *Hanger not less than 45 degrees from vertical installed within 6 in. (150 mm) of the vertical hanger arranged for restraint against upward movement, provided it is utilized such that *l*/*r* does not exceed 400, where the rod extends to the pipe or a surge clip has been installed

(6) Other approved means

18.6.2 Wire Restraint.

18.6.2.1
Wire used for restraint shall be located within 2 ft (600 mm) of a hanger.

18.6.2.2
The hanger closest to a wire restraint shall be of a type that resists upward movement of a branch line.

18.6.3
The end sprinkler on a branch line shall be restrained.

18.6.3.1
The location of the restraint from end of the line shall not be greater than 36 in. (900 mm) for 1 in. (25 mm) pipe, 48 in. (1219 mm) for 1 ¼ in. (32 mm) pipe, and 60 in. (1.5 m) for 1 ½ in. (40 mm) or larger pipe.

18.6.4*
Branch lines shall be laterally restrained at intervals not exceeding those specified in Table 18.6.4(a) or Table 18.6.4(b) based on branch line diameter and the value of C_p.

Table 18.6.4(a) Maximum Spacing (ft)(m) of Steel Pipe Restraints

Pipe	Seismic Coefficient, C_p			
(in.) (mm)	$C_p \leq 0.50$	$0.5 < C_p \leq 0.71$	$0.71 < C_P \leq 1.40$	$C_P > 1.40$
½ (15)	34 (10.3)	29 (8.8)	20 (6.1)	18 (5.5)
¾ (20)	38 (11.6)	32 (9.7)	23 (7.0)	20 (6.1)
1 (25)	43 (13.1)	36 (11.0)	26 (7.9)	22 (6.7)
1¼ (32)	46 (14.0)	39 (11.9)	27 (8.2)	24 (7.3)
1½ (40)	49 (14.9)	41 (12.5)	29 (8.8)	25 (7.6)
2 (50)	53 (16.1)	45 (13.7)	31 (9.4)	27 (8,2)

Table 18.6.4(b) Maximum Spacing (ft) of CPVC, Copper, and Red Brass Pipe Restraints

Pipe	Seismic Coefficient C_p			
(in.) (mm)	$C_p \leq 0.50$	$0.5 < C_p \leq 0.71$	$0.71 < C_P \leq 1.40$	$C_P > 1.40$
½ (15)	26 (7.9)	22 (6.7)	16 (4.9)	13 (4.0)
¾ (20)	31 (9.4)	26 (7.9)	18 (5.5)	15 (4.6)
1 (25)	34 (10.3)	28 (8.5)	20 (6.1)	17 (5.2)
1¼ (32)	37 (11.3)	31 (9.4)	22 (6.7)	19 (5.8)
1½ (40)	40 (12.2)	34 (10.3)	24 (7.3)	20 (6.1)
2 (50)	45 (13.7)	38 (11.6)	27 (8.2)	23 (7.0)

18.6.5
Where the branch lines are supported by rods less than 6 in. (150 mm) long measured between the top of the pipe and the point of attachment to the building structure, the requirements of 18.6.1 through 18.6.4 shall not apply and additional restraint shall not be required for the branch lines.

18.6.6*
Sprigs 4 ft (1.2 m) or longer shall be restrained against lateral movement.

18.6.7
Drops and armovers shall not require restraint.

18.7 Hangers and Fasteners Subject to Earthquakes.

18.7.1
Where seismic protection is provided, C-type clamps (including beam and large flange clamps) used to attach hangers to the building structure shall be equipped with a restraining strap unless the provisions of 18.7.1.1 are satisfied.

18.7.1.1
As an alternative to the installation of a required restraining strap, a device investigated and specifically listed to restrain the clamp to the structure is permitted where the intent of the device is to resist the worst-case expected horizontal load.

18.7.2
The restraining strap shall be listed for use with a C-type clamp or shall be a steel strap of not less than 16 gauge (1.57 mm) thickness and not less than 1 in. (25 mm) wide for pipe diameters 8 in. (200 mm) or less and 14 gauge (1.98 mm) thickness and not less than 1¼ in. (32 mm) wide for pipe diameters greater than 8 in. (200 mm).

18.7.3
The restraining strap shall wrap around the beam flange not less than 1 in. (25 mm).

18.7.4
A lock nut on a C-type clamp shall not be used as a method of restraint.

18.7.5
A lip on a "C" or "Z" purlin shall not be used as a method of restraint.

18.7.6
Where purlins or beams do not provide a secure lip to a restraining strap, the strap shall be through-bolted or secured by a self-tapping screw.

18.7.7
In areas where the horizontal force factor exceeds 0.50 W_p, powder-driven studs shall be permitted to attach hangers to the building structure where they are specifically listed for use in areas subject to earthquakes.

18.7.8*
Where seismic protection is provided, concrete anchors used to secure hangers to the building structure shall be in accordance with ACI 355.2, *Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary*, and installed in accordance with manufacturer's instructions.

18.7.9
Where seismic protection is provided, cast-in-place anchors used to secure hangers to the building structure shall be in accordance with ICC-ES AC446, *Acceptance Criteria for Headed Cast-in Specialty Inserts in Concrete,* and installed in accordance with manufacturer's instructions.

18.8* Pipe Stands Subject to Earthquakes.

18.8.1
In areas where the horizontal force factor exceeds 0.5 W_p, pipe stands over 4 ft (1.2 m) in height shall be certified by a registered professional engineer to be adequate for the seismic forces.

18.8.2
Where seismic protection is provided, concrete anchors used to secure pipe stands to their bases shall be in accordance with ACI 355.2, *Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary*, and shall be installed in accordance with manufacturer's instructions.

D.2.24.2 Installation Requirements.

D.2.24.2.1 Protection of Vertical Openings.
Any vertical opening shall be protected in accordance with NFPA *101*, Section 8.6, except under the following conditions:
(1) In Class A or Class B mercantile occupancies protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA *101*, 9.7.1.1(1), unprotected vertical openings shall be permitted at one of the following locations:
(a) Between any two floors

(b) Among the street floor, the first adjacent floor below, and adjacent floor (or mezzanine) above

(2) In Class C mercantile occupancies, unprotected openings shall be permitted between the street floor and the mezzanine.

(3) The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for unenclosed vertical openings permitted in NFPA *101*, 37.3.1(1) and (2). [*101*:37.3.1]

D.2.24.2.2
Rooms housing building service equipment, janitor closets, and service elevators shall be permitted to open directly onto exit passageways, provided that the following criteria are met:
(1) The required fire resistance rating between such rooms or areas and the exit passageway shall be maintained in accordance with NFPA *101*, 7.1.3.2.

(2) Such rooms or areas shall be protected by an approved, supervised automatic sprinkler system in accordance with NFPA *101*, 9.7.1.1(1), but the exceptions in NFPA 13 allowing the omission of sprinklers from such rooms shall not be permitted. [*101*:37.4.4.6.2]

D.2.25 New Business Occupancies.

D.2.25.1 Design Requirements. (Reserved)

D.2.25.2 Installation Requirements. (Reserved)

D.2.26 Existing Business Occupancies.

D.2.26.1 Design Requirements. (Reserved)

D.2.26.2 Installation Requirements. (Reserved)

D.2.27 Industrial Occupancies. (Reserved)

D.2.27.1 Design Criteria.

D.2.27.1.1 Special Provisions — High-Rise Buildings.
The provisions of NFPA *101*, 11.8.5.2.4(2), for jockey pumps and NFPA *101*, 11.8.5.2.4(3), for air compressors serving dry-pipe and pre-action systems shall not apply to special-purpose industrial occupancies. [***101*:**40.4.1]

D.2.28 Storage Occupancies. (Reserved)

Annex E Development of the Design Approach to Conform with SEI/ASCE 7

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

E.1

Seismic design of nonstructural components is governed by the provisions of Chapter 13 of ASCE/SEI 7, *Minimum Design Loads for Buildings and Other Structures*. In ASCE/SEI 7, fire sprinkler piping is classified as a "Designated Seismic System," due to its critical safety function. Design earthquake forces are multiplied by an Importance Factor, I_p = 1.5, and both the bracing and the piping itself must be designed for seismic forces.

The lateral sway bracing provisions of 18.5.5 were developed to allow the use of the concept of Zone of Influence (ZOI), while providing designs that comply with ASCE/SEI 7. One of the main changes between the current seismic sway bracing design approach adopted in NFPA 13 and the approach used in early editions of NFPA 13 is that the spacing of the sway braces can be constrained by the flexural capacity of the pipe, as well as the capacity of the brace assembly or the capacity of the connection between the brace assembly and the supporting structure. NFPA 13 provides a design that complies with the seismic design requirements of ASCE/SEI 7 for the pipe itself.

The ZOI approach yields the force demand on the bracing element and connections to the structure. Another way to look at a ZOI force is as a reaction in a system of continuous beams (i.e., the multiple spans of a piping system). By using conservative simplifying assumptions, a maximum ZOI force limited by the flexural capacity of the pipe can be developed for a given pipe size and span (spacing between horizontal sway braces). The method used to develop these maximum ZOI forces is described in the following paragraphs, along with a discussion of the assumptions on the geometry of the piping system, the determination of the seismic design force coefficients, and the flexural capacity of the pipe.

In the discussion that follows, the term "main" can be taken to mean a sprinkler main, either a feed main or a cross-main that requires sway bracing.

E.2 Assumptions on System Geometry.

While every fire sprinkler system is uniquely designed for a particular structure, there are general similarities in the layout and geometry that can be used to simplify the design approach for earthquake protection. These similarities were used to develop assumptions on the effects of piping system continuity on the distribution of bending and shear forces in the pipe, and assumptions on spacing of branch lines between sway brace locations.

E.2.1 Continuity in Piping Systems.

For lateral brace design purposes, piping systems can be idealized as a system of continuous beams. The bending moments in the sprinkler mains (the beams) were computed assuming three continuous spans, which generates the largest bending moment in any system of continuous beams. The loads generated by the branch lines are idealized as point loads. The tributary mass of the main is lumped along with the mass of the branch lines as point loads at the assumed branch line locations.

E.2.2 Branch Line Locations.

In many sprinkler system installations, the branch lines constitute a substantial portion of the seismic mass. While there are significant variations in the spacing of the branch lines, their geometry is constrained by the need to provide adequate water coverage, which imposes limits on the spacing of the branches. Defining a "span" of the main as the distance between lateral sway braces, the seismic provisions make the following assumptions:

(1) There is a branch located at the center of the sprinkler main for spans of 25 ft (7.6 m) or less.

(2) There are branches at third-points of the sprinkler main for spans greater than 25 ft (7.6 m) and less than 40 ft (12.2 m).

(3) There are branches at quarter-points of the sprinkler main for spans of 40 ft(12.2 m).

It was further assumed that there is a branch line located in close proximity to each sway brace.

The layout of branch lines, maximum bending moment M_{max} in the pipe, and reaction R_{max} (horizontal loads at sway brace locations) for sprinkler mains with spans less than 25 ft (7.6 m) is illustrated in Figure

E.2.2(a). Maximum demands for spans greater than 25 ft (7.6 m) and less than 40 ft (12.2 m) are given in Figure E.2.2(b), and for spans of 40 ft (12.2 m), in Figure E.2.2(c).

Figure E.2.2(a) Maximum Demands for Spans Less Than 25 ft.

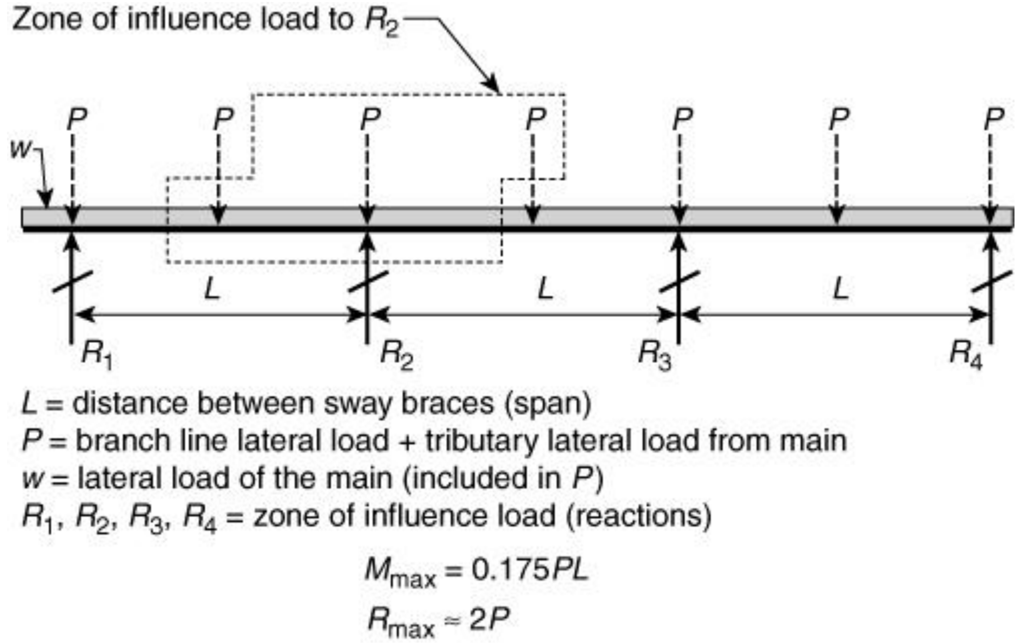


Figure E.2.2(b) Maximum Demands for Spans Greater Than 25 ft and Less Than 40 ft.

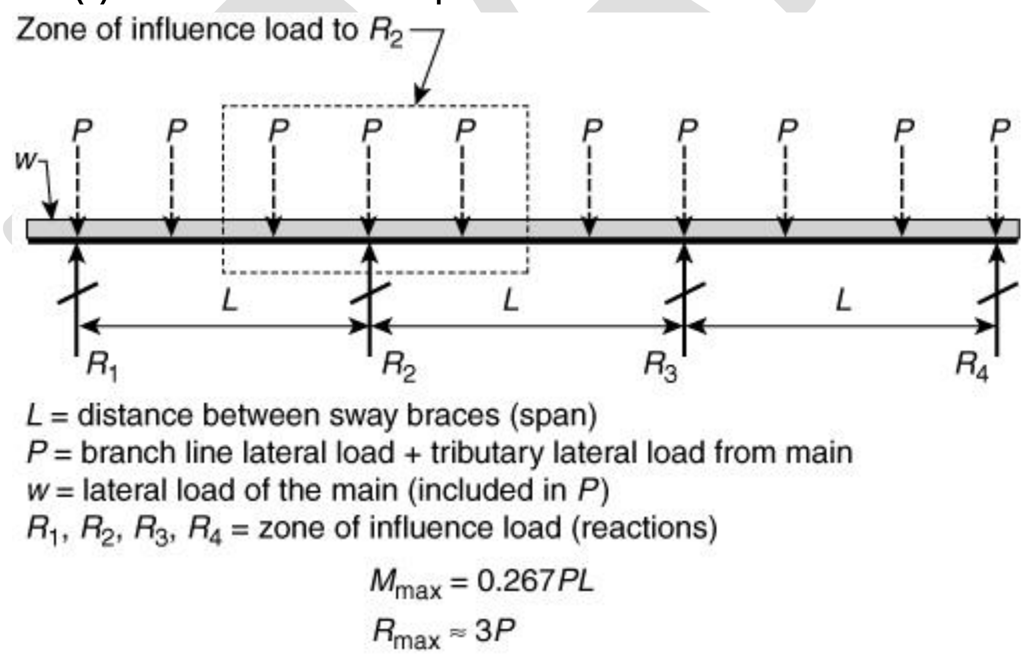
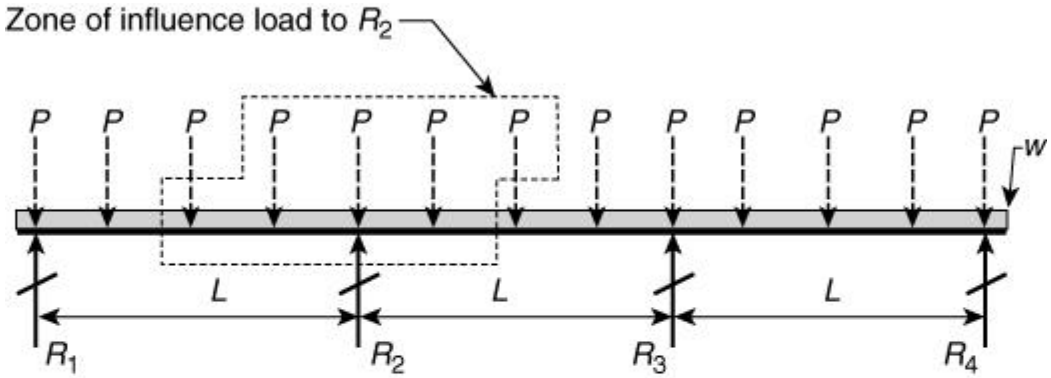


Figure E.2.2(c) Maximum Demands for Spans of 40 ft.



L = distance between sway braces (span)
P = branch line lateral load + tributary lateral load from main
w = lateral load of the main (included in P)
R_1, R_2, R_3, R_4 = zone of influence load (reactions)

$$M_{max} = 0.372PL$$

$$R_{max} \approx 4P$$

E.3 Computing the Seismic Demand on Piping Systems.

In ASCE/SEI 7, seismic demands on nonstructural components and systems are a function of the ground shaking intensity, the ductility and dynamic properties of the component or system, and the height of attachment of the component in the structure. Seismic forces are determined at strength design (SD) levels. The horizontal seismic design force is given by

$$F_p = \frac{0.4a_p S_{DS} W_p}{\left(\frac{R_p}{I_p}\right)}\left(1+2\frac{z}{h}\right)$$ **[E.3a]**

where:

F_p = seismic design force

S_{DS} = short period spectral acceleration, which takes into account soil conditions at the site

a_p = component amplification factor, taken as 2.5 for piping systems

I_p = component importance factor, taken as 1.5 for fire sprinkler systems

z = height of the component attachment to the structure

h = average roof height of the structure

W_p = component operating weight

R_p = component response modification factor as follows:

R_p = 9 for high-deformability piping with joints made by welding or brazing

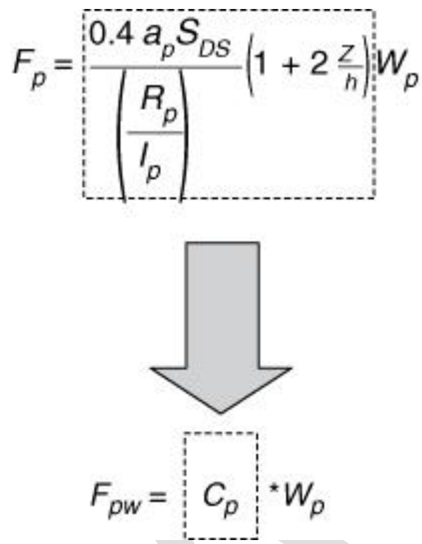
R_p = 4.5 for high- or limited-deformability piping with joints made by threading, bonding, compression couplings, or grooved couplings

R_p = 1.5 for low-deformability piping such as cast iron and nonductile plastics

F_p need not be greater than 1.6 $S_{DS}I_pW_p$ and cannot be less than 0.30 $S_{DS}I_pW_p$.

As illustrated in Figure E.3, NFPA 13 uses a simplified seismic factor, C_p, which combines ground shaking S_{DS}, dynamic amplification a_p, component response R_p/I_p, and location in the building (z/h) into a single variable. Conservative assumptions are made for each variable, so that the only information needed to find C_p is the short-period mapped spectral acceleration for the Maximum Considered Earthquake (MCE), S_s.

Figure E.3 Simplified Seismic Factor, C_p.



The importance factor (I_p) for fire sprinkler systems is specified in ASCE/SEI 7 as 1.5. The amplification factor (a_p) for piping systems is specified as 2.5. Piping systems (even when seismically braced) are considered flexible, since the fundamental period of vibration for the system is greater than 0.06 seconds. A component response factor of R_p = 4.5 was assumed for all piping. Finally, it was assumed that the system is installed at the roof level, h.

Assume the system is laterally braced at the roof, $z = h$ and substitute these values into the lateral force equation

$$F_p = \frac{0.4a_pS_{DS}W_p}{\left(\frac{R_p}{I_p}\right)}\left(1+2\frac{z}{h}\right) = \frac{0.4(2.5)S_{DS}W_p}{\left(\frac{4.5}{1.5}\right)}\left(1+2\frac{h}{h}\right) = (1.0)S_{DS}W_p$$

[E.3b]

ASCE/SEI 7 forces are determined at the strength design (SD) level. NFPA 13 is based on Allowable Stress Design (ASD). To convert F_p to an ASD load, F_{pw}, the load from ASCE/SEI 7 is multiplied by a 0.7 load factor.

$$F_{pw} = 0.7F_p = 0.7S_{DS}W_p = C_pW_p$$ **[E.3c]**

Solving for C_p,

$$C_p = 0.7S_{DS}$$ **[E.3d]**

The short-period spectral acceleration, S_{DS}, is obtained by modifying the mapped short-period spectral acceleration, S_S, for the effects of the local soil conditions. In the United States, values for S_S are obtained from seismic hazard maps published by the U.S. Geological Survey (USGS). Free software available from USGS will generate values for S_S based on the latitude and longitude of the project site. The spectral acceleration used for seismic design is determined by

$$-S_{DS} = \frac{2}{3} S_S F_a$$ **[E.3e]**

F_a is an amplification factor based on soil conditions and the intensity of ground shaking expected (measured by S_S). Soil conditions are defined by site classification, ranging from Site Class A (hard rock) to Site Class F (extremely soft soils and fill). The values of F_a are given in ASCE/SEI 7 Table 11.4-1 and vary from 0.8 to 2.5. For the purposes of the ZOI method, the values of F_a are taken as the maximum tabulated values and are summarized in Table E.3.

Table E.3 Values of F_a

	Mapped Maximum Considered Earthquake Spectral Response Acceleration Parameter at Short Period					
	$S_S \leq 0.33$	**$S_S = 0.5$**	**$S_S = 0.75$**	**$S_S = 0.95$**	**$S_S = 1.0$**	**$S_S \geq 1.25$**
F_a	2.24	1.7	1.2	1.1	1.1	1.0

Note: Use straight-line interpolation for intermediate values of S_S.

$$C_p = 0.7 S_{DS} = \frac{2}{3}\left(0.7 S_s F_a\right) = 0.467 S_s F_a$$ **[E.3f]**

Table 18.5.9.3 was populated by solving for C_p for different values of S_S. For example when S_S = 1.0:

$$C_p = 0.467 S_s F_a = 0.467(1.0)(1.1) = 0.51$$ **[E.3g]**

E.4 Flexural Capacity of Piping.

The flexural capacity for different diameters and thicknesses of pipe were computed using Allowable Stress Design (ASD). NFPA 13 has traditionally used ASD for design. While ASCE/SEI 7 generally uses the Strength Design (SD) approach, ASD is preferred for the design of piping systems. For example, the ASTM B 31, *Standards of Pressure Piping*, series of piping codes are based on ASD. ASD was chosen for sprinkler piping design to limit the complexity of the analysis. Use of SD would require the use of the plastic modulus, Z, of the pipe rather than the elastic section modulus, S. Use of Z would trigger analysis of local and global buckling behavior of the pipe. SD is most appropriate when used with compact pipe sections that can develop the full limit capacity of the material, including strain hardening. Thin-wall pipes and materials without well defined post-elastic behavior are not easily considered using SD.

Permissible stresses in the pipe for seismic loading are from 13.6.11 of ASCE/SEI 7. Assuming high- or limited-deformability pipe with threaded or grooved couplings, the permissible flexural stress under SD level demands is $0.7F_y$, where F_y is the yield stress of the material. Since seismic design in NFPA 13 is based on ASD, the SD capacity must be reduced to an ASD level.

The permissible flexural stress for ASD is determined by adjusting the SD level flexural capacity. The SD capacity is first reduced by a load factor to ASD levels, and then can be increased by the allowable stress increase for seismic loading. The use of an allowable stress increase for piping systems is typical when determining the strength of the pipe itself.

For fire sprinkler piping, the SD flexural capacity, M_{cap}, is reduced by a load factor of 0.7 to yield the ASD flexural capacity. The duration of load factor for the piping system, taken as 1.33, is then applied. Taking S as the section modulus of pipe, this yields an allowable moment capacity in the pipe.

$$M_{cap} = 0.7(1.33)\left(0.7 S F_y\right) = 0.65 S F_y$$ **[E.4a]**

To populate Table 18.5.5.2(a) through Table 18.5.5.2(i), which give the maximum Zone of Influence loads, the largest reaction (due to branch lines and the tributary mass of the main) limited by flexure for a given pipe size and span between sway braces was computed.

For example, to determine the maximum permissible ZOI for a 4 in. (100 mm) diameter steel Schedule 10 main spanning 30 ft (9.1 m), first compute the flexural capacity of the pipe.

S = 1.76 in.^{3}(28800 mm^3)

F_y = 30,000 psi (2050 bar)

The flexural capacity of the pipe is

$$M_{cap} = (0.65F_y)S = (0.65)(30{,}000)(1.76) \qquad \textbf{[E.4b]}$$

= 34,320 in.-lb (3900 kgn) = 2860 ft-lb (395 kgn)

For spans greater than 25 ft (7.6 m) and less than 40 ft (12 m), the branch lines are assumed to be located at ⅓-points in the span. The point load P is associated with the branch line and tributary mass of the main and L is distance between sway braces. From Figure E.2.2(b), the maximum moment in the main, M_{max}, is

$M_{max} = 0.267PL$

Setting $M_{cap} = M_{max}$ and solving for P,

$$M_{cap} = (0.65F_y)S = 0.267PL$$

$$P = \frac{M_{cap}}{0.267L}$$

$$= \frac{2860}{0.267(30) = 357 \text{ lb}} \qquad \textbf{[E.4c]}$$

The maximum permissible ZOI load = 3P = 1071 lb. (485 kg).

E.5 Sample Seismic Calculation using the ZOI Method.

To illustrate the application of the ZOI method, the approach can be applied to a sample problem based on the sample seismic bracing calculation in Figure A.18.5(b). The sample calculation yielded a total weight of 480 lb (220 kg), which was obtained using a seismic factor of 0.5. To determine our own seismic factor, to get the total weight of the water-filled pipe, divide by the seismic factor of 0.5,

$$W_p = \frac{480}{0.5} = 960 \text{ lb } (435 \text{ kg}) \qquad \textbf{[E.5a]}$$

Assume the 4 in. (100 mm) Schedule 10 pipe is the main that will be braced and that distance between sway braces (span) is 20 ft (6.1 m). The installation is in a region of high seismicity, and based on the latitude and longitude of the building site, S_S = 1.75.

To calculate the seismic load, use Table 18.5.9.3 to determine the seismic coefficient, C_p. The value of S_s = 1.75 coordinates to 0.82.

The horizontal force on the brace, from 18.5.6.2 is

$$F_{pw} = C_pW_p = 0.82(960) = 787 \text{ lb} \qquad \textbf{[E.5b]}$$

From Table 18.5.5.2(a), the maximum ZOI load, F_{pw}, for a 4 in. Schedule 10 pipe spanning 20 ft (6.1 m) is 1634 lb (740 kg), which is larger than the calculated demand of 787 lb (355 kg). The 4 in. (100 mm) Schedule 10 pipe is adequate for the seismic load and a brace would be selected with a minimum capacity of 787 lb (355 kg).

If the sway brace was attached to the 2 in. (50 mm) Schedule 40 pipe, the ZOI demand F_{pw} of 787 lb (355 kg) would be compared to the maximum capacity for a 2 in. (50 mm) Schedule 40 pipe found in Table 18.5.5.2(a)(b). For a 20 ft (6.1 m) span, this is 520 lb (235 kg), less than the demand of 787 lb (355 kg). A 2 in. (50 mm) pipe would be inadequate, and a sway brace would have to be added to reduce the ZOI demand, or the system pipe size increased.

E.6 Limitations of the ZOI Method.

The ZOI approach can be used for a variety of piping materials. There are, however, important limitations of which the designer should be aware. The first is that the appropriate component response factor, R_p, must be used. To select the proper value, the piping systems must be classified as high-, limited-, or low-deformability. Definitions of these terms are given in Section 11.2 of ASCE/SEI 7. The second major assumption is that the flexural behavior of the pipe is not governed by local buckling of the pipe wall. For steel pipe, this can be achieved by observing the thickness to diameter limits given in the *AISC Specifications for the Design, Fabrication, and Erection of Structural Steel Buildings*. Establishing the local buckling characteristics of pipe fabricated from other materials can require testing.

The tables for the maximum load, F_{pw}, in zone of influence are based on common configurations of mains and branch lines. There can be cases where the actual configuration of the piping system could generate higher stresses in the piping than assumed in the tables. For example, a main braced at 40 ft intervals, with a single branch line in the center of the span, can have a smaller maximum load capacity, F_{pw}, than the tabulated value. Where the configuration of the mains and branch lines vary significantly from the assumed layout, the pipe stresses should be checked by engineering analysis.

E.7 Allowable Loads for Concrete Anchors.

This section provides step-by-step examples of the procedures for determining the allowable loads for concrete anchors as they are found in Table 18.5.12.2(a) through Table 18.5.12.2(f). Table 18.5.12.2(a) through Table 18.5.12.2(f) were developed using the prying factors found in Table E.7(a) and the representative strength design seismic shear and tension values for concrete anchors found in Table E.7(b).

Table E.7(a) Prying Factors for Table 9.3.5.12.2(a) through Table 9.3.5.12.2(f) Concrete Anchors

***Pr* Range**	**Fig. 9.3.5.12.1 Designated Angle Category**								
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Lowest	2	1.1	0.7	1.2	1.1	1.1	1.4	0.9	0.8
Low	3.5	1.8	1.0	1.7	1.8	2.0	1.9	1.3	1.1
High	5.0	2.5	1.3	2.2	2.5	2.9	2.4	1.7	1.4
Highest	6.5	3.2	1.6	2.7	3.2	3.8	2.9	2.1	1.7

Table E.7(b) Representative Strength Design Seismic Shear and Tension Values Used for Concrete Anchors

Anchor Dia. (in.)	**Nominal Embedment (in.)**	**LRFD Tension (lb)**	**LRFD Shear (lb)**
Wedge Anchors in 3000 psi LW Sand Concrete on Metal Deck			
⅜	2	573	1172
½	2.375	804	1616
⅝	3.125	1102	1744
Wedge Anchors in 3000 psi LW Sand Concrete			
⅜	2	637	550
½	3.625	871	745
⅝	3.875	1403	1140
¾	4.125	1908	1932
Wedge Anchors in 3000 psi NW Concrete			
⅜	2	1063	917

Anchor Dia. (in.)	Nominal Embedment (in.)	LRFD Tension (lb)	LRFD Shear (lb)
½	3.625	2639	2052
⅝	3.875	3004	2489
¾	4.125	3179	3206
Wedge Anchors in 4000 psi NW Concrete			
⅜	2	1226	1088
½	3.625	2601	2369
⅝	3.875	3469	2586
¾	4.125	3671	3717
Wedge Anchors in 6000 psi NW Concrete			
⅜	2.25	1592	1322
½	3.625	3186	2902
⅝	3.875	4249	3167
¾	4.125	4497	4553
Undercut Anchors in 3000 psi NW Concrete			
⅜	5	4096	1867
½	7	5322	2800
⅝	9.5	6942	5675
¾	12	10182	9460

E.7.1 Selecting a Wedge Anchor Using Table 9.3.5.12.2(a) through Table 9.3.5.12.2(f).

E.7.1.1 Procedure.

Step 1. Determine the ASD horizontal earthquake load F_{pw}.

Step 1a. Calculate the weight of the water-filled pipe within the zone of influence of the brace.

Step 1b. Find the applicable seismic coefficient C_p in Table 18.5.9.3

Step 1c. Multiply the zone of influence weight by C_p to determine the ASD horizontal earthquake load F_{pw}.

Step 2. Select a concrete anchor from Table 18.5.12.2(a) through Table 18.5.12.2(f) with a maximum load capacity that is greater than the calculated horizontal earthquake load F_{pw} from Step 1.

Step 2a. Locate the table for the applicable concrete strength.

Step 2b. Find the column in the selected table for the applicable designated angle category (A thru I) and the appropriate prying factor *Pr* range.

Step 2c. Scan down the category column to find a concrete anchor diameter, embedment depth, and maximum load capacity that is greater than the calculated horizontal earthquake load F_{pw} from Step 1.

(ALTERNATIVE) Step 2. As an alternative to using the maximum load values in Table 18.5.12.2(a) through Table 18.5.12.2(f), select an AC355.2 seismically pre-qualified concrete anchor with a load-carrying capacity that exceeds the calculated F_{pw}, with calculations, including the effects of prying, based on seismic shear and tension values taken from an ICC-ES Report and calculated in accordance with ACI 318, Chapter 17, and adjusted to ASD values by multiplying by 0.43 per 18.5.12.7.3(D).

E.7.1.2 Example.

Step 1. Zone of influence F_{pw}.

Step 1a. 40 ft of 2½ in. Sch. 10 pipe plus 15% fitting allowance

40 × 5.89 lb/ft × 1.15 = 270.94 lb

Step 1b. Seismic coefficient C_p from Table 18.5.9.3

C_p = 0.35

Step 1c.F_{pw} = 0.35 × 270.94 = 94.8 lb

Step 2. Select a concrete anchor from Table 18.5.12.2(a) through Table 18.5.12.2(f).

Step 2a. Use the table for 4000 psi Normal Weight Concrete.

Step 2b. Fastener orientation "A" – assume the manufacturer's prying factor is 3.0 for the fitting. Use the *Pr* range of 2.1–3.5.

Step 2c. Allowable F_{pw} on ⅜ in. dia. with 2 in. embedment = 135 lb and is greater than the calculated F_{pw} of 94.8 lb.

E.7.2 Calculation for Maximum Load Capacity of Concrete Anchors.
This example shows how the effects of prying and brace angle are calculated.

E.7.2.1 Procedure.
Step 1. Determine the allowable seismic tension value (T_{allow}) and the allowable seismic shear value (V_{allow}) for the anchor, based on data found in the anchor manufacturer's approved evaluation report. Note that, in this example, it is assumed the evaluation report provides the allowable tension and shear capacities. If this is not the case, the strength design anchor capacities must be determined using the procedures in ACI 318, Chapter 17, which are then converted to ASD values by dividing by a factor of 1.4. As an alternative to calculating the allowable seismic tension value (T_{allow}) and the allowable seismic shear value (V_{allow}) for the anchor, the seismic tension and shear values that were used to calculate the Figure 18.5.12.1 for anchor allowable load tables can be used.

Step 1a. Find the ASD seismic tension capacity (T_{allow}) for the anchor according to the strength of concrete, diameter of the anchor, and embedment depth of the anchor. Divide the ASD tension value by 2.0 and then multiply by 1.2.

Step 1b. Find the ASD seismic shear capacity (V_{allow}) for the anchor according to the strength of concrete, diameter of the anchor, and embedment depth of the anchor. Divide the ASD shear value by 2.0 and then multiply by 1.2.

Step 2. Calculate the applied seismic tension (T) and the applied seismic shear (V) based on the calculated horizontal earthquake load F_{pw}.

Step 2a. Calculate the designated angle category applied tension factor, including the effects of prying (*Pr*), using the following formulas:

Category A, B, and C

$$Pr = \frac{\left(\frac{C+A}{Tan\theta}\right) - D}{A}$$

Category D, E, and F

$$Pr = \frac{(C+A) - \left(\frac{D}{Tan\theta}\right)}{A}$$

Category G, H, and I

$$Pr = \frac{\left(\frac{D}{B}\right)}{Sin\theta}$$

Step 2b. Calculate the ASD applied seismic tension (*T*) on the anchor, including the effects of prying, and when applied at the applicable brace angle from vertical and the designated angle category (A through I) using the following formula:

$$T = F_{pw} \times Pr$$

Step 2c. Calculate the ASD applied seismic shear (*V*) on the anchor, when applied at the applicable brace angle from vertical and the designated angle category (A through I) using the following formulas:

Category A, B, and C

$$V = F_{pw}$$

Category D, E, and F

$$V = \frac{F_{pw}}{Tan\theta}$$

Category G, H, and I

$$V = \frac{F_{pw}}{Sin\theta}$$

Step 3. Check the anchor for combined tension and shear loads using the formula:

$$\left(\frac{T}{T_{allow}}\right) + \left(\frac{V}{V_{allow}}\right) \leq 1.2$$

Confirm that T/T_{allow} and V/V_{allow} ≤1.0.

E.7.2.2 Example: Sample Calculation, Maximum Load Capacity of Concrete Anchors as Shown in Table 9.3.5.12.2(a) through Table 9.3.5.12.2(f).

In this example, a sample calculation is provided showing how the values in Table 18.5.12.2(a) through Table 18.5.12.2(f) were calculated.

Step 1. Determine the allowable seismic tension value (T_{allow}) and the allowable seismic shear value (V_{allow}) for a concrete anchor in Figure 18.5.12.1.

Step 1a. The Table E.7(b) strength design seismic tension value (T_{allow}) for a ½ in. carbon steel anchor with 3⅝ in. embedment depth in 4000 psi normal weight concrete is 2601 lb. Therefore, the allowable stress design seismic tension value (T_{allow}) is 2601/1.4/2.0 × 1.2 = 1115 lb.

Step 1b. The Table E.7(b) strength design seismic shear value (V_{allow}) for a ½ in. carbon steel anchor with 3⅝ in. embedment is 2369 lb. Therefore, the allowable stress design seismic shear value (V_{allow}) is 2369/1.4/2.0 × 1.2 = 1015 lb.

Step 2. Use the applied seismic tension value (*T*) and the applied seismic shear value (*V*) based on an ASD horizontal earthquake load (F_{pw}) of 170 lb, a 30-degree brace angle from vertical, and designated angle category A.

Step 2a. Calculate the ASD applied seismic tension value (*T*) on the anchor, including the effects of prying, using the following formula and **Figure E.7.2.2**.

$$T = \frac{F_{pw}\left[\left(\frac{C+A}{Tan\theta}\right) - D\right]}{A}$$

where:

T = applied service tension load, including the effect of prying

F_{pw} = horizontal earthquake load (F_{pw} = 170)

Tan = tangent of brace angle from vertical ($Tan\theta$ 0°= 0.5774)

A = 0.7500

B = 1.5000

C = 2.6250

$T = F_{pw} \times Pr$

$$T = \frac{\left\{F_{pw}\left[\left(\frac{2.625+0.75}{0.5774}\right) - 1.0\right]\right\}}{0.75}$$

$$T = \frac{\left[F_{pw}\left(5.8452 - 1.0\right)\right]}{0.75}$$

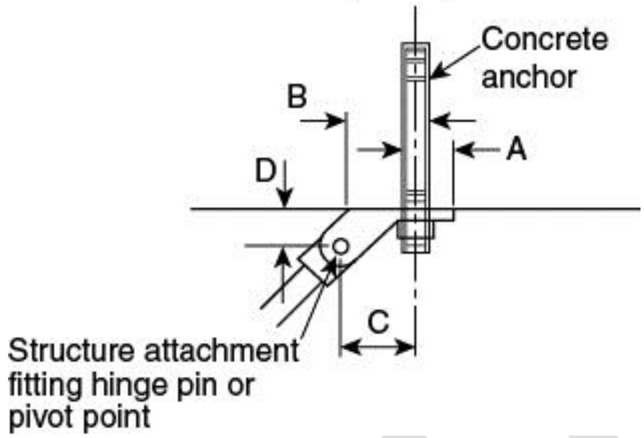
$$T = F_{pw}\left(\frac{4.8451}{0.75}\right)$$

$T = F_{pw} \times 6.46$

T = 170 lb × 6.46=1098.2 lb

Figure E.7.2.2 Concrete Anchor for Sample Calculation in E.7.2.2.

Anchor orientation A, B, C
(C > B)



Step 2b. The ASD applied seismic shear value (*V*)on the anchor for anchor orientations A, B, and C is equal to the ASD horizontal earthquake load F_{pw} = 170 lb.

Step 3. Calculate the maximum allowable horizontal earthquake load F_{pw} using the formula:

$$\left(\frac{T}{T_{allow}}\right)+\left(\frac{V}{V_{allow}}\right)\leq 1.2$$

$$\left(\frac{1098.2}{1115}\right)+\left(\frac{170}{1015}\right)=0.9849+0.1675=1.1524(\leq 1.2)$$

Annex F Informational References

F.1 Referenced Publications.

The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter **2** for other reasons.

F.1.1 NFPA Publications.

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1, *Fire Code*, 2018 edition.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2016 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2018 edition.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, 2019 edition.

NFPA 13E, *Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems*, 2015 edition.

NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*, 2019 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2016 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2017 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 2015 edition.

Dimensions Found in NFPA 13-2016

Length					
.003”	.08 mm	7.5”	190 mm	26”	650 mm
.0315”	.8 mm	8”	200 mm	27.6”	690 mm
1/32”	0.8 mm	8.5”	215 mm	28”	700 mm
1/16”	1.6 mm	9”	225 mm	29”	725 mm
3/32”	2 mm	9.25”	230 mm	30”	750 mm
1/8”	3 mm	9.5”	240 mm	30.5”	765 mm
3/16”	5 mm	10”	250 mm	31”	775 mm
¼”	6 mm	11”	275 mm	32”	800 mm
5/16”	8 mm	11.5”	290 mm	33”	825 mm
3/8”	10 mm	12”	300 mm	35”	875 mm
½”	13 mm	12.25”	305 mm	35.4”	885 mm
17/32”	13 mm	12.5”	315 mm	36”	900 mm
9/16”	14 mm	12.75”	320 mm	37”	925 mm
5/8”	16 mm	14”	350 mm	38”	950 mm
¾”	19 mm	15”	375 mm	40”	1000 mm
7/8”	22 mm	15.5”	390 mm	42”	1050 mm
1”	25 mm	16”	400 mm	44”	1100 mm
1.5”	40 mm	16.25”	410 mm	47”	1175 mm
1.75”	45 mm	16.5”	415 mm	48”	1200 mm
2”	50 mm	17”	425 mm	54”	1350 mm
2.5”	65 mm	17.5”	440 mm	55”	1375 mm
2.75”	70 mm	18”	450 mm	57”	1425 mm
3”	75 mm	19”	475 mm	58”	1450 mm
3.5”	90 mm	20”	500 mm	66”	1650 mm
4”	100 mm	21”	525 mm	68”	1700 mm
4.5”	115 mm	22”	550 mm	72”	1800 mm
5”	125 mm	22.5”	565 mm	76”	1900 mm
5.5”	140 mm	23”	575 mm	78”	1950 mm
5.75”	145 mm	24”	600 mm	96”	2400 mm
6”	150 mm	25”	625 mm	102”	2550 mm
7”	175 mm	25.5”	640 mm	120”	3000 mm
				148”	3700 mm

Length					
3.5ft	1.1 m	10’-10”	3.3 m	22’-6”	6.9 m
3’-8”	1.1 m	11’-0”	3.4 m	24ft	7.3 m
4ft	1.2 m	11’-3”	3.4 m	25ft	7.6 m
4’-2”	1.3 m	11’-5”	3.5 m	25’-3”	7.7 m
4.5ft	1.4 m	11’-6”	3.5 m	26ft	7.9 m
4’-7”	1.4 m	11’-611/16”	3.5 m	27ft	8.2 m
4’-9”	1.4 m	11’-8”	3.6 m	28ft	8.5 m
5ft	1.5 m	12ft	3.7 m	28’-8”	8.7 m
5’-2”	1.6 m	12’-4”	3.8 m	29’-8”	9 m
5.5ft	1.7 m	13ft	4.0 m	30ft	9.1 m
5’-8”	1.7 m	13’-6”	4.1 m	32ft	10 m
5’-9 5/16”	1.8 m	13’-71/2”	4.2 m	33ft	10 m
6ft	1.8 m	13’-11”	4.2 m	35ft	11 m
6’-3”	1.9 m	14ft	4.3 m	36ft	11 m
6’-4”	1.9 m	14’-6”	4.4 m	40ft	12 m
6.5ft	2 m	15ft	4.6 m	41’-3”	13 m
6’-10”	2.1 m	15’-4”	4.7 m	45ft	14 m
7ft	2.1 m	16ft	4.9 m	50ft	15 m
7.5ft	2.3 m	16’-6”	5.0 m	51’-6”	16 m
7’-7”	2.3 m	16’-8”	5.1 m	55ft	17 m
7’-9”	2.4 m	17ft	5.2 m	60ft	18 m
8ft	2.4 m	18ft	5.5 m	65ft	20 m
8’-2”	2.5 m	18’-6”	5.6 m	70ft	21 m
8’-4”	2.5 m	19’-2”	5.8 m	75ft	23 m
8’-77/8”	2.6 m	19’-10”	6 m	76ft	23 m
9ft	2.7 m	19’-11”	6.1 m	80ft	24 m
9’-5”	2.9 m	20ft	6.1 m	100ft	30 m
9’-6”	2.9 m	20’-8”	6.3 m	200ft	61 m
10ft	3 m	21’-6”	6.6 m	250ft	76 m
10.5ft	3.2 m	21’-10”	6.7 m	300ft	91 m
10’-9”	3.3 m	22 ft	6.7 m	400ft	120 m

Area					
3.5 ft2	0.3 m2	256 ft2	24 m2	2,700 ft2	250 m2
6 ft2	0.6 m2	300 ft2	28 m2	2,734 ft2	255 m2
10 ft2	0.9 m2	306 ft2	28 m2	2,800 ft2	260 m2
12 ft2	1.1 m2	324 ft2	30 m2	3,000 ft2	280 m2
16 ft2	1.5 m2	395 ft2	37 m2	3,250 ft2	300 m2
18 ft2	1.7m2	400 ft2	37 m2	3,300 ft2	305 m2
20 ft2	1.9m2	450 ft2	42 m2	3,450 ft2	320 m2
24 ft2	2.2m2	504 ft2	47 m2	3,500 ft2	325 m2
25 ft2	2.3 m2	585 ft2	54 m2	3,600 ft2	335 m2
32 ft2	3.0 m2	600 ft2	56 m2	3,750 ft2	350 m2
50 ft2	4.6 m2	648 ft2	60 m2	3,900 ft2	360 m2
55 ft2	5.1 m2	700 ft2	65 m2	4,000 ft2	370 m2
64 ft2	5.9 m2	756 ft2	70 m2	4,100 ft2	380 m2
70 ft2	6.5 m2	768 ft2	71 m2	4,500 ft2	420 m2
80 ft2	7.4 m2	800 ft2	74 m2	4,800 ft2	445 m2
90 ft2	8.4 m2	1,000 ft2	93 m2	5,000 ft2	465 m2
100 ft2	9 m2	1,200ft2	112 m2	6,000 ft2	555 m2
110 ft2	10 m2	1,300 ft2	120 m2	6,400 ft2	595 m2
120 ft2	11 m2	1,365 ft2	125 m2	8,000 ft2	740 m2
124 ft2	12 m2	1,400 ft2	130 m2	8,800 ft2	820 m2
130 ft2	12 m2	1,500 ft2	140 m2	10,000 ft2	930 m2
144 ft2	13 m2	1,700 ft2	160 m2	13,100 ft2	1 215 m2
150 ft2	14 m2	1,800 ft2	165 m2	25,000 ft2	2 320 m2
168 ft2	16 m2	1,950 ft2	180 m2	40,000 ft2	3 720 m2
175 ft2	16 m2	2,000 ft2	185 m2	50,000 ft2	4 650 m2
196 ft2	18 m2	2,300 ft2	215 m2	52,000 ft2	4 830 m2
200 ft2	18 m2	2,500 ft2	230m2	100,000 ft2	9 230 m2
225 ft2	20 m2	2,535 ft2	235 m2		
250 ft2	23 m2	2,600 ft2	240 m2		

Volume			
1.76 cuin	28 ml	160 ft3	4.5 m3
15.5 ft3	0.5 m3	400 ft3	11 m3
17.4 ft3	0.5 m3	1,000 ft3	28 m3
17.6 ft3	0.5 m3	1,800 ft3	51 m3
20.7 ft3	0.6 m3	2,100 ft3	59 m3
21.1 ft3	0.6 m3	2,300 ft3	65 m3
22 ft3	0.6 m3	6,500 ft3	184 m3
100 ft3	2.8 m3	2.25M ft3	63,720 m3

Capacity	
16 oz.	0.5 l
32 oz.	1 l
1 gal	4 l
5 gal	20 l
40 gal	150 l
100 gal	380 l
150 gal	570 l
250 gal	950 l
500 gal	1900 l
750 gal	2850 l
300,000 gal	1,135,500 l

Drill Size	
3/32”	2,3 mm
1/8”	3,2 mm
3/8”	10 mm

Density of Cotton Bales	
22.0 lb/ft^3	350 kg/m^3
22.7 lb/ft^3	365 kg/m^3
24.2 lb/ft^3	390 kg/m^3
28.4 lb/ft^3	455 kg/m^3
28.7 lb/ft^3	460 kg/m^3
32.2 lb/ft^3	515 kg/m^3

Flow					
30 gpm	115 lpm	300 gpm	1150 lpm	1000 gpm	3800 lpm
15 gpm	57 lpm	400 gpm	1500 lpm	1500 gpm	5700 lpm
20 gpm	75 lpm	500 gpm	1900 lpm	1992 gpm	7540 lpm
50 gpm	190 lpm	600 gpm	2250 lpm	1993 gpm	7543 lpm
60 gpm	230 lpm	700 gpm	2650 lpm	2156 gpm	8160 lpm
100 gpm	380 lpm	750 gpm	2850 lpm	2575 gpm	9750 lpm
102.8 gpm	390 lpm	800 gpm	3050 lpm	4907 gpm	18,572 lpm
200 gpm	760 lpm	850 gpm	3200 lpm		
215.8 gpm	815 lpm	900 gpm	3400 lpm		
250 gpm	950 lpm				

Pressure			
5 psi	0.3 bar	75	5.2 bar
7	0.5 bar	90	6.2 bar
10	0.7 bar	100	6.9 bar
11	.8 bar	150	10 bar
15	1.0 bar	165	11 bar
20	1.4 bar	175	12 bar
22	15 bar	189	13 bar
25	1.7 bar	200	14 bar
30	2.1 bar	259	17 bar
35	2.4 bar	300	21 bar
50	3.4 bar	400	28 bar
63	4.3 bar		

Gauge	
12	2.8 mm
14	1.98 mm
16	1.57 mm
22	.78 mm
24	.63mm

Weight			
6 lb	2.7 kg	350 lb	160 kg
10 lb	4.5 kg	440 lb	200 kg
20 lb	9.1 kg	520 lb	235 kg
40 lb	18 kg	750 lb	340 kg
61 lb	27 kg	787 lb	355 kg
91 lb	41 kg	1200 lb	544 kg
131 lb	59 kg	1634 lb	740 kg
200 lb	91 kg	2000 lb	907 kg
250 lb	115 kg	2300 lb	1043 kg
		4000 lb	1815 kg

Velocity	
30 mph	49 km/h

Discharge Density			
gpm/ft2	mm/min	gpm/ft2	mm/min
.005	.2	.425	17.3
.05	2.04	.426	17.4
.1	4.1	.44	17.9
.15	6.1	.45	18.3
.16	6.5	.46	18.7
.17	7.0	.49	20
.18	7.3	.5	20.4
.19	7.7	.55	22.4
.2	8.2	.56	22.8
.21	8.6	.57	23.2
.225	9.2	.6	24.5
.24	9.8	.61	24.9
.25	10.2	.65	26.5
.26	10.6	.68	27.7
.28	11.4	.7	28.5
.29	11.8	.74	30.2
.3	12.2	.75	30.6
.31	12.6	.77	31.4
.32	13.0	.8	32.6
.33	13.4	.85	34.6
.34	13.9	.9	36.7
.35	14.3	.92	37.5
.37	15.1	.96	39.1
.375	15.3	1.1	44.8
.39	15.9	1.2	48.9
.4	16.3	6.0	245
.42	17.1	7.5	306

Second Revision No. 16-NFPA 13-2017 [Section No. 17.2.1.1]

17.2.1.1

Unless the requirements of 17.2.1.2 are met, 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 17.2.1.1.

Table 17.2.1.1 Hanger Rod Sizes

Pipe Size		Diameter of Rod	
in.	mm	in.	mm
Up to and including 4	100	⅜	10
5	125	½	12
6	150		
8	200		
10	250	⅝	16
12	300	¾	20

Supplemental Information

File Name	Description	Approved
Table_17.2.1.1_Hanger_Rod_Sizes.docx	Revised Table 17.2.1.1. For staff use.	

Submitter Information Verification

Submitter Full Name: AUT-HBS
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jul 11 14:37:02 EDT 2017

Committee Statement

Committee Statement: 12 in. pipe must be supported with ¾ in. rod as is identified in Table 17.2.2.10.1.
Response Message:

Second Revision No. 1016-NFPA 13-2017 [Section No. 17.2.4.6.1]

17.2.4.6.1

Screws in the side of a timber or joist shall be not less than 2½ in. (65 mm) from the lower edge where supporting pipe is up to and including nominal 2½ in. (65 mm) and not less than 3 in. (75 mm) where supporting pipe is greater than nominal 2½ in. (65 mm).

Submitter Information Verification

Submitter Full Name: AUT-HBS
Organization: National Fire Protection Assoc
Street Address:
City:
State:
Zip:
Submittal Date: Mon Aug 07 09:12:33 EDT 2017

Committee Statement

Committee Statement: Editorial revision.
Response Message:

Second Revision No. 1017-NFPA 13-2017 [Section No. 17.3.1]

17.3.1

For trapeze hangers, the minimum size of steel angle or pipe span between structural members shall be such that the section modulus required in Table 17.3.1(a) does not exceed the available section modulus of the trapeze member from Table 17.3.1(b) or Table 17.3.1(c).

Table 17.3.1(a) Section Modulus Required for Trapeze Members (in.^{3})

Nominal Diameter of Pipe Being Supported – Schedule 10 Steel												
Span (ft)	1	1.25	1.5	2	2.5	3	3.5	4	5	6	8	10
1.5	0.08	0.08	0.09	0.09	0.10	0.11	0.12	0.13	0.15	0.18	0.26	0.34
2.0	0.11	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.20	0.24	0.34	0.45
2.5	0.14	0.14	0.15	0.16	0.18	0.21	0.23	0.25	0.30	0.36	0.50	0.69
3.0	0.16	0.17	0.18	0.19	0.20	0.22	0.24	0.26	0.31	0.36	0.51	0.67
3.5	0.19	0.20	0.21	0.22	0.24	0.26	0.28	0.30	0.36	0.42	0.60	0.78
4.0	0.22	0.22	0.24	0.25	0.27	0.30	0.32	0.34	0.41	0.48	0.68	0.89
4.5	0.24	0.25	0.27	0.28	0.30	0.33	0.36	0.38	0.46	0.54	0.77	1.01
5.0	0.27	0.28	0.30	0.31	0.34	0.37	0.40	0.43	0.51	0.60	0.85	1.12
5.5	0.30	0.31	0.33	0.34	0.37	0.41	0.44	0.47	0.56	0.66	0.94	1.23
6.0	0.33	0.34	0.35	0.38	0.41	0.44	0.48	0.51	0.61	0.71	1.02	1.34
6.5	0.35	0.36	0.38	0.41	0.44	0.48	0.52	0.56	0.66	0.77	1.11	1.45
7.0	0.38	0.39	0.41	0.44	0.47	0.52	0.56	0.60	0.71	0.83	1.19	1.56
7.5	0.41	0.42	0.44	0.47	0.51	0.55	0.60	0.64	0.76	0.89	1.28	1.68
8.0	0.43	0.45	0.47	0.50	0.54	0.59	0.63	0.68	0.82	0.95	1.36	1.79
8.5	0.46	0.48	0.50	0.53	0.58	0.63	0.67	0.73	0.87	1.01	1.45	1.90
9.0	0.49	0.50	0.53	0.56	0.61	0.66	0.71	0.77	0.92	1.07	1.53	2.01
9.5	0.52	0.53	0.56	0.60	0.64	0.70	0.75	0.81	0.97	1.13	1.62	2.12
10.0	0.54	0.56	0.59	0.63	0.68	0.74	0.79	0.85	1.02	1.19	1.70	2.23
10.5	0.57	0.59	0.62	0.66	0.71	0.78	0.83	0.90	1.07	1.25	1.79	2.35
11.0	0.60	0.62	0.65	0.69	0.74	0.81	0.87	0.94	1.12	1.31	1.87	2.46
11.5	0.63	0.64	0.68	0.72	0.78	0.85	0.91	0.98	1.17	1.37	1.96	2.57
12.0	0.65	0.67	0.71	0.75	0.81	0.89	0.95	1.02	1.22	1.43	2.04	2.68
12.5	0.68	0.70	0.74	0.78	0.85	0.92	0.99	1.07	1.27	1.49	2.13	2.79
13.0	0.71	0.73	0.77	0.81	0.88	0.96	1.03	1.11	1.33	1.55	2.21	2.90
13.5	0.73	0.76	0.80	0.85	0.91	1.00	1.07	1.15	1.38	1.61	2.30	3.02
14.0	0.76	0.78	0.83	0.88	0.95	1.03	1.11	1.20	1.43	1.67	2.38	3.13
14.5	0.79	0.81	0.86	0.91	0.98	1.07	1.15	1.24	1.48	1.73	2.47	3.24
15.0	0.82	0.84	0.89	0.94	1.02	1.11	1.19	1.28	1.53	1.79	2.56	3.35
15.5	0.84	0.87	0.92	0.97	1.05	1.14	1.23	1.32	1.58	1.85	2.64	3.46
16.0	0.87	0.90	0.95	1.00	1.08	1.18	1.27	1.37	1.63	1.91	2.73	3.58
Nominal Diameter of Pipe Being Supported – Schedule 40 Steel												
Span (ft)	1	1.25	1.5	2	2.5	3	3.5	4	5	6	8	10
1.5	0.08	0.09	0.09	0.1	0.11	0.12	0.14	0.15	0.18	0.22	0.30	0.41
2.0	0.11	0.11	0.12	0.13	0.15	0.16	0.18	0.20	0.24	0.29	0.40	0.55
2.5	0.14	0.14	0.15	0.16	0.17	0.18	0.20	0.21	0.25	0.30	0.43	0.56
3.0	0.16	0.17	0.18	0.20	0.22	0.25	0.27	0.30	0.36	0.43	0.60	0.82
3.5	0.19	0.20	0.21	0.23	0.26	0.29	0.32	0.35	0.42	0.51	0.70	0.96
4.0	0.22	0.23	0.24	0.26	0.29	0.33	0.36	0.40	0.48	0.58	0.80	1.10
4.5	0.25	0.26	0.27	0.29	0.33	0.37	0.41	0.45	0.54	0.65	0.90	1.23

Span (ft)	Nominal Diameter of Pipe Being Supported – Schedule 10 Steel											
	1	1.25	1.5	2	2.5	3	3.5	4	5	6	8	10
5.0	0.27	0.29	0.30	0.33	0.37	0.41	0.45	0.49	0.60	0.72	1.00	1.37
5.5	0.30	0.31	0.33	0.36	0.40	0.45	0.50	0.54	0.66	0.79	1.10	1.51
6.0	0.33	0.34	0.36	0.39	0.44	0.49	0.54	0.59	0.72	0.87	1.20	1.64
6.5	0.36	0.37	0.40	0.42	0.48	0.54	0.59	0.64	0.78	0.94	1.31	1.78
7.0	0.38	0.40	0.43	0.46	0.52	0.58	0.63	0.69	0.84	1.01	1.41	1.92
7.5	0.41	0.43	0.46	0.49	0.55	0.62	0.68	0.74	0.90	1.08	1.51	2.06
8.0	0.44	0.46	0.49	0.52	0.59	0.66	0.72	0.79	0.96	1.16	1.61	2.19
8.5	0.47	0.48	0.52	0.56	0.63	0.70	0.77	0.84	1.02	1.23	1.71	2.33
9.0	0.49	0.51	0.55	0.59	0.66	0.74	0.81	0.89	1.08	1.30	1.81	2.47
9.5	0.52	0.54	0.58	0.62	0.70	0.78	0.86	0.94	1.14	1.37	1.91	2.60
10.0	0.55	0.57	0.61	0.65	0.74	0.82	0.90	0.99	1.20	1.45	2.01	2.74
10.5	0.58	0.60	0.64	0.69	0.77	0.86	0.95	1.04	1.26	1.52	2.11	2.88
11.0	0.60	0.63	0.67	0.72	0.81	0.91	0.99	1.09	1.32	1.59	2.21	3.01
11.5	0.63	0.66	0.70	0.75	0.85	0.95	1.04	1.14	1.38	1.66	2.31	3.15
12.0	0.66	0.68	0.73	0.78	0.88	0.99	1.08	1.19	1.44	1.73	2.41	3.29
12.5	0.69	0.71	0.76	0.82	0.92	1.03	1.13	1.24	1.5	1.81	2.51	3.43
13.0	0.71	0.74	0.79	0.85	0.96	1.07	1.17	1.29	1.56	1.88	2.61	3.56
13.5	0.74	0.77	0.82	0.88	0.99	1.11	1.22	1.34	1.62	1.95	2.71	3.70
14.0	0.77	0.80	0.85	0.91	1.03	1.15	1.26	1.39	1.68	2.02	2.81	3.84
14.5	0.80	0.83	0.88	0.95	1.07	1.19	1.31	1.43	1.74	2.1	2.91	3.97
15.0	0.82	0.86	0.91	0.98	1.10	1.24	1.35	1.48	1.8	2.17	3.01	4.11
15.5	0.85	0.88	0.94	1.01	1.14	1.28	1.4	1.53	1.86	2.24	3.11	4.25
16.0	0.88	0.91	0.97	1.05	1.18	1.32	1.44	1.58	1.92	2.31	3.21	4.39

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

Note: The table is based on a maximum bending stress of 15 ksi (103.4 MPa) and a midspan concentrated load from 15 ft (4.6 m) of water-filled pipe, plus 250 lb (114 kg).

Table 17.3.1(b) Available Section Modulus of Common Trapeze Hangers (in.^{3})

Pipe		Modulus (in.^{3})	Angles (in.)	Modulus (in.^{3})
in.	mm			
Schedule 10				
1	25	0.12	1½ × 1½ × 3⁄16	0.10
1¼	32	0.19	2 × 2 × ⅛	0.13
1½	40	0.26	2 × 1½ × 3⁄16	0.18
2	50	0.42	2 × 2 × 3⁄16	0.19
2½	65	0.69	2 × 2 × ¼	0.25
3	80	1.04	2½ × 1½ × 3⁄16	0.28
3½	90	1.38	2½ × 2 × 3⁄16	0.29
4	100	1.76	2 × 2 × 5⁄16	0.30
5	125	3.03	2½ × 2½ × 3⁄16	0.30
6	150	4.35	2 × 2 × ⅜	0.35
			2½ × 2½ × ¼	0.39
			3 × 2 × 3⁄16	0.41
Schedule 40				

Pipe				
in.	mm	Modulus (in.^{3})	Angles (in.)	Modulus (in.^{3})
1	25	0.13	3 × 2½ × 3⁄16	0.43
1¼	32	0.23	3 × 3 × 3⁄16	0.44
1½	40	0.33	2½ × 2½ × 5⁄16	0.48
2	50	0.56	3 × 2 × ¼	0.54
2½	65	1.06	2½ × 2 × ⅜	0.55
3	80	1.72	2½ × 2½ × ⅜	0.57
3½	90	2.39	3 × 3 × ¼	0.58
4	100	3.21	3 × 3 × 5⁄16	0.71
5	125	5.45	2½ × 2½ × ½	0.72
6	150	8.50	3½ × 2½ × ¼	0.75
			3 × 2½ × ⅜	0.81
			3 × 3 × ⅜	0.83
			3½ × 2½ × 5⁄16	0.93
			3 × 3 × 7⁄16	0.95
			4 × 4 × ¼	1.05
			3 × 3 × ½	1.07
			4 × 3 × 5⁄16	1.23
			4 × 4 × 5⁄16	1.29
			4 × 3 × ⅜	1.46
			4 ×4 × ⅜	1.52
			5 × 3½ × 5⁄16	1.94
			4 × 4 × ½	1.97
			4 × 4 × ⅝	2.40
			4 × 4 × ¾	2.81
			6 × 4 × ⅜	3.32
			6 × 4 × ½	4.33
			6 × 4 × ¾	6.25
			6 × 6 × 1	8.57

Table 17.3.1(c) Available Section Modulus of Common Trapeze Hangers (cm^3)

Pipe		-	-	-
in.	mm	Modulus (cm^3)	Angles (mm)	Modulus (cm^3)
Schedule 10		-	-	-
1	25	1.97	40 × 40 × 5	1.64
1¼	32	3.11	50 × 50 × 3	2.13
1½	40	4.26	50 × 40 × 5	2.95
2	50	6.88	50 × 50 × 5	3.11
2½	65	11.3	50 × 50 × 6	4.10
3	80	17.0	65 × 40 × 5	4.59
3½	90	22.6	65 × 50 × 5	4.75
4	100	28.8	50 × 50 × 8	4.92
5	125	49.7	65 × 65 × 5	4.92
6	150	71.3	50 × 50 × 10	5.74
			65 × 65 × 6	6.39

Pipe in.	Pipe mm	Modulus (cm^3)	Angles (mm)	Modulus (cm^3)
Schedule 10		-	-	-
			80× 50 × 5	6.72
Schedule 40				
1	25	2.1	80 × 65 × 10	7.05
1¼	32	3.8	3 × 3 × 3⁄16	7.21
1½	40	5.4	65 × 65 × 8	7.87
2	50	9.2	3 × 2 × ¼	8.85
2½	65	17.4	65 × 50 × 10	9.01
3	80	28.2	65 × 65 × 10	9.34
3½	90	39.2	80 × 80 × 6	9.50
4	100	52.6	80 × 80 × 8	11.6
5	125	89.3	65 × 65 ×15	11.8
6	150	139.3	90 × 65 ×6	12.3
			80 × 65 × 10	13.3
			80 × 80 × 10	13.6
			90 × 65 × 8	15.2
			80 × 80 × 11	15.6
			100 × 100 × 6	17.2
			80 × 80 × 15	17.5
			100 × 80 × 8	20.2
			100 × 100 × 8	21.1
			100 × 80 × 10	23.9
			100 ×100 × 10	24.9
			125 × 90 × 8	31.8
			100 × 100 × 16	32.3
			100 × 100 × 8	39.3
			100 × 100 × 20	46.0
			150 × 100 × 10	54.4
			150 × 100 × 15	71.0
			150 × 100 × 20	102
			150 × 150 × 25	140

Submitter Information Verification

Submitter Full Name: AUT-HBS
Organization: National Fire Protection Assoc
Street Address:
City:
State:
Zip:
Submittal Date: Mon Aug 07 09:16:31 EDT 2017

Committee Statement

Committee Statement: Editorial revision.

Response Message:

Second Revision No. 1-NFPA 13-2017 [Section No. 17.4.1.3.1]

17.4.1.3.1

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 (115 kg) applied at the point of hanging, except where permitted by 17.4.1.1.2, 17.4.1.3.3, and 17.4.1.4.1.

Submitter Information Verification

Submitter Full Name: AUT-HBS

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Mon Jun 26 08:42:01 EDT 2017

Committee Statement

Committee Statement: This additional value assigned to the load of the pipe does not vary. It is always just 250 lbs. This is the only paragraph that includes the phrase "a minimum of" with this variable whereas 17.1.2(1), 17.1.4.1.1, 17.1.4.1.2, Table 17.3.1(a), and 17.5.1.2(1) all simply say "plus 250 lbs".

Response Message:

Public Comment No. 66-NFPA 13-2017 [Section No. 17.4.1.3.1]

Second Revision No. 2-NFPA 13-2017 [Section No. 17.4.3.4.4.4]

17.4.3.4.4.4

Unless flexible ~~sprinkler~~ hose fittings in accordance with 17.4.1.3.3.1and ceilings in accordance with 17.4.1.3.3.2 are used, the hanger closest to the sprinkler shall be of a type that restrains the pipe from upward movement ~~of the pipe~~ .

Submitter Information Verification

Submitter Full Name: AUT-HBS
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jun 26 09:07:24 EDT 2017

Committee Statement

Committee Statement: Note that this issue was resolved in Committee action.

Use of an approved ceiling is important factor when used flexible hose fittings. The ceiling must be strong enough to withstand the induced thrust after fusing of a sprinkler at a pressure above 100 psi. This requirement would require other forms of branch piping to restrain against upward movement. This change distiguishes between prevention and restraint. Prevention is absolute and restraint would acknowledge minor movement while a surge clip is being compressor.

Response Message:

Public Comment No. 149-NFPA 13-2017 [Section No. 17.4.3.4.4.4]

Second Revision No. 3-NFPA 13-2017 [Section No. 17.4.4.9]

~~**17.4.4.9**~~

~~The unsupported lengths of mains shall be in accordance with the distances in 9.2.3.4.~~

Submitter Information Verification

Submitter Full Name: AUT-HBS
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jun 26 09:24:52 EDT 2017

Committee Statement

Committee Statement: Delete. This section creates a conflict with the requirements of 17.4.4.10 as revised by FR-610.

Response Message:

Public Comment No. 150-NFPA 13-2017 [Section No. 17.4.4.9]

Second Revision No. 1018-NFPA 13-2017 [Section No. 17.5.4.5 [Excluding any Sub-Sections]]

The minimum diameter for the anchors shall be ½ in. (13 mm) for pipe stand diameters up to and including 3 in. (75 mm) and ⅝ in. (16 mm) for pipe stands 4 in. (100 mm) diameter and larger.

Submitter Information Verification

Submitter Full Name: AUT-HBS
Organization: National Fire Protection Assoc
Street Address:
City:
State:
Zip:
Submittal Date: Mon Aug 07 09:23:36 EDT 2017

Committee Statement

Committee Statement: Editorial revision.
Response Message:

Second Revision No. 1019-NFPA 13-2017 [Section No. 17.5.4.5.1]

17.5.4.5.1

Where the pipe stand complies with 17.5.3.2, ⅜ in. (10 mm) anchors shall be permitted.

Submitter Information Verification

Submitter Full Name: AUT-HBS
Organization: National Fire Protection Assoc
Street Address:
City:
State:
Zip:
Submittal Date: Mon Aug 07 09:25:57 EDT 2017

Committee Statement

Committee Statement: Editorial revision.
Response Message:

Second Revision No. 4-NFPA 13-2017 [Section No. 17.6]

~~**17.6** Protection Criteria for Rack Storage of Group A Plastic Commodities Stored Up to and Including 25 ft (7.6 m) in Height.~~

~~**17.6.1** Control Mode Density/Area Sprinkler Protection Criteria for Single-, Double-, and Multiple-Row Racks for Group A Plastic Commodities Stored Up to and Including 25 ft (7.6 m) in Height.~~

~~**17.6.1.1** Storage 5 ft (1.5 m) or Less in Height.~~

~~For the storage of Group A plastics stored 5 ft (1.5 m) or less in height, the sprinkler design criteria for miscellaneous storage specified in Chapter 13 shall be used.~~

~~**17.6.1.1.1**~~

~~For storage 5 ft (1.5 m) or less in height that does not meet the definition of *Miscellaneous Storage* that is on solid shelf racks, in-rack sprinklers shall be provided in accordance with 17.1.5, and ceiling sprinkler protection shall be provided in accordance with Chapter 13 .~~

~~**17.6.1.2** Ceiling Sprinkler Water Demand.~~

~~See Section C.22 .~~

~~**17.6.1.2.1**~~

~~For Group A plastic commodities in cartons, encapsulated or nonencapsulated in single-, double-, and multiple-row racks and with a clearance to ceiling up to and including 10 ft. (3.0 m), ceiling sprinkler water demand in terms of density [gpm/ft^2 (mm/min)] and area of operation [ft^2 (m^2)] shall be selected from Figure 17.6.1.2.1(a) through Figure 17.6.1.2.1(f) .~~

~~**Figure 17.6.1.2.1(a) Storage 5 ft to 10 ft (1.5 m to 3.0 m) in Height with Up to 10 ft (3.0 m) Clearance to Ceiling.**~~

~~**Figure 17.6.1.2.1(b) Storage 15 ft (4.6 m) in Height with Up to 10 ft (3.0 m) Clearance to Ceiling.**~~

~~**Figure 17.6.1.2.1(c) Storage 20 ft (6.1 m) in Height with <5 ft (1.5 m) Clearance to Ceiling.**~~

~~**Figure 17.6.1.2.1(d) Storage 20 ft (6.1 m) in Height with 5 ft to 10 ft (1.5 m to 3.0 m) Clearance to Ceiling.**~~

~~**Figure 17.6.1.2.1(e) Storage 25 ft (7.6 m) in Height with <5 ft (1.5 m) Clearance to Ceiling.** ***(See Note 2.)***~~

~~**Figure 17.6.1.2.1(f) Storage 25 ft (7.6 m) in Height with 5 ft to 10 ft (1.5 m to 3.0 m) Clearance to Ceiling.** ***(See Note 2.)***~~

~~**17.6.1.2.2**~~

~~Linear interpolation of design densities and areas of application shall be permitted between storage heights with the same clearance to ceiling.~~

~~**17.6.1.2.3**~~

~~No interpolation between clearance to ceiling shall be permitted.~~

~~**17.6.1.2.4**~~

~~An option shall be selected from the appropriate Figure 17.6.1.2.1(a) through Figure 17.6.1.2.1(f) given the storage height and clearance being protected. The density/area criteria at the top of each option shall be applied to the ceiling sprinklers and the in-rack sprinklers shown in the option (if any) shall be provided. Options that do not show multiple-row racks in the figures shall not be permitted to protect multiple-row rack storage. Notes in each figure shall be permitted to clarify options or to present additional options not shown in the figures.~~

~~**17.6.1.3**~~

~~For storage of Group A plastics between 5 ft and 12 ft (1.5 m and 3.7 m) in height, the installation requirements for extra hazard systems shall apply.~~

~~17.6.1.4~~

~~Exposed unexpanded Group A plastics protected with control mode density/area sprinklers shall be protected in accordance with one of the following:~~

~~Maximum 10 ft (3.0 m) storage in a maximum 20 ft (6.1 m) high building with ceiling sprinklers designed for a minimum 0.8 gpm/ft^2 (32.6 mm/min) density over 2500 ft^2 (232 m^2) and no in-rack sprinklers required as shown in Figure 17.6.1.4(a)~~

~~Maximum 10 ft (3.0 m) storage in a maximum 20 ft (6.1 m) high building with ceiling sprinklers designed for a minimum 0.45 gpm/ft^2 (18.3 mm/min) density over 2000 ft^2 (186 m^2) and one level of in-rack sprinklers required at alternate transverse flues as shown in Figure 17.6.1.4(b)~~

~~Maximum 10 ft (3.0 m) storage in a maximum 20 ft (6.1 m) high building with ceiling sprinklers designed for a minimum 0.3 gpm/ft^2 (12.2 mm/min) density over 2000 ft^2 (186 m^2) and one level of in-rack sprinklers required in every transverse flue as shown in Figure 17.6.1.4(c)~~

~~Maximum 15 ft (4.6 m) storage in a maximum 25 ft (7.6 m) high building with ceiling sprinklers designed for a minimum 0.45 gpm/ft^2 (18.3 mm/min) density over 2000 ft^2 (186 m^2) and one level of in-rack sprinklers required at alternate transverse flues as shown in Figure 17.6.1.4(d)~~

~~Maximum 15 ft (4.6 m) storage in a maximum 25 ft (7.6 m) high building with ceiling sprinklers designed for a minimum 0.3 gpm/ft^2 (12.2 mm/min) density over 2000 ft^2 (186 m^2) and one level of in-rack sprinklers required in every transverse flue as shown in Figure 17.6.1.4(e)~~

~~Maximum 20 ft (6.1 m) storage in a maximum 25 ft (7.6 m) high building with ceiling sprinklers designed for a minimum 0.6 gpm/ft^2 (24.4 mm/min) density over 2000 ft^2 (186 m^2) and one level of in-rack sprinklers required at alternate transverse flues as shown in Figure 17.6.1.4(f)~~

~~Maximum 20 ft (6.1 m) storage in a maximum 25 ft (7.6 m) high building with ceiling sprinklers designed for a minimum 0.45 gpm/ft^2 (18.3 mm/min) density over 2000 ft^2 (186 m^2) and one level of in-rack sprinklers required in every transverse flue as shown in Figure 17.6.1.4(g)~~

~~Maximum 20 ft (6.1 m) storage in a maximum 30 ft (9.1 m) high building with ceiling sprinklers designed for a minimum 0.8 gpm/ft^2 (32.6 mm/min) density over 1500 ft^2 (139 m^2) and one level of in-rack sprinklers required at alternate transverse flues as shown in Figure 17.6.1.4(h)~~

~~Maximum 20 ft (6.1 m) storage in a maximum 30 ft (9.1 m) high building with ceiling sprinklers designed for a minimum 0.6 gpm/ft^2 (24.4 mm/min^2) density over 1500 ft^2 (139 m^2) and one level of in-rack sprinklers required in every transverse flue as shown in Figure 17.6.1.4(i)~~

~~Maximum 20 ft (6.1 m) storage in a maximum 30 ft (9.1 m) high building with ceiling sprinklers designed for a minimum 0.3 gpm/ft^2 (12.2 mm/min) density over 2000 ft^2 (186 m^2) and two levels of in-rack sprinklers required in every transverse flue as shown in Figure 17.6.1.4(j)~~

~~Maximum 25 ft (7.6 m) storage in a maximum 35 ft (11 m) high building with ceiling sprinklers designed for a minimum 0.8 gpm/ft^2 (32.6 mm/min) density over 1500 ft^2 (139 m^2) and one level of in-rack sprinklers required in every transverse flue as shown in Figure 17.6.1.4(k)~~

~~Maximum 25 ft (7.6 m) storage in a maximum 35 ft (11 m) high building with ceiling sprinklers designed for a minimum 0.3 gpm/ft^2 (12.2 mm/min) density over 2000 ft^2 (186 m^2) and two levels of in-rack sprinklers required in every transverse flue as shown in Figure 17.6.1.4(l)~~

~~Figure 17.6.1.4(a) Exposed Nonexpanded Group A Plastic Up to 10 ft (3.0 m) in Height in Up to a 20 ft (6.1 m) High Building with No In-Rack Sprinklers.~~

~~**Figure 17.6.1.4(b) Exposed Nonexpanded Group A Plastic Up to 10 ft (3.0 m) in Height in Up to a 20 ft (6.1 m) High Building with One Level of In-Rack Sprinklers.**~~

~~**Figure 17.6.1.4(c) Exposed Nonexpanded Group A Plastics Up to 10 ft (3.0 m) in Height in Up to a 20 ft (6.1 m) High Building with One Level of Closely Spaced In-Rack Sprinklers.**~~

~~**Figure 17.6.1.4(d) Exposed Nonexpanded Group A Plastics Up to 15 ft (4.6 m) in Height in Up to a 25 ft (7.6 m) High Building with One Level of In-Rack Sprinklers.**~~

~~**Figure 17.6.1.4(e) Exposed Nonexpanded Group A Plastics Up to 15 ft (4.6 m) in Height in Up to a 25 ft (7.6 m) High Building with One Level of Closely Spaced In-Rack Sprinklers.**~~

~~**Figure 17.6.1.4(f) Exposed Nonexpanded Group A Plastics Up to 20 ft (6.1 m) in Height in Up to a 25 ft (7.6 m) High Building with One Level of In-Rack Sprinklers.**~~

~~**Figure 17.6.1.4(g) Exposed Nonexpanded Group A Plastics Up to 20 ft (6.1 m) in Height in Up to a 25 ft (7.6 m) High Building with One Level of Closely Spaced In-Rack Sprinklers.**~~

~~**Figure 17.6.1.4(h) Exposed Nonexpanded Group A Plastics Up to 20 ft (6.1 m) in Height in Up to a 30 ft (9.1 m) High Building with One Level of In-Rack Sprinklers.**~~

~~**Figure 17.6.1.4(i) Exposed Nonexpanded Group A Plastics Up to 20 ft in (6.1 m) Height in Up to a 30 ft (9.1 m) High Building with One Level of Closely Spaced In-Rack Sprinklers.**~~

~~**Figure 17.6.1.4(j) Exposed Nonexpanded Group A Plastics Up to 20 ft (6.1 m) in Height in Up to a 30 ft (9.1 m) High Building with Two Levels of Closely Spaced In-Rack Sprinklers.**~~

~~**Figure 17.6.1.4(k) Exposed Nonexpanded Group A Plastics Up to 25 ft (7.6 m) in Height in Up to a 35 ft (10.7 m) High Building with One Level of Closely Spaced In-Rack Sprinklers.**~~

~~**Figure 17.6.1.4(l) Exposed Nonexpanded Group A Plastics Up to 25 ft (7.6 m) in Height in Up to a 35 ft (10.7 m) High Building with Two Levels of Closely Spaced In-Rack Sprinklers.**~~

~~**17.6.1.5** In-Rack Sprinkler Requirements Where Control Mode Density/Area Sprinklers Are Being Used at Ceiling.~~

~~**17.6.1.5.1** In-Rack Sprinkler Clearance.~~

~~The minimum of 6 in. (150 mm) vertical clear space shall be maintained between the sprinkler deflectors and the top of a tier of storage.~~

(A)

Sprinkler discharge shall not be obstructed by horizontal rack members.

17.6.1.5.2

The spacing of in-rack sprinklers shall be in accordance with Figure 17.6.1.2.1(a) through Figure 17.6.1.2.1(f) .

17.6.1.5.3

In-rack sprinklers shall be located at an intersection of transverse and longitudinal flues while not exceeding the maximum spacing rules.

17.6.1.5.4

Where distances between transverse flues exceed the maximum allowable distances, sprinklers shall be installed at the intersection of the transverse and longitudinal flues, and additional sprinklers shall be installed between transverse flues to meet the maximum distance rules.

17.6.1.5.5

Where no transverse flues exist, in-rack sprinklers shall not exceed the maximum spacing rules.

17.6.1.5.6 In-Rack Sprinkler Water Demand.

The water demand for sprinklers installed in racks shall be based on simultaneous operation of the most hydraulically remote sprinklers as follows:

Eight sprinklers where only one level is installed in racks

Fourteen sprinklers (seven on each top two levels) where more than one level is installed in racks

17.6.1.5.7 In-Rack Sprinkler Discharge Pressure.

Sprinklers in racks shall discharge at not less than 15 psi (1.0 bar) for all classes of commodities. *(See Section C.19 .)*

17.6.2 CMSA Sprinklers for Rack Storage of Group A Plastic Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

17.6.2.1

Protection of single-, double-, and multiple-row rack storage for nonexpanded Group A plastic commodities shall be in accordance with Table 17.6.2.1 .

Table 17.6.2.1 CMSA Sprinkler Design Criteria for Single-, Double-, and Multiple-Row Racks of Group A Plastic Commodities Stored Up and Including 25 ft (7.6 m) in Height

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
Single-, double-, and multiple-row racks (no open-top containers)	Cartoned nonexpanded plastics	20	6.1	25	7.6	11.2 (160) Upright	Wet	15	50	3.4
						16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
-				30	9.1	11.2 (160) Upright	Wet Wet	3020	50 75	3.4 5.2
-						16.8 (240) Upright	Wet	15*	22	1.5
-		-	-			19.6 (280) Pendent	Wet	15	16	1.1
-		25	7.6	30	9.1	11.2 (160) Upright	Wet	15 + 1 level of in-rack	50	3.4
-						16.8 (240) Upright	Wet	15*	22	1.5
-						19.6 (280) Pendent	Wet	15	16	1.1
-		25	7.6	35	11	11.2 (160) Upright	Wet	30 + 1 level of in-rack	50	3.4
-							Wet	20 + 1 level of in-rack	75	5.2
-						16.8 (240) Upright	Wet	30 + 1 level of in-rack	22	1.5
-							Wet	20 + 1 level of in-rack	35	2.4
-						19.6 (280) Pendent	Wet	15	25	1.7
-	Exposed nonexpanded plastics	20	6.1	25	7.6	11.2 (160) Upright	Wet	15	50	3.4
-						16.8 (240) Upright	Wet	15	22	1.5
-		20	6.1	30	9.1	11.2 (160) Upright	Wet	30	50	3.4
-							Wet	20	75	5.2
-						16.8 (240) Upright	Wet	15*	22	1.5
-		25	7.6	30	9.1	11.2 (160) Upright	Wet	15 + 1 level of in-rack	50	3.4
-						16.8 (240) Upright	Wet	15*	22	1.5
-		25	7.6	35	11	11.2 (160) Upright	Wet	30 + 1 level of in-rack	50	3.4
-							Wet	20 + 1 level of in-rack	75	5.2

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
-						16.8 (240) Upright	Wet	30 + 1 level of in-rack	22	1.5
-							Wet	20 + 1 level of in-rack	35	2.4

*Minimum 8 ft (2.4 m) aisle.

17.6.2.1.1

CMSA sprinklers shall not be permitted to protect storage on solid shelf racks unless the solid shelf racks are protected with in-rack sprinklers in accordance with 17.1.5.

17.6.2.1.1.1

Where solid shelves are used, in-rack sprinklers shall be installed in every level below the highest solid shelf.

17.6.2.2

Protection shall be provided as specified in Table 17.6.2.1 or appropriate NFPA standards in terms of minimum operating pressure and the number of sprinklers to be included in the design area.

17.6.2.3 Open Wood Joist Construction.

17.6.2.3.1

Where CMSA sprinklers are installed under open wood joist construction, firestopping in accordance with 17.6.2.3.2 shall be provided or the minimum operating pressure of the sprinklers shall be 50 psi (3.4 bar) for a K-11.2 (160) sprinkler or 22 psi (1.5 bar) for a K-16.8 (240) sprinkler.

17.6.2.3.2

Where each joist channel of open wood joist construction is fully firestopped to its full depth at intervals not exceeding 20 ft (6.1 m), the lower pressures specified in Table 17.6.2.1 shall be permitted to be used.

17.6.2.4 Preaction Systems.

For the purpose of using Table 17.6.2.1 , preaction systems shall be classified as dry pipe systems.

17.6.2.5

Building steel shall not require special protection where Table 17.6.2.1 is applied as appropriate for the storage configuration.

17.6.2.6 In-Rack Sprinkler Requirements Where CMSA Sprinklers Are Used at Ceiling.

17.6.2.6.1

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

17.6.2.6.2

The minimum of 6 in. (150 mm) vertical clear space shall be maintained between the sprinkler deflectors and the top of a tier of storage.

(A)

Sprinkler discharge shall not be obstructed by horizontal rack members.

17.6.2.6.3

In-rack sprinklers shall be located at an intersection of transverse and longitudinal flues.

17.6.2.6.4

The maximum horizontal distance between in-rack sprinklers shall be 5 ft (1.5 m).

~~**17.6.2.6.5**~~

~~Where distances between transverse flues exceed the maximum allowable distances, sprinklers shall be installed at the intersection of the transverse and longitudinal flues, and additional sprinklers shall be installed between transverse flues to meet the maximum distance rules.~~

~~**17.6.2.6.6**~~

~~Where no transverse flues exist, in-rack sprinklers shall not exceed the maximum spacing rules.~~

~~**17.6.2.6.7** In-Rack Sprinkler Water Demand.~~

~~The water demand for sprinklers installed in racks shall be based on simultaneous operation of the most hydraulically remote eight sprinklers.~~

~~**17.6.2.6.8** In-Rack Sprinkler Discharge Pressure.~~

~~Sprinklers in racks shall discharge at not less than 15 psi (1.0 bar) for all classes of commodities. *(See Section C.19 .)*~~

~~**17.6.3** Special Design for Rack Storage of Plastics Commodities Stored Up to and Including 25 ft (7.6 m) in Height.~~

~~**17.6.3.1** Slatted Shelves.~~

~~**17.6.3.1.1***~~

~~Slatted rack shelves shall be considered equivalent to solid rack shelves where the shelving is not considered open rack shelving or where the requirements of 17.6.3.1 are not met. *(See Section C.20 .)*~~

~~**A.17.6.3.1.1**~~

~~Slatting of decks or walkways or the use of open grating as a substitute for automatic sprinkler thereunder is not acceptable.~~

~~In addition, where shelving of any type is employed, it is for the basic purpose of providing an intermediate support between the structural members of the rack. As a result, it becomes almost impossible to define and maintain transverse flue spaces across the rack as required.~~

~~**17.6.3.1.2**~~

~~A wet pipe system that is designed to provide a minimum of 0.6 gpm/ft ^{2} (24.4 mm/min) density over a minimum area of 2000 ft ^{2} (186 m ^{2}) or K-14.0 (200) ESFR sprinklers operating at a minimum of 50 psi (3.4 bar), K-16.8 (240) sprinklers operating at a minimum of 32 psi (2.2 bar), or K-25.2 (360) ESFR sprinklers operating at a minimum of 15 psi (1.0 bar) shall be permitted to protect single- and double-row racks with slatted rack shelving racks where all of the following conditions are met:~~

~~Sprinklers shall be K-11.2 (160), K-14.0 (200), or K-16.8 (240) orifice spray sprinklers with a temperature rating of ordinary, intermediate, or high and shall be listed for storage occupancies or shall be K-14.0 (200), K-16.8 (240), or K-25.2 (360) ESFR.~~

~~The protected commodities shall be limited to Class I through Class IV, Group B plastics, Group C plastics, cartoned (expanded and unexpanded) Group A plastics, and exposed (unexpanded) Group A plastics.~~

~~Slats in slatted rack shelving shall be a minimum nominal 2 in. (50 mm) thick by maximum nominal 6 in. (150 mm) wide with the slats held in place by spacers that maintain a minimum 2 in. (50 mm) opening between each slat.~~

~~Where K-11.2 (160), K-14.0 (200), or K-16.8 (240) orifice sprinklers are used, there shall be no slatted shelf levels in the rack above 12 ft (3.7 m). Open rack shelving using wire mesh shall be permitted for shelf levels above 12 ft (3.7 m).~~

~~Transverse flue spaces at least 3 in. (75 mm) wide shall be provided at least every 10 ft (3.0 m) horizontally.~~

~~Longitudinal flue spaces at least 6 in. (150 mm) wide shall be provided for double-row racks. Longitudinal flue spaces shall not be required when ESFR sprinklers are used.~~

~~The aisle widths shall be at least 7 ½ ft (2.3 m).~~

~~The maximum roof height shall be 27 ft (8.2 m) or 30 ft (9.1 m) where ESFR sprinklers are used.~~

~~The maximum storage height shall be 20 ft (6.1 m).~~

~~Solid plywood or similar materials shall not be placed on the slatted shelves so that they block the 2 in. (50 mm) spaces between slats, nor shall they be placed on the wire mesh shelves.~~

Submitter Information Verification

Submitter Full Name: AUT-HBS
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jun 26 09:31:19 EDT 2017

Committee Statement

Committee Statement: It appears that section 17.6 includes requirements from the 2016 edition, which were intended to be relocated to chapter 25 for in-rack sprinklers. The requirements of Section 17.6 have been relocated to 25.9.3 as Rack Storage of Group A Commodities Up To and Including 25 ft (7.6m) in Height

Response Message:

Public Comment No. 151-NFPA 13-2017 [Section No. 17.6]

Second Revision No. 17-NFPA 13-2017 [Section No. 18.1]

18.1* Protection of Piping Against Damage Where Subject to Earthquakes.

A.18.1

Sprinkler systems are protected against earthquake damage by means of the following:

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

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

Areas known to have a potential for earthquakes have been identified in building code and insurance maps.

Displacement due to story drift is addressed in Sections 18.2 through 18.4 .

Piping in racks needs to be treated like other sprinkler piping and protected in accordance with the proper rules. Piping to which in-rack sprinklers are directly attached should be treated as branch line piping. Piping that connects branch lines in the racks should be treated as mains. The bracing, restraint, flexibility, and requirements for flexible couplings are the same in the rack structures as at the ceiling.

Cloud ceilings can cause challenges for a sprinkler system in an earthquake where sprinklers are installed below the clouds to protect the floor below. Depending on the support structure of the cloud and the construction material of the cloud, differential movement could damage a sprinkler that is not installed in a fashion to accommodate the movement. Currently, there are no structural requirements in ASCE/SEI 7, *Minimum Design Loads for Buildings and Other Structures* , for the clouds to be seismically braced. Unbraced cloud ceilings in higher seismic areas could easily displace during design earthquakes half the suspension length or more. One solution might be to use flexible sprinkler hose with the bracket connected to the cloud so that the sprinkler will move with the cloud should seismic motion occur provided the ceiling system is constructed per ASTM C635/C635M, *Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems of Acoustical Tile and Lay-In Panel Ceilings* , and ASTM C636/C636M, *Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels* , then special connections could require an engineered design. When a sprinkler is rigidly piped to the cloud, appropriate flexibility and clearances should be maintained to handle the anticipated movement.

18.1.1

Where water-based fire protection systems are required to be protected against damage from earthquakes, the requirements of ~~Section~~ Chapter ~~18.1~~ 18 shall apply, unless the requirements of 18.1.2 are met.

18.1.2

Alternative methods of providing earthquake protection of sprinkler systems based on a 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 shall be permitted.

18.1.3 Obstructions to Sprinklers.

Braces and restraints shall not obstruct sprinklers and shall comply with the obstruction rules of Chapters ~~8~~ 10 through 14 .

Submitter Information Verification

Submitter Full Name: AUT-HBS

Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jul 11 14:47:05 EDT 2017

Committee Statement

Committee Statement: Restore previous annex language A.9.3.1 as A.18.1. Cloud ceilings are discussed in the installation section of NFPA 13. However, the materials of construction as well as the support system of a cloud can vary dramatically from one project to another. These variations will produce a different amount of movement. It is important to make sure that the fire sprinkler is installed in a way so that it is unlikely that the fire sprinkler will be damaged during an earthquake event. This language at least offers an awareness to the user that they need to be concerned about this interaction.

Response Message:

Second Revision No. 8-NFPA 13-2017 [Section No. 18.2.3.1]

18.2.3.1

The flexible couplings shall be installed as follows:

(1)* Within 24 in. (600 mm) of the top and bottom of all risers, unless the following provisions are met:

(a) In risers less than 3 ft (900 mm) in length, flexible couplings shall be permitted to be omitted.

(b) In risers 3 ft to 7 ft (900 mm to 2.1 m) in length, one flexible coupling shall be adequate.

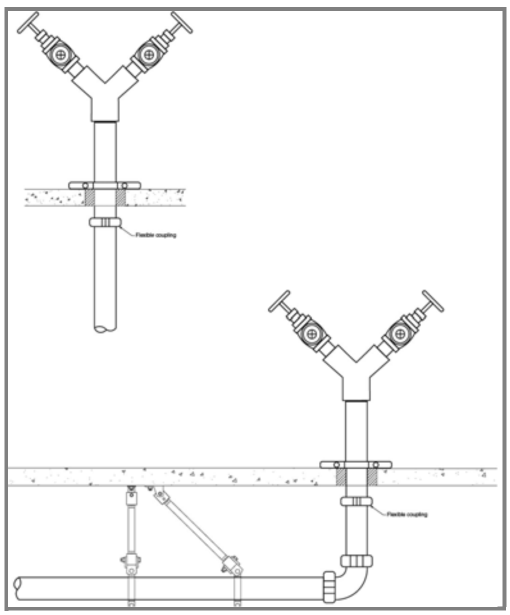
(2) Within 12 in. (300 mm) above and within 24 in. (600 mm) below the floor in multistory buildings, unless the following provision is met:

(a)* In risers up to 7 ft (2.1 m) in length terminating above the roof assembly or top landing, the flexible coupling shall not be required above the landing or roof assembly.

A.18.2.3.1(2)(a)

See Figure A.18.2.3.1(2)(a) .

Figure A.18.2.3.1(2)(a) Flexible Coupling on Upper Landing or Roof Assembly.



(3) On both sides of concrete or masonry walls within 1 ft (300 mm) of the wall surface, unless clearance is provided in accordance with Section 18.4

(4)* Within 24 in. (600 mm) of building expansion joints

(5) Within 24 in. (600 mm) of the top of drops exceeding 15 ft (4.6 m) in length to portions of systems supplying more than one sprinkler, regardless of pipe size

(6) Within 24 in. (600 mm) above and 24 in. (600 mm) below any intermediate points of support for a riser or other vertical pipe

Supplemental Information

File Name	Description	Approved

Figure_A.18.2.3.1_2_a_Flexible_Coupling_on_Upper_Landing_or_Roof.pdf	Figure A.18.2.3.1(2)(a) Flexible Coupling on Upper Landing or Roof Assembly. For staff use.
18.2.3.1.docx	For Clarity of list in 18.2.3.1 see attached word doc. For staff use.

Submitter Information Verification

Submitter Full Name: AUT-HBS
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jul 10 15:01:40 EDT 2017

Committee Statement

Committee Statement: When standpipe risers terminate at the top floor, the coupling above the floor level provides no benefit for the protection of pipe.

Response Message:

Public Comment No. 204-NFPA 13-2017 [Section No. 18.2.3.1]

Second Revision No. 6-NFPA 13-2017 [Section No. 18.4.1]

18.4.1*

Clearance shall be provided around all piping extending through walls, floors, platforms, and foundations, including drains, fire department connections, and other auxiliary piping.

A.18.4.1

Penetrations with or without clearance for seismic protection also need to meet building code requirements for fire resistance ratings as applicable.

Submitter Information Verification

Submitter Full Name: AUT-HBS
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jun 27 08:00:41 EDT 2017

Committee Statement

Committee Statement: Fire resistance ratings need to be considered in addition to seismic performance requirements. Use of annular openings around pipes or rigid pipe passing through an assembly with flexible couplings on either side would still be required to comply with fire resistance rating requirements of the building code.

Response Message:

Public Comment No. 152-NFPA 13-2017 [New Section after A.18.4]

Second Revision No. 5-NFPA 13-2017 [Sections 18.5.5.11.1, 18.5.5.11.2]

18.5.5.11.1

Branch lines shall comply with the following:

(1) The branch lines shall be individually supported by wraparound u-hooks or u-hooks arranged to keep pipe tight to the ~~underside of the~~ structural element provided the legs are bent out at least 30 degrees from the vertical and the maximum length of each leg and the rod size satisfies the conditions of Table 18.5.11.8(a), Table 18.5.11.8(b), and Table 18.5.11.8(c), or the length of the rod shall be calculated .

(2) At least 75 percent of all the hangers on the branch line shall meet the requirements of 18.5.5.11.2(1).

(3) Consecutive hangers on the branch line shall not be permitted to exceed the limitation in 18.5.5.11.2(1).

18.5.5.11.2

Mains shall comply with all the following:

(1) The main piping shall be individually supported by wraparound u-hooks or u-hooks arranged to keep pipe tight to the ~~underside of the~~ structural element provided the legs are bent out at least 30 degrees from the vertical and the maximum length of each leg and rod size satisfies the conditions of Table 18.5.11.8(a), Table 18.5.11.8(b), and Table 18.5.11.8(c).

(2) At least 75 percent of all the hangers on the main shall meet the requirements of 18.5.5.11.2(1).

(3) Consecutive hangers on the main shall not be permitted to exceed the limitation in 18.5.5.11.2(1).

(4) The seismic coefficient (C_p) shall not exceed 0.5.

(5) The nominal pipe diameter shall not exceed 6 in. (152 mm) for feed mains and 4 in. (102 mm) for cross mains.

(6) Hangers shall not be omitted in accordance with 17.4.4.3, 17.4.4.4, or 17.4.4.5.

Submitter Information Verification

Submitter Full Name: AUT-HBS
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Mon Jun 26 10:41:11 EDT 2017

Committee Statement

Committee Statement: The pipe may be laid on top of the structural element. This would be common in sprinkler retrofit applications where a suspended ceiling is attached to the underside the the joists.

Response Message:

Public Comment No. 210-NFPA 13-2017 [Sections 18.5.5.11.1, 18.5.5.11.2]

Second Revision No. 7-NFPA 13-2017 [Section No. 18.5.8.1]

18.5.8.1*

Tops of risers exceeding 3 ft (900 mm) in length shall be provided with a four-way brace.

18.5.8.1.1*

The four-way brace shall not be required for risers up to 7 ft (2.1 m) in length that terminate above the roof assembly or top landing.

A.18.5.8.1.1

See Figure A.18.2.3.1(2)(a) .

Submitter Information Verification

Submitter Full Name: AUT-HBS
Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jun 27 10:13:24 EDT 2017

Committee Statement

Committee Statement: When fire department connections, standpipe risers, or similar terminate at the top floor or above the roof level, the four-way brace does not provide any benefit.

Seismic Application - Design Data 12.26 Rev. A (Page 9)

Victaulic grooved products have consistently demonstrated the ability to withstand considerable forces during earthquakes. When exposed to bending forces, they have remained intact. A bending moment will occur when the joint deflects beyond its maximum allowable angular deflection.

Minimum Required Bending Moment at Coupling on Standard Wall Pipe

Coupling Size 4 in. - Bending Moment 3645 ft-lb

Coupling Size 6 in. - Bending Moment 7085 ft-lb

Response Message:

Public Comment No. 206-NFPA 13-2017 [Section No. 18.5.8.1]

Second Revision No. 12-NFPA 13-2017 [Section No. 18.5.12.2]

18.5.12.2*

For individual fasteners, unless alternative allowable loads are determined and certified by a registered professional engineer, the loads determined in 18.5.9 shall not exceed the allowable loads provided in Table 18.5.12.2(a) through Table 18.5.12.2(m) or 18.5.12.7.

Table 18.5.12.2(a) Maximum Load for Wedge Anchors in 3000 psi (207 bar) Lightweight Cracked Concrete on Metal Deck

Wedge Anchors in 3000 psi Sand Lightweight Cracked Concrete on 4 1/2 in. Flute Wi									
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Max. Flute Center Offset (in.)	A	B	C	D	E	F
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr* ≤
3/8	2.375	6.25	1	123	183	233	—	—	—
1/2	3.750	6.25	1	147	231	310	—	—	—
5/8	3.875	6.25	1	188	292	387	—	—	—
3/4	4.500	6.25	1	255	380	486			
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Max. Flute Center Offset (in.)	A	B	C	D	E	F
				Pr 2.1–3.5	*Pr* 1.2–1.8	*Pr* 0.8–1.0	*Pr* 1.3–1.7	*Pr* 1.2–1.8	*Pr* 1.2-
3/8	2.375	6.25	1	79	133	193	—	—	—
1/2	3.750	6.25	1	86	160	247	—	—	—
5/8	3.875	6.25	1	113	204	311	—	—	—
3/4	4.500	6.25	1	165	275	402	—	—	—
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Max. Flute Center Offset (in.)	A	B	C	D	E	F
				Pr 3.6–5.0	*Pr* 1.9–2.5	*Pr* 1.1–1.3	*Pr* 1.8–2.2	*Pr* 1.9–2.5	*Pr* 2.1–
3/8	2.375	6.25	1	56	104	165	—	—	—
1/2	3.750	6.25	1	60	121	205	—	—	—
5/8	3.875	6.25	1	79	157	260	—	—	—
3/4	4.500	6.25	1	116	216	343	—	—	—
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Max. Flute Center Offset (in.)	A	B	C	D	E	F
				Pr 5.1–6.5	*Pr* 2.6–3.2	*Pr* 1.4–1.6	*Pr* 2.3–2.7	*Pr* 2.6–3.2	*Pr* 3.0–
3/8	2.375	6.25	1	43	85	144	—	—	—
1/2	3.750	6.25	1	46	94	175	—	—	—
5/8	3.875	6.25	1	60	124	224	—	—	—
3/4	4.500	6.25	1	89	177	299	—	—	—

* *Pr* = Prying Factor Range. (Refer to Annex for additional information.)

Table 18.5.12.2(b) Maximum Load for Wedge Anchors in 3000 psi (207 bar) Lightweight Cracked Concrete

Wedge Anchors in 3000 psi Lightweight Cracked Concrete (lb)									
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr*

Wedge Anchors in 3000 psi Lightweight Cracked Concrete (lb)

Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A *Pr* ≤ 2.0	B *Pr* ≤ 1.1	C *Pr* ≤ 0.7	D *Pr* ≤ 1.2	E *Pr* ≤ 1.1	*Pr*
3/8	2.375	5	4	142	216	280	162	216	2
1/2	3.750	6	6	200	314	419	243	314	3
5/8	3.875	6	6	259	394	512	297	394	4
3/4	4.500	7	8	356	552	731	424	552	6

Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A *Pr* 2.1–3.5	B *Pr* 1.2–1.8	C *Pr* 0.8–1.0	D *Pr* 1.3–1.7	E *Pr* 1.2–1.8	*Pr* 1
3/8	2.375	5	4	89	154	229	133	154	1
1/2	3.750	6	6	119	218	335	195	218	2
5/8	3.875	6	6	163	281	418	244	281	2
3/4	4.500	7	8	214	386	588	343	386	3

Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A *Pr* 3.6–5.0	B *Pr* 1.9–2.5	C *Pr* 1.1–1.3	D *Pr* 1.8–2.2	E *Pr* 1.9–2.5	*Pr* 2
3/8	2.375	5	4	62	119	194	113	119	1
1/2	3.750	6	6	83	167	279	163	167	1
5/8	3.875	6	6	113	218	354	207	218	1
3/4	4.500	7	8	150	297	492	288	297	2

Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A *Pr* 5.1–6.5	B *Pr* 2.6–3.2	C *Pr* 1.4–1.6	D *Pr* 2.3–2.7	E *Pr* 2.6–3.2	*Pr* 3
3/8	2.375	5	4	47	97	168	98	97	
1/2	3.750	6	6	63	130	239	140	130	1
5/8	3.875	6	6	87	178	306	179	178	1
3/4	4.500	7	8	115	234	422	248	234	1

* *Pr* = Prying Factor Range. (Refer to Annex for additional information.)

Table 18.5.12.2(c) Maximum Load for Wedge Anchors in 3000 psi (207 bar) Normal Weight Cracked Concrete

Wedge Anchors in 3000 psi Normal Weight Cracked Concrete (lb)

Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A *Pr* ≤ 2.0	B *Pr* ≤ 1.1	C *Pr* ≤ 0.7	D *Pr* ≤ 1.2	E *Pr* ≤ 1.1	F *Pr* ≤ 1.1	G *Pr* ≤ 1.4
3/8	2.375	5	4	189	274	342	197	274	340	170
1/2	3.750	6	6	272	423	563	326	423	490	281
5/8	3.875	6	6	407	623	814	472	623	733	406
3/4	4.500	7	8	613	940	1232	715	940	1104	615

Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A *Pr* 2.1–3.5	B *Pr* 1.2–1.8	C *Pr* 0.8–1.0	D *Pr* 1.3–1.7	E *Pr* 1.2–1.8	F *Pr* 1.2–2.0	G *Pr* 1.5–1.9	1

Wedge Anchors in 3000 psi Normal Weight Cracked Concrete (lb)

Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr* ≤ 1.1	*Pr* ≤ 1.4	
3⁄8	2.375	5	4	125	203	288	167	203	219	147	
1⁄2	3.750	6	6	162	295	451	263	295	285	233	
5⁄8	3.875	6	6	252	441	662	386	441	442	341	
3⁄4	4.500	7	8	378	665	999	583	665	662	515	
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	
				Pr 3.6–5.0	*Pr* 1.9–2.5	*Pr* 1.1–1.3	*Pr* 1.8–2.2	*Pr* 1.9–2.5	*Pr* 2.1–2.9	*Pr* 2.0–2.4	1
3⁄8	2.375	5	4	92	162	249	145	162	159	130	
1⁄2	3.750	6	6	113	226	377	220	226	196	199	
5⁄8	3.875	6	6	176	341	557	326	341	304	293	
3⁄4	4.500	7	8	264	514	841	493	514	456	443	
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	
				Pr 5.1–6.5	*Pr* 2.6–3.2	*Pr* 1.4–1.6	*Pr* 2.3–2.7	*Pr* 2.6–3.2	*Pr* 3.0–3.8	*Pr* 2.5–2.9	1
3⁄8	2.375	5	4	70	134	220	128	134	121	116	
1⁄2	3.750	6	6	87	178	323	190	178	149	173	
5⁄8	3.875	6	6	135	276	481	283	276	232	258	
3⁄4	4.500	7	8	203	413	725	426	413	348	389	

* *Pr* = Prying Factor Range. (Refer to Annex for additional information.)

Table 18.5.12.2(d) Maximum Load for Wedge Anchors in 4000 psi (276 bar) Normal Weight Cracked Concrete

Wedge Anchors in 4000 psi Normal Weight Cracked Concrete (lb)

Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr*
3⁄8	2.375	5	4	206	293	360	208	293	3
1⁄2	3.750	6	6	304	466	610	353	466	5
5⁄8	3.875	6	6	469	716	935	542	716	8
3⁄4	4.500	7	8	657	997	1293	750	997	1
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr 2.1–3.5	*Pr* 1.2–1.8	*Pr* 0.8–1.0	*Pr* 1.3–1.7	*Pr* 1.2–1.8	1.2
3⁄8	2.375	5	4	138	221	307	178	221	2
1⁄2	3.750	6	6	188	330	495	289	330	3
5⁄8	3.875	6	6	291	508	761	444	508	5
3⁄4	4.500	7	8	414	711	1057	617	711	7
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr 3.6–5.0	*Pr* 1.9–2.5	*Pr* 1.1–1.3	*Pr* 1.8–2.2	*Pr* 1.9–2.5	*Pr* 2

Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	Wedge Anchors in 4000 psi Normal Weight Cracked Concrete (lb)					
				A	B	C	D	E	
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr*
3/8	2.375	5	4	103	177	268	156	177	1
1/2	3.750	6	6	131	255	417	244	255	2
5/8	3.875	6	6	203	393	641	375	393	3
3/4	4.500	7	8	289	553	894	524	553	5
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr 5.1–6.5	*Pr* 2.6–3.2	*Pr* 1.4–1.6	*Pr* 2.3–2.7	*Pr* 2.6–3.2	*Pr* 3
3/8	2.375	5	4	80	148	237	139	148	1
1/2	3.750	6	6	100	205	360	211	205	1
5/8	3.875	6	6	156	319	554	325	319	2
3/4	4.500	7	8	222	452	774	455	452	3

* *Pr* = Prying Factor Range. (Refer to Annex for additional information.)

Table 18.5.12.2(e) Maximum Load for Wedge Anchors in 6000 psi (414 bar) Normal Weight Cracked Concrete

Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	Wedge Anchors in 6000 psi Normal Weight Cracked Concrete (lb)					
				A	B	C	D	E	
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr*
3/8	2.375	5	4	225	313	379	219	313	4
1/2	3.750	6	6	354	529	676	392	529	6
5/8	3.875	6	6	546	812	1036	601	812	9
3/4	4.500	7	8	763	1127	1429	829	1127	1
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr 2.1–3.5	*Pr* 1.2–1.8	*Pr* 0.8–1.0	*Pr* 1.3–1.7	*Pr* 1.2–1.8	*Pr* 1
3/8	2.375	5	4	153	240	327	190	240	2
1/2	3.750	6	6	228	382	559	326	382	4
5/8	3.875	6	6	353	589	859	500	589	6
3/4	4.500	7	8	496	822	1190	693	822	8
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr 3.6–5.0	*Pr* 1.9–2.5	*Pr* 1.1–1.3	*Pr* 1.8–2.2	*Pr* 1.9–2.5	*Pr* 2
3/8	2.375	5	4	115	194	288	168	194	2
1/2	3.750	6	6	161	299	477	279	299	2
5/8	3.875	6	6	249	462	733	429	462	4
3/4	4.500	7	8	354	647	1019	596	647	6
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr 5.1–6.5	*Pr* 2.6–3.2	*Pr* 1.4–1.6	*Pr* 2.3–2.7	*Pr* 2.6–3.2	*Pr* 3

				Wedge Anchors in 6000 psi Normal Weight Cracked Concrete (lb)					
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr ≤ 2.0	Pr ≤ 1.1	Pr ≤ 0.7	Pr ≤ 1.2	Pr ≤ 1.1	Pr
3⁄8	2.375	5	4	91	163	257	150	163	1
1⁄2	3.750	6	6	123	246	415	243	246	2
5⁄8	3.875	6	6	192	380	639	375	380	3
3⁄4	4.500	7	8	272	533	891	523	533	4

* *Pr* = Prying Factor Range. (Refer to Annex for additional information.)

Table 18.5.12.2(f) Maximum Load for Metal Deck Inserts in 3000 psi (207 bar) Lightweight Cracked Concrete on Metal Deck

			Metal Deck Inserts in 3000 psi Sand Lightweight Cracked Concrete on 4 1⁄2 in. Flute W						
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Max. Flute Center Offset (in.)	A	B	C	D	E	F
				Pr ≤ 2.0	Pr ≤ 1.1	Pr ≤ 0.7	Pr ≤ 1.2	Pr ≤ 1.1	Pr ≤
3⁄8	1.750	6.25	1	135	192	236	—	—	—
1⁄2	1.750	6.25	1	138	199	247	—	—	—
5⁄8	1.750	6.25	1	138	199	247	—	—	—
3⁄4	1.750	6.25	1	164	257	344			
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Max. Flute Center Offset (in.)	A	B	C	D	E	F
				Pr 2.1–3.5	Pr 1.2–1.8	Pr 0.8–1.0	Pr 1.3–1.7	Pr 1.2–1.8	Pr 1.2-
3⁄8	1.750	6.25	1	90	144	201	—	—	—
1⁄2	1.750	6.25	1	91	148	209	—	—	—
5⁄8	1.750	6.25	1	91	148	209	—	—	—
3⁄4	1.750	6.25	1	97	178	275	—	—	—
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Max. Flute Center Offset (in.)	A	B	C	D	E	F
				Pr 3.6–5.0	Pr 1.9–2.5	Pr 1.1–1.3	Pr 1.8–2.2	Pr 1.9–2.5	Pr 2.1-
3⁄8	1.750	6.25	1	67	115	175	—	—	—
1⁄2	1.750	6.25	1	67	118	181	—	—	—
5⁄8	1.750	6.25	1	67	118	181	—	—	—
3⁄4	1.750	6.25	1	67	136	229	—	—	—
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Max. Flute Center Offset (in.)	A	B	C	D	E	F
				Pr 5.1–6.5	Pr 2.6–3.2	Pr 1.4–1.6	Pr 2.3–2.7	Pr 2.6–3.2	Pr 3.0-
3⁄8	1.750	6.25	1	52	96	155	—	—	—
1⁄2	1.750	6.25	1	52	98	160	—	—	—
5⁄8	1.750	6.25	1	52	98	160	—	—	—
3⁄4	1.750	6.25	1	52	106	196	—	—	—

* *Pr* = Prying Factor Range. (Refer to Annex for additional information.)

Table 18.5.12.2(g) Maximum Load for Wood Form Inserts in 3000 psi (207 bar) Lightweight Cracked Concrete

				Wood Form Inserts in 3000 psi Lightweight Cracked Concrete (lb)					
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr*
3/8	1.100	4	6	224	316	387	223	316	4
1/2	1.690	4	6	252	376	480	278	376	4
5/8	1.750	4	8	252	376	480	278	376	4
3/4	1.750	4	8	252	376	480	278	376	4
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr 2.1–3.5	*Pr* 1.2–1.8	*Pr* 0.8–1.0	*Pr* 1.3–1.7	*Pr* 1.2–1.8	*Pr* 1
3/8	1.100	4	6	150	239	331	192	239	2
1/2	1.690	4	6	163	272	398	231	272	2
5/8	1.750	4	8	163	272	398	231	272	2
3/4	1.750	4	8	163	272	398	231	272	2
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr 3.6–5.0	*Pr* 1.9–2.5	*Pr* 1.1–1.3	*Pr* 1.8–2.2	*Pr* 1.9–2.5	*Pr* 2
3/8	1.100	4	6	113	193	290	169	193	1
1/2	1.690	4	6	115	213	339	198	213	1
5/8	1.750	4	8	115	213	339	198	213	1
3/4	1.750	4	8	115	213	339	198	213	1
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr 5.1–6.5	*Pr* 2.6–3.2	*Pr* 1.4–1.6	*Pr* 2.3–2.7	*Pr* 2.6–3.2	*Pr* 3
3/8	1.100	4	6	88	161	257	150	161	1
1/2	1.690	4	6	88	175	296	173	175	1
5/8	1.750	4	8	88	175	296	173	175	1
3/4	1.750	4	8	88	175	296	173	175	1

* *Pr* = Prying Factor Range. (Refer to Annex for additional information.)

Table 18.5.12.2(h) Maximum Load for Wood Form Inserts in 3000 psi (207 bar) Normal Weight Cracked Concrete

				Wood Form Inserts in 3000 psi Normal Weight Cracked Concrete (l					
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr*
3/8	1.100	4	6	248	342	411	237	342	4
1/2	1.690	4	6	297	443	565	327	443	5
5/8	1.750	4	8	297	443	565	327	443	5
3/4	1.750	4	8	297	443	565	327	443	5

Wood Form Inserts in 3000 psi Normal Weight Cracked Concrete (I									
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr*
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr 2.1–3.5	*Pr* 1.2–1.8	*Pr* 0.8–1.0	*Pr* 1.3–1.7	*Pr* 1.2–1.8	*Pr* 1
3/8	1.100	4	6	170	264	357	207	264	2
1/2	1.690	4	6	192	321	468	272	321	3
5/8	1.750	4	8	192	321	468	272	321	3
3/4	1.750	4	8	192	321	468	272	321	3
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr 3.6–5.0	*Pr* 1.9–2.5	*Pr* 1.1–1.3	*Pr* 1.8–2.2	*Pr* 1.9–2.5	*Pr* 2
3/8	1.100	4	6	129	215	315	184	215	2
1/2	1.690	4	6	135	251	399	233	251	2
5/8	1.750	4	8	135	251	399	233	251	2
3/4	1.750	4	8	135	251	399	233	251	2
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr 5.1–6.5	*Pr* 2.6–3.2	*Pr* 1.4–1.6	*Pr* 2.3–2.7	*Pr* 2.6–3.2	*Pr* 3
3/8	1.100	4	6	104	181	282	165	181	1
1/2	1.690	4	6	104	207	348	204	207	1
5/8	1.750	4	8	104	207	348	204	207	1
3/4	1.750	4	8	104	207	348	204	207	1

* *Pr* = Prying Factor Range. (Refer to Annex for additional information.)

Table 18.5.12.2(i) Maximum Load for Wood Form Inserts in 4000 psi (276 bar) Normal Weight Cracked Concrete

Wood Form Inserts in 4000 psi Normal Weight Cracked Concrete (I									
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr*
3/8	1.100	4	6	270	364	431	249	364	4
1/2	1.690	4	6	335	493	623	361	493	6
5/8	1.750	4	8	344	511	653	378	511	6
3/4	1.750	4	8	344	511	653	378	511	6
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	
				Pr 2.1–3.5	*Pr* 1.2–1.8	*Pr* 0.8–1.0	*Pr* 1.3–1.7	*Pr* 1.2–1.8	*Pr* 1
3/8	1.100	4	6	188	287	379	220	287	3
1/2	1.690	4	6	218	361	520	303	361	3
5/8	1.750	4	8	222	371	541	315	371	3
3/4	1.750	4	8	222	371	541	315	371	3

Wood Form Inserts in 4000 psi Normal Weight Cracked Concrete (l									
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A *Pr* ≤ 2.0	B *Pr* ≤ 1.1	C *Pr* ≤ 0.7	D *Pr* ≤ 1.2	E *Pr* ≤ 1.1	*Pr*
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A *Pr* 3.6–5.0	B *Pr* 1.9–2.5	C *Pr* 1.1–1.3	D *Pr* 1.8–2.2	E *Pr* 1.9–2.5	*Pr* 2
3/8	1.100	4	6	145	236	338	197	236	2
1/2	1.690	4	6	157	284	446	261	284	2
5/8	1.750	4	8	157	290	461	270	290	2
3/4	1.750	4	8	157	290	461	270	290	2
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A *Pr* 5.1–6.5	B *Pr* 2.6–3.2	C *Pr* 1.4–1.6	D *Pr* 2.3–2.7	E *Pr* 2.6–3.2	*Pr* 3
3/8	1.100	4	6	117	201	305	178	201	2
1/2	1.690	4	6	120	234	390	229	234	2
5/8	1.750	4	8	120	239	402	236	239	2
3/4	1.750	4	8	120	239	402	236	239	2

* *Pr* = Prying Factor Range. (Refer to Annex for additional information.)

Table 18.5.12.2(j) Maximum Load for Wood Form Inserts in 6000 psi (414 bar) Normal Weight Cracked Concrete

Wood Form Inserts in 6000 psi Normal Weight Cracked Concrete (l									
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A *Pr* ≤ 2.0	B *Pr* ≤ 1.1	C *Pr* ≤ 0.7	D *Pr* ≤ 1.2	E *Pr* ≤ 1.1	*Pr*
3/8	1.100	4	6	302	395	458	264	395	5
1/2	1.690	4	6	385	551	680	394	551	6
5/8	1.750	4	8	421	627	800	463	627	7
3/4	1.750	4	8	421	627	800	463	627	7
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A *Pr* 2.1–3.5	B *Pr* 1.2–1.8	C *Pr* 0.8–1.0	D *Pr* 1.3–1.7	E *Pr* 1.2–1.8	*Pr* 1
3/8	1.100	4	6	216	319	409	237	319	3
1/2	1.690	4	6	256	413	578	336	413	4
5/8	1.750	4	8	272	454	662	386	454	4
3/4	1.750	4	8	272	454	662	386	454	4
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A *Pr* 3.6–5.0	B *Pr* 1.9–2.5	C *Pr* 1.1–1.3	D *Pr* 1.8–2.2	E *Pr* 1.9–2.5	*Pr* 2
3/8	1.100	4	6	169	267	370	215	267	2
1/2	1.690	4	6	192	330	503	293	330	3
5/8	1.750	4	8	192	356	565	331	356	3
3/4	1.750	4	8	192	356	565	331	356	3

Wood Form Inserts in 6000 psi Normal Weight Cracked Concrete (l									
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A Pr ≤ 2.0	B Pr ≤ 1.1	C Pr ≤ 0.7	D Pr ≤ 1.2	E Pr ≤ 1.1	Pr
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A Pr 5.1–6.5	B Pr 2.6–3.2	C Pr 1.4–1.6	D Pr 2.3–2.7	E Pr 2.6–3.2	Pr 3
3/8	1.100	4	6	138	229	337	196	229	2
1/2	1.690	4	6	147	275	445	260	275	2
5/8	1.750	4	8	147	293	493	289	293	2
3/4	1.750	4	8	147	293	493	289	293	2

* Pr = Prying Factor Range. (Refer to Annex for additional information.)

Table 18.5.12.2(a) Maximum Load for Wedge Anchors in 3000 psi (207 bar) Lightweight Cracked Concrete on Metal Deck

Wedge Anchors in 3000 psi Lightweight Cracked Concrete on Metal Deck (lb)										
Diameter (in.)	Embedment (in.)	A Pr * ≤2.0	B Pr ≤1.1	C Pr ≤0.7	D Pr ≤1.2	E Pr ≤1.1	F Pr ≤1.1	G Pr ≤1.4	H Pr ≤0.9	I Pr ≤0.8
3/8	2	117	184	246	—	—	—	—	—	—
1/2	2 3/8	164	257	344	—	—	—	—	—	—
5/8	3 1/8	214	326	424	—	—	—	—	—	—
Diameter (in.)	Embedment (in.)	A Pr 2.1–3.5	B Pr 1.2–1.8	C Pr 0.8–1.0	D Pr 1.3–1.7	E Pr 1.2–1.8	F Pr 1.2–2.0	G Pr 1.5–1.9	H Pr 1.0–1.3	I Pr 0.9–1.1
3/8	2	69	127	196	—	—	—	—	—	—
1/2	2 3/8	97	178	274	—	—	—	—	—	—
5/8	3 1/8	133	232	346	—	—	—	—	—	—
Diameter (in.)	Embedment (in.)	A Pr 3.6–5.0	B Pr 1.9–2.5	C Pr 1.1–1.3	D Pr 1.8–2.2	E Pr 1.9–2.5	F Pr 2.1–2.9	G Pr 2.0–2.4	H Pr 1.4–1.7	I Pr 1.2–1.4
3/8	2	48	97	163	—	—	—	—	—	—
1/2	2 3/8	67	136	228	—	—	—	—	—	—
5/8	3 1/8	93	179	292	—	—	—	—	—	—
Diameter (in.)	Embedment (in.)	A Pr 5.1–6.5	B Pr 2.6–3.2	C Pr 1.4–1.6	D Pr 2.3–2.7	E Pr 2.6–3.2	F Pr 3.0–3.8	G Pr 2.5–2.9	H Pr 1.8–2.1	I Pr 1.5–1.7
3/8	2	36	75	139	—	—	—	—	—	—
1/2	2 3/8	51	106	196	—	—	—	—	—	—
5/8	3 1/8	71	146	252	—	—	—	—	—	—

* Pr = Prying Factor Range. (Refer to Annex for additional information.)

1 lb = 0.45 kg

Table 18.5.12.2(c) Maximum Load for Wedge Anchors in 3000 psi (207 bar) Lightweight Cracked Concrete

Wedge Anchors in 3000 psi Lightweight Cracked Concrete (lb)										
		A	B	C	D	E	F	G	H	I
Diameter (in.)	Embedment (in.)	*Pr* * ≤2.0	*Pr* ≤1.1	*Pr* ≤0.7	*Pr* ≤1.2	*Pr* ≤1.1	*Pr* ≤1.1	*Pr* ≤1.4	*Pr* ≤0.9	*Pr* ≤0.8
3/8	2	102	144	175	101	144	184	87	128	152
1/2	2 3/8	140	196	238	137	196	251	118	174	207
5/8	3 1/4	222	308	372	215	308	397	220	272	323
3/4	4 1/8	327	469	580	336	469	586	289	426	504
		A	B	C	D	E	F	G	H	I
Diameter (in.)	Embedment (in.)	*Pr* 2.1–3.5	*Pr* 1.2–1.8	*Pr* 0.8–1.0	*Pr* 1.3–1.7	*Pr* 1.2–1.8	*Pr* 1.2–2.0	*Pr* 1.5–1.9	*Pr* 1.0–1.3	*Pr* 0.9–1.1
3/8	2	69	109	150	87	109	121	76	110	133
1/2	2 3/8	94	149	205	119	149	166	104	150	181
5/8	3 1/4	151	237	322	187	237	265	201	236	285
3/4	4 1/8	217	351	492	286	351	380	252	362	436
		A	B	C	D	E	F	G	H	I
Diameter (in.)	Embedment (in.)	*Pr* 3.6–5.0	*Pr* 1.9–2.5	*Pr* 1.1–1.3	*Pr* 1.8–2.2	*Pr* 1.9–2.5	*Pr* 2.1–2.9	*Pr* 2.0–2.4	*Pr* 1.4–1.7	*Pr* 1.2–1.4
3/8	2	52	88	132	76	88	90	68	97	118
1/2	2 3/8	71	121	180	104	121	124	93	132	161
5/8	3 1/4	114	192	284	165	192	198	185	208	254
3/4	4 1/8	162	280	427	249	280	281	223	315	385
		A	B	C	D	E	F	G	H	I
Diameter (in.)	Embedment (in.)	*Pr* 5.1–6.5	*Pr* 2.6–3.2	*Pr* 1.4–1.6	*Pr* 2.3–2.7	*Pr* 2.6–3.2	*Pr* 3.0–3.8	*Pr* 2.5–2.9	*Pr* 1.8–2.1	*Pr* 1.5–1.7
3/8	2	41	74	117	68	74	70	61	86	106
1/2	2 3/8	56	101	160	93	101	97	84	118	145
5/8	3 1/4	91	161	253	148	161	157	172	186	230
3/4	4 1/8	124	233	378	221	233	214	200	279	344

* *Pr* = Prying Factor Range. (Refer to Annex for additional information.)

1 lb = 0.45 kg

Table 18.5.12.2(e) Maximum Load for Wedge Anchors in 3000 psi (207 bar) Normal Weight Cracked Concrete

Wedge Anchors in 3000 psi Normal Weight Cracked Concrete (lb)										
		A	B	C	D	E	F	G	H	I
Diameter (in.)	Embedment (in.)	*Pr* * ≤2.0	*Pr* ≤1.1	*Pr* ≤0.7	*Pr* ≤1.2	*Pr* ≤1.1	*Pr* ≤1.1	*Pr* ≤1.4	*Pr* ≤0.9	*Pr* ≤0.8
3/8	2	171	240	292	169	240	307	145	214	254
1/2	3 5/8	412	567	682	394	567	735	340	498	592
5/8	3 7/8	480	668	809	468	668	859	479	591	703
3/4	4 1/8	545	780	965	559	780	976	482	709	839
		A	B	C	D	E	F	G	H	I
Diameter (in.)	Embedment (in.)	*Pr* 2.1–3.5	*Pr* 1.2–1.8	*Pr* 0.8–1.0	*Pr* 1.3–1.7	*Pr* 1.2–1.8	*Pr* 1.2–2.0	*Pr* 1.5–1.9	*Pr* 1.0–1.3	*Pr* 0.9–1.1

Wedge Anchors in 3000 psi Normal Weight Cracked Concrete (lb)										
3/8	2	116	183	252	146	183	203	128	184	223
1/2	3 5/8	282	438	592	344	438	493	302	434	523
5/8	3 7/8	327	512	699	406	512	571	438	512	618
3/4	4 1/8	363	584	819	477	584	634	420	604	727
		A	B	C	D	E	F	G	H	I
Diameter (in.)	Embedment (in.)	*Pr* 3.6–5.0	*Pr* 1.9–2.5	*Pr* 1.1–1.3	*Pr* 1.8–2.2	*Pr* 1.9–2.5	*Pr* 2.1–2.9	*Pr* 2.0–2.4	*Pr* 1.4–1.7	*Pr* 1.2–1.4
3/8	2	87	148	221	128	148	152	114	162	198
1/2	3 5/8	214	357	523	305	357	371	271	384	469
5/8	3 7/8	247	415	615	359	415	428	404	452	551
3/4	4 1/8	271	467	712	416	467	468	371	526	641
		A	B	C	D	E	F	G	H	I
Diameter (in.)	Embedment (in.)	*Pr* 5.1–6.5	*Pr* 2.6–3.2	*Pr* 1.4–1.6	*Pr* 2.3–2.7	*Pr* 2.6–3.2	*Pr* 3.0–3.8	*Pr* 2.5–2.9	*Pr* 1.8–2.1	*Pr* 1.5–1.7
3/8	2	69	124	197	115	124	118	103	145	178
1/2	3 5/8	173	301	469	274	301	296	247	345	425
5/8	3 7/8	197	349	549	321	349	337	374	404	498
3/4	4 1/8	208	389	629	369	389	357	333	465	573

* *Pr* = Prying Factor Range. (Refer to Annex for additional information.)

1 lb = 0.45 kg

Table 18.5.12.2(e) Maximum Load for Wedge Anchors in 4000 psi (276 bar) Normal Weight Cracked Concrete

Wedge Anchors in 4000 psi Normal Weight Cracked Concrete (lb)										
		A	B	C	D	E	F	G	H	I
Diameter (in.)	Embedment (in.)	*Pr* * ≤2.0	*Pr* ≤1.1	*Pr* ≤0.7	*Pr* ≤1.2	*Pr* ≤1.1	*Pr* ≤1.1	*Pr* ≤1.4	*Pr* ≤0.9	*Pr* ≤0.8
3/8	2	200	282	344	199	282	359	171	251	299
1/2	3 5/8	430	607	742	430	607	770	370	544	645
5/8	3 7/8	532	729	872	505	729	950	511	636	758
3/4	4 1/8	630	903	1117	647	903	1129	558	821	971
		A	B	C	D	E	F	G	H	I
Diameter (in.)	Embedment (in.)	*Pr* 2.1–3.5	*Pr* 1.2–1.8	*Pr* 0.8–1.0	*Pr* 1.3–1.7	*Pr* 1.2–1.8	*Pr* 1.2–2.0	*Pr* 1.5–1.9	*Pr* 1.0–1.3	*Pr* 0.9–1.1
3/8	2	135	214	295	171	214	236	150	216	261
1/2	3 5/8	289	460	636	370	460	506	325	467	563
5/8	3 7/8	367	566	760	442	566	642	470	557	672
3/4	4 1/8	419	676	948	552	676	733	486	699	841
		A	B	C	D	E	F	G	H	I
Diameter (in.)	Embedment (in.)	*Pr* 3.6–5.0	*Pr* 1.9–2.5	*Pr* 1.1–1.3	*Pr* 1.8–2.2	*Pr* 1.9–2.5	*Pr* 2.1–2.9	*Pr* 2.0–2.4	*Pr* 1.4–1.7	*Pr* 1.2–1.4
3/8	2	101	172	258	150	172	176	134	190	232
1/2	3 5/8	218	370	556	325	370	377	290	410	500
5/8	3 7/8	280	463	674	393	463	484	435	494	603

Wedge Anchors in 4000 psi Normal Weight Cracked Concrete (lb)										
3/4	4 1/8	313	540	824	481	540	541	430	608	741
		A	B	C	D	E	F	G	H	I
Diameter (in.)	Embedment (in.)	Pr	Pr	Pr	Pr	Pr	Pr	Pr	Pr	Pr
		5.1–6.5	2.6–3.2	1.4–1.6	2.3–2.7	2.6–3.2	3.0–3.8	2.5–2.9	1.8–2.1	1.5–1.7
3/8	2	79	144	230	134	144	137	121	169	209
1/2	3 5/8	170	310	494	289	310	292	261	365	449
5/8	3 7/8	226	391	605	354	391	389	406	445	547
3/4	4 1/8	241	449	728	427	449	413	386	538	663

* *Pr* = Prying Factor Range. (Refer to Annex for additional information.)

1 lb = 0.45 kg

Table 18.5.12.2(k) Maximum Load for Wedge Anchors in 6000 psi (414 bar) Normal Weight Cracked Concrete

Wedge Anchors in 6000 psi Normal Weight Cracked Concrete (lb)										
		A	B	C	D	E	F	G	H	I
Diameter (in.)	Embedment (in.)	Pr *	Pr	Pr	Pr	Pr	Pr	Pr	Pr	Pr
		≤2.0	≤1.1	≤0.7	≤1.2	≤1.1	≤1.1	≤1.4	≤0.9	≤0.8
3/8	2 1/4	254	354	428	199	354	585	213	313	372
1/2	3 5/8	527	744	910	418	744	1227	454	667	791
5/8	3 7/8	652	893	1069	504	893	1481	626	780	928
3/4	4 1/8	772	1106	1369	622	1106	1819	684	1005	1190
		A	B	C	D	E	F	G	H	I
Diameter (in.)	Embedment (in.)	Pr	Pr	Pr	Pr	Pr	Pr	Pr	Pr	Pr
		2.1–3.5	1.2–1.8	0.8–1.0	1.3–1.7	1.2–1.8	1.2–2.0	1.5–1.9	1.0–1.3	0.9–1.1
3/8	2 1/4	172	271	370	215	271	302	188	271	327
1/2	3 5/8	355	564	780	453	564	621	399	573	690
5/8	3 7/8	450	694	932	542	694	786	576	682	823
3/4	4 1/8	514	828	1162	676	828	898	595	856	1030
		A	B	C	D	E	F	G	H	I
Diameter (in.)	Embedment (in.)	Pr	Pr	Pr	Pr	Pr	Pr	Pr	Pr	Pr
		3.6–5.0	1.9–2.5	1.1–1.3	1.8–2.2	1.9–2.5	2.1–2.9	2.0–2.4	1.4–1.7	1.2–1.4
3/8	2 1/4	130	219	325	189	219	226	169	239	292
1/2	3 5/8	267	454	682	398	454	462	355	502	613
5/8	3 7/8	343	567	826	481	567	593	534	606	739
3/4	4 1/8	384	662	1009	590	662	663	527	745	909
		A	B	C	D	E	F	G	H	I
Diameter (in.)	Embedment (in.)	Pr	Pr	Pr	Pr	Pr	Pr	Pr	Pr	Pr
		5.1–6.5	2.6–3.2	1.4–1.6	2.3–2.7	2.6–3.2	3.0–3.8	2.5–2.9	1.8–2.1	1.5–1.7
3/8	2 1/4	103	184	290	170	184	178	153	214	263
1/2	3 5/8	209	380	606	355	380	358	320	447	551
5/8	3 7/8	277	480	741	433	480	476	497	545	671
3/4	4 1/8	295	551	892	523	551	506	473	660	813

* *Pr* = Prying Factor Range. (Refer to Annex for additional information.)

1 lb = 0.45 kg

Table 18.5.12.2(I) Maximum Load for Undercut Anchors in 3000 psi (207 bar) Normal Weight Cracked Concrete

Undercut Anchors in 3000 psi Normal Weight Cracked Concrete (lb)

Diameter (in.)	Embedment (in.)	A	B	C	D	E	F	G	H	I
		Pr *	*Pr*	*Pr*	*Pr*	*Pr*	*Pr*	*Pr*	*Pr*	*Pr*
		≤2.0	≤1.1	≤0.7	≤1.2	≤1.1	≤1.1	≤1.4	≤0.9	≤0.8
3/8	4 3/8	501	638	726	420	638	889	362	525	630
1/2	7	700	911	1051	608	911	1245	525	761	912
5/8	9 1/2	1106	1535	1855	1074	1535	1975	1098	1356	1612
3/4	12	1701	2404	2946	1707	2404	3041	1472	2161	2561
Diameter (in.)	Embedment (in.)	A	B	C	D	E	F	G	H	I
		Pr	*Pr*	*Pr*	*Pr*	*Pr*	*Pr*	*Pr*	*Pr*	*Pr*
		2.1–3.5	1.2–1.8	0.8–1.0	1.3–1.7	1.2–1.8	1.2–2.0	1.5–1.9	1.0–1.3	0.9–1.1
3/8	4 3/8	368	526	658	381	526	643	333	477	578
1/2	7	505	738	942	547	738	882	479	685	829
5/8	9 1/2	754	1179	1604	933	1179	1318	1005	1177	1419
3/4	12	1143	1819	2520	1468	1819	1996	1291	1854	2233
Diameter (in.)	Embedment (in.)	A	B	C	D	E	F	G	H	I
		Pr	*Pr*	*Pr*	*Pr*	*Pr*	*Pr*	*Pr*	*Pr*	*Pr*
		3.6–5.0	1.9–2.5	1.1–1.3	1.8–2.2	1.9–2.5	2.1–2.9	2.0–2.4	1.4–1.7	1.2–1.4
3/8	4 3/8	291	447	601	350	447	504	309	437	534
1/2	7	395	620	854	497	620	683	440	622	760
5/8	9 1/2	572	957	1413	825	957	989	927	1039	1268
3/4	12	860	1463	2202	1287	1463	1486	1149	1624	1980
Diameter (in.)	Embedment (in.)	A	B	C	D	E	F	G	H	I
		Pr	*Pr*	*Pr*	*Pr*	*Pr*	*Pr*	*Pr*	*Pr*	*Pr*
		5.1–6.5	2.6–3.2	1.4–1.6	2.3–2.7	2.6–3.2	3.0–3.8	2.5–2.9	1.8–2.1	1.5–1.7
3/8	4 3/8	241	389	554	323	389	414	287	403	496
1/2	7	324	535	780	455	535	557	407	570	701
5/8	9 1/2	456	806	1263	739	806	781	859	931	1145
3/4	12	670	1223	1955	1146	1223	1147	1035	1444	1778

* *Pr* = Prying Factor Range. (Refer to Annex for additional information.)

1 lb = 0.45 kg

Table 18.5.12.2(k) Maximum Load for Connections to Steel Using Unfinished Steel Bolts

Connections to Steel (Values Assume Bolt Perpendicular to Mounting Surface

Diameter of Unfinished Steel Bolt (in.)

¼									⅜								
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
400	500	600	300	500	650	325	458	565	900	1200	1400	800	1200	1550	735	1035	1278

Diameter of Unfinished Steel Bolt (in.)

½									⅝								
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
1600	2050	2550	1450	2050	2850	1300	1830	2260	2500	3300	3950	2250	3300	4400	2045	2880	3557

Table 18.5.12.2(l) Maximum Load for Through-Bolts in Sawn Lumber or Glue-Laminated Timbers

Through-Bolts in Sawn Lumber or Glue-Laminated Timbers (Load Perpendicular to Gra

Length of Bolt in Timber (in.)		Bolt Diameter (in.)																						
		½									⅝									¾				
		A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I	A	B	C	D	E
	1½	115	165	200	135	230	395	130	215	310	135	190	235	155	270	460	155	255	380	155	220	270	180	310
	2½	140	200	240	160	280	480	165	275	410	160	225	280	185	320	550	190	320	495	180	255	310	205	360
	3½	175	250	305	200	350	600	200	330	485	200	285	345	230	400	685	235	405	635	220	310	380	255	440
	5½	—	—	—	—	—	—	—	—	—	280	395	485	325	560	960	315	515	735	310	440	535	360	620

Note: Wood fastener maximum capacity values are based on the 2001 National Design Specifications (NDS) for wood with a specific gravity of 0.35. Values for other types of wood can be obtained by multiplying the above values by the factors in ~~Table 9.3.5.12.2(j)~~ Table 18.5.12.2(n). .

Table 18.5.12.2(m) Maximum Load for Lag Screws and Lag Bolts in Wood

Lag Screws and Lag Bolts in Wood (Load Perpendicular to Grain — Holes Predrilled Using Good

Length of Bolt in Timber (in.)		Lag Bolt Diameter (in.)																						
		½									⅝									¾				
		A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I	A	B	C	D	E
	3½	165	190	200	170	220	310	80	120	170	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4½	180	200	200	175	235	350	80	120	170	300	355	380	315	400	550	145	230	325	—	—	—	—	—
	5½	190	200	200	175	245	380	80	120	170	320	370	380	320	420	610	145	230	325	435	525	555	425	550
	6½	195	205	200	175	250	400	80	120	170	340	375	380	325	435	650	145	230	325	465	540	555	430	570

Note: Wood fastener maximum capacity values are based on the 2001 National Design Specifications (NDS) for wood with a specific gravity of 0.35. Values for other types of wood can be obtained by multiplying the above values by the factors in ~~Table 9.3.5.12.2(j)~~ Table 18.5.12.2(n). .

Table 18.5.12.2(n) Factors for Wood Based on Specific Gravity

Specific Gravity of Wood	Multiplier
0.36 thru 0.49	1.17
0.50 thru 0.65	1.25
0.66 thru 0.73	1.50

Supplemental Information

File Name	Description	Approved
Tables_18.5.12.2_a-j.pdf	New Table 18.5.12.2(a) through Table 18.5.12.2(j). For staff use.	

Submitter Information Verification

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Submittal Date: Tue Jul 11 11:03:40 EDT 2017

Committee Statement

Committee Statement:	Tables have been revised to reflect recalculated shear and tension values supplied by several concrete anchor manufacturers. New tables have been added to address concrete inserts. Renumber remaining tables.
Response Message:	

Second Revision No. 10-NFPA 13-2017 [Section No. 18.5.12.7.1]

18.5.12.7.1*

~~Concrete~~ Post-installed concrete anchors shall be prequalified for seismic applications in accordance with ACI 355.2, *Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary*, and installed in accordance with the manufacturer's instructions.

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Committee Statement

Committee Statement: Editorial revision.
Response Message:

Second Revision No. 11-NFPA 13-2017 [New Section after 18.5.12.7.4]

18.5.12.7.5

Headed cast-in specialty inserts (concrete inserts) as prescribed in Table 18.5.12.2(a) through Table 18.5.12.2(j) shall be prequalified for seismic applications in accordance with ICC-ES AC446, *Acceptance Criteria for Headed Cast-in Specialty Inserts in Concrete* , and installed in accordance with the manufacturer's instructions.

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Committee Statement

Committee Statement: The added text gives descriptive information for concrete inserts that have been added to Table 18.5.12.2(a) through Table 18.5.12.2(j).

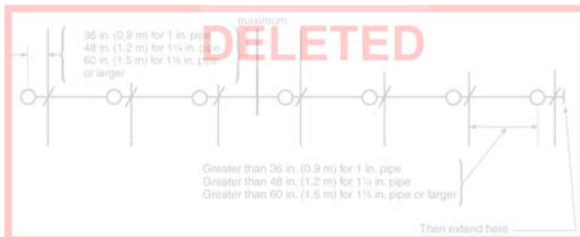
Response Message:

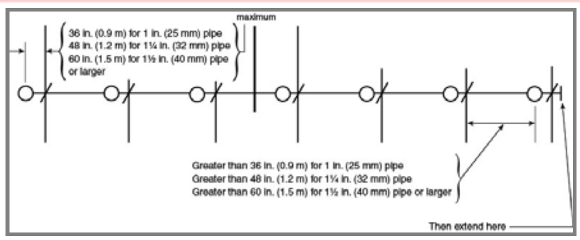
Second Revision No. 1032-NFPA 13-2017 [Section No. A.17.4.3.4]

A.17.4.3.4

Sprinkler piping should be adequately secured to restrict the movement of piping upon sprinkler operation. The reaction forces caused by the flow of water through the sprinkler could result in displacement of the sprinkler, thereby adversely affecting sprinkler discharge. Listed CPVC pipe has specific requirements for piping support to include additional pipe bracing of sprinklers. *(See Figure A.17.4.3.4.)*

Figure A.17.4.3.4 Distance from Sprinkler to Hanger.





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Committee Statement

Committee Statement: Editorial.

Response Message:

Second Revision No. 1033-NFPA 13-2017 [Section No. A.17.4.3.4.4]

A.17.4.3.4.4

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

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

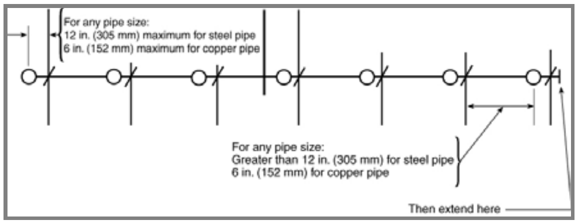
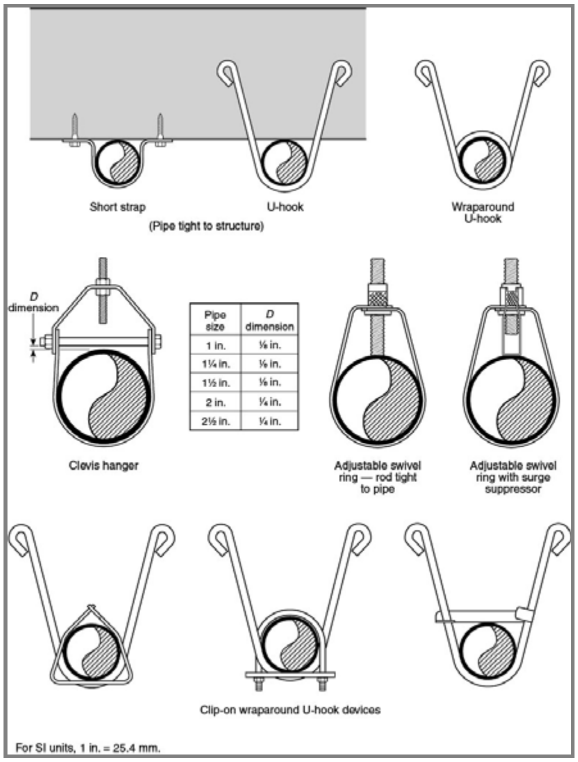


Figure A.17.4.3.4.4(b) Examples of Acceptable Hangers for End-of-Line (or Armover) Pendent Sprinklers.



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Committee Statement

Committee Statement: Editorial.

Response Message:

Second Revision No. 1034-NFPA 13-2017 [Section No. A.18.5.7.2]

A.18.5.7.2

See Figure A.18.5.7.2.

Figure A.18.5.7.2 Examples of Brace Locations for Change in Direction of Pipe.

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Zip:
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Committee Statement

Committee Statement: Editorial.
Response Message:

Second Revision No. 13-NFPA 13-2017 [Section No. A.18.5.12]

A.18.5.12

Current fasteners for anchoring to concrete are referred to as post-installed anchors. Concrete anchors can be cast-in-place [installed before the concrete is placed — see Figure A.18.5.12(a) and Figure A.18.5.12(b)] or post-installed [installed in hardened concrete — see Figure A.18.5.12(c)]. Examples of cast-in-place concrete anchors are embedded steel bolts or concrete inserts. There are several types of post-installed anchors, including expansion anchors, chemical or adhesive anchors, and undercut anchors. The criteria in Table 18.5.12.2(a) through Table 18.5.12.2(l) Table 18.5.12.2(j) are based on the use of listed cast-in-place concrete inserts and listed post-installed wedge expansion anchors and undercut anchors . The values for "effective embedment" for cast-in-place anchors and "nominal embedment" for post-installed anchors as shown in the tables represent the majority of commonly available anchors on the market at the time of publishing. Use of other anchors in concrete should be in accordance with the listing provisions of the anchor. Anchorage designs are usable under allowable stress design (ASD) methods.

Values in Table 18.5.12.2(a) through Table 18.5.12.2(l) Table 18.5.12.2(j) are based on ultimate strength design values obtained using the procedures in ACI 318, Appendix D *Building Code Requirements for Structural Concrete and Commentary* , Chapter 17 , which are then adjusted for ASD. Concrete inserts are installed into wood forms for concrete members using fasteners prior to the casting of concrete or inserted into wood forms for concrete members using fasteners prior to the casting of concrete or inserted into a hole cut in steel deck that will be filled with concrete topping slab. A bolt or rod can be installed into the internally threaded concrete insert after the wood form is removed from the concrete or from the underside of the steel deck after it is filled with concrete topping slab. Wedge anchors are torque-controlled expansion anchors that are set by applying a torque to the anchor's nut, which causes the anchor to rise while the wedge stays in place. This causes the wedge to be pulled onto a coned section of the anchor and presses the wedge against the wall of the hole. Undercut anchors might or might not be torque-controlled. Typically, the main hole is drilled, a special second drill bit is inserted into the hole, and flare is drilled at the base of the main hole. Some anchors are self-drilling and do not require a second drill bit. The anchor is then inserted into the hole, and when torque is applied, the bottom of the anchor flares out into the flared hole, and a mechanical lock is obtained. Consideration should be given with respect to the position near the edge of a slab and the spacing of anchors. For full capacity in Table 18.5.12.2(a) through Table 18.5.12.2(j), the edge distance spacing between anchors and the thickness of concrete should conform to the anchor manufacturer's recommendations.

Calculation of ASD shear and tension values to be used in A.18.5.12.2 calculations should be performed in accordance with ACI 318, Chapter 17 formulas using the variables and recommendations obtained from the approved evaluation service reports (such as ICC-ES Reports) for a particular anchor, which should then be adjusted to ASD values. All post-installed concrete anchors must be prequalified in accordance with ACI 355.2, *Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary*, or other approved qualification procedures (ASCE/SEI 7, *Minimum Design Loads for Buildings and Other Structures* , Section 13.4.2.3). This information is usually available from the anchor manufacturer.

The following variables below are among those contained in the approved evaluation reports for use in ACI 318, Chapter 17 calculations. These variables do not include the allowable tension and shear capacities but do provide the information needed to calculate them. The strength design capacities must be calculated using the appropriate procedures in ACI 318, Chapter 17, and then converted to allowable stress design capacities.

D_a = Anchor anchor diameter

L_{anch} = total anchor length

h_{nom}= Nominal nominal embedment

h_{ef} = Effective effective embedment

h_{min} = Min. minimum concrete thickness

C_{ac} = Critical critical edge distance

N_{sa} = Steel steel strength in tension

l_e = Length length of anchor in shear

$N_{p,cr}$ = Pull pull -out strength cracked concrete

K_{cp} = Coefficient coefficient for pryout strength

$V_{sa,eq}$ = Shear shear strength single anchor seismic loads

$V_{st.deck,eq}$ = ~~Shear~~ shear strength single anchor seismic loads installed through the soffit of the metal deck

Figure A.18.5.12(a) Metal Deck Insert.

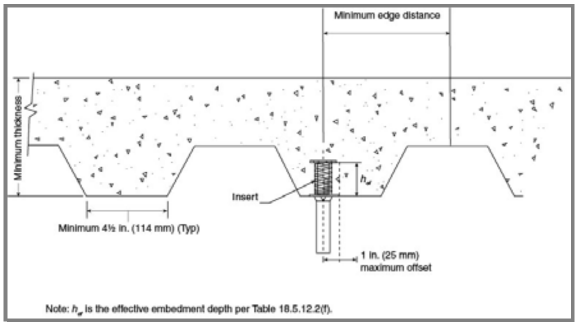


Figure A.18.5.12(b) Wood Form Insert.

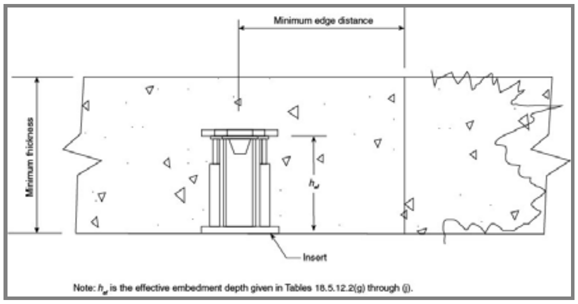
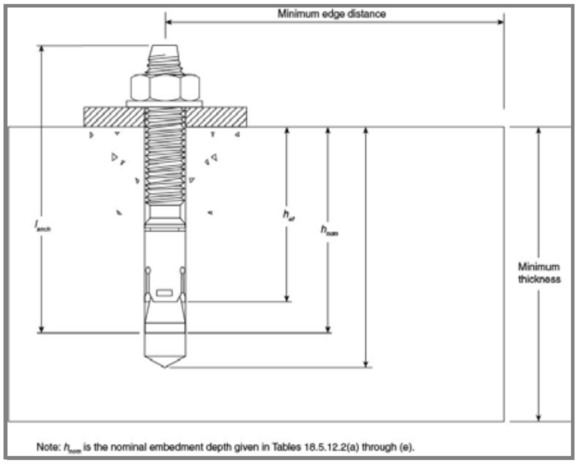


Figure A.18.5.12(c) Wedge Anchor.



Supplemental Information

File Name	Description	Approved
Metal_Deck_Rev19Jun_4pm_Fig_A.JPG	Figure A-for staff use	
Wood_Form_Insert_Rev19Jun_4pm_Fig_B.JPG	Figure B--for staff use	
Wedge_Anchor_Rev19Jun_4pm_Fig_C.JPG	Figure C---for staff use	

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Street Address:
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Submittal Date: Tue Jul 11 11:28:12 EDT 2017

Committee Statement

Committee Statement: The added text provides descriptions of the concrete inserts that were added to the body of the standard.

Response Message:

Second Revision No. 14-NFPA 13-2017 [Section No. A.18.5.12.2]

A.18.5.12.2

The values for the concrete insert and wedge anchor tables ~~and the undercut anchor tables~~ have been developed using the following formula:

$$\left(\frac{T}{T_{allow}}\right)+\left(\frac{T}{V_{allow}}\right)\leq 1.2$$ **[A.18.5.12.2a]**

where:

T = applied service tension load, including the effect of prying (F_{pw} × Pr)

F_{pw} = horizontal earthquake load

Pr = prying factor based on fitting geometry and brace angle from vertical

T_{allow} = allowable service tension load

V = applied service shear load

V_{allow} = allowable service shear load

T/T_{allow} = shall not be greater than 1.0.

V/V_{allow} = shall not be greater than 1.0.

The allowable tension and shear loads come from the anchor manufacturer's published data. The design loads have been amplified by an overstrength factor of 2.0, and the allowable strength of the anchors has been increased by a factor of 1.2. The effect of prying on the tension applied to the anchor is considered when developing appropriate capacity values. The applied tension equation includes the prying effect, which varies with the orientation of the fastener in relationship to the brace necessary at various brace angles. The letters A through D in the following equations are dimensions of the attachment geometry as indicated in Figure A.18.5.12.2(a) through Figure A.18.5.12.2(c).

where:

Cr = critical angle at which prying flips to the toe or the heel of the structure attachment fitting

Pr = prying factor for service tension load effect of prying

$Tan\theta$ = tangent of brace angle from vertical

$Sin\theta$ = sine of brace angle from vertical

The greater Pr value calculated in tension or compression applies.

The Pr value cannot be less than 1.000/$Tan\theta$ for designated angle category A, B, and C; 1.000 for designated angle category D, E, and F; or 0.000 for designated angle category G, H, and I.

For designated angle category A, B, and C, the applied tension, including the effect of prying (Pr), is as follows:

$$Cr = Tan^{-1}\left(\frac{C}{D}\right)$$ **[A.18.5.12.2b]**

For braces acting in **TENSION**

If Cr > brace angle from vertical:

$$Pr = \frac{\left(\frac{C+A}{Tan\theta}\right)-D}{A}$$ **[A.18.5.12.2c]**

If Cr < brace angle from vertical:

$$Pr = \frac{D-\left(\frac{C-B}{Tan\theta}\right)}{B}$$ **[A.18.5.12.2d]**

For braces acting in **COMPRESSION**

If Cr > brace angle from vertical:

$$Pr = \frac{\left(\frac{C-B}{Tan\theta}\right)-D}{B}$$ **[A.18.5.12.2e]**

If *Cr* < brace angle from vertical:

$$Pr = \frac{D-\left(\frac{C+A}{Tan\theta}\right)}{A}$$ **[A.18.5.12.2f]**

For designated angle category D, E, and F, the applied tension, including the effect of prying (*Pr*), is as follows:

$$Cr = Tan^{-1}\left(\frac{D}{C}\right)$$ **[A.18.5.12.2g]**

For braces acting in **TENSION**

If *Cr* > brace angle from vertical:

$$Pr = \frac{\left(\frac{D}{Tan\theta}\right)-(C-B)}{B}$$ **[A.18.5.12.2h]**

If *Cr* < brace angle from vertical:

$$Pr = \frac{(C+A)-\left(\frac{D}{Tan\theta}\right)}{A}$$ **[A.18.5.12.2i]**

For braces acting in **COMPRESSION**

If *Cr* > brace angle from vertical:

$$Pr = \frac{\left(\frac{D}{Tan\theta}\right)-(C+A)}{A}$$ **[A.18.5.12.2j]**

If *Cr* < brace angle from vertical:

$$Pr = \frac{(C-B)-\left(\frac{D}{Tan\theta}\right)}{B}$$ **[A.18.5.12.2k]**

For designated angle category G, H, and I the applied tension, including the effect of prying (*Pr*), is as follows:

For braces acting in **TENSION**

$$Pr = \frac{\left(\frac{D}{B}\right)}{Sin\theta}$$ **[A.18.5.12.2l]**

For braces acting in **COMPRESSION**

$$Pr = \frac{\left(\frac{D}{A}\right)}{Sin\theta}$$ **[A.18.5.12.2m]**

The lightweight concrete anchor tables, Table 18.5.12.2(a)~~and~~ through Table 18.5.12.2(c) were based on sand lightweight concrete, which represents a conservative assumption for the strength of the material. For seismic applications, cracked concrete was assumed.

Figure A.18.5.12.2(a) Dimensions of Concrete Anchor for Orientations A, B, and C.

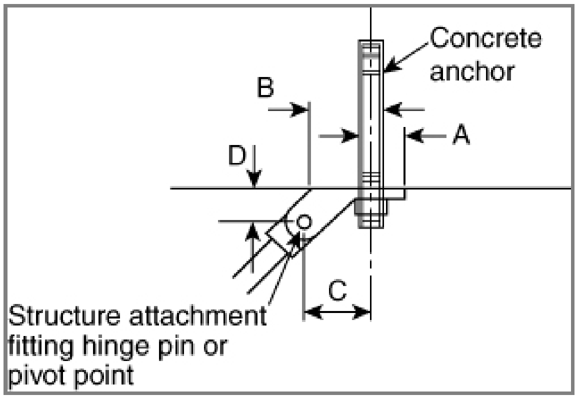


Figure A.18.5.12.2(b) Dimensions of Concrete Anchor for Orientations D, E, and F.

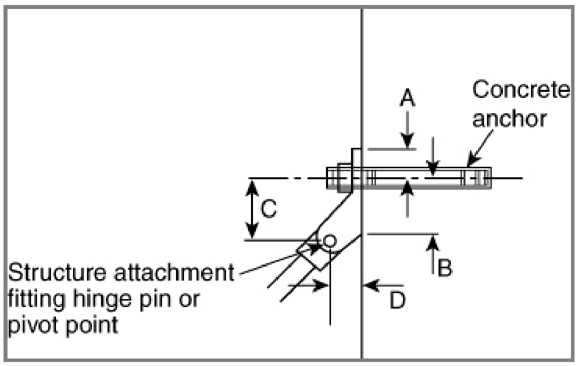
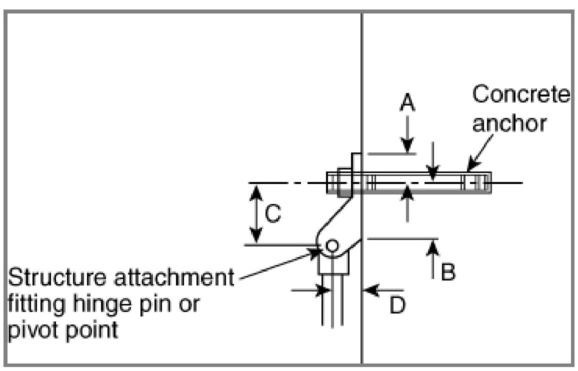


Figure A.18.5.12.2(c) Dimensions of Concrete Anchor for Orientations G, H, and I.



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Committee Statement

Committee Statement:	The added text provides descriptions of the concrete inserts that were added to the body of the standard.
Response Message:	

Second Revision No. 15-NFPA 13-2017 [Chapter E]

Annex E Development of the Design Approach to Conform with ~~SEI/ASCE 7~~ ASCE/SEI 7 and Suggested Conversion Factor Adjustments for Locations Outside the United States

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

E.1 General.

Seismic design of nonstructural components is governed by the provisions of Chapter 13 of ASCE/SEI 7, *Minimum Design Loads for Buildings and Other Structures*. In ASCE/SEI 7, fire sprinkler piping is classified as a "Designated Seismic System," due to its critical safety function. Design earthquake forces are multiplied by an ~~Importance Factor, I_p = 1.5, and both the bracing and the piping itself must be designed for seismic forces~~ importance factor, I_p = 1.5, and both the bracing and the piping itself must be designed for seismic forces. The seismic design requirements for the hanging and bracing of sprinkler piping systems provided in NFPA 13, Chapter 18 , presume that sprinkler piping is being constructed in the United States or in a country or jurisdictions where the seismic requirements are those specified in ASCE/SEI 7. There are locations outside the United States that wish to use the seismic design requirements of NFPA 13, Chapter 18 . In Section E.3 of this annex, suggested conversion factor adjustments are provided to adjust country building code design ground motion criteria to those in ASCE/SEI 7 so the procedures of NFPA 13, Chapter 18 , can be used .

The lateral sway bracing provisions of 18.5.5 were developed to allow the use of the concept of ~~Zone~~ zone of ~~Influence~~ influence (ZOI), while providing designs that comply with ASCE/SEI 7. One of the main changes between the current seismic sway bracing design approach adopted in NFPA 13 and the approach used in early editions of NFPA 13 is that the spacing of the sway braces can be constrained by the flexural capacity of the pipe, as well as the capacity of the brace assembly or the capacity of the connection between the brace assembly and the supporting structure. NFPA 13 provides a design that complies with the seismic design requirements of ASCE/SEI 7 for the pipe itself.

The ZOI approach yields the force demand on the bracing element and connections to the structure. Another way to look at a ZOI force is as a reaction in a system of continuous beams (i.e., the multiple spans of a piping system). By using conservative simplifying assumptions, a maximum ZOI force limited by the flexural capacity of the pipe can be developed for a given pipe size and span (spacing between horizontal sway braces). The method used to develop these maximum ZOI forces is described in the following paragraphs, along with a discussion of the assumptions on the geometry of the piping system, the determination of the seismic design force coefficients, and the flexural capacity of the pipe.

In the discussion that follows, the term "main" can be taken to mean a sprinkler main, either a feed main or a cross-main, that requires sway bracing.

E.2 Assumptions on System Geometry.

While every fire sprinkler system is uniquely designed for a particular structure, there are general similarities in the layout and geometry that can be used to simplify the design approach for earthquake protection. These similarities were used to develop assumptions on the effects of piping system continuity on the distribution of bending and shear forces in the pipe, and assumptions on spacing of branch lines between sway brace locations.

E.2.1 Continuity in Piping Systems.

For lateral brace design purposes, piping systems can be idealized as a system of continuous beams. The bending moments in the sprinkler mains (the beams) were computed assuming three continuous spans, which generates the largest bending moment in any system of continuous beams. The loads generated by the branch lines are idealized as point loads. The tributary mass of the main is lumped along with the mass of the branch lines as point loads at the assumed branch line locations.

E.2.2 Branch Line Locations.

In many sprinkler system installations, the branch lines constitute a substantial portion of the seismic mass. While there are significant variations in the spacing of the branch lines, their geometry is constrained by the need to provide adequate water coverage, which imposes limits on the spacing of the branches. Defining a "span" of the main as the distance between lateral sway braces, the seismic provisions make the following assumptions:

(1) There is a branch located at the center of the sprinkler main for spans of 25 ft (7.6 m) or less.

(2) There are branches at third-points of the sprinkler main for spans greater than 25 ft (7.6 m) and less than 40 ft (12.2 m).

(3) There are branches at quarter-points of the sprinkler main for spans of 40 ft (12.2 m).

It was further assumed that there is a branch line located in close proximity to each sway brace.

The layout of branch lines, maximum bending moment M_{max} in the pipe, and reaction R_{max} (horizontal loads at sway brace locations) for sprinkler mains with spans less than 25 ft (7.6 m) is illustrated in Figure E.2.2(a). Maximum demands for spans greater than 25 ft (7.6 m) and less than 40 ft (12.2 m) are given in Figure E.2.2(b), and for spans of 40 ft (12.2 m) in Figure E.2.2(c).

Figure E.2.2(a) Maximum Demands for Spans Less Than 25 ft (7.6 m) .

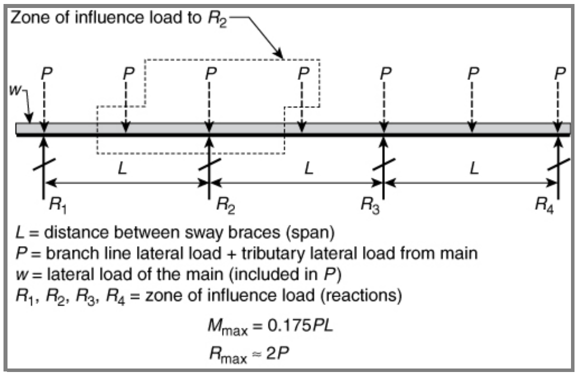


Figure E.2.2(b) Maximum Demands for Spans Greater Than 25 ft (7.6 m) and Less Than 40 ft (12.2 m) .

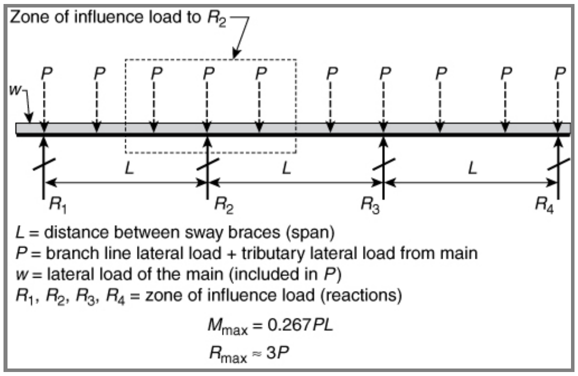
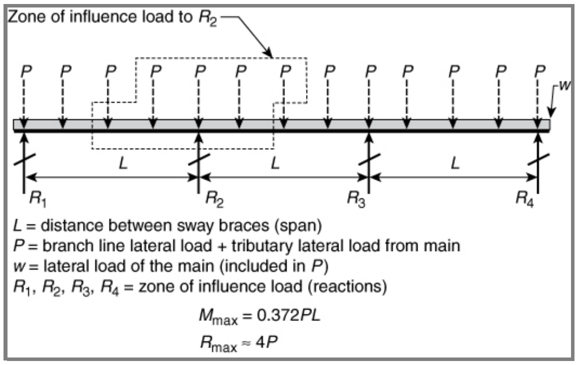


Figure E.2.2(c) Maximum Demands for Spans of 40 ft (12.2 m) .



E.3 Computing the Seismic Demand on Piping Systems.

In ASCE/SEI 7, seismic demands on nonstructural components and systems are a function of the ground shaking intensity, the ductility and dynamic properties of the component or system, and the height of attachment of the component in the structure. Seismic forces are determined at strength design (SD) levels. The horizontal seismic design force is given by

$$F_p = \frac{0.4 a_p S_{DS} W_p}{\left(\frac{R_p}{I_p}\right)}\left(1 + 2\frac{z}{h}\right) \quad \textbf{[E.3a]}$$

where:

F_p = seismic design force

S_{DS} = short period spectral acceleration, which takes into account soil conditions at the site

a_p = component amplification factor, taken as 2.5 for piping systems

I_p = component importance factor, taken as 1.5 for fire sprinkler systems

z = height of the component attachment to the structure

h = average roof height of the structure

W_p = component operating weight

R_p = component response modification factor as follows:

R_p = 9 for high-deformability piping with joints made by welding or brazing

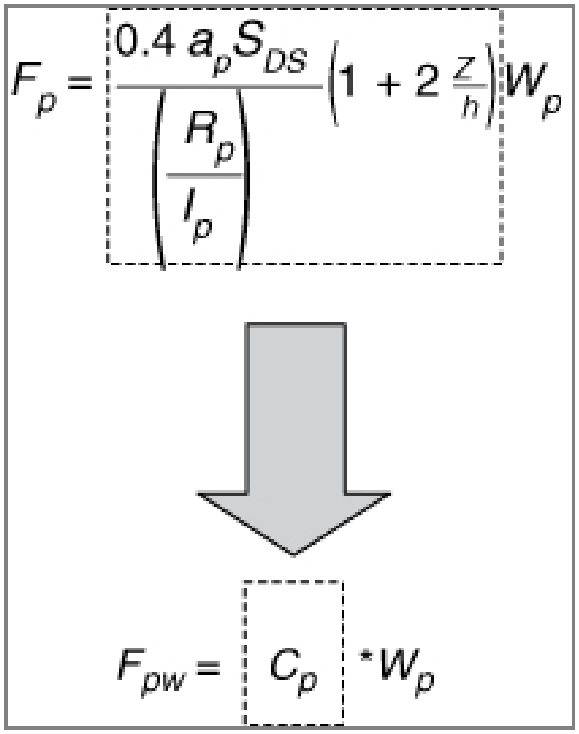
R_p = 4.5 for high- or limited-deformability piping with joints made by threading, bonding, compression couplings, or grooved couplings

R_p = 1.5 for low-deformability piping such as cast iron and nonductile plastics

F_p need not be greater than 1.6 $S_{DS}I_pW_p$ and cannot be less than 0.30 $S_{DS}I_pW_p$.

As illustrated in Figure E.3, NFPA 13 uses a simplified seismic factor, C_p, which combines ground shaking S_{DS}, dynamic amplification a_p, component response R_p/I_p, and location in the building (z/h) into a single variable. Conservative assumptions are made for each variable so that the only information needed to find C_p is the short-period mapped spectral acceleration for the ~~Maximum Considered Earthquake~~ maximum considered earthquake (MCE), S_S.

Figure E.3 Simplified Seismic Factor, C_p.



The importance factor (I_p) for fire sprinkler systems is specified in ASCE/SEI 7 as 1.5. The amplification factor (a_p) for piping systems is specified as 2.5. Piping systems (even when seismically braced) are considered flexible, since the fundamental period of vibration for the system is greater than 0.06 seconds. A component response factor of R_p = 4.5 was assumed for all piping. Finally, it was assumed that the system is installed at the roof level, h.

Assume the system is laterally braced at the roof, $z = h$ and substitute these values into the lateral force equation

$$F_p = \frac{0.4 a_p S_{DS} W_p}{\left(\frac{R_p}{I_p}\right)}\left(1+2\frac{z}{h}\right) = \frac{0.4(2.5) S_{DS} W_p}{\left(\frac{4.5}{1.5}\right)}\left(1+2\frac{h}{h}\right) = (1.0) S_{DS} W_p \qquad \textbf{[E.3b]}$$

ASCE/SEI 7 forces are determined at the strength design (SD) level. NFPA 13 is based on ~~Allowable Stress Design~~ allowable stress design (ASD). To convert F_p to an ASD load, F_{pw}, the load from ASCE/SEI 7 is multiplied by a 0.7 load factor.

$$F_{pw} = 0.7 F_p = 0.7 S_{DS} W_p = C_p W_p \qquad \textbf{[E.3c]}$$

Solving for C_p,

$$C_p = 0.7 S_{DS} \qquad \textbf{[E.3d]}$$

The short-period spectral acceleration, S_{DS}, is obtained by modifying the mapped short-period spectral acceleration, S_S, for the effects of the local soil conditions. In the United States, values for S_S are obtained from seismic hazard maps published by the U.S. Geological Survey (USGS). ~~Free software~~ Web-based tools available from USGS will generate values for S_S based on the latitude and longitude of the project site. ~~The spectral acceleration used for seismic design is determined by~~ Most countries do not base their seismic hazard maps on the ground motion criteria that USGS uses to determine the S_S values specified in ASCE/SEI 7. Instead, these countries might use seismic zones [similar to those in the outdated Uniform Building Code (UBC)] to convey the seismic hazard. Although different countries might use different zone identifiers, often zones are numbered, with the highest number seismic zone having the strongest potential ground motions (e.g., in the UBC, Zones 0 to 4 were used, and Zone 4 had the highest seismic hazard). Although not universally true, often there is a zone factor, Z, associated with each zone that represents the peak ground acceleration based on design earthquake ground motions having a 10 percent chance of being exceeded in a 50-year period (i.e., about a 500-year return period). For these countries, a suggested correlating adjustment is $S_S = 3.75 Z$. The 3.75 factor was determined by multiplying the peak ground acceleration by a factor of 2.5 to convert it to peak spectral acceleration and then by a factor of 1.5 to convert design earthquake ground motions to maximum considered earthquake ground motions, which are the basis for determining S_S. For example, for a Z factor of 0.4 (the highest value in the UBC), the value of S_S would be 1.5 (resulting in $C_p = 0.7$ from Table 18.5.9.3). Also, for these countries, if a value of S_1 is needed, the value might be taken as 1.5 Z, which is the same relative relationship between the short period and one second spectral acceleration that was used in the 1997 UBC. The spectral acceleration used for seismic design is determined by

$$-S_{DS} = \frac{2}{3} S_S F_a \quad \textbf{[E.3e]}$$

F_a is an amplification factor based on soil conditions and the intensity of ground shaking expected (measured by S_S). Soil conditions are defined by site classification, ranging from Site Class A (hard rock) to Site Class F (extremely soft soils and fill). The values of F_a are given in ASCE/SEI 7 Table 11.4-1, and vary from 0.8 to 2.5. For the purposes of the ZOI method, the values of F_a are taken as the maximum tabulated values and are summarized in Table E.3.

Table E.3 Values of F_a

-	Mapped Maximum Considered Earthquake Spectral Response Acceleration Parameter at Short Period					
-	$S_S \leq 0.33$	$S_S = 0.5$	$S_S = 0.75$	$S_S = 0.95$	$S_S = 1.0$	$S_S \geq 1.25$
F_a	2.24	1.7	1.2	1.1	1.1	1.0

Note: Use straight-line interpolation for intermediate values of S_S.

$$C_p = 0.7 S_{DS} = \frac{2}{3}\left(0.7 S_s F_a\right) = 0.467 S_s F_a \quad \textbf{[E.3f]}$$

Table 18.5.9.3 was populated by solving for C_p for different values of S_S. For example when $S_S = 1.0$:

$$C_p = 0.467 S_s F_a = 0.467(1.0)(1.1) = 0.51 \quad \textbf{[E.3g]}$$

E.4 Flexural Capacity of Piping.

The flexural capacity for different diameters and thicknesses of pipe were computed using ~~Allowable Stress Design~~ allowable stress design (ASD). NFPA 13 has traditionally used ASD for design. While ASCE/SEI 7 generally uses the ~~Strength Design~~ strength design (SD) approach, ASD is preferred for the design of piping systems. For example, the ASTM B31, *Standards of Pressure Piping*, series of piping codes are based on ASD. ASD was chosen for sprinkler piping design to limit the complexity of the analysis. Use of SD would require the use of the plastic modulus, *Z*, of the pipe rather than the elastic section modulus, *S*. Use of *Z* would trigger analysis of local and global buckling behavior of the pipe. SD is most appropriate when used with compact pipe sections that can develop the full limit capacity of the material, including strain hardening. Thin-wall pipes and materials without well-defined post-elastic behavior are not easily considered using SD.

Permissible stresses in the pipe for seismic loading are from 13.6.11 of ASCE/SEI 7. Assuming high- or limited-deformability pipe with threaded or grooved couplings, the permissible flexural stress under SD level demands is $0.7F_y$, where F_y is the yield stress of the material. Since seismic design in NFPA 13 is based on ASD, the SD capacity must be reduced to an ASD level.

The permissible flexural stress for ASD is determined by adjusting the SD level flexural capacity. The SD capacity is first reduced by a load factor to ASD levels, and then can be increased by the allowable stress increase for seismic loading. The use of an allowable stress increase for piping systems is typical when determining the strength of the pipe itself.

For fire sprinkler piping, the SD flexural capacity, M_{cap}, is reduced by a load factor of 0.7 to yield the ASD flexural capacity. The duration of load factor for the piping system, taken as 1.33, is then applied. Taking *S* as the section modulus of pipe, this yields an allowable moment capacity in the pipe.

$$M_{cap} = 0.7(1.33)\left(0.7SF_y\right) = 0.65SF_y \quad \textbf{[E.4a]}$$

To populate Table 18.5.5.2(a) through Table 18.5.5.2(i), which give the maximum ~~Zone of Influence~~ zone of influence loads, the largest reaction (due to branch lines and the tributary mass of the main) limited by flexure for a given pipe size and span between sway braces was computed.

For example, to determine the maximum permissible ZOI for a 4 in. (100 mm) diameter steel Schedule 10 main spanning 30 ft (9.1 m), first compute the flexural capacity of the pipe.

S = 1.76 in.^{3} (28800 mm^3)

F_y = 30,000 psi (2050 bar)

The flexural capacity of the pipe is

$$M_{cap} = (0.65F_y)S = (0.65)(30{,}000)(1.76) \quad \textbf{[E.4b]}$$

= 34,320 in.-lb (3900 kgn) = 2860 ft-lb (395 kgn)

For spans greater than 25 ft (7.6 m) and less than 40 ft (12 m), the branch lines are assumed to be located at ⅓-points in the span. The point load *P* is associated with the branch line and tributary mass of the main and *L* is distance between sway braces. From Figure E.2.2(b), the maximum moment in the main, M_{max}, is

$M_{max} = 0.267PL$

Setting $M_{cap} = M_{max}$ and solving for *P*,

$$\begin{aligned} M_{cap} &= \left(0.65F_y\right)S = 0.267PL \\ P &= \frac{M_{cap}}{0.267L} \\ &= \frac{2860}{0.267(30) = 357\ \text{lb}} \end{aligned} \quad \textbf{[E.4c]}$$

The maximum permissible ZOI load = 3*P* = 1071 lb. (485 kg).

E.5 Sample Seismic Calculation ~~using~~ Using the ZOI Method.

To illustrate the application of the ZOI method, the approach can be applied to a sample problem based on the sample seismic bracing calculation in Figure A.18.5(b). The sample calculation yielded a total weight of 480 lb (220 kg), which was obtained using a seismic factor of 0.5. To determine our own seismic factor, to get the total weight of the water-filled pipe, divide by the seismic factor of 0.5,

$$W_p = \frac{480}{0.5} = 960 \text{ lb } (435 \text{ kg}) \quad \textbf{[E.5a]}$$

Assume the 4 in. (100 mm) Schedule 10 pipe is the main that will be braced and that distance between sway braces (span) is 20 ft (6.1 m). The installation is in a region of high seismicity, and based on the latitude and longitude of the building site, S_S = 1.75.

To calculate the seismic load, use Table 18.5.9.3 to determine the seismic coefficient, C_p. The value of S_S = 1.75 coordinates to 0.82.

The horizontal force on the brace, from 18.5.6.2, is

$$F_{pw} = C_p W_p = 0.82(960) = 787 \text{ lb} \quad \textbf{[E.5b]}$$

From Table 18.5.5.2(a), the maximum ZOI load, F_{pw}, for a 4 in. Schedule 10 pipe spanning 20 ft (6.1 m) is 1634 lb (740 kg), which is larger than the calculated demand of 787 lb (355 kg). The 4 in. (100 mm) Schedule 10 pipe is adequate for the seismic load and a brace would be selected with a minimum capacity of 787 lb (355 kg).

If the sway brace was attached to the 2 in. (50 mm) Schedule 40 pipe, the ZOI demand F_{pw} of 787 lb (355 kg) would be compared to the maximum capacity for a 2 in. (50 mm) Schedule 40 pipe found in ~~Table 18.5.5.2(a)~~ Table 18.5.5.2(c) and Table 18.5.5.2(d) . For a 20 ft (6.1 m) span, this is 520 lb (~~235~~ 236 kg), less than the demand of 787 lb (355 kg). A 2 in. (50 mm) pipe would be inadequate, and a sway brace would have to be added to reduce the ZOI demand, or the system pipe size increased.

E.6 Limitations of the ZOI Method.

The ZOI approach can be used for a variety of piping materials. There are, however, important limitations of which the designer should be aware. The first is that the appropriate component response factor, R_p, must be used. To select the proper value, the piping systems must be classified as high-, limited-, or low-deformability. Definitions of these terms are given in Section 11.2 of ASCE/SEI 7. The second major assumption is that the flexural behavior of the pipe is not governed by local buckling of the pipe wall. For steel pipe, this can be achieved by observing the thickness to diameter limits given in the *AISC Specifications for the Design, Fabrication, and Erection of Structural Steel Buildings*. Establishing the local buckling characteristics of pipe fabricated from other materials can require testing.

The tables for the maximum load, F_{pw}, in zone of influence are based on common configurations of mains and branch lines. There can be cases where the actual configuration of the piping system could generate higher stresses in the piping than assumed in the tables. For example, a main braced at 40 ft (12.2 m) intervals, with a single branch line in the center of the span, can have a smaller maximum load capacity, F_{pw}, than the tabulated value. Where the configuration of the mains and branch lines vary significantly from the assumed layout, the pipe stresses should be checked by engineering analysis.

E.7 Allowable Loads for Concrete Anchors.

This section provides step-by-step examples of the procedures for determining the allowable loads for concrete anchors as they are found in Table 18.5.12.2(a) through Table 18.5.12.2(j). Table 18.5.12.2(a) through Table 18.5.12.2(j) were developed using the prying factors found in Table E.7(a) and the representative strength design seismic shear and tension values for concrete anchors found in Table E.7(b).

Table E.7(a) Prying Factors for Table ~~9.3.5.12.2~~ 18.5.12.2 (a) through Table ~~9.3.5.12.2~~ 18.5.12.2 (j) Concrete Anchors

Pr Range	~~Fig. 9.3.5.12.1~~ Figure 18.5.12.1 Designated Angle Category								
	A	B	C	D	E	F	G	H	I
Lowest	2	1.1	0.7	1.2	1.1	1.1	1.4	0.9	0.8
Low	3.5	1.8	1.0	1.7	1.8	2.0	1.9	1.3	1.1
High	5.0	2.5	1.3	2.2	2.5	2.9	2.4	1.7	1.4
Highest	6.5	3.2	1.6	2.7	3.2	3.8	2.9	2.1	1.7

Table E.7(b) Representative Strength Design Seismic Shear and Tension Values Used for Concrete Anchors

Anchor Dia. (in.)	Min. Nominal Embedment (in.)	LRFD Tension (lb)	LRFD Shear (lb)	-	Anchor Dia. (in.)	Min. Effective Embedment (in.)	LRFD Tension (lb)	LRFD Shear (lb)
Wedge Anchors in 3000 psi (207 bar) Lightweight Sand Concrete on 4 1/2 in. Flute Width Metal Deck					**Metal Deck Inserts in 3000 psi (207 bar) Lightweight Sand Concrete on 4 1/2 in. Flute Width Metal Deck**			
3/8	2.375	670	871		3/8	1.750	804	774
1/2	3.750	714	1489		1/2	1.750	804	837
5/8	3.875	936	1739		5/8	1.750	804	837
3/4	4.500	1372	1833		3/4	1.750	804	1617
Wedge Anchors in 3000 psi (207 bar) Lightweight Sand Concrete					**Wood Form Inserts in 3000 psi (207 bar) Lightweight Sand Concrete**			
3/8	2.375	739	1141		3/8	1.100	1358	1235
1/2	3.750	983	1955		1/2	1.690	1358	1811
5/8	3.875	1340	2091		5/8	1.750	1358	1811
3/4	4.500	1762	3280		3/4	1.750	1358	1811
Wedge Anchors in 3000 psi (207 bar) Normal Weight Concrete					**Wood Form Inserts in 3000 psi (207 bar) Normal Weight Concrete**			
3/8	2.375	1087	1170		3/8	1.100	1598	1235
1/2	3.750	1338	2574		1/2	1.690	1598	2130
5/8	3.875	2070	3424		5/8	1.750	1598	2130
3/4	4.500	3097	5239		3/4	1.750	1598	2130
Wedge Anchors in 4000 psi (276 bar) Normal Weight Concrete					**Wood Form Inserts in 4000 psi (276 bar) Normal Weight Concrete**			
3/8	2.375	1233	1170		3/8	1.100	1845	1235
1/2	3.750	1545	2574		1/2	1.690	1845	2249
5/8	3.875	2390	3900		5/8	1.750	1845	2460
3/4	4.500	3391	5239		3/4	1.750	1845	2460
Wedge Anchors in 6000 psi (414 bar) Normal Weight Concrete					**Wood Form Inserts in 6000 psi (414 bar) Normal Weight Concrete**			
3/8	2.375	1409	1170		3/8	1.100	2259	1235
1/2	3.750	1892	2574		1/2	1.690	2259	2249

Anchor Dia. (in.)	Min. Nominal Embedment (in.)	LRFD Tension (lb)	LRFD Shear (lb)	-	Anchor Dia. (in.)	Min. Effective Embedment (in.)	LRFD Tension (lb)	LRFD Shear (lb)
5⁄8	3.875	2928	3900		5⁄8	1.750	2259	3013
3⁄4	4.500	4153	5239		3⁄4	1.750	2259	3013

Table E.7(b) Representative Strength Design Seismic Shear and Tension Values Used for Concrete Anchors

Anchor Dia.(in.)	Nominal Embedment (in.)	LRFD Tension(lb)	LRFD Shear(lb)
Wedge Anchors in 3000 psi LW Sand Concrete on Metal Deck			
3⁄8	2	573	1172
1⁄2	2.375	804	1616
5⁄8	3.125	1102	1744
Wedge Anchors in 3000 psi LW Sand Concrete			
3⁄8	2	637	550
1⁄2	3.625	871	745
5⁄8	3.875	1403	1140
3⁄4	4.125	1908	1932
Wedge Anchors in 3000 psi NW Concrete			
3⁄8	2	1063	917
1⁄2	3.625	2639	2052
5⁄8	3.875	3004	2489
3⁄4	4.125	3179	3206
Wedge Anchors in 4000 psi NW Concrete			
3⁄8	2	1226	1088
1⁄2	3.625	2601	2369
5⁄8	3.875	3469	2586
3⁄4	4.125	3671	3717
Wedge Anchors in 6000 psi NW Concrete			
3⁄8	2.25	1592	1322
1⁄2	3.625	3186	2902
5⁄8	3.875	4249	3167
3⁄4	4.125	4497	4553
Undercut Anchors in 3000 psi NW Concrete			
3⁄8	5	4096	1867
1⁄2	7	5322	2800
5⁄8	9.5	6942	5675
3⁄4	12	10182	9460

E.7.1 Selecting a Wedge Anchor Using Table 9.3.5.12.2 18.5.12.2 (a) through Table 9.3.5.12.2(f) 18.5.12.2(e) .

E.7.1.1 Procedure.

Step 1. Determine the ASD horizontal earthquake load F_{pw}.

Step 1a. Calculate the weight of the water-filled pipe within the zone of influence of the brace.

Step 1b. Find the applicable seismic coefficient C_p in Table 18.5.9.3

Step 1c. Multiply the zone of influence weight by C_p to determine the ASD horizontal earthquake load F_{pw}.

Step 2. Select a concrete anchor from Table 18.5.12.2(a) through Table 18.5.12.2(e) with a maximum load capacity that is greater than the calculated horizontal earthquake load F_{pw} from Step 1.

Step 2a. Locate the table for the applicable concrete strength.

Step 2b. Find the column in the selected table for the applicable designated angle category (A thru I) and the appropriate prying factor *Pr* range.

Step 2c. Scan down the category column to find a concrete anchor diameter, embedment depth, and maximum load capacity that is greater than the calculated horizontal earthquake load F_{pw} from Step 1.

(ALTERNATIVE) Step 2. As an alternative to using the maximum load values in Table 18.5.12.2(a) through Table 18.5.12.2(e), select ~~an AC355.2 seismically pre-qualified~~ a concrete anchor ~~with a load-carrying capacity~~ that ~~exceeds the calculated F_{pw}, with calculations~~ has been tested in accordance with ACI 355.2, *Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary*, for seismic loading and that has an allowable strength, including the effects of prying, ~~based on seismic shear and tension values~~ taken ~~from an ICC-ES Report and calculated~~ as 0.43 times the normal strength determined in accordance with ACI 318, *Building Code Requirements for Structural Concrete and Commentary*, Chapter 17, ~~and adjusted to ASD values by multiplying by 0.43~~ as per 18.5.12.7.3(D).

E.7.1.2 Example.

Step 1. Zone of influence F_{pw}.

Step 1a. 40 ft of 2½ in. Sch. 10 pipe plus 15% fitting allowance

40 × 5.89 lb/ft × 1.15 = 270.94 lb

Step 1b. Seismic coefficient C_p from Table 18.5.9.3

$C_p = 0.35$

Step 1c. $F_{pw} = 0.35 \times 270.94 = 94.8$ lb

Step 2. Select a concrete anchor from Table 18.5.12.2(a) through Table 18.5.12.2(e).

Step 2a. Use the table for 4000 psi Normal Weight Concrete.

Step 2b. Fastener orientation "A" – assume the manufacturer's prying factor is 3.0 for the fitting. Use the *Pr* range of 2.1–3.5.

Step 2c. Allowable F_{pw} on ⅜ in. dia. with ~~2~~ 2.375 in. embedment = ~~135~~ 138 lb and is greater than the calculated F_{pw} of 94.8 lb.

E.7.2 Calculation for Maximum Load Capacity of Concrete Anchors.

This example shows how the effects of prying and brace angle are calculated when using Table E.7(a).

E.7.2.1 Procedure.

Step 1. Determine the allowable seismic tension value (T_{allow}) and the allowable seismic shear value (V_{allow}) for the anchor, based on data found in the anchor manufacturer's approved evaluation report. Note that, in this example, it is assumed the evaluation report provides the allowable tension and shear capacities. If this is not the case, the strength design anchor capacities must be determined using the procedures in ACI 318, Chapter 17, which are then converted to ASD values by dividing by a factor of 1.4. As an alternative to calculating the allowable seismic tension value (T_{allow}) and the allowable seismic shear value (V_{allow}) for the anchor, the seismic tension and shear values that were used to calculate ~~the~~ Figure 18.5.12.1 for anchor allowable load tables can be used.

Step 1a. Find the ASD seismic tension capacity (T_{allow}) for the anchor according to the strength of concrete, diameter of the anchor, and embedment depth of the anchor. Divide the ASD tension value by 2.0 and then multiply by 1.2.

Step 1b. Find the ASD seismic shear capacity (V_{allow}) for the anchor according to the strength of concrete, diameter of the anchor, and embedment depth of the anchor. Divide the ASD shear value by 2.0 and then multiply by 1.2.

Step 2. Calculate the applied seismic tension (*T*) and the applied seismic shear (*V*) based on the calculated horizontal earthquake load F_{pw}.

Step 2a. Calculate the designated angle category applied tension factor, including the effects of prying (*Pr*), using the following formulas:

Category A, B, and C

$$Pr = \frac{\left(\frac{C+A}{Tan\theta}\right) - D}{A}$$ **[E.7.2.1a]**

Category D, E, and F

$$Pr = \frac{(C+A) - \left(\frac{D}{Tan\theta}\right)}{A}$$ **[E.7.2.1b]**

Category G, H, and I

$$Pr = \frac{\left(\frac{D}{B}\right)}{Sin\theta}$$ **[E.7.2.1c]**

Step 2b. Calculate the ASD applied seismic tension (*T*) on the anchor, including the effects of prying, and when applied at the applicable brace angle from vertical and the designated angle category (A through I) using the following formula:

$$T = F_{pw} \times Pr$$ **[E.7.2.1d]**

Step 2c. Calculate the ASD applied seismic shear (*V*) on the anchor, when applied at the applicable brace angle from vertical and the designated angle category (A through I) using the following formulas:

Category A, B, and C

$$V = F_{pw}$$ **[E.7.2.1e]**

Category D, E, and F

$$V = \frac{F_{pw}}{Tan\theta}$$ **[E.7.2.1f]**

Category G, H, and I

$$V = \frac{F_{pw}}{Sin\theta}$$ **[E.7.2.1g]**

Step 3. Check the anchor for combined tension and shear loads using the following formula:

$$\left(\frac{T}{T_{allow}}\right)+\left(\frac{V}{V_{allow}}\right)\leq 1.2$$ **[E.7.2.1h]**

Confirm that T/T_{allow} and V/V_{allow} ≤1.0.

E.7.2.2 Example: Sample Calculation, Maximum Load Capacity of Concrete Anchors as Shown in Table ~~9.3.5.12.2(a)~~ 18.5.12.2(a) through Table ~~9.3.5.12.2(f)~~ 18.5.12.2(e) .

In this example, a sample calculation is provided showing how the values in Table 18.5.12.2(a) through Table 18.5.12.2(e) were calculated.

Step 1. Determine the allowable seismic tension value (T_{allow}) and the allowable seismic shear value (V_{allow}) for a concrete anchor in Figure 18.5.12.1.

Step 1a. The Table E.7(b) strength design seismic tension value (T_{allow}) for a ½ in. carbon steel anchor with 3~~5/8~~ 3/4 in. embedment depth in 4000 psi normal weight concrete is ~~2601~~ 1545 lb. Therefore, the allowable stress design seismic tension value (T_{allow}) is ~~2601~~ 1545 /1.4/2.0 × 1.2 = ~~1115~~ 662 lb.

Step 1b. The Table E.7(b) strength design seismic shear value (V_{allow}) for a ½ in. carbon steel anchor with 3~~5/8~~ 3/4 in. embedment is ~~2369~~ 2574 lb. Therefore, the allowable stress design seismic shear value (V_{allow}) is ~~2369~~ 2574 /1.4/2.0 × 1.2 = ~~1015~~ 1103 lb.

Step 2. Use the applied seismic tension value (T) and the applied seismic shear value (V) based on an ASD horizontal earthquake load (F_{pw}) of ~~170~~ 100 lb, a 30-degree brace angle from vertical, and designated angle category A.

Step 2a. Calculate the ASD applied seismic tension value (T) on the anchor, including the effects of prying, using the following formula and Figure E.7.2.2.

$$T = \frac{F_{pw}\left[\left(\frac{C+A}{Tan\theta}\right) - D\right]}{A} \qquad \textbf{[E.7.2.2a]}$$

where:

T = applied service tension load, including the effect of prying

F_{pw} = horizontal earthquake load (F_{pw} = 170)

Tan = tangent of brace angle from vertical ($Tan\theta$ 0°= 0.5774)

A = 0.7500

B = 1.5000

C = 2.6250

$T = F_{pw} \times Pr$

$$T = \frac{\left\{F_{pw}\left[\left(\frac{2.625+0.75}{0.5774}\right)-1.0\right]\right\}}{0.75}$$

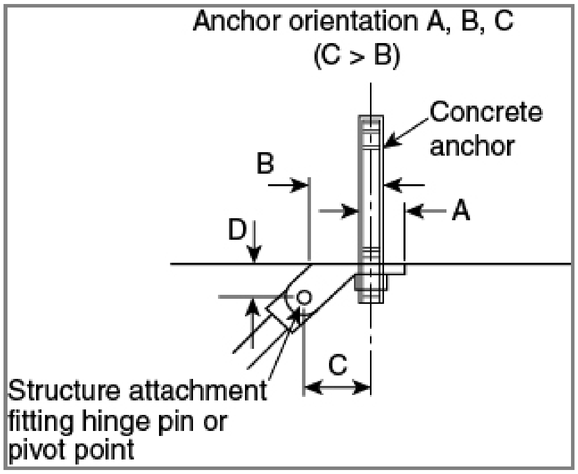
$$T = \frac{\left[F_{pw}\left(5.8452-1.0\right)\right]}{0.75}$$

$$T = F_{pw}\left(\frac{4.8451}{0.75}\right)$$

$T = F_{pw} \times 6.46$

T = ~~170~~ 100 lb × 6.46 = ~~1098~~ 646 lb

Figure E.7.2.2 Concrete Anchor for Sample Calculation in E.7.2.2.



Step 2b. The ASD applied seismic shear value (*V*) on the anchor for anchor orientations A, B, and C is equal to the ASD horizontal earthquake load F_{pw} = ~~170~~ 100 lb.

Step 3. Calculate the maximum allowable horizontal earthquake load F_{pw} using the formula:

$$\left(\frac{T}{T_{allow}}\right)+\left(\frac{V}{V_{allow}}\right)\leq 1.2 \qquad \textbf{[E.7.2.2b]}$$

$$\left(\frac{1098.2}{1115}\right)+\left(\frac{170}{1015}\right)=0.9849+0.1675=1.1524(\leq 1.2)$$

$$\left(\frac{646}{662}\right)+\left(\frac{100}{1103}\right)=1.0665(\leq 1.2)$$

Supplemental Information

File Name	Description	Approved
Table_E_7_b_rev_6-24-17.pdf	New Table E.7(b). For staff use.	

Submitter Information Verification

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Committee Statement

Committee Statement: General text revisions have been added to clarify the use of wedge-type anchors and concrete inserts. The reason for this change is to provide guidance to jurisdictions/sprinkler contractors outside the United States that want to use the seismic provisions of NFPA 13 but do not have a criteria that converts their building code ground motions design criteria to those used in Chapter 18.

Response Message: