NFPA 13-Proposed 2016 Edition
Standard for the Installation of Sprinkler Systems
TIA Log No.: 1185
Reference: Table 9.2.6.3.1, A.9.2.6.3.1 and Table 9.2.6.5.3
Comment Closing Date: June 19, 2015
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1. Revise Table 9.2.6.3.1 to read as follows:

Table 9.2.6.3.1 Maximum Pipe Stand Heights [a]						
System Pipe Diameter [c]	**Pipe Stand Diameter [b]**					
	1-1/2 in.	**2 in.**	**2-1/2 in.**	**3 in.**	**4 in.**	**6 in.**
1-1/2 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
2-1/2 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).

2. Revise section A.9.2.6.3.1 to read as follows:

A.9.2.6.3.1 When a pipe stand does not resist lateral (e.g., earthquake or wind) forces, its maximum height and the weight of pipe it can support are based primarily on a limiting slenderness ratio (Kl/r), and on the axial and bending stresses caused by the vertical load applied at a specified eccentricity.

The pipe stand heights presented in Table 9.2.6.3.1 have been calculated using a “K” of 2.1 (i.e., assuming the pipe stand is an individual cantilever column) and a slenderness ratio limit of 300, except where combined axial and bending stresses caused by the vertical load at an eccentricity of 12 in. (0.30 m) controls the design. In these cases, the pipe stand height is reduced such that the allowable axial stress (Fa) is sufficient to limit the combined axial stress ratio (fa/Fa, i.e., actual axial stress divided by allowable axial stress) plus the bending stress ratio (fb/Fb, i.e., actual bending stress divided by allowable bending stress) to 1.0. Two cases are considered, a vertical load at a 12 in. (0.30 m) eccentricity equal to: a) 5 times the weight of the water-filled pipe plus 250 lb (114 kg) using a bending stress allowable of 28,000 psi (193 MPa), and b) the weight of the water-filled pipe plus 250 lb (114 kg) using a bending stress allowable of 15,000 psi (103 MPa). No drift limit was imposed.

When an engineering analysis is conducted, different pipe stand heights could be calculated if other assumptions are warranted based on actual conditions. For example, K=1.0 can be used if the pipe at the top of the pipe stand is braced in both horizontal directions, or a shorter cantilever column could be used to limit drift.

~~The slenderness ratio (*l/r*) for pipe stands should not exceed 200. The values presented in Table 9.2.6.3.1 have been calculated so as not to exceed this.~~ Pipe stands are intended to be a single piece of pipe. For lengths that require joining pipes they should be welded to ensure the strength is maintained.

3. Revise Table 9.2.6.5.3 and replace the Note to read as follows:

Table 9.2.6.5.3 Required Section Modulus for Pipe Stand Horizontal Support Arms (in^3)

Nominal Diameter of Pipe Being Supported (in.)	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2	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), or 2) 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).

Substantiation:

Pipe Stand Heights (Table 9.2.6.3.1 and Paragraph A.9.2.6.3.1). Pipe stands in Section 9.2.6 are allowed to be used as individual cantilever columns. When used in this manner, the heights currently allowed in Table 9.2.6.3.1 result, for several pipe stands, in stresses significantly exceeding those allowed by building codes and ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. In addition, the information currently provided in A.9.2.6.3.1 is technically incorrect, stating that the slenderness ratio is the column length divided by its least radius of gyration (l/r), implying a “K” factor of 1.0 in the common slenderness ratio formula (Kl/r). In fact, the value for “K” is 2.1 for a cantilever column.

The slenderness ratio (Kl/r) is a key factor for design of a column. In this formula, “K” is an effective length factor, “l” is the length of the column (inches) and “r” is the least radius of gyration (inches). The American Institute of Steel Construction (AISC) *Manual of Steel Construction Allowable Stress Design* 9th Edition, Table C-C2.1 shows axially loaded columns and the theoretical and recommended values of “K.” The loading case that applies to a free-standing pipe stand, cantilevered from the base, where the pipe is not restrained from translation and the top can rotate is Case (e) from that table, with a theoretical value of “K” equal to 2.0 and a recommended value of K=2.1.

Section 9.2.6 has no requirement that the tops of pipe stands be braced in two orthogonal horizontal directions as would be needed to justify a value of 1.0 for “K” in the slenderness ratio formula. There is also no requirement that the pipe stands be limited in their application to looped systems having adequate detailing such that multiple pipe stands act, with the supported pipe, as a pseudo-moment-resisting frame system to limit sway in two orthogonal horizontal directions, thus potentially justifying a “K” factor less than 2.1.

Since Section 9.2.6 allows pipe stands to be used as individual cantilever columns, a worst case value for “K” equal to 2.1 (not 1.0) should be used to develop Table 9.2.6.3.1. In addition, Paragraph 9.2.6.1.2 states (as has always been the case) that pipe stands are to be designed for five times the weight of water-filled pipe plus 250 lbs. and their spacing should not exceed that given in Table 9.2.2.1(a) – which for most cases will be 15 ft. Paragraph 9.2.6.5.2 and its Annex material allow the pipe to be supported up to 1 ft. away from the centerline of the pipe stand. Using the required vertical load at the allowed eccentricity and the correct “K” factor results in significant overstresses of the 1-1/2 inch and 2 inch diameter pipe stands for heights currently allowed in Table 9.2.6.3.1.

Limiting Kl/r to 200 is common in structural design, however, the AISC Manual of Steel Construction (9^{th} edition) states it is a preferable (i.e., not an absolute) requirement. Kl/r=300 is a commonly used limitation for tension members to prevent excessive flexibility. Because the vertical forces used for design of pipe stands are very conservative, and because most pipe stands will support a pipe that is part of a piping system that will usually provide some degree of lateral restraint, a limit on Kl/r of 300 was used to develop revisions to Table 9.2.6.3.1. However, it should be noted that as the height increases, the lateral deflection for even a small horizontal force at the top of a pipe stand that truly acts as an individual cantilever can become large. Using the heights currently allowed in Table 9.2.6.3.1, the horizontal force at the top of the pipe stand needed to cause a deflection of 1 inch ranges from only 16 lbs. (10 foot tall 1-1/2 inch diameter stand) to 52 lbs. (30 foot tall 6 inch diameter stand). Using a Kl/r of 300, the pipe stand horizontal stiffnesses are increased by a factor of about 1.4 to 2.6; using a Kl/r of 200 would increase the stiffnesses by a factor of 4.8 to 9. If drift is a significant concern, a further reduction of the heights might be appropriate.

The revised pipe stand heights were thus determined based on a limitation of Kl/r=300 (which controls in most cases for which a height is specified in the Table 9.2.6.3.1 revision) or based on the height calculated such that the allowable axial stress (Fa) is sufficient to limit the combined axial stress ratio (fa/Fa, i.e., actual axial stress divided by allowable axial stress) plus the bending stress ratio (fb/Fb, i.e., actual bending stress divided by allowable bending stress) to 1.0. Fb used was 28,000 psi as allowed by AISC 360-10, *Specification for Structural Steel Buildings* when the vertical load was taken as 5 times the weight of the water-filled pipe plus 250 lbs. at a 12 inch eccentricity. Pipe stands were also checked using an Fb of 15,000 psi (as commonly allowed in NFPA 13) when the vertical load was taken as the weight of the water-filled pipe plus 250 lbs. at a 12 inch eccentricity. Where a pipe stand is not allowed to be used to support a particular system pipe diameter, this is due to stress limitations. Additionally, heights of the 1-1/2 inch pipe stands, the 2 inch pipe stands supporting 2-1/2 inch or 3 inch system pipe, and the 4 inch diameter pipe stand supporting up to 8 inch diameter pipe are based on stress limitations.

Pipe Stand Horizontal Support Arms (Table 9.2.6.5.3). Section moduli in the current Table 9.2.6.5.3 were determined based on the weight of the water-filled pipe plus 250 lbs. and thus are not in accordance with Paragraph 9.2.6.1.2, which requires that five times the weight of the water-filled pipe plus 250 lbs. be used.

As discussed above, Paragraph 9.2.6.1.2 states that pipe stands are to be designed for five times the weight of water-filled pipe plus 250 lbs. and their spacing should not exceed that given in Table 9.2.2.1(a) – which for most cases will be 15 ft. (the spacing for 1 inch and 1-1/4 inch pipe is 12 ft. but 15 ft. has been used for simplicity in the table since the effect is small). Paragraph 9.2.6.5.2 and its Annex material allow the pipe to be supported up to 1 ft. away from the centerline of the pipe stand. As part of the pipe stand, the horizontal support arm should be designed for five times the weight of water-filled pipe plus 250 lbs. vs. a bending stress allowable of 28,000 psi as discussed above. Although not explicitly stated, the horizontal support arm bending stresses should also not exceed the usual 15,000 psi allowed in NFPA 13 when the load equals the weight of water-filled pipe plus 250 lbs. This condition controls for some of the smaller pipes.

Emergency Nature:
Paragraph 9.2.6.1.2 states that pipe stands are to be designed for five times the weight of water-filled pipe plus 250 lbs. but the individual cantilever pipe stand heights in the current Table 9.2.6.3.1 and required section moduli for pipe stand horizontal support arms in the current Table 9.2.6.5.3 do not comply with building code stress limitations for these loads. Additionally, the information currently provided in A.9.2.6.3.1 is technically incorrect, implying a "K" factor of 1.0 in the common slenderness ratio formula (Kl/r) when, in fact, the correct value for "K" is 2.1 for a cantilever column.

The slenderness factor in Paragraph A.9.2.6.3.1 is demonstrably incorrect for the allowed cantilever column condition and using this annex information may lead users to incorrectly design pipe stands not covered in the table, potentially causing an unsafe condition. Additionally, publication of pipe stand heights currently in Table 9.2.6.3.1 and horizontal support arm section moduli currently in Table 9.2.6.5.3 would create a conflict within the same section of NFPA 13 in which provided tables do not comply with the stated requirements of Paragraph 9.2.6.1.2. This will only serve to confuse users. Since these new tables and the Annex paragraph have not yet been published in NFPA 13, making these changes now will provide consistency within Section 9.2.6, and will prevent several years of confusion and misapplication of the standard.

Anyone may submit a comment by the closing date indicated above. To submit a comment, please identify the number of the TIA and forward to the Secretary, Standards Council, 1 Batterymarch Park, Quincy, MA 02169-7471.