

Pipe Design GUIDE

FOR USE WITH
Special Hazard
Fire Suppression Systems



FSSA

Fire Suppression Systems Association

Third Edition
August 2019
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FSSA PDH-3 PIPE DESIGN HANDBOOK

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Special Hazard
Fire Suppression Systems

Third Edition
August 2019



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Foreword

The Fire Suppression Systems Association (FSSA) has developed this handbook to provide guidance to system designers on how to apply the ASME B31.1 Power Piping Code equations in a uniform and consistent manner to determine the maximum allowable internal working pressure for piping used in special hazard fire suppression systems.

The FSSA Technical Committee was assigned the task to address this issue. The resulting document provides the necessary guidelines, along with supplemental information, to assist the system designer in complying with the pipe strength requirements specified in the applicable NFPA Standards. This handbook is currently referenced in several of the NFPA standards.

The first edition of this document was published in June 2001.

The second edition of the handbook was published in August 2003, and includes revisions to Section 3, Appendix A, and Appendix C; along with the addition of new Section 6 and new Appendix B.

The third edition of the handbook was published in August 2019 and includes in-depth revisions to Section 2 to coincide with piping requirements addressed in NFPA 2001, 2018 edition. A new Section 3 is added to address the conventional requirements in ASME B 31.1. Updates were applied to Section 4. A new Section 6 was added providing information on the pressure testing of installed system piping. Section 7 addresses Pipe Supports and Hangers. Pipe Requirements for FSSA Equipment Manufacturers Engineered Systems (existing Appendix A) was removed. Pipe Fittings for use in CLEAN AGENT SYSTEM Piping (existing Appendix B) was removed. A new Appendix A addressing CO₂ pipe requirements was added.

CAUTION

This document provides general guidelines and is not intended to provide all information necessary to determine equipment and material requirements for specific installations or applications. Always refer to the equipment manufacturer's instructions and recommendations, along with other regulations and NFPA Standards that may apply.

Some limitations and restrictions apply. Please refer to the text and notes, which follow.

This document is subject to modifications. Users should obtain the latest version. The FSSA, its members, and those participating in its activities accept no responsibility or liability to any one for the completeness or use of, or reliance on this document, or for compliance with the provisions herein.

1. INTRODUCTION

This document provides general information and guidelines on the design of piping and tubing systems for use with various types of special hazard fire suppression systems based on the parameters set forth in applicable NFPA agent standards.

This third edition contains expanded lists of pressure tables in Sections 2 and 3. These tables provide the system designer with maximum allowable internal working pressures that have been pre-calculated for various types of pipe and tubing materials and end connections.

The maximum allowable working pressure tables in Section 2 are based on the allowable stress values (SE) given in ASTM B31.1 Appendix increased by 20% as permitted by NFPA 2001. Section 2 applies to normally unpressurized piping in NFPA 2001 clean agent systems in which the agent discharge lasts less than 60 minutes. For all other pipe networks, Section 3 applies. See APPENDIX A for CO₂ pipe considerations.

1.1. Definitions

Some terms used in this document, related to pipe and tubing and supports / hangers are defined below.

Brazing: A metal joining process where fusion is produced by use of a nonferrous filler metal having a melting point above 800°F (425°C) but lower than that of the base metals used. The filler metal is distributed between the closely fitted surfaces of the joint by capillary action.

Butt Joint: A joint between two members lying approximately in the same plane.

Filler Metal: Metal that is added during welding, soldering, or brazing.

Full Fillet Weld: A fillet weld whose size is equal to the thickness of the thinner member joined.

Maximum Allowable Stress (SE): The maximum stress value that may be used in the design formulas for a given material and design temperature. These values are given in the Tables in Appendix A of the Power Piping Code, and in Table 2-1 of this document; and include the longitudinal seam joint efficiency factors.

Maximum Allowable Working Pressure: The pressure at a coincident temperature to which the piping can be subjected without exceeding the maximum allowable stress.

Nominal Thickness: The thickness given in the product material specification or standard, exclusive of manufacturing tolerances.

Pipe and Tube: The fundamental difference between pipe and tube is the dimensional standard to which each is manufactured. As used in this document both have a round cross section.

A pipe is a tube of round cross section conforming to the dimensional requirements for nominal pipe size as tabulated in ANSI B36.10.

A tube is a hollow product of round cross section that may be specified with respect to any two, but not all three of the following: outside diameter, inside diameter, and wall thickness. (Types K, L, and M copper tube may also be specified by nominal size and type only).

Electric Resistance Welded Pipe and Tubing (ERW): Pipe or tubing having a longitudinal butt joint where fusion is produced by the heat obtained from resistance to the flow of electric current in a circuit of which the pipe/tubing is a part, and by the application of pressure.

Furnace Butt Welded Pipe: Pipe having its longitudinal butt joint forge welded by mechanical pressure developed in drawing the furnace heated metal through a cone shaped die which serves as a combined forming and welding die.

Electric Fusion Welded Pipe: Pipe having a longitudinal butt joint where fusion is produced in the preformed metal by manual or automatic arc welding. The weld may be made with or without the use of filler metal.

Seamless Pipe: Pipe produced by several methods that result in a round pipe that does not have a longitudinal seam.

Soldering: A metal joining process where fusion is produced by heating to a suitable temperature and by using a nonferrous alloy that melts at temperatures below 800°F (425°C) and having a melting point below that of the base metals being used.

Rigid Support: The method of securing pipe or tubing to structural members (e.g. bearing walls, ceiling structures, floors, or columns) to prevent movement in any direction.

Intermediate Support: The method of supporting piping or tubing to counter the force of gravity. The supports are normally located between rigid supports but are not intended to counter longitudinal or lateral sway, or as bracing against thrusts associated with changes in direction.

2. DESIGN CRITERIA FOR NFPA 2001 PIPING SYSTEMS

20% INCREASE IN ALLOWABLE STRESS (SE)

In this section, calculations to determine the maximum allowable working pressure for various types of pipe and tubing, are based on the equations given in the ASME B31.1 Power Piping Code, 2018 edition and the criteria set forth in NFPA Standard 2001, Edition 2018.

The calculations assume that the clean agent system pipe section:

1. Is normally unpressurized
2. Does not connect the cylinder outlet to a stop valve. (The presence of stop valves could possibly trap agent and pressurize the pipe upstream of the stop valve for longer than 60 minutes.)
3. Does not contain pressurized agent for longer than 60 minutes.

Calculations take into account pressure-temperature ratings for allowable stress, longitudinal joint efficiencies, end connection factors, and other allowances and limitations used in the design of actuation and distribution system piping.

2.1. Limitations established for pipe and tubing used in NFPA 2001 Clean Agent fire suppression systems are set by:

(Note: Where the word “pipe” is used it is understood to also mean “tubing”).

- (a) Maximum pressure expected in the pipe, or as specified in the applicable NFPA Standard, whichever is greater.
- (b) Materials of construction of the pipe, tensile strength, yield strength, and temperature limitations of the pipe material.
- (c) End connection joining methods, (e.g. threaded, welded, grooved, etc.).
- (d) Pipe construction method, (e.g. seamless, ERW, furnace welded, etc.).
- (e) Pipe internal diameter.
- (f) Pipe wall thickness.
- (g) Cast iron pipe, ASTM A-120 steel pipe, aluminum pipe, or non-metallic pipe, shall not be used.

2.2. The calculations are based on the following:

- (a) The appropriate maximum allowable stress value (SE) as taken from Appendix A of the Power Piping Code (PPC).
- (b) The SE values taken from Appendix A of the Power Piping Code shall be based on a temperature of not less than +130°F for the material being used.
(Note: 130°F temperature designation is based on the maximum operating temperature of most listed/approved fire suppression systems.)
- (c) For piping, the calculations address threaded, welded, brazed, rolled and cut groove end connections.
- (d) For tubing, the calculations address the use of compression or flare fittings; or welded, brazed, or soldered end connections.
- (e) Materials addressed in the calculations include steel pipe and tubing, stainless steel pipe and tubing, and copper tubing.

2.3. Design Calculations for NFPA 2001 Piping Systems

NFPA 2001, 2018 edition, Section 4.2.1.1 states:

“... The thickness of the piping shall be calculated in accordance with ASME B31.1. The internal pressure used for this calculation shall not be less than the greater of the following values:

- 1) The normal charging pressure in the agent container at 70°F (21°C).
- 2) Eighty percent of the maximum pressure in the agent container at a maximum storage temperature of not less than 130°F (55°C), using the manufacturer’s maximum allowable fill density ...”.

To determine the clean agent system pipe thickness, the designer must first determine the greatest internal pressure specified in NFPA 2001 as noted above. The determined internal pressure value is one of the numerous variables inserted into the following ASME B31.1 equation for the determination of thickness of pipe:

$$T = \frac{Pd + 2SEWA + 2yPA}{2(SEW + Py - P)}$$

Where the nomenclature used in the above equation is as follows:

T = Pipe wall thickness, minimum

P = Internal pressure

d = internal pipe diameter

SE = Maximum allowable stress in pipe material due to internal pressure and joint efficiency at the design temperature. These SE values include the weld joint efficiency (or casting factor).

A = additional thickness to compensate for material removed in threading or cut-grooving

y = coefficient related to metal composition and temperature.

W = Weld strength reduction factor. This is equal to one (W = 1) for seamless pipe or for seam-welded pipe operating below the creep range.

The equation above provides for the minimum pipe wall thickness required for the maximum internal design pressure of the clean agent fire suppression system being designed. However, no system designer can choose just any thickness of pipe and have it be timely in delivery or cost effective. There are common pipe types, manufacturing processes, diameters and grades typically provided in every country; designers will normally design systems around these available types of pipe.

In this typical situation using standardized pipe types, the system designer can acquire the pipe wall thicknesses of available pipe types and must determine the maximum working pressures of the readily available pipe types in the market.

To determine the maximum working pressure ASME B31.1 provides the following equation:

$$P = \frac{2SEW(T - A)}{d - 2y(T - A) + 2T}$$

The nomenclature is the same as previously indicated.

Since manufacturing standards for pipe and tube invariably permit some tolerance from the nominal thickness specified, manufacturing tolerance should be taken into account when specifying the pipe wall thickness, T , in the above equation.

The calculated maximum working pressure (p) is compared to the clean agent system pressure as specified by NFPA 2001 and the clean agent system pressure value must always be less than the calculated maximum working pressure value (p).

2.4. Maximum Allowable Stress (SE) Values (for NFPA 2001 Piping Systems)

In section A.4.2.1.1 of NFPA 2001, 2018 Edition, it is stated: "...ASME B31.1 allows the pressure to exceed the maximum design pressure, provided it is for short operating periods. Clean agent piping systems are not subjected to continuous pressurization. When discharge times are less than 60 minutes in duration, NFPA 2001 allows the yield stress factor (SE) published in ASME B31.1 to be increased by 20 percent when calculating the pipe thickness."

To directly address the most common type of systems, the maximum allowable working pressures shown in the Pipe Pressure Tables in this section use SE values that have been increased by 20% for use with pipe that is normally unpressurized in systems with discharge times less than 60 minutes in duration.

Table 2-1 gives values for SE as taken from Appendix A of the ASME B31.1, Power Piping Code, along with SE values increased by 20% for use in the calculations.

CAUTION

The SE values used in the calculations are also limited to the maximum temperatures shown in Table 2-1. If higher temperatures are anticipated, then the SE values must be reduced to agree with the values shown in Appendix A of the Power Piping Code at the higher temperature for the piping materials being used.

Table 2-1.

	Pipe or Tube Material	ASTM Spec	SE Value		SE Value Increased 20% (psi)
			PSI ¹	Temperature	
Steel Pipe	Seamless	A 106 Gr. C	20000	-20 to +600	24000
	Seamless	A 53 Gr. B	17100	-20 to +650	20520
	Seamless	A 106 Gr. B	17100	-20 to +650	20520
	Seamless	A 53 Gr. A	13700	-20 to +650	16440
	Seamless	A 106 Gr. A	13700	-20 to +650	16440
	ERW	A 53 Gr. B	14600	-20 to +650	17520
	ERW	A 53 Gr. A	11700	-20 to +650	14040
	Furnace Welded	A 53 Gr. F	8200	-20 to +650	9840
Stainless Steel Pipe	Type 304 Seamless	A 312	15000	-20 to +300	18000
	Type 304 Welded	A 312	12700	-20 to +300	15240
	Type 304L Seamless	A 312	12800	-20 to +300	15360
	Type 304L Welded	A 312	10900	-20 to +300	13080
	Type 316 Seamless	A 312	15600	-20 to +300	18720
	Type 316 Welded	A 312	13200	-20 to +300	15840
	Type 316L Seamless	A 312	12700	-20 to +300	15240
	Type 316L Welded	A 312	10800	-20 to +300	12960
Steel Tubing	Seamless	A 179	13400	-20 to +500	16080
	ERW	A 178 Gr. A	11400	-20 to +500	13680
	ERW	A 178 Gr. C	14600	-20 to +650	17520
Stainless Steel Tubing	Type 304 Seamless	A 213, A 269	15000	-20 to +300	18000
	Type 304 ERW	A 249, A 269	12700	-20 to +300	15240
	Type 304L Seamless	A 213, A 269	12800	-20 to +300	15360
	Type 304L ERW	A 249, A 269	10900	-20 to +300	13080
	Type 316 Seamless	A 213, A 269	15600	-20 to +300	18720
	Type 316 ERW	A 249, A 269	13200	-20 to +300	15840
	Type 316L Seamless	A 213, A 269	12700	-20 to +300	15240
	Type 316L ERW	A 249, A 269	10800	-20 to +300	12960
Copper Tubing ²	Seamless, Annealed	B 88, B 280	4900	-20 to +200	5880
	Seamless, Drawn	B 88, B 280	10300	-20 to +250	12360

¹ Taken from Appendix A ASME B31.1.

² When using copper tubing with brazed or soldered connections, the maximum allowable stress (SE) must be based on the annealed value.

2.5. Pipe Pressure Tables

The following Tables provide values of maximum allowable working pressure for various types of pipe and tubing. These values have been calculated using the formulae, SE values and end connections shown in Section 2.3 and Table 2-1.

- Table 2-2: Steel Pipe with Threaded End Connections.
- Table 2-3: Steel Pipe with Rolled Groove or Welded End Connections.
- Table 2-4: Steel Pipe with Cut Groove End Connections.
- Table 2-5: Stainless Steel Pipe with Threaded End Connections.
- Table 2-6: Stainless Steel Pipe with Welded End Connections.
- Table 2-7: Steel Tubing with Welded, Brazed, Flared, or Compression Fitting Ends.
- Table 2-8: ASTM A-213 Stainless Steel Tubing with Welded, Brazed, Flared or Compression Fitting Ends.
- Table 2-9: ASTM A-249 Stainless Steel Tubing with Welded, Brazed, Flared, or Compression Fitting Ends.
- Table 2-10: ASTM A-269 Stainless Steel Tubing with Welded, Brazed, Flared, or Compression Fitting Ends.
- Table 2-11: ASTM B-88 Seamless Copper Water Tubing with Brazed, Soldered, Flared, or Compression Fitting Ends. (Annealed and Drawn Tempers).
- Table 2-12: ASTM B-280 Seamless Copper Refrigeration Tubing with Brazed, Soldered, Flared or Compression Fitting Ends. (Annealed and Drawn Tempers).

Dimensions for diameter and thickness are in inches. Wall thickness values used in these tables are based on the minimum wall thickness considering the following manufacturing tolerances:

A53 and A106 and A312 permit 12.5% under tolerance on thickness.

A178, A179, and A213 Tubing allow zero under tolerance on thickness.

A249 and A269 permit 10% under tolerance on thickness.

B88 and B280 copper tube permit 10% under tolerance on thickness.

The thickness values are rounded to the nearest 1/1000 inch.

CAUTION

- a. The values of maximum allowable working pressure, shown in Tables 2-2 to 2-12, have been calculated subject to the following limitations:
 - The pipe/tubing system is not normally pressurized.
 - System discharge time does not exceed 60 minutes in duration.
 - The pipe/tubing is not normally exposed to ambient temperatures that exceed the temperature limitations shown in Table 2-1, for the material being used.
- b. If the pipe/tubing system is subjected to higher ambient temperatures for a specific application, then the SE values and the resultant maximum allowable working pressures, must be reduced to agree with the lower SE values coincident with the higher temperatures for the material being used. The SE values and temperature data are found in Appendix A of the Power Piping Code.
- c. For pipe/tubing normally under continuous pressure, or for systems having discharge times longer than 60 minutes, the values of maximum allowable working pressure given in Section 3 must be used.

2.6. How to Use the Tables

The following example illustrates typical procedures that can be used to select the proper pipe/tubing for use in a specific application, where the pipe system must conform to NFPA 2001.

Example #1: 360 psi HFC-227ea Clean Agent System using threaded steel pipe.

Given:

- The piping is not normally pressurized.
- There are no stop valves between the agent containers and the nozzles.
- The discharge time is less than 60 minutes.
- The application allows the use of seamless, welded, or furnace welded steel pipe with threaded end connections.
- Pipe sizes: 2" and 3" schedule 40.
- Minimum pipe design pressure: 416 psi. [This value is obtained from NFPA-2001, 2018 edition, Table 4-2.1.1(b) for HFC-227ea at 72 Lb/Ft³ fill density].
- Use threaded fittings.
- Maximum ambient temperature that the pipe will normally be exposed to: +130°F.

Find:

- The types and grades of schedule 40 steel pipe that can be used in both 2" and 3" sizes.

Procedure:

- a. Check Table 2-1 for steel pipe. Note that the SE values are acceptable for temperatures up to +650°F except for A106 Grade C for which the SE value up to 600°F is given. This satisfies the requirement of +130°F.
- b. Go to Table 2-2, titled "Steel Pipe with Threaded End Connections (A = thread depth)". Look in the schedule 40 section.
- c. Look across the rows for 2" and 3" sizes, for the grades and types of steel pipe where the calculated maximum allowable working pressures are equal to or greater than 416 psi.
- d. Inspection shows that, for the 2" and 3" pipe sizes, all grades and types of schedule 40 steel pipe are acceptable. Further inspection shows for this example, all grades and types of schedule 40 steel pipe shown can be used in all sizes up to 8" NPS.
- e. Check pipe suppliers for commercial availability.
- f. Check pressure rating of the threaded fittings to be used.

Table 2-2.
Maximum Allowable Working Pressure (PSIG)
Steel Pipe with Threaded End Connections (A = thread depth)

	NPS Pipe Size	Min. Wall Thick. (t)	“A” Dim.	Grade:	A-106C	A-53B A-106B	A-53B	A-53A A-106A	A-53A	A-53F
				Type:	Smls.	Smls.	ERW	Smls.	ERW	Furnace
				SE:	24000	20520	17520	16440	14040	9840
Sch. 40	1/4	0.077	0.044		3084	2637	2251	2113	1804	1264
	3/8	0.080	0.044		2674	2286	1952	1832	1564	1096
	1/2	0.095	0.057		2253	1926	1645	1543	1318	924
	3/4	0.099	0.057		1983	1696	1448	1359	1160	813
	1	0.116	0.070		1727	1477	1261	1183	1011	708
	1-1/4	0.123	0.070		1573	1345	1148	1077	920	645
	1-1/2	0.127	0.070		1475	1261	1077	1011	863	605
	2	0.135	0.070		1343	1148	980	920	786	551
	2-1/2	0.178	0.100		1331	1138	972	912	779	546
	3	0.189	0.100		1246	1065	910	853	729	511
	4	0.207	0.100		1163	995	849	797	681	477
	5	0.226	0.100		1107	947	808	758	648	454
	6	0.245	0.100		1069	914	781	732	626	438
	8	0.282	0.100		1030	881	752	706	603	422
Sch. 80	1/4	0.104	0.044		5854	5005	4273	4010	3424	2400
	3/8	0.110	0.044		5092	4353	3717	3488	2979	2088
	1/2	0.129	0.057		4417	3777	3225	3026	2584	1811
	3/4	0.135	0.057		3791	3241	2767	2597	2218	1554
	1	0.157	0.070		3353	2867	2448	2297	1962	1375
	1-1/4	0.167	0.070		2942	2516	2148	2016	1721	1206
	1-1/2	0.175	0.070		2775	2373	2026	1901	1624	1138
	2	0.191	0.070		2549	2180	1861	1746	1491	1045
	2-1/2	0.242	0.100		2468	2110	1802	1691	1444	1012
	3	0.263	0.100		2322	1985	1695	1591	1358	952
	4	0.295	0.100		2155	1842	1573	1476	1260	883
	5	0.328	0.100		2034	1739	1485	1393	1190	834
	6	0.378	0.100		2084	1782	1521	1428	1219	855
	8	0.438	0.100		1942	1660	1418	1330	1136	796
Sch. 120	4	0.382	0.100		3167	2708	2312	2169	1853	1298
	5	0.438	0.100		3065	2621	2238	2100	1793	1257
	6	0.492	0.100		2981	2549	2176	2042	1744	1222
	8	0.628	0.100		3090	2642	2256	2116	1808	1267

Note: All dimensions are in inches.

Table 2-2. (Continued)

	NPS Pipe Size	Min. Wall Thick. (t)	“A” Dim.	Grade:	A-106C	A-53B A-106B	A-53B	A-53A A-106A	A-53A	A-53F
				Type:	Smls.	Smls.	ERW	Smls.	ERW	Furnace
				SE:	24000	20520	17520	16440	14040	9840
Sch. 160	1/2	0.164	0.057		6808	5821	4970	4664	3983	2791
	3/4	0.191	0.057		6822	5833	4980	4673	3991	2797
	1	0.219	0.070		5981	5114	4366	4097	3499	2452
	1-1/4	0.219	0.070		4642	3969	3388	3180	2715	1903
	1-1/2	0.246	0.070		4802	4106	3506	3289	2809	1969
	2	0.300	0.070		5039	4308	3678	3452	2948	2066
	2-1/2	0.328	0.100		4064	3475	2967	2784	2378	1666
	3	0.382	0.100		4134	3534	3018	2832	2418	1695
	4	0.465	0.100		4163	3560	3039	2852	2436	1707
	5	0.547	0.100		4122	3524	3009	2823	2411	1690
	6	0.628	0.100		4086	3494	2983	2799	2390	1675
	8	0.793	0.100		4122	3524	3009	2823	2411	1690
XXS	1/2	0.257	0.057			12071				
	3/4	0.270	0.057			9938				
	1	0.313	0.070			8899				
	1-1/4	0.334	0.070			7478				
	1-1/2	0.350	0.070			6856				
	2	0.382	0.070			6025				
	2-1/2	0.483	0.100			6119				
	3	0.525	0.100			5520				
	4	0.590	0.100			4895				
	5	0.656	0.100			4458				
	6	0.756	0.100			4413				
	8	0.766	0.100			3378				

Note: All dimensions are in inches.

Table 2-3.

Maximum Allowable Working Pressure (PSIG)

Steel Pipe with Rolled Groove or Welded End Connections (A = 0)³

	NPS Pipe Size	Min. Wall Thick. (t)	Grade:	A-106C	A-53B A-106B	A-53B	A-53A A-106A	A-53A	A-53F
			Type:	Smls.	Smls.	ERW	Smls.	ERW	Furnace
			SE:	24000	20520	17520	16440	14040	9840
Sch. 40	1/4	0.077		7726	6606	5640	5292	4520	3168
	3/8	0.080		6285	5373	4588	4305	3677	2577
	1/2	0.095		5969	5103	4357	4088	3492	2447
	3/4	0.099		4895	4185	3573	3353	2864	2007
	1	0.116		4556	3895	3326	3121	2665	1868
	1-1/4	0.123		3781	3233	2760	2590	2212	1550
	1-1/2	0.127		3390	2898	2474	2322	1983	1390
	2	0.135		2858	2444	2087	1958	1672	1172
	2-1/2	0.178		3127	2673	2282	2142	1829	1282
	3	0.189		2709	2316	1978	1856	1585	1111
	4	0.207		2292	1960	1673	1570	1341	940
	5	0.226		2016	1723	1471	1381	1179	826
	6	0.245		1829	1564	1335	1253	1070	750
	8	0.282		1612	1378	1176	1104	943	661
Sch. 80	1/4	0.104		10928	9344	7978	7486	6393	4481
	3/8	0.110		8995	7691	6566	6161	5262	3688
	1/2	0.129		8404	7185	6135	5757	4916	3446
	3/4	0.135		6879	5882	5022	4712	4024	2820
	1	0.157		6336	5417	4625	4340	3707	2598
	1-1/4	0.167		5252	4490	3834	3597	3072	2153
	1-1/2	0.175		4773	4081	3484	3269	2792	1957
	2	0.191		4126	3527	3012	2826	2414	1692
	2-1/2	0.242		4332	3704	3162	2967	2534	1776
	3	0.263		3838	3281	2801	2629	2245	1573
	4	0.295		3321	2839	2424	2275	1943	1362
	5	0.328		2970	2540	2168	2035	1738	1218
	6	0.378		2870	2454	2095	1966	1679	1177
	8	0.438		2541	2172	1855	1740	1486	1042
Sch. 120	4	0.382		4372	3738	3191	2995	2557	1792
	5	0.438		4033	3448	2944	2763	2359	1654
	6	0.492		3790	3240	2767	2596	2217	1554
	8	0.628		3711	3173	2709	2542	2171	1522

Note: All dimensions are in inches.

³ When using mechanical grooved fittings, the maximum allowable working pressure of the piping system will be limited to the working pressure of the grooved fitting.

Table 2-3. (Continued)

	NPS Pipe Size	Min. Wall Thick. (t)	Grade:	A-106C	A-53B A-106B	A-53B	A-53A A-106A	A-53A	A-53F
			Type:	Smls.	Smls.	ERW	Smls.	ERW	Furnace
			SE:	24000	20520	17520	16440	14040	9840
Sch. 160	1/2	0.164		11106	9496	8107	7608	6497	4553
	3/4	0.191		10218	8737	7459	7000	5978	4190
	1	0.219		9223	7885	6733	6318	5395	3781
	1-1/4	0.219		7080	6053	5168	4850	4142	2903
	1-1/2	0.246		6933	5928	5061	4749	4056	2842
	2	0.300		6745	5767	4924	4620	3946	2765
	2-1/2	0.328		6026	5152	4399	4128	3525	2471
	3	0.382		5740	4908	4190	3932	3358	2353
	4	0.465		5407	4623	3947	3704	3163	2217
	5	0.547		5123	4380	3740	3509	2997	2100
	6	0.628		4923	4210	3594	3373	2880	2019
	8	0.793		4764	4073	3477	3263	2787	1953
XXS	1/2	0.257			16626				
	3/4	0.270			13286				
	1	0.313			12066				
	1-1/4	0.334			9842				
	1-1/2	0.350			8867				
	2	0.382			7576				
	2-1/2	0.483			7965				
	3	0.525			6995				
	4	0.590			6011				
	5	0.656			5344				
	6	0.756			5154				
	8	0.766			3924				

Note: All dimensions are in inches.

Table 2-4.

Maximum Allowable Working Pressure (PSIG)

Steel Pipe with Cut Groove End Connections (A = Groove Depth)⁴

	NPS Pipe Size	Min. Wall Thick. (t)	"A" Dim.	Grade:	A-106C	A-53B A-106B	A-53B	A-53A A106A	A-53A	A-53F
				Type:	Smls.	Smls.	ERW	Smls.	ERW	Furnace
				SE:	24000	20520	17520	16440	14040	9840
Sch. 40	1/2	0.095	0.056		2315	1979	1690	1585	1354	949
	3/4	0.099	0.056		2032	1738	1484	1392	1189	833
	1	0.116	0.063		1999	1709	1459	1369	1169	820
	1 1/4	0.123	0.063		1787	1528	1304	1224	1045	733
	1 1/2	0.127	0.063		1662	1421	1213	1138	972	681
	2	0.135	0.063		1491	1275	1089	1022	872	611
	2 1/2	0.178	0.078		1717	1468	1254	1176	1005	704
	3	0.189	0.078		1562	1335	1140	1070	914	640
	4	0.207	0.083		1352	1156	987	926	791	555
	5	0.226	0.084		1251	1069	913	857	732	513
	6	0.245	0.085		1182	1011	863	810	692	485
Sch. 80	1/2	0.129	0.056		4483	3833	3273	3071	2623	1838
	3/4	0.135	0.056		3843	3286	2805	2632	2248	1576
	1	0.157	0.063		3639	3112	2657	2493	2129	1492
	1 1/4	0.167	0.063		3166	2707	2311	2169	1852	1298
	1 1/2	0.175	0.063		2970	2539	2168	2034	1737	1217
	2	0.191	0.063		2704	2312	1974	1852	1582	1108
	2 1/2	0.242	0.078		2869	2453	2094	1965	1678	1176
	3	0.263	0.078		2649	2265	1934	1815	1550	1086
	4	0.295	0.083		2350	2009	1715	1610	1375	963
	5	0.328	0.084		2182	1866	1593	1495	1276	895
	6	0.378	0.085		2201	1882	1607	1508	1287	902
Sch. 120	4	0.382	0.083		3368	2880	2459	2307	1971	1381
	5	0.438	0.084		3218	2752	2349	2205	1883	1320
	6	0.492	0.085		3101	2652	2264	2124	1814	1272
	8	0.628	0.092		3139	2684	2291	2150	1836	1287

Note: All dimensions are in inches.

⁴ When using mechanical grooved fittings, the maximum allowable working pressure of the piping system will be limited to the working pressure of the grooved fitting or the working pressure of the pipe, whichever is less.

Table 2-4. (Continued)

	NPS Pipe Size	Min. Wall Thick. (t)	"A" Dim.	Grade:	A-106C	A-53B A-106B	A-53B	A-53A A106A	A-53A	A-53F
				Type:	Smls.	Smls.	ERW	Smls.	ERW	Furnace
				SE:	24000	20520	17520	16440	14040	9840
Sch. 160	1/2	0.164	0.056		6879	5882	5022	4712	4024	2820
	3/4	0.191	0.056		6879	5882	5022	4712	4024	2820
	1	0.219	0.063		6291	5379	4593	4310	3680	2579
	1.25	0.219	0.063		4878	4170	3561	3341	2853	2000
	1.5	0.246	0.063		5009	4283	3657	3431	2930	2054
	2	0.300	0.063		5205	4451	3800	3566	3045	2134
	2.5	0.328	0.078		4486	3836	3275	3073	2624	1839
	3	0.382	0.078		4480	3831	3271	3069	2621	1837
	4	0.465	0.083		4372	3738	3191	2995	2557	1792
	5	0.547	0.084		4280	3659	3124	2932	2504	1755
	6	0.628	0.085		4210	3600	3073	2884	2463	1726
	8	0.793	0.092		4173	3568	3046	2858	2441	1711

Note: All dimensions are in inches.

Table 2-5.

Maximum Allowable Working Pressure (PSIG)

Stainless Steel Pipe with Threaded End Connections (A = Thread Depth)

	NPS Pipe Size	Min. Wall Thick. (t)	"A" Dim.	Grade:	A-312/ 304	A-312/ 304	A-312/ 304L	A-312/ 304L	A-312/ 316	A-312/ 316	A-312/ 316L	A-312/ 316L
				Type:	Smls.	Welded	Smls.	Welded	Smls.	Welded	Smls.	Welded
				SE:	18000	15240	15360	13080	18720	15840	15240	12960
Sch. 40	1/4	0.077	0.044		2313	1958	1974	1681	2406	2036	1958	1665
	3/8	0.080	0.044		2006	1698	1711	1457	2086	1765	1698	1444
	1/2	0.095	0.057		1690	1431	1442	1228	1757	1487	1431	1217
	3/4	0.099	0.057		1488	1260	1269	1081	1547	1309	1260	1071
	1	0.116	0.07		1296	1097	1106	941	1347	1140	1097	933
	1 1/4	0.123	0.07		1180	999	1007	857	1227	1038	999	849
	1 1/2	0.127	0.07		1107	937	944	804	1151	974	937	797
	2	0.135	0.07		1007	853	860	732	1048	886	853	725
	2 1/2	0.178	0.1		998	845	852	725	1038	879	845	719
	3	0.189	0.1		934	791	797	679	972	822	791	673
	4	0.207	0.1		873	739	745	634	908	768	739	628
	5	0.226	0.1		830	703	709	603	864	731	703	598
	6	0.245	0.1		802	679	684	583	834	706	679	577
	8	0.282	0.1		773	654	659	561	804	680	654	556
Sch. 80	1/4	0.104	0.044		4390	3717	3746	3190	4566	3863	3717	3161
	3/8	0.110	0.044		3819	3233	3259	2775	3971	3360	3233	2749
	1/2	0.129	0.057		3313	2805	2827	2407	3445	2915	2805	2385
	3/4	0.135	0.057		2843	2407	2426	2066	2957	2502	2407	2047
	1	0.157	0.07		2515	2129	2146	1827	2615	2213	2129	1811
	1 1/4	0.167	0.07		2207	1868	1883	1604	2295	1942	1868	1589
	1 1/2	0.175	0.07		2081	1762	1776	1513	2165	1832	1762	1499
	2	0.191	0.07		1912	1619	1632	1389	1989	1683	1619	1377
	2 1/2	0.242	0.1		1851	1567	1580	1345	1925	1629	1567	1333
	3	0.263	0.1		1741	1474	1486	1265	1811	1532	1474	1254
	4	0.295	0.1		1616	1368	1379	1174	1681	1422	1368	1164
	5	0.328	0.1		1525	1292	1302	1109	1586	1342	1292	1098
	6	0.378	0.1		1563	1323	1334	1136	1626	1376	1323	1125
	8	0.438	0.1		1456	1233	1243	1058	1515	1282	1233	1049

Note: All dimensions are in inches.

Table 2-5. (Continued)

	NPS Pipe Size	Min. Wall Thick. (t)	"A" Dim.	Grade:	A-312/ 304	A-312/ 304	A-312/ 304L	A-312/ 304L	A-312/ 316	A-312/ 316	A-312/ 316L	A-312/ 316L
				Type:	Smls.	Welded	Smls.	Welded	Smls.	Welded	Smls.	Welded
				SE:	18000	15240	15360	13080	18720	15840	15240	12960
Sch. 120	4	0.382	0.1		2375	2011	2027	1726	2470	2090	2011	1710
	5	0.438	0.1		2299	1947	1962	1671	2391	2023	1947	1655
	6	0.492	0.1		2236	1893	1908	1625	2325	1968	1893	1610
	8	0.628	0.1		2317	1962	1977	1684	2410	2039	1962	1668
Sch. 160	1/2	0.164	0.057		5106	4323	4357	3710	5310	4493	4323	3676
	3/4	0.191	0.057		5117	4332	4366	3718	5321	4503	4332	3684
	1	0.219	0.07		4486	3798	3828	3260	4665	3947	3798	3230
	1 1/4	0.219	0.07		3481	2948	2971	2530	3621	3064	2948	2507
	1 1/2	0.246	0.07		3602	3049	3073	2617	3746	3169	3049	2593
	2	0.300	0.07		3779	3200	3225	2746	3930	3326	3200	2721
	2 1/2	0.328	0.1		3048	2581	2601	2215	3170	2683	2581	2195
	3	0.382	0.1		3100	2625	2646	2253	3224	2728	2625	2232
	4	0.465	0.1		3123	2644	2665	2269	3248	2748	2644	2248
	5	0.547	0.1		3091	2617	2638	2246	3215	2720	2617	2226
	6	0.628	0.1		3065	2595	2615	2227	3187	2697	2595	2206
	8	0.793	0.1		3091	2617	2638	2246	3215	2720	2617	2226

Note: Some sizes, grades and schedule combinations may not be commercially available.
All dimensions are in inches.

Table 2-6.
Maximum Allowable Working Pressure (PSIG)
Stainless Steel Pipe with Welded End Connections (A = 0)

	NPS Pipe Size	Min. Wall Thick. (t)	Grade:	A-312/ 304	A-312/ 304	A-312/ 304L	A-312/ 304L	A-312/ 316	A-312/ 316	A-312/ 316L	A-312/ 316L
			Type:	Smls.	Welded	Smls.	Welded	Smls.	Welded	Smls.	Welded
			SE:	18000	15240	15360	13080	18720	15840	15240	12960
Sch. 40	1/4	0.077		5794	4906	4944	4211	6026	5099	4906	4172
	3/8	0.080		4714	3991	4022	3425	4902	4148	3991	3394
	1/2	0.095		4476	3790	3820	3253	4655	3939	3790	3223
	3/4	0.099		3671	3108	3133	2668	3818	3231	3108	2643
	1	0.116		3417	2893	2916	2483	3553	3007	2893	2460
	1 1/4	0.123		2836	2401	2420	2061	2949	2495	2401	2042
	1 1/2	0.127		2542	2152	2169	1847	2644	2237	2152	1830
	2	0.135		2144	1815	1829	1558	2230	1887	1815	1544
	2 1/2	0.178		2345	1985	2001	1704	2439	2064	1985	1688
	3	0.189		2032	1720	1734	1476	2113	1788	1720	1463
	4	0.207		1719	1456	1467	1249	1788	1513	1456	1238
	5	0.226		1512	1280	1290	1098	1572	1330	1280	1088
	6	0.245		1372	1162	1171	997	1427	1207	1162	988
	8	0.282		1209	1023	1031	878	1257	1064	1023	870
Sch. 80	1/4	0.104		8196	6939	6994	5956	8524	7213	6939	5901
	3/8	0.110		6746	5712	5757	4902	7016	5937	5712	4857
	1/2	0.129		6303	5336	5379	4580	6555	5547	5336	4538
	3/4	0.135		5159	4368	4403	3749	5366	4540	4368	3715
	1	0.157		4752	4023	4055	3453	4942	4182	4023	3421
	1 1/4	0.167		3939	3335	3361	2862	4096	3466	3335	2836
	1 1/2	0.175		3580	3031	3055	2601	3723	3150	3031	2577
	2	0.191		3094	2620	2640	2248	3218	2723	2620	2228
	2 1/2	0.242		3249	2751	2773	2361	3379	2859	2751	2339
	3	0.263		2878	2437	2456	2091	2993	2533	2437	2072
	4	0.295		2491	2109	2125	1810	2590	2192	2109	1793
	5	0.328		2228	1886	1901	1619	2317	1960	1886	1604
	6	0.378		2152	1822	1837	1564	2238	1894	1822	1550
	8	0.438		1906	1613	1626	1385	1982	1677	1613	1372

Table 2-6. (Continued)

	NPS Pipe Size	Min. Wall Thick. (t)	Grade:	A-312/ 304	A-312/ 304	A-312/ 304L	A-312/ 304L	A-312/ 316	A-312/ 316	A-312/ 316L	A-312/ 316L
			Type:	Smls.	Welded	Smls.	Welded	Smls.	Welded	Smls.	Welded
			SE:	18000	15240	15360	13080	18720	15840	15240	12960
Sch. 120	4	0.382		3279	2776	2798	2382	3410	2885	2776	2361
	5	0.438		3025	2561	2581	2198	3146	2662	2561	2178
	6	0.492		2842	2407	2425	2065	2956	2501	2407	2047
	8	0.628		2783	2357	2375	2023	2895	2449	2357	2004
Sch. 160	1/2	0.164		8330	7052	7108	6053	8663	7330	7052	5997
	3/4	0.191		7664	6489	6540	5569	7970	6744	6489	5518
	1	0.219		6917	5856	5903	5026	7194	6087	5856	4980
	1 1/4	0.219		5310	4496	4531	3858	5522	4673	4496	3823
	1 1/2	0.246		5200	4402	4437	3778	5408	4576	4402	3744
	2	0.300		5059	4283	4317	3676	5261	4452	4283	3642
	2 1/2	0.328		4520	3827	3857	3284	4700	3977	3827	3254
	3	0.382		4305	3645	3674	3128	4477	3788	3645	3100
	4	0.465		4055	3433	3460	2947	4217	3569	3433	2920
	5	0.547		3842	3253	3279	2792	3996	3381	3253	2766
	6	0.628		3693	3126	3151	2683	3840	3249	3126	2659
	8	0.793		3573	3025	3049	2596	3716	3144	3025	2572

Note: Some sizes, grades and schedule combinations may not be commercially available.
All dimensions are in inches.

NOTE applying to Tables 2-7 through 2-12: All dimensions are in inches. The maximum allowable working pressure of a pipe network using flared or compression fittings is limited to the maximum allowable working pressure of the fitting or the pipe, whichever is less.

Table 2-7.

Maximum Allowable Working Pressure (PSIG)

Steel Tubing with Welded, Braze, Flared or Compression Fitting Ends (A = 0)

Nom. Tube Size	OD	Wall Thick. (t)	Grade:	A-179	A-178 Gr. C	A-178 Gr. A	Nom. Tube Size	OD	Wall Thick. (t)	Grade:	A-179	A-178 Gr. C	A-178 Gr. A
			Type:	Smls.	ERW	ERW				Type:	Smls.	ERW	ERW
			SE:	16080	17520	13680				SE:	16080	17520	13680
1/4	0.250	0.022		3044	3317	2590	3/4	0.750	0.035		1559	1699	1326
	0.250	0.028		3956	4311	3366		0.750	0.049		2217	2416	1886
	0.250	0.032		4586	4997	3902		0.750	0.058		2651	2888	2255
	0.250	0.035		5070	5524	4314		0.750	0.065		2995	3263	2548
	0.250	0.042		6242	6801	5310		0.750	0.072		3344	3644	2845
	0.250	0.049		7476	8145	6360		0.750	0.083		3905	4254	3322
	0.250	0.065		10558	11503	8982		0.750	0.095		4533	4939	3856
	0.250	0.083		14539	15841	12369		0.750	0.109		5289	5762	4499
	0.250	0.095		17559	19131	14938		0.750	0.120		5901	6429	5020
3/8	0.375	0.022		1980	2157	1684	1	0.750	0.134		6704	7305	5704
	0.375	0.028		2554	2783	2173		0.750	0.156		8025	8743	6827
	0.375	0.032		2945	3209	2506		0.750	0.172		9033	9841	7684
	0.375	0.035		3244	3534	2760		0.750	0.188		10084	10987	8579
	0.375	0.049		4693	5113	3992		0.750	0.219		12253	13350	10424
	0.375	0.058		5676	6185	4829		0.750	0.250		14618	15927	12436
	0.375	0.065		6472	7051	5506		1.000	0.028		921	1004	784
	0.375	0.083		8650	9424	7359		1.000	0.035		1158	1262	985
	0.375	0.095		10218	11133	8693		1.000	0.049		1640	1787	1395
1/2	0.375	0.120		13832	15071	11768		1.000	0.058		1956	2131	1664
	0.500	0.035		2385	2598	2029		1.000	0.065		2205	2403	1876
	0.500	0.049		3420	3726	2909		1.000	0.072		2457	2677	2090
	0.500	0.058		4112	4480	3498		1.000	0.083		2859	3115	2432
	0.500	0.065		4666	5084	3970		1.000	0.095		3306	3603	2813
	0.500	0.072		5234	5703	4453		1.000	0.109		3840	4184	3267
	0.500	0.083		6156	6707	5237		1.000	0.120		4269	4651	3632
	0.500	0.095		7206	7851	6130		1.000	0.134		4827	5259	4106
	0.500	0.109		8492	9252	7224		1.000	0.156		5732	6246	4877
	0.500	0.120		9552	10408	8127		1.000	0.172		6414	6988	5457
	0.500	0.134		10971	11954	9334		1.000	0.188		7116	7754	6054
	0.500	0.156		13371	14569	11376		1.000	0.219		8539	9304	7265
	0.500	0.188		17294	18843	14713		1.000	0.250		10050	10950	8550
5/8	0.625	0.065		3648	3975	3104		1.000	0.281		11658	12702	9918
								1.000	0.313		13429	14631	11424
								1.000	0.375		17229	18771	14657

Table 2-7. (Continued)

Nom. Tube Size	OD	Wall Thick. (t)	Grade:	A-179	A-178 Gr. C	A-178 Gr. A	Nom. Tube Size	OD	Wall Thick. (t)	Grade:	A-179	A-178 Gr. C	A-178 Gr. A
			Type:	Smls.	ERW	ERW				Type:	Smls.	ERW	ERW
			SE:	16080	17520	13680				SE:	16080	17520	13680
1 1/4	1.250	0.035		921	1004	784	2	2.000	0.035		571	622	486
	1.250	0.049		1301	1418	1107		2.000	0.049		804	876	684
	1.250	0.065		1745	1901	1484		2.000	0.065		1073	1169	913
	1.250	0.083		2255	2457	1919		2.000	0.083		1380	1504	1174
	1.250	0.095		2602	2835	2214		2.000	0.095		1588	1730	1351
	1.250	0.109		3015	3285	2565		2.000	0.109		1833	1997	1559
	1.250	0.120		3344	3644	2845		2.000	0.120		2027	2208	1724
	1.250	0.125		3496	3809	2974		2.000	0.125		2116	2305	1800
	1.250	0.134		3771	4109	3208		2.000	0.134		2277	2481	1937
	1.250	0.156		4459	4858	3793		2.000	0.148		2530	2756	2152
	1.250	0.188		5498	5991	4678		2.000	0.156		2675	2915	2276
	1.250	0.219		6553	7140	5575		2.000	0.165		2841	3095	2417
	1.250	0.250		7657	8343	6514		2.000	0.180		3119	3398	2653
	1.250	0.281		8815	9604	7499		2.000	0.188		3269	3562	2781
	1.250	0.313		10070	10972	8567		2.000	0.219		3860	4205	3284
	1.250	0.344		11349	12365	9655		2.000	0.240		4269	4651	3632
	1.250	0.375		12695	13832	10800		2.000	0.250		4467	4867	3800
	1.250	0.438		15658	17060	13321		2.000	0.281		5091	5547	4331
1 1/2	1.500	0.035		765	833	651	2 1/2	2.000	0.313		5753	6269	4895
	1.500	0.049		1079	1175	918		2.000	0.344		6414	6988	5457
	1.500	0.058		1283	1398	1092		2.000	0.375		7094	7729	6035
	1.500	0.065		1444	1573	1228		2.000	0.438		8539	9304	7265
	1.500	0.072		1605	1749	1366		2.000	0.500		10050	10950	8550
	1.500	0.083		1862	2029	1584		2.000	0.563		11684	12731	9940
	1.500	0.095		2146	2338	1825		2.000	0.625		13400	14600	11400
	1.500	0.109		2481	2703	2111		2.000	0.750		17229	18771	14657
	1.500	0.120		2749	2995	2338		2.250	0.095		1405	1531	1196
	1.500	0.125		2871	3129	2443		2.500	0.035		455	496	387
	1.500	0.134		3094	3371	2632		2.500	0.049		640	698	545
	1.500	0.156		3648	3975	3104		2.500	0.065		854	930	726
	1.500	0.172		4060	4424	3454		2.500	0.083		1097	1195	933
	1.500	0.188		4480	4881	3811		2.500	0.095		1260	1373	1072
	1.500	0.219		5316	5792	4523		2.500	0.109		1453	1583	1236
	1.500	0.250		6185	6738	5262		2.500	0.120		1605	1749	1366
	1.500	0.281		7087	7721	6029		2.500	0.125		1675	1825	1425
	1.500	0.313		8055	8777	6853		2.500	0.134		1801	1962	1532
	1.500	0.344		9033	9841	7684		2.500	0.148		1999	2177	1700
	1.500	0.375		10050	10950	8550		2.500	0.156		2112	2301	1797
	1.500	0.438		12253	13350	10424		2.500	0.180		2457	2677	2090
	1.500	0.500		14618	15927	12436		2.500	0.188		2573	2804	2189
1 3/4	1.750	0.095		1825	1989	1553		2.500	0.219		3030	3301	2577

Table 2-7. (Continued)

Nom. Tube Size	OD	Wall Thick. (t)	Grade:	A-179	A-178 Gr. C	A-178 Gr. A	Nom. Tube Size	OD	Wall Thick. (t)	Grade:	A-179	A-178 Gr. C	A-178 Gr. A
			Type:	Smls.	ERW	ERW				Type:	Smls.	ERW	ERW
			SE:	16080	17520	13680				SE:	16080	17520	13680
2 1/2	2.500	0.220		3044	3317	2590	3 1/4	3.250	0.120		1224	1333	1041
	2.500	0.250		3496	3809	2974		3.250	0.134		1371	1494	1167
	2.500	0.281		3972	4328	3379		3.250	0.148		1520	1656	1293
	2.500	0.313		4475	4875	3807		3.250	0.180		1864	2031	1586
	2.500	0.344		4973	5418	4230	3 1/2	3.500	0.120		1134	1235	965
	2.500	0.375		5482	5973	4664		3.500	0.134		1270	1384	1081
	2.500	0.437		6535	7121	5560	4	4.000	0.134		1107	1206	942
	2.500	0.500		7657	8343	6514		4.000	0.148		1226	1336	1043
	2.500	0.563		8834	9625	7515	4 1/2	4.500	0.134		981	1069	835
	2.500	0.625		10050	10950	8550		4.500	0.148		1086	1184	924
3	2.500	0.750		12695	13832	10800							
	2.750	0.109		1316	1434	1120							
	3.000	0.049		532	580	453							
	3.000	0.065		709	773	603							
	3.000	0.083		910	991	774							
	3.000	0.095		1045	1138	889							
	3.000	0.109		1203	1311	1024							
	3.000	0.120		1329	1448	1131							
	3.000	0.125		1386	1510	1179							
	3.000	0.134		1490	1623	1267							
	3.000	0.148		1652	1800	1405							
	3.000	0.156		1745	1901	1484							
	3.000	0.165		1850	2016	1574							
	3.000	0.180		2027	2208	1724							
	3.000	0.188		2122	2312	1805							
	3.000	0.219		2493	2717	2121							
	3.000	0.250		2871	3129	2443							
	3.000	0.281		3256	3548	2770							
	3.000	0.313		3661	3989	3115							
	3.000	0.344		4060	4424	3454							
	3.000	0.375		4467	4867	3800							
	3.000	0.437		5303	5777	4511							
	3.000	0.500		6185	6738	5262							
	3.000	0.563		7102	7737	6042							
	3.000	0.625		8040	8760	6840							
	3.000	0.688		9033	9841	7684							
	3.000	0.750		10050	10950	8550							
	3.000	0.875		12235	13330	10409							
	3.000	1.000		14618	15927	12436							

Table 2-8.

Maximum Allowable Working Pressure (PSIG)

A-213 Stainless Steel Tubing with Welded, Brazed, Flared or Compression Fitting Ends (A = 0)

Nom. Tube Size	Max. OD	Min. Wall Thick. (t)	Grade:	A-213	A-213	A-213	A-213
				304	304L	316	316L
			Type:	Smls.	Smls.	Smls.	Smls.
			SE:	18000	15360	18720	15240
1/4	0.254	0.020		2835	2419	2948	2400
	0.254	0.028		3969	3386	4127	3360
	0.254	0.032		4535	3870	4717	3840
	0.254	0.035		4961	4233	5159	4200
	0.254	0.049		6945	5926	7223	5880
	0.254	0.065		9213	7861	9581	7800
3/8	0.379	0.028		2660	2270	2766	2252
	0.379	0.035		3325	2837	3458	2815
	0.379	0.049		4654	3972	4841	3941
	0.379	0.065		6174	5269	6421	5227
1/2	0.504	0.028		2000	1707	2080	1693
	0.504	0.035		2500	2133	2600	2117
	0.504	0.049		3500	2987	3640	2963
	0.504	0.065		4643	3962	4829	3931
	0.504	0.083		5929	5059	6166	5020
	0.504	0.095		6786	5790	7057	5745
	0.504	0.120		8571	7314	8914	7257
3/4	0.754	0.035		1671	1426	1738	1415
	0.754	0.049		2340	1996	2433	1981
	0.754	0.065		3103	2648	3228	2628
	0.754	0.083		3963	3382	4121	3355
	0.754	0.095		4536	3871	4717	3840
	0.754	0.120		5729	4889	5959	4851
	1.006	0.035		1252	1069	1303	1060
	1.006	0.049		1753	1496	1824	1485
	1.006	0.065		2326	1985	2419	1969
	1.006	0.083		2970	2535	3089	2515
	1.006	0.095		3400	2901	3536	2878
	1.006	0.120		4294	3664	4466	3636
	1.006	0.188		6728	5741	6997	5696
	1.006	0.250		8946	7634	9304	7575

Table 2-8. (Continued)

Nom. Tube Size	Max. OD	Min. Wall Thick. (t)	Grade:	A-213	A-213	A-213	A-213
				304	304L	316	316L
			Type:	Smls.	Smls.	Smls.	Smls.
			SE:	18000	15360	18720	15240
1 1/4	1.256	0.035		1003	856	1043	849
	1.256	0.049		1404	1198	1461	1189
	1.256	0.065		1863	1590	1938	1577
	1.256	0.083		2379	2030	2474	2014
	1.256	0.095		2723	2324	2832	2305
	1.256	0.120		3439	2935	3577	2912
	1.256	0.188		5389	4598	5604	4562
	1.256	0.250		7166	6115	7452	6067
1 1/2	1.506	0.035		837	714	870	708
	1.506	0.049		1171	1000	1218	992
	1.506	0.065		1554	1326	1616	1316
	1.506	0.083		1984	1693	2063	1680
	1.506	0.120		2869	2448	2983	2429
	1.506	0.188		4494	3835	4674	3805
	1.506	0.250		5976	5100	6215	5060
2	2.010	0.035		627	535	652	531
	2.010	0.049		878	749	913	743
	2.010	0.065		1164	993	1211	986
	2.010	0.083		1487	1269	1546	1259
	2.010	0.120		2149	1834	2235	1820
	2.010	0.180		3224	2751	3353	2730
	2.010	0.188		3367	2873	3502	2851
	2.010	0.250		4478	3821	4657	3791
2 1/2	2.512	0.049		702	599	730	595
	2.512	0.065		932	795	969	789
	2.512	0.120		1720	1468	1789	1456
	2.512	0.188		2694	2299	2802	2281
	2.512	0.250		3583	3057	3726	3033
3	3.015	0.065		776	662	807	657
	3.015	0.083		991	846	1031	839
	3.015	0.120		1433	1223	1490	1213
	3.015	0.188		2245	1916	2335	1901
	3.015	0.250		2985	2547	3104	2527

Table 2-9.

Maximum Allowable Working Pressure (PSIG)

A-249 Stainless Steel Tubing with Welded, Brazed, Flared or Compression Fitting Ends (A = 0)

Nom. Tube Size	Max. OD	Min. Wall Thick. (t)		A-249	A-249	A-249	A-249
			Grade:	304	304L	316	316L
			Type:	Welded	Welded	Welded	Welded
			SE:	15240	13080	15840	12960
1/4	0.254	0.018		2160	1854	2245	1837
	0.254	0.025		3000	2575	3118	2551
	0.254	0.029		3480	2987	3617	2959
	0.254	0.032		3840	3296	3991	3266
	0.254	0.044		5280	4532	5488	4490
	0.254	0.059		7080	6077	7359	6021
3/8	0.379	0.025		2011	1726	2090	1710
	0.379	0.032		2574	2209	2675	2188
	0.379	0.044		3539	3037	3678	3009
	0.379	0.059		4745	4072	4932	4035
1/2	0.504	0.025		1512	1298	1571	1286
	0.504	0.032		1935	1661	2011	1646
	0.504	0.044		2661	2284	2766	2263
	0.504	0.059		3568	3062	3709	3034
	0.504	0.075		4536	3893	4714	3857
	0.504	0.086		5201	4464	5406	4423
	0.504	0.108		6531	5606	6789	5554
3/4	0.754	0.032		1294	1110	1345	1100
	0.754	0.044		1779	1527	1849	1513
	0.754	0.059		2385	2047	2479	2028
	0.754	0.075		3032	2602	3151	2578
	0.754	0.086		3476	2984	3613	2956
	0.754	0.108		4366	3747	4538	3713
1	1.006	0.032		970	832	1008	824
	1.006	0.044		1333	1144	1386	1134
	1.006	0.059		1788	1534	1858	1520
	1.006	0.075		2272	1950	2362	1932
	1.006	0.086		2606	2236	2708	2216
	1.006	0.108		3272	2808	3401	2783
	1.006	0.169		5120	4395	5322	4354
	1.006	0.225		6817	5851	7085	5797

Table 2-9. (Continued)

Nom. Tube Size	Max. OD	Min. Wall Thick. (t)		A-249	A-249	A-249	A-249
			Grade:	304	304L	316	316L
			Type:	Welded	Welded	Welded	Welded
			SE:	15240	13080	15840	12960
1 1/4	1.256	0.032		777	666	807	660
	1.256	0.044		1068	916	1110	908
	1.256	0.059		1432	1229	1488	1218
	1.256	0.075		1820	1562	1892	1548
	1.256	0.086		2087	1791	2169	1775
	1.256	0.108		2621	2249	2724	2229
	1.256	0.169		4101	3520	4263	3488
	1.256	0.225		5460	4686	5675	4643
1 1/2	1.506	0.032		648	556	673	551
	1.506	0.044		891	764	926	757
	1.506	0.059		1194	1025	1241	1015
	1.506	0.075		1518	1303	1578	1291
	1.506	0.108		2186	1876	2272	1859
	1.506	0.169		3420	2936	3555	2909
	1.506	0.225		4554	3908	4733	3873
2	2.010	0.032		485	416	504	413
	2.010	0.044		667	573	693	567
	2.010	0.059		895	768	930	761
	2.010	0.075		1137	976	1182	967
	2.010	0.108		1638	1406	1702	1393
	2.010	0.162		2457	2108	2553	2089
	2.010	0.169		2563	2200	2664	2179
	2.010	0.225		3412	2928	3546	2901
2 1/2	2.512	0.044		534	458	555	454
	2.512	0.059		716	614	744	609
	2.512	0.108		1310	1125	1362	1114
	2.512	0.169		2051	1760	2131	1744
	2.512	0.225		2730	2343	2838	2322
3	3.015	0.059		596	512	620	507
	3.015	0.075		758	651	788	645
	3.015	0.108		1092	937	1135	928
	3.015	0.169		1708	1466	1776	1453
	3.015	0.225		2275	1952	2364	1934

Table 2-10.

Maximum Allowable Working Pressure (PSIG)

A-269 Stainless Steel Tubing with Welded, Brazed, Flared or Compression Fitting Ends (A = 0)

Nom. Tube Size	Max. OD	Min. Wall Thick. (t)		A-269	A-269	A-269	A-269	A-269	A-269	A-269	A-269
			Grade:	304	304	304L	304L	316	316	316L	316L
			Type:	Smls.	Welded	Smls.	Welded	Smls.	Welded	Smls.	Welded
			SE:	18000	15240	15360	13080	18720	15840	15240	12960
1/4	0.255	0.018		2541	2152	2168	1847	2643	2236	2152	1830
	0.255	0.025		3529	2988	3012	2565	3671	3106	2988	2541
	0.255	0.029		4094	3466	3494	2975	4258	3603	3466	2948
	0.255	0.032		4518	3825	3855	3283	4698	3976	3825	3253
	0.255	0.044		6212	5259	5301	4514	6460	5466	5259	4472
	0.255	0.059		8329	7052	7108	6053	8663	7330	7052	5997
3/8	0.380	0.025		2368	2005	2021	1721	2463	2084	2005	1705
	0.380	0.032		3032	2567	2587	2203	3153	2668	2567	2183
	0.380	0.044		4168	3529	3557	3029	4335	3668	3529	3001
	0.380	0.059		5589	4732	4770	4062	5813	4919	4732	4024
1/2	0.505	0.025		1782	1509	1521	1295	1853	1568	1509	1283
	0.505	0.032		2281	1931	1947	1658	2372	2007	1931	1642
	0.505	0.044		3137	2656	2677	2279	3262	2760	2656	2258
	0.505	0.059		4206	3561	3589	3056	4374	3701	3561	3028
	0.505	0.075		5347	4527	4562	3885	5560	4705	4527	3850
	0.505	0.086		6131	5191	5232	4455	6376	5395	5191	4414
	0.505	0.108		7699	6518	6570	5595	8007	6775	6518	5543
3/4	0.755	0.032		1526	1292	1302	1109	1587	1343	1292	1099
	0.755	0.044		2098	1776	1790	1525	2182	1846	1776	1511
	0.755	0.059		2813	2382	2401	2044	2926	2476	2382	2026
	0.755	0.075		3576	3028	3052	2599	3719	3147	3028	2575
	0.755	0.086		4101	3472	3499	2980	4265	3609	3472	2952
	0.755	0.108		5150	4360	4394	3742	5356	4532	4360	3708
1	1.005	0.032		1146	971	978	833	1192	1009	971	825
	1.005	0.044		1576	1334	1345	1145	1639	1387	1334	1135
	1.005	0.059		2113	1789	1803	1536	2198	1860	1789	1522
	1.005	0.075		2687	2275	2293	1952	2794	2364	2275	1934
	1.005	0.086		3081	2608	2629	2239	3204	2711	2608	2218
	1.005	0.108		3869	3275	3301	2811	4023	3404	3275	2785
	1.005	0.169		6054	5125	5166	4399	6296	5327	5125	4359
	1.005	0.225		8060	6824	6878	5857	8382	7093	6824	5803

Table 2-10. (Continued)

Nom. Tube Size	Max. OD	Min. Wall Thick. (t)		A-269	A-269	A-269	A-269	A-269	A-269	A-269	A-269
			Grade:	304	304	304L	304L	316	316	316L	316L
			Type:	Smls.	Welded	Smls.	Welded	Smls.	Welded	Smls.	Welded
			SE:	18000	15240	15360	13080	18720	15840	15240	12960
1 1/4	1.255	0.032		918	777	783	667	955	808	777	661
	1.255	0.044		1262	1069	1077	917	1313	1111	1069	909
	1.255	0.059		1692	1433	1444	1230	1760	1489	1433	1219
	1.255	0.075		2151	1822	1836	1563	2237	1893	1822	1549
	1.255	0.086		2467	2089	2105	1793	2566	2171	2089	1776
	1.255	0.108		3098	2623	2644	2251	3222	2726	2623	2231
	1.255	0.169		4848	4104	4137	3523	5042	4266	4104	3490
	1.255	0.225		6454	5465	5508	4690	6712	5680	5465	4647
1 1/2	1.510	0.032		763	646	651	554	793	671	646	549
	1.510	0.044		1049	888	895	762	1091	923	888	755
	1.510	0.059		1407	1191	1200	1022	1463	1238	1191	1013
	1.510	0.075		1788	1514	1526	1299	1860	1574	1514	1287
	1.510	0.108		2575	2180	2197	1871	2678	2266	2180	1854
	1.510	0.169		4029	3411	3438	2928	4190	3546	3411	2901
	1.510	0.225		5364	4542	4577	3898	5579	4721	4542	3862
2	2.010	0.032		573	485	489	416	596	504	485	413
	2.010	0.044		788	667	672	573	820	693	667	567
	2.010	0.059		1057	895	902	768	1099	930	895	761
	2.010	0.075		1343	1137	1146	976	1397	1182	1137	967
	2.010	0.108		1934	1638	1651	1406	2012	1702	1638	1393
	2.010	0.162		2901	2457	2476	2108	3018	2553	2457	2089
	2.010	0.169		3027	2563	2583	2200	3148	2664	2563	2179
	2.010	0.225		4030	3412	3439	2928	4191	3546	3412	2901
2 1/2	2.510	0.044		631	534	539	459	656	555	534	454
	2.510	0.059		846	716	722	615	880	745	716	609
	2.510	0.108		1549	1311	1322	1126	1611	1363	1311	1115
	2.510	0.169		2424	2052	2068	1761	2521	2133	2052	1745
	2.510	0.225		3227	2732	2754	2345	3356	2840	2732	2324
3	3.010	0.059		706	597	602	513	734	621	597	508
	3.010	0.075		897	759	765	652	933	789	759	646
	3.010	0.108		1292	1094	1102	939	1343	1137	1094	930
	3.010	0.169		2021	1711	1725	1469	2102	1779	1711	1455
	3.010	0.225		2691	2278	2296	1955	2799	2368	2278	1938

Note: Some sizes, grades and schedule combinations may not be commercially available.
Maximum allowable pressure may be limited by the fitting used.

Table 2-11.

Maximum Allowable Working Pressure (PSIG)

ASTM B-88 Seamless Copper Water Tubing with Brazed, Flared or Compression Fitting Ends (A = 0)

Nom. Tube Size	Max. OD Drawn	Max. OD Annealed	Tube Type	Min. Wall Thick. (t)	Grade:	B-88	B-88
					Type:	Drawn	Annealed
					SE:	12360	5880
1/4	0.376	0.377	K	0.032		2071	983
	0.376	0.377	L	0.027		1775	842
	0.376	0.377	M	N/A		N/A	N/A
3/8	0.501	0.503	K	0.044		2171	1030
	0.501	0.503	L	0.031		1530	725
	0.501	0.503	M	0.023		1135	538
1/2	0.626	0.628	K	0.044		1738	825
	0.626	0.628	L	0.036		1422	675
	0.626	0.628	M	0.025		987	469
5/8	0.751	0.753	K	0.044		1448	688
	0.751	0.753	L	0.038		1251	594
	0.751	0.753	M	N/A		N/A	N/A
3/4	0.876	0.878	K	0.059		1665	790
	0.876	0.878	L	0.041		1157	549
	0.876	0.878	M	0.029		818	388
1	1.127	1.129	K	0.059		1295	615
	1.127	1.129	L	0.045		987	469
	1.127	1.129	M	0.031		680	323
1 1/4	1.377	1.379	K	0.059		1060	503
	1.377	1.379	L	0.049		880	418
	1.377	1.379	M	0.038		682	324
1 1/2	1.627	1.630	K	0.065		988	469
	1.627	1.630	L	0.054		820	390
	1.627	1.630	M	0.044		669	318
2	2.127	2.130	K	0.075		872	414
	2.127	2.130	L	0.063		732	348
	2.127	2.130	M	0.052		604	287
2 1/2	2.627	2.630	K	0.085		800	380
	2.627	2.630	L	0.072		678	322
	2.627	2.630	M	0.059		555	264

Table 2-11. (Continued)

Nom. Tube Size	Max. OD Drawn	Max. OD Annealed	Tube Type	Min. Wall Thick. (t)	Grade:	B-88	B-88
					Type:	Drawn	Annealed
					SE:	12360	5880
3	3.127	3.130	K	0.098		775	368
	3.127	3.130	L	0.081		640	304
	3.127	3.130	M	0.065		514	244
3 1/2	3.627	3.630	K	0.108		736	350
	3.627	3.630	L	0.090		613	292
	3.627	3.630	M	0.075		511	243
4	4.127	4.130	K	0.121		725	345
	4.127	4.130	L	0.099		593	282
	4.127	4.130	M	0.085		509	242
5	5.127	5.130	K	0.144		694	330
	5.127	5.130	L	0.113		545	259
	5.127	5.130	M	0.098		473	225
6	6.127	6.130	K	0.173		698	332
	6.127	6.130	L	0.126		508	242
	6.127	6.130	M	0.110		444	211
8	8.127	8.131	K	0.244		742	353
	8.127	8.131	L	0.180		548	260
	8.127	8.131	M	0.153		465	221

Note: If soldering or brazing drawn (straight) tubing use annealed allowable pressure.
Maximum allowable pressure may be limited by the fitting used.

Table 2-12.

Maximum Allowable Working Pressure (PSIG)

ASTM B-280 Seamless Copper Refrigeration Tubing with Brazed, Flared or Compression Fitting Ends

(A = 0)

Nom. Tube Size	Max. OD	Tubing Type	Min. Wall Thick. (t)	Grade:	B-280	B-280
				Type:	Drawn	Annealed
				SE:	12360	5880
					(Straight)	(Coil)
1/4	0.252	Coil	0.027			1260
	0.251	Straight	0.023		2216	
5/16	0.314	Coil	0.029			1086
3/8	0.377	Coil	0.029			905
	0.376	Straight	0.027		1775	
1/2	0.502	Coil	0.029			679
	0.501	Straight	0.031		1530	
5/8	0.627	Coil	0.031			581
	0.626	Straight	0.036		1422	
3/4	0.753	Coil	0.031			484
	0.751	Straight	0.038		1251	
7/8	0.878	Coil	0.041			549
	0.876	straight	0.041		1157	
1 1/8	1.129	Coil	0.045			469
	1.127	Straight	0.046		1009	
1 3/8	1.379	Coil	0.049			418
	1.377	Straight	0.049		880	
1 5/8	1.630	Coil	0.054			390
	1.627	Straight	0.054		820	
2 1/8	2.127	Straight	0.063		732	
2 5/8	2.627	Straight	0.072		678	
3 1/8	3.127	Straight	0.081		640	
3 5/8	3.627	Straight	0.090		613	
4 1/8	4.127	Straight	0.099		593	

Note: If soldering or brazing drawn (straight) tubing use annealed allowable pressure.

Maximum allowable pressure may be limited by the fitting used.

3. DESIGN CRITERIA FOR SPECIAL HAZARDS PIPING SYSTEMS⁵

0% INCREASE IN ALLOWABLE STRESS (SE)

In this section, the calculations to determine the maximum allowable working pressure for various types of pipe and tubing are based on the equations given in the ASME B31.1 Power Piping Code, 2018 edition.

The criteria specified follows the basic format found in NFPA standards, and covers pressure-temperature ratings for allowable stress, longitudinal joint efficiencies, end connection factors, and other allowances and limitations used in the design of actuation and distribution system piping.

3.1. Limitations established for pipe and tubing used in special hazard fire suppression systems are set by:

(Note: Where the word “pipe” is used it is understood to also mean “tubing”).

- (a) Maximum pressure expected in the pipe, or as specified in the applicable NFPA Standard.
- (b) Materials of construction of the pipe, tensile strength, yield strength, and temperature limitations of the material.
- (c) End connection joining methods, (e.g. threaded, welded, grooved, etc.).
- (d) Pipe construction method, (e.g. seamless, ERW, furnace welded, etc.).
- (e) Pipe diameter.
- (f) Pipe wall thickness.
- (g) Cast iron pipe, steel pipe conforming to ASTM A-120, aluminum pipe⁶, or non-metallic pipe, shall not be used.

3.2. The calculations are based on the following:

- (a) The maximum allowable stress value (SE) taken from Appendix A of the Power Piping Code, ASME B31.1.
- (b) The SE values taken from Appendix A of the Power Piping Code are based on a temperature of not less than +130°F for the material being used.

Note: 130°F specification is based on the maximum operating temperature of most listed/approved fire suppression systems.

- (c) For piping, the calculations include threaded, welded, brazed, rolled and cut groove, end connections.
- (d) For tubing, the calculations include the use of compression or flare fittings; or welded, brazed, or soldered end connections.
- (e) Materials addressed in the calculations include steel pipe and tubing, stainless steel pipe and tubing, and copper tubing.

⁵ NFPA 2001 permits the SE values given in Appendix A of ASME B31.1 to be increased by 20% under certain conditions discussed in Section 2 of this book. If those conditions are not met, the SE value may not be increased.

⁶ Aluminum pipe is forbidden by NFPA 2001 for clean agent systems. Aluminum pipe is NOT FORBIDDEN by NFPA 12, NFPA 12A, nor by ASME B31.1.

3.3. Design Calculations for Special Hazards Piping Systems

The following equation from ASME B31.1 may be used to calculate the minimum pipe wall thickness T for a specified maximum internal pressure P :

$$T = \frac{Pd + 2SEWA + 2yPA}{2(SEW + Py - P)}$$

Where the nomenclature used in the above equation is as follows:

T = Pipe wall thickness, minimum

P = Internal pressure

d = internal pipe diameter

SE = Maximum allowable stress in pipe material due to internal pressure and joint efficiency at the design temperature. These values include the weld joint efficiency (or casting factor).

A = additional thickness to compensate for material removed in threading or cut-grooving

y = coefficient related to metal composition and temperature.

W = Weld strength reduction factor. This is equal to one ($W = 1$) for seamless pipe or for seam-welded pipe operating below the creep range.

Note that in this document it is assumed that pipe will be operating below the creep range. Therefore, the weld strength reduction factor W is set to 1 in all the calculations in this guide.

Because pipe comes in standard sizes and wall thicknesses, system designers typically will be using standard pipe sizes and types and determining the maximum working pressures for those standard pipe sizes and types.

To determine the maximum working pressure given a known wall thickness T , ASME B31.1 provides the following equation:

$$P = \frac{2SEW(T - A)}{d - 2y(T - A) + 2T}$$

The nomenclature is the same as provided above.

The calculated maximum working pressure (p) is compared to the maximum system pressure as specified by codes, standards or specification. The calculated maximum working pressure value (p) must always be greater than or equal to the maximum system pressure. NFPA standards typically provide the maximum system pressures that must be considered.

Table 3-1 gives values for SE as taken from Appendix A of the ASME B31.1, Power Piping Code.

CAUTION

The SE values used in the calculations are also limited to the maximum temperatures shown in Table 3-1. If higher temperatures are anticipated, then the SE values must be reduced to agree with the values shown in Appendix A of the Power Piping Code at the higher temperature for the piping materials being used.

Table 3-1.

	Pipe or Tube Material	ASTM Spec	SE Value	
			PSI ⁷	Temperature
Steel Pipe	Seamless	A 106 Gr. C	20000	-20 to +600
	Seamless	A 53 Gr. B	17100	-20 to +650
	Seamless	A 106 Gr. B	17100	-20 to +650
	Seamless	A 53 Gr. A	13700	-20 to +650
	Seamless	A 106 Gr. A	13700	-20 to +650
	ERW	A 53 Gr. B	14600	-20 to +650
	ERW	A 53 Gr. A	11700	-20 to +650
	Furnace Welded	A 53 Gr. F	8200	-20 to +650
Stainless Steel Pipe	Type 304 Seamless	A 312	15000	-20 to +300
	Type 304 Welded	A 312	12700	-20 to +300
	Type 304L Seamless	A 312	12800	-20 to +300
	Type 304L Welded	A 312	10900	-20 to +300
	Type 316 Seamless	A 312	15600	-20 to +300
	Type 316 Welded	A 312	13200	-20 to +300
	Type 316L Seamless	A 312	12700	-20 to +300
	Type 316L Welded	A 312	10800	-20 to +300
Steel Tubing	Seamless	A 179	13400	-20 to +500
	ERW	A 178 Gr. A	11400	-20 to +500
	ERW	A 178 Gr. C	14600	-20 to +650
Stainless Steel Tubing	Type 304 Seamless	A 213, A 269	15000	-20 to +300
	Type 304 ERW	A 249, A 269	12700	-20 to +300
	Type 304L Seamless	A 213, A 269	12800	-20 to +300
	Type 304L ERW	A 249, A 269	10900	-20 to +300
	Type 316 Seamless	A 213, A 269	15600	-20 to +300
	Type 316 ERW	A 249, A 269	13200	-20 to +300
	Type 316L Seamless	A 213, A 269	12700	-20 to +300
	Type 316L ERW	A 249, A 269	10800	-20 to +300
Copper Tubing ⁸	Seamless, Annealed	B 88, B 280	4900	-20 to +200
	Seamless, Drawn	B 88, B 280	10300	-20 to +250

⁷ Taken from Appendix A, ASME B31.1.

⁸ When using copper tubing with brazed or soldered connections, the maximum allowable stress (SE) must be based on the annealed value.

3.4. Pipe Pressure Tables

The following Tables provide values of maximum allowable working pressure for various types of pipe and tubing. These values have been calculated using the formulae, SE values and end connections shown in Section 3.3 and Table 3-1.

- Table 3-2: Steel Pipe with Threaded End Connections.
- Table 3-3: Steel Pipe with Rolled Groove or Welded End Connections.
- Table 3-4: Steel Pipe with Cut Groove End Connections.
- Table 3-5: Stainless Steel Pipe with Threaded End Connections.
- Table 3-6: Stainless Steel Pipe with Welded End Connections.
- Table 3-7: Steel Tubing with Welded, Brazed, Flared, or Compression Fitting Ends.
- Table 3-8: ASTM A-213 Stainless Steel Tubing with Welded, Brazed, Flared, or Compression Fitting Ends.
- Table 3-9: ASTM A-249 Stainless Steel Tubing with Welded, Brazed, Flared, or Compression Fitting Ends.
- Table 3-10: ASTM A-269 Stainless Steel Tubing with Welded, Brazed, Flared, or Compression Fitting Ends.
- Table 3-11: ASTM B-88 Seamless Copper Water Tubing with Brazed, Soldered, Flared, or Compression Fitting Ends. (Annealed and Drawn Tempers).
- Table 3-12: ASTM B-280 Seamless Copper Refrigeration Tubing with Brazed, Soldered, Flared or Compression Fitting Ends. (Annealed and Drawn Tempers).

Dimensions for diameter and thickness are in inches. Wall thickness values used in these tables are based on the minimum wall thickness considering the following manufacturing tolerances:

A53 and A106 and A312 permit 12.5% under tolerance on thickness.

A178, A179, and A213 Tubing allow zero under tolerance on thickness.

A249 and A269 permit 10% under tolerance on thickness.

B88 and B280 copper tube permits 10% under tolerance on thickness.

The thickness values are rounded to the nearest 1/1000 inch.

3.5. How to Use the Tables

The following example illustrates typical procedures to select the proper pipe/tubing for use in a specific application, where calculation of pipe wall thickness and maximum allowable working pressure using the ASME B31.1 Power Piping Code is specified.

Example #1: High Pressure CO₂ System, using stainless steel tubing for the cylinder manifold. Since stainless steel tubing is not specifically listed in NFPA 12 for CO₂ system application (See APPENDIX A), ASME B31.1 must be used to determine the minimum wall thickness. NFPA-12, 2018 Edition, section 4.7.1.7.2 specifies that the minimum pipe design pressure shall be 2,800 psi (19,306 kPa) when using this material.

Given:

- The application requires that Type 304 seamless or welded or stainless steel tubing be used.
- Tubing Size = 1" OD
- Minimum design pressure specified: 2,800 psi
- Use either flare or compression type tubing fittings (A=0).
- Maximum ambient temperature that the tubing will be exposed to: +120°F.

Find:

- Minimum wall thickness capable of withstanding a minimum allowable working pressure of 2,800 psi.

Procedure:

- a. Check Table 3-1 for Type 304 stainless steel tubing. Note that the SE values are acceptable for temperatures up to +300°F. This satisfies the requirement of +120°F.
- b. Go to Table 3-8, titled "Stainless Steel Tubing with Welded, Brazed, Flared or Compression Fitting Ends (A=0)".
- c. For 1" tube size, look under the Type 304 seamless and welded columns for wall thickness where the calculated working pressure is 2,800 psi or greater.
- d. Inspection of Table 3-8 shows that the following sizes are acceptable:
 - 1" OD x 0.095" wall thickness (or greater) Type 304 seamless tubing is acceptable.
- e. Check with tubing supplier(s) for commercially available sizes and wall thickness.
- f. Check with tubing fitting manufacturer(s) for pressure ratings of fittings.

NOTE: The maximum allowable working pressure of a pipe network using flared or compression fittings is limited to the maximum allowable working pressure of the fitting or the pipe, whichever is less.

Table 3-2

Maximum Allowable Working Pressure (PSIG)

Steel Pipe with Threaded End Connections (A = thread depth)

	NPS Pipe Size	Wall Thick. (t)	“A” Dim.	Grade:	A-106C	A-53B A-106B	A-53B	A-53A A-106A	A-53A	A-53F
				Type:	Smls.	Smls.	ERW	Smls.	ERW	Furnace
				SE:	20000	17100	14600	13700	11700	8200
Sch. 40	1/4	0.077	0.044		2570	2197	1876	1761	1504	1054
	3/8	0.080	0.044		2228	1905	1627	1526	1304	914
	1/2	0.095	0.057		1877	1605	1371	1286	1098	770
	3/4	0.099	0.057		1653	1413	1207	1132	967	678
	1	0.116	0.070		1440	1231	1051	986	842	590
	1-1/4	0.123	0.070		1311	1121	957	898	767	537
	1-1/2	0.127	0.070		1230	1051	898	842	719	504
	2	0.135	0.070		1119	957	817	767	655	459
	2-1/2	0.178	0.100		1109	948	810	760	649	455
	3	0.189	0.100		1038	888	758	711	607	426
	4	0.207	0.100		970	829	708	664	567	398
	5	0.226	0.100		923	789	674	632	540	378
	6	0.245	0.100		891	762	650	610	521	365
	8	0.282	0.100		859	734	627	588	502	352
	1/4	0.104	0.044		4878	4171	3561	3341	2854	2000
	3/8	0.110	0.044		4243	3628	3097	2906	2482	1740
Sch. 80	1/2	0.129	0.057		3681	3147	2687	2521	2153	1509
	3/4	0.135	0.057		3159	2701	2306	2164	1848	1295
	1	0.157	0.070		2794	2389	2040	1914	1635	1146
	1-1/4	0.167	0.070		2452	2096	1790	1680	1434	1005
	1-1/2	0.175	0.070		2313	1977	1688	1584	1353	948
	2	0.191	0.070		2124	1816	1551	1455	1243	871
	2-1/2	0.242	0.100		2057	1759	1502	1409	1203	843
	3	0.263	0.100		1935	1654	1413	1325	1132	793
	4	0.295	0.100		1796	1535	1311	1230	1050	736
	5	0.328	0.100		1695	1449	1237	1161	992	695
	6	0.378	0.100		1737	1485	1268	1190	1016	712
	8	0.438	0.100		1618	1384	1181	1109	947	663
	4	0.382	0.100		2639	2256	1926	1808	1544	1082
	5	0.438	0.100		2555	2184	1865	1750	1494	1047
	6	0.492	0.100		2484	2124	1814	1702	1453	1019
	8	0.628	0.100		2575	2201	1880	1764	1506	1056
Sch. 120	4	0.382	0.100		2639	2256	1926	1808	1544	1082
	5	0.438	0.100		2555	2184	1865	1750	1494	1047
	6	0.492	0.100		2484	2124	1814	1702	1453	1019
	8	0.628	0.100		2575	2201	1880	1764	1506	1056

Note: All dimensions are in inches

Table 3-2. (Continued)

	NPS Pipe Size	Wall Thick. (t)	“A” Dim.	Grade:	A-106C	A-53B A-106B	A-53B	A-53A A-106A	A-53A	A-53F
				Type:	Smls.	Smls.	ERW	Smls.	ERW	Furnace
				SE:	20000	17100	14600	13700	11700	8200
Sch. 160	1/2	0.164	0.057		5673	4851	4142	3886	3319	2326
	3/4	0.191	0.057		5685	4861	4150	3894	3326	2331
	1	0.219	0.070		4984	4261	3638	3414	2916	2043
	1-1/4	0.219	0.070		3868	3307	2824	2650	2263	1586
	1-1/2	0.246	0.070		4002	3422	2921	2741	2341	1641
	2	0.300	0.070		4199	3590	3065	2876	2456	1722
	2-1/2	0.328	0.100		3387	2896	2473	2320	1981	1389
	3	0.382	0.100		3445	2945	2515	2360	2015	1412
	4	0.465	0.100		3470	2966	2533	2377	2030	1423
	5	0.547	0.100		3435	2937	2507	2353	2009	1408
	6	0.628	0.100		3405	2911	2486	2332	1992	1396
	8	0.793	0.100		3435	2937	2507	2353	2009	1408
XXS	1/2	0.257	.057			10059				
	3/4	0.270	.057			8282				
	1	0.313	.070			7416				
	1-1/4	0.334	.070			6232				
	1-1/2	0.350	.070			5714				
	2	0.382	.070			5020				
	2-1/2	0.483	.100			5100				
	3	0.525	.100			4600				
	4	0.590	.100			4079				
	5	0.656	.100			3715				
	6	0.756	.100			3678				
	8	0.766	.100			2815				

Note: All dimensions are in inches

Table 3-3.

Maximum Allowable Working Pressure (PSIG)

Steel Pipe with Rolled Groove or Welded End Connections (A = 0)

	NPS Pipe Size	Wall Thick. (t)	Grade:	A-106C	A-53B A-106B	A-53B	A-53A A-106A	A-53A	A-53F
			Type:	Smls.	Smls.	ERW	Smls.	ERW	Furnace
			SE:	20000	17100	14600	13700	11700	8200
Sch. 40	1/4	0.077		6438	5505	4700	4410	3766	2640
	3/8	0.080		5237	4478	3823	3588	3064	2147
	1/2	0.095		4974	4253	3631	3407	2910	2039
	3/4	0.099		4079	3488	2978	2794	2386	1672
	1	0.116		3796	3246	2771	2601	2221	1557
	1-1/4	0.123		3151	2694	2300	2158	1843	1292
	1-1/2	0.127		2825	2415	2062	1935	1652	1158
	2	0.135		2382	2037	1739	1632	1393	977
	2-1/2	0.178		2606	2228	1902	1785	1524	1068
	3	0.189		2258	1930	1648	1546	1321	926
	4	0.207		1910	1633	1395	1309	1118	783
	5	0.226		1680	1436	1226	1151	983	689
	6	0.245		1524	1303	1113	1044	892	625
	8	0.282		1343	1148	980	920	786	551
Sch. 80	1/4	0.104		9107	7786	6648	6238	5327	3734
	3/8	0.110		7496	6409	5472	5135	4385	3073
	1/2	0.129		7003	5988	5112	4797	4097	2871
	3/4	0.135		5732	4901	4185	3927	3354	2350
	1	0.157		5280	4514	3854	3617	3089	2165
	1-1/4	0.167		4376	3742	3195	2998	2560	1794
	1-1/2	0.175		3977	3401	2903	2724	2327	1631
	2	0.191		3438	2940	2510	2355	2011	1410
	2-1/2	0.242		3610	3087	2635	2473	2112	1480
	3	0.263		3198	2734	2335	2191	1871	1311
	4	0.295		2767	2366	2020	1896	1619	1135
	5	0.328		2475	2116	1807	1696	1448	1015
	6	0.378		2391	2045	1746	1638	1399	980
	8	0.438		2117	1810	1546	1450	1239	868
Sch. 120	4	0.382		3643	3115	2659	2495	2131	1494
	5	0.438		3361	2874	2454	2302	1966	1378
	6	0.492		3158	2700	2305	2163	1848	1295
	8	0.628		3093	2644	2258	2118	1809	1268

Note: All dimensions are in inches

Table 3-3. (Continued)

	NPS Pipe Size	Wall Thick. (t)	Grade:	A-106C	A-53B A-106B	A-53B	A-53A A-106A	A-53A	A-53F
			Type:	Smls.	Smls.	ERW	Smls.	ERW	Furnace
			SE:	20000	17100	14600	13700	11700	8200
Sch. 160	1/2	0.164		9255	7913	6756	6340	5414	3795
	3/4	0.191		8515	7281	6216	5833	4981	3491
	1	0.219		7686	6571	5610	5265	4496	3151
	1-1/4	0.219		5900	5044	4307	4041	3451	2419
	1-1/2	0.246		5777	4940	4217	3957	3380	2369
	2	0.300		5621	4806	4103	3850	3288	2304
	2-1/2	0.328		5022	4294	3666	3440	2938	2059
	3	0.382		4783	4090	3492	3277	2798	1961
	4	0.465		4506	3852	3289	3086	2636	1847
	5	0.547		4269	3650	3116	2924	2497	1750
	6	0.628		4103	3508	2995	2810	2400	1682
	8	0.793		3970	3394	2898	2719	2322	1628
XXS	1/2	0.257			13855				
	3/4	0.270			11072				
	1	0.313			10055				
	1-1/4	0.334			8201				
	1-1/2	0.350			7389				
	2	0.382			6313				
	2-1/2	0.483			6638				
	3	0.525			5830				
	4	0.590			5009				
	5	0.656			4453				
	6	0.756			4295				
	8	0.766			3270				

Note: All dimensions are in inches

Table 3-4.

Maximum Allowable Working Pressure (PSIG)

Steel Pipe with Cut Groove End Connections (A = Groove Depth)

	NPS Pipe Size	Min. Wall Thick. (t)	"A" Dim.	Grade:	A-106C	A-53B A-106B	A-53B	A-53A A106A	A-53A	A-53F
				Type:	Smls.	Smls.	ERW	Smls.	ERW	Furnace
				SE:	20000	17100	14600	13700	11700	8200
Sch. 40	1/2	0.095	0.056		1929	1649	1408	1321	1128	791
	3/4	0.099	0.056		1694	1448	1236	1160	991	694
	1	0.116	0.063		1666	1424	1216	1141	975	683
	1 1/4	0.123	0.063		1489	1273	1087	1020	871	610
	1 1/2	0.127	0.063		1385	1184	1011	949	810	568
	2	0.135	0.063		1243	1063	907	851	727	510
	2 1/2	0.178	0.078		1431	1224	1045	980	837	587
	3	0.189	0.078		1302	1113	950	892	761	534
	4	0.207	0.083		1127	964	823	772	659	462
	5	0.226	0.084		1042	891	761	714	610	427
	6	0.245	0.085		985	842	719	675	576	404
Sch. 80	8	0.282	0.092		897	767	655	614	525	368
	1/2	0.129	0.056		3736	3194	2727	2559	2186	1532
	3/4	0.135	0.056		3202	2738	2338	2194	1873	1313
	1	0.157	0.063		3033	2593	2214	2077	1774	1243
	1 1/4	0.167	0.063		2638	2256	1926	1807	1543	1082
	1 1/2	0.175	0.063		2475	2116	1806	1695	1448	1015
	2	0.191	0.063		2253	1926	1645	1543	1318	924
	2 1/2	0.242	0.078		2391	2044	1745	1638	1399	980
	3	0.263	0.078		2208	1888	1612	1512	1291	905
	4	0.295	0.083		1958	1674	1430	1341	1146	803
	5	0.328	0.084		1818	1555	1327	1246	1064	745
Sch. 120	6	0.378	0.085		1834	1568	1339	1256	1073	752
	8	0.438	0.092		1658	1417	1210	1136	970	680
	4	0.382	0.083		2807	2400	2049	1923	1642	1151
	5	0.438	0.084		2682	2293	1958	1837	1569	1100
Sch. 160	6	0.492	0.085		2584	2210	1887	1770	1512	1060
	8	0.628	0.092		2616	2237	1910	1792	1530	1072
	1/2	0.164	0.056		5732	4901	4185	3927	3354	2350
	3/4	0.191	0.056		5732	4901	4185	3927	3354	2350
	1	0.219	0.063		5243	4483	3827	3591	3067	2150
	1.25	0.219	0.063		4065	3475	2967	2784	2378	1666
	1.5	0.246	0.063		4174	3569	3047	2859	2442	1711
	2	0.300	0.063		4338	3709	3167	2971	2538	1779
	2.5	0.328	0.078		3738	3196	2729	2561	2187	1533
	3	0.382	0.078		3734	3192	2726	2558	2184	1531
	4	0.465	0.083		3643	3115	2659	2495	2131	1494
	5	0.547	0.084		3567	3049	2604	2443	2086	1462
	6	0.628	0.085		3509	3000	2561	2403	2052	1439
	8	0.793	0.092		3477	2973	2538	2382	2034	1426

Note: Maximum allowable pressure may be limited by the fitting used.

All dimensions are in inches.

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Table 3-5.

Maximum Allowable Working Pressure (PSIG)

Stainless Steel Pipe with Threaded End Connections (A = Thread Depth)

	NPS Pipe Size	Min. Wall Thick. (t)	"A" Dim.	Grade:	A-312 304	A-312 304	A-312 304L	A-312 304L	A-312 316	A-312 316	A-312 316L	A-312 316L
				Type:	Smls.	Welded	Smls.	Welded	Smls.	Welded	Smls.	Welded
				SE:	15000	12700	12800	10900	15600	13200	12700	10800
Sch. 40	1/4	0.077	0.044		1928	1632	1645	1401	2005	1696	1632	1388
	3/8	0.080	0.044		1671	1415	1426	1214	1738	1471	1415	1203
	1/2	0.095	0.057		1408	1192	1202	1023	1464	1239	1192	1014
	3/4	0.099	0.057		1240	1050	1058	901	1289	1091	1050	893
	1	0.116	0.07		1080	914	921	785	1123	950	914	777
	1 1/4	0.123	0.07		983	832	839	714	1022	865	832	708
	1 1/2	0.127	0.07		922	781	787	670	959	811	781	664
	2	0.135	0.07		839	711	716	610	873	739	711	604
	2 1/2	0.178	0.1		832	704	710	605	865	732	704	599
	3	0.189	0.1		779	659	664	566	810	685	659	561
	4	0.207	0.1		727	616	621	528	756	640	616	524
	5	0.226	0.1		692	586	591	503	720	609	586	498
	6	0.245	0.1		668	566	570	486	695	588	566	481
Sch. 80	8	0.282	0.1		644	545	549	468	670	567	545	464
	1/4	0.104	0.044		3659	3098	3122	2659	3805	3220	3098	2634
	3/8	0.110	0.044		3182	2694	2716	2312	3310	2800	2694	2291
	1/2	0.129	0.057		2761	2337	2356	2006	2871	2429	2337	1988
	3/4	0.135	0.057		2369	2006	2022	1722	2464	2085	2006	1706
	1	0.157	0.07		2096	1774	1788	1523	2180	1844	1774	1509
	1 1/4	0.167	0.07		1839	1557	1569	1336	1913	1618	1557	1324
	1 1/2	0.175	0.07		1735	1469	1480	1260	1804	1526	1469	1249
	2	0.191	0.07		1593	1349	1360	1158	1657	1402	1349	1147
	2 1/2	0.242	0.1		1543	1306	1316	1121	1604	1358	1306	1111
	3	0.263	0.1		1451	1229	1238	1055	1509	1277	1229	1045
	4	0.295	0.1		1347	1140	1149	979	1401	1185	1140	970
	5	0.328	0.1		1271	1076	1085	924	1322	1119	1076	915
Sch. 120	6	0.378	0.1		1303	1103	1112	947	1355	1146	1103	938
	8	0.438	0.1		1214	1028	1036	882	1262	1068	1028	874
	4	0.382	0.1		1979	1676	1689	1438	2058	1742	1676	1425
	5	0.438	0.1		1916	1622	1635	1392	1993	1686	1622	1379
Sch. 160	6	0.492	0.1		1863	1578	1590	1354	1938	1640	1578	1342
	8	0.628	0.1		1931	1635	1648	1403	2008	1699	1635	1390
	1/2	0.164	0.057		4255	3603	3631	3092	4425	3744	3603	3064
	3/4	0.191	0.057		4264	3610	3639	3098	4434	3752	3610	3070
	1	0.219	0.07		3738	3165	3190	2716	3888	3290	3165	2691
	1 1/4	0.219	0.07		2901	2456	2476	2108	3017	2553	2456	2089
	1 1/2	0.246	0.07		3001	2541	2561	2181	3121	2641	2541	2161
	2	0.300	0.07		3149	2666	2687	2288	3275	2771	2666	2267
	2 1/2	0.328	0.1		2540	2151	2168	1846	2642	2235	2151	1829
	3	0.382	0.1		2584	2188	2205	1877	2687	2274	2188	1860
	4	0.465	0.1		2602	2203	2221	1891	2706	2290	2203	1874
	5	0.547	0.1		2576	2181	2198	1872	2679	2267	2181	1855
	6	0.628	0.1		2554	2162	2179	1856	2656	2247	2162	1839
	8	0.793	0.1		2576	2181	2198	1872	2679	2267	2181	1855

Note: Some sizes, grades and schedule combinations may not be commercially available. All dimensions are in inches.

Table 3-6.
Maximum Allowable Working Pressure (PSIG)
Stainless Steel Pipe with Welded End Connections (A = 0)

	NPS Pipe Size	Min. Wall Thick. (t)	Grade:	A-312 304	A-312 304	A-312 304L	A-312 304L	A-312 316	A-312 316	A-312 316L	A-312 316L
			Type:	Smls.	Welded	Smls.	Welded	Smls.	Welded	Smls.	Welded
			SE:	15000	12700	12800	10900	15600	13200	12700	10800
Sch. 40	1/4	0.077		4829	4088	4120	3509	5022	4249	4088	3477
	3/8	0.080		3928	3326	3352	2854	4085	3457	3326	2828
	1/2	0.095		3730	3158	3183	2711	3880	3283	3158	2686
	3/4	0.099		3059	2590	2611	2223	3182	2692	2590	2203
	1	0.116		2847	2411	2430	2069	2961	2506	2411	2050
	1 1/4	0.123		2363	2001	2016	1717	2457	2079	2001	1701
	1 1/2	0.127		2119	1794	1808	1539	2203	1864	1794	1525
	2	0.135		1787	1513	1524	1298	1858	1572	1513	1286
	2 1/2	0.178		1954	1655	1668	1420	2032	1720	1655	1407
	3	0.189		1693	1434	1445	1230	1761	1490	1434	1219
	4	0.207		1433	1213	1223	1041	1490	1261	1213	1032
	5	0.226		1260	1067	1075	915	1310	1109	1067	907
	6	0.245		1143	968	976	831	1189	1006	968	823
Sch. 80	8	0.282		1007	853	859	732	1048	886	853	725
	1/4	0.104		6830	5783	5828	4963	7103	6011	5783	4918
	3/8	0.110		5622	4760	4797	4085	5847	4947	4760	4048
	1/2	0.129		5252	4447	4482	3817	5463	4622	4447	3782
	3/4	0.135		4299	3640	3669	3124	4471	3783	3640	3096
	1	0.157		3960	3353	3379	2878	4118	3485	3353	2851
	1 1/4	0.167		3282	2779	2801	2385	3414	2888	2779	2363
	1 1/2	0.175		2983	2526	2545	2168	3102	2625	2526	2148
	2	0.191		2579	2183	2200	1874	2682	2269	2183	1857
	2 1/2	0.242		2708	2292	2310	1967	2816	2383	2292	1949
	3	0.263		2398	2031	2047	1743	2494	2111	2031	1727
	4	0.295		2076	1757	1771	1508	2159	1826	1757	1494
	5	0.328		1856	1572	1584	1349	1931	1634	1572	1337
Sch. 120	6	0.378		1794	1519	1531	1303	1865	1578	1519	1291
	8	0.438		1588	1345	1355	1154	1652	1397	1345	1143
	4	0.382		2732	2313	2331	1985	2842	2404	2313	1967
	5	0.438		2521	2134	2151	1832	2622	2218	2134	1815
Sch. 160	6	0.492		2369	2005	2021	1721	2463	2084	2005	1705
	8	0.628		2319	1964	1979	1685	2412	2041	1964	1670
	1/2	0.164		6941	5877	5923	5044	7219	6108	5877	4998
	3/4	0.191		6387	5407	5450	4641	6642	5620	5407	4598
	1	0.219		5764	4880	4919	4189	5995	5072	4880	4150
	1 1/4	0.219		4425	3746	3776	3215	4602	3894	3746	3186
	1 1/2	0.246		4333	3669	3698	3149	4506	3813	3669	3120
	2	0.300		4215	3569	3597	3063	4384	3710	3569	3035
	2 1/2	0.328		3766	3189	3214	2737	3917	3314	3189	2712
	3	0.382		3588	3037	3061	2607	3731	3157	3037	2583
	4	0.465		3379	2861	2884	2456	3515	2974	2861	2433
	5	0.547		3202	2711	2732	2327	3330	2817	2711	2305
	6	0.628		3077	2605	2626	2236	3200	2708	2605	2216
	8	0.793		2977	2521	2541	2163	3096	2620	2521	2144

Note: Some sizes, grades and schedule combinations may not be commercially available. All dimensions are in inches.

NOTE applying to Tables 3-7 through 3-12: All dimensions are in inches. The maximum allowable working pressure of a pipe network using flared or compression fittings is limited to the maximum allowable working pressure of the fitting or the pipe, whichever is less.

Table 3-7.

Maximum Allowable Working Pressure (PSIG)

Steel Tubing with Welded, Brazed, Flared or Compression Fitting Ends (A = 0)

Nom. Tube Size	OD	Wall Thick. (t)	Grade:	A-179	A-178 Gr. C	A-178 Gr. A	Nom. Tube Size	OD	Wall Thick. (t)	Grade:	A-179	A-178 Gr. C	A-178 Gr. A
			Type:	Smls.	ERW	ERW				Type:	Smls.	ERW	ERW
			SE:	13400	14600	11400				SE:	13400	14600	11400
1/4	0.250	0.022		2537	2764	2158	3/4	0.750	0.035		1299	1416	1105
	0.250	0.028		3297	3592	2805		0.750	0.049		1847	2013	1572
	0.250	0.032		3822	4164	3251		0.750	0.058		2209	2407	1879
	0.250	0.035		4225	4604	3595		0.750	0.065		2496	2719	2123
	0.250	0.042		5201	5667	4425		0.750	0.072		2787	3036	2371
	0.250	0.049		6230	6787	5300		0.750	0.083		3254	3545	2768
	0.250	0.065		8798	9586	7485		0.750	0.095		3777	4116	3214
	0.250	0.083		12115	13200	10307		0.750	0.109		4407	4802	3750
	0.250	0.095		14632	15943	12448		0.750	0.120		4917	5358	4183
	0.375	0.022		1650	1797	1403		0.750	0.134		5587	6087	4753
3/8	0.375	0.028		2128	2319	1811	1	0.750	0.156		6687	7286	5689
	0.375	0.032		2454	2674	2088		0.750	0.172		7527	8201	6404
	0.375	0.035		2703	2945	2300		0.750	0.188		8403	9155	7149
	0.375	0.049		3911	4261	3327		0.750	0.219		10211	11125	8687
	0.375	0.058		4730	5154	4024		0.750	0.250		12182	13273	10364
	0.375	0.065		5393	5876	4588		1.000	0.028		768	836	653
	0.375	0.083		7208	7854	6132		1.000	0.035		965	1051	821
	0.375	0.095		8515	9278	7244		1.000	0.049		1367	1489	1163
	0.375	0.120		11527	12559	9806		1.000	0.058		1630	1776	1387
	0.500	0.035		1987	2165	1691		1.000	0.065		1838	2002	1563
1/2	0.500	0.049		2850	3105	2424		1.000	0.072		2048	2231	1742
	0.500	0.058		3427	3734	2915		1.000	0.083		2383	2596	2027
	0.500	0.065		3888	4237	3308		1.000	0.095		2755	3002	2344
	0.500	0.072		4362	4752	3711		1.000	0.109		3200	3487	2723
	0.500	0.083		5130	5589	4364		1.000	0.120		3558	3876	3027
	0.500	0.095		6005	6542	5108		1.000	0.134		4022	4383	3422
	0.500	0.109		7077	7710	6020		1.000	0.156		4777	5205	4064
	0.500	0.120		7960	8673	6772		1.000	0.172		5345	5824	4547
	0.500	0.134		9143	9961	7778		1.000	0.188		5930	6461	5045
	0.500	0.156		11143	12141	9480		1.000	0.219		7116	7753	6054
5/8	0.500	0.188		14412	15703	12261		1.000	0.250		8375	9125	7125
	0.625	0.065		3040	3312	2586		1.000	0.281		9715	10585	8265
								1.000	0.313		11191	12193	9520
								1.000	0.375		14357	15643	12214

Table 3-7. (Continued)

Nom. Tube Size	OD	Wall Thick. (t)	Grade:	A-179	A-178 Gr. C	A-178 Gr. A	Nom. Tube Size	OD	Wall Thick. (t)	Grade:	A-179	A-178 Gr. C	A-178 Gr. A
			Type:	Smls.	ERW	ERW				Type:	Smls.	ERW	ERW
			SE:	13400	14600	11400				SE:	16080	17520	13680
1 1/4	1.250	0.035		768	836	653	2	2.000	0.035		476	518	405
	1.250	0.049		1085	1182	923		2.000	0.049		670	730	570
	1.250	0.065		1454	1584	1237		2.000	0.065		894	974	761
	1.250	0.083		1879	2048	1599		2.000	0.083		1150	1253	979
	1.250	0.095		2169	2363	1845		2.000	0.095		1323	1442	1126
	1.250	0.109		2512	2737	2137		2.000	0.109		1527	1664	1299
	1.250	0.120		2787	3036	2371		2.000	0.120		1689	1840	1437
	1.250	0.125		2913	3174	2478		2.000	0.125		1763	1921	1500
	1.250	0.134		3142	3424	2673		2.000	0.134		1897	2067	1614
	1.250	0.156		3716	4048	3161		2.000	0.148		2108	2297	1793
	1.250	0.188		4582	4992	3898		2.000	0.156		2230	2429	1897
	1.250	0.219		5461	5950	4646		2.000	0.165		2367	2579	2014
	1.250	0.250		6381	6952	5429		2.000	0.180		2599	2832	2211
	1.250	0.281		7346	8004	6249		2.000	0.188		2724	2968	2317
	1.250	0.313		8392	9143	7139		2.000	0.219		3216	3504	2736
	1.250	0.344		9458	10304	8046		2.000	0.240		3558	3876	3027
	1.250	0.375		10579	11526	9000		2.000	0.250		3722	4056	3167
	1.250	0.438		13048	14217	11101		2.000	0.281		4242	4622	3609
1 1/2	1.500	0.035		637	694	542	2 1/4	2.000	0.313		4794	5224	4079
	1.500	0.049		899	979	765		2.000	0.344		5345	5824	4547
	1.500	0.058		1069	1165	910		2.000	0.375		5912	6441	5029
	1.500	0.065		1203	1311	1023		2.000	0.438		7116	7753	6054
	1.500	0.072		1338	1458	1138		2.000	0.500		8375	9125	7125
	1.500	0.083		1552	1691	1320		2.000	0.563		9737	10609	8284
	1.500	0.095		1788	1948	1521		2.000	0.625		11167	12167	9500
	1.500	0.109		2068	2253	1759		2.000	0.750		14357	15643	12214
	1.500	0.120		2291	2496	1949		2.250	0.095		1171	1276	996
	1.500	0.125		2393	2607	2036	2 1/2	2.500	0.035		379	413	323
	1.500	0.134		2578	2809	2194		2.500	0.049		534	581	454
	1.500	0.156		3040	3312	2586		2.500	0.065		712	775	605
	1.500	0.172		3383	3686	2878		2.500	0.083		914	996	778
	1.500	0.188		3733	4068	3176		2.500	0.095		1050	1144	894
	1.500	0.219		4430	4827	3769		2.500	0.109		1211	1319	1030
	1.500	0.250		5154	5615	4385		2.500	0.120		1338	1458	1138
	1.500	0.281		5906	6434	5024		2.500	0.125		1396	1521	1188
	1.500	0.313		6713	7314	5711		2.500	0.134		1501	1635	1277
	1.500	0.344		7527	8201	6404		2.500	0.148		1665	1815	1417
	1.500	0.375		8375	9125	7125		2.500	0.156		1760	1918	1497
	1.500	0.438		10211	11125	8687		2.500	0.180		2048	2231	1742
	1.500	0.500		12182	13273	10364		2.500	0.188		2144	2336	1824
	1.750	0.095		1521	1657	1294		2.500	0.219		2525	2751	2148

Table 3-7. (Continued)

Nom. Tube Size	OD	Wall Thick. (t)	Grade:	A-179	A-178 Gr. C	A-178 Gr. A	Nom. Tube Size	OD	Wall Thick. (t)	Grade:	A-179	A-178 Gr. C	A-178 Gr. A
			Type:	Smls.	ERW	ERW				Type:	Smls.	ERW	ERW
			SE:	13400	14600	11400				SE:	16080	17520	13680
2 1/2	2.500	0.220		2537	2764	2158	3.25	3.250	0.120		1020	1111	867
	2.500	0.250		2913	3174	2478		3.250	0.134		1143	1245	972
	2.500	0.281		3310	3606	2816		3.250	0.148		1267	1380	1078
	2.500	0.313		3729	4063	3172		3.250	0.180		1553	1692	1321
	2.500	0.344		4144	4515	3525	3.5	3.500	0.120		945	1029	804
	2.500	0.375		4568	4977	3886		3.500	0.134		1058	1153	900
	2.500	0.437		5446	5934	4633	4	4.000	0.134		923	1005	785
	2.500	0.500		6381	6952	5429		4.000	0.148		1022	1113	869
	2.500	0.563		7362	8021	6263		4.500	0.134		818	891	696
	2.500	0.625		8375	9125	7125	4.5	4.500	0.148		905	986	770
2 3/4	2.500	0.750		10579	11526	9000							
	2.750	0.109		1097	1195	933							
3	3.000	0.049		444	483	377							
	3.000	0.065		591	644	503							
	3.000	0.083		758	826	645							
	3.000	0.095		871	949	741							
	3.000	0.109		1003	1093	853							
	3.000	0.120		1107	1207	942							
	3.000	0.125		1155	1259	983							
	3.000	0.134		1241	1353	1056							
	3.000	0.148		1376	1500	1171							
	3.000	0.156		1454	1584	1237							
	3.000	0.165		1542	1680	1312							
	3.000	0.180		1689	1840	1437							
	3.000	0.188		1768	1926	1504							
	3.000	0.219		2078	2264	1768							
	3.000	0.250		2393	2607	2036							
	3.000	0.281		2714	2957	2309							
	3.000	0.313		3051	3324	2595							
	3.000	0.344		3383	3686	2878							
	3.000	0.375		3722	4056	3167							
	3.000	0.437		4419	4815	3759							
	3.000	0.500		5154	5615	4385							
	3.000	0.563		5918	6448	5035							
	3.000	0.625		6700	7300	5700							
	3.000	0.688		7527	8201	6404							
	3.000	0.750		8375	9125	7125							
	3.000	0.875		10196	11109	8674							
	3.000	1.000		12182	13273	10364							

Table 3-8.

Maximum Allowable Working Pressure (PSIG)

A-213 Seamless Stainless Steel Tubing with Welded, Brazed, Flared or Compression Fitting Ends (A = 0)

Nom. Tube Size	Max. OD	Min. Wall Thick (t)	Grade:	A-213 304	A-213 304L	A-213 316	A-213 316L
			Type:	Smls.	Smls.	Smls.	Smls.
			SE:	15000	12800	15600	12700
1/4	0.254	0.020		2362	2016	2457	2000
	0.254	0.028		3307	2822	3439	2800
	0.254	0.032		3780	3225	3931	3200
	0.254	0.035		4134	3528	4299	3500
	0.254	0.049		5787	4939	6019	4900
	0.254	0.065		7677	6551	7984	6500
3/8	0.379	0.028		2216	1891	2305	1877
	0.379	0.035		2770	2364	2881	2346
	0.379	0.049		3879	3310	4034	3284
	0.379	0.065		5145	4391	5351	4356
1/2	0.504	0.028		1667	1422	1733	1411
	0.504	0.035		2083	1778	2167	1764
	0.504	0.049		2917	2489	3033	2469
	0.504	0.065		3869	3302	4024	3276
	0.504	0.083		4940	4216	5138	4183
	0.504	0.095		5655	4825	5881	4788
	0.504	0.120		7143	6095	7429	6048
3/4	0.754	0.035		1393	1188	1448	1179
	0.754	0.049		1950	1664	2028	1651
	0.754	0.065		2586	2207	2690	2190
	0.754	0.083		3302	2818	3434	2796
	0.754	0.095		3780	3225	3931	3200
	0.754	0.120		4775	4074	4966	4042
	1.006	0.035		1044	891	1085	884
	1.006	0.049		1461	1247	1520	1237
	1.006	0.065		1938	1654	2016	1641
	1.006	0.083		2475	2112	2574	2096
	1.006	0.095		2833	2417	2946	2399
	1.006	0.120		3579	3054	3722	3030
	1.006	0.188		5606	4784	5831	4747
	1.006	0.250		7455	6362	7753	6312

Table 3-8. (Continued)

Nom. Tube Size	Max. OD	Min. Wall Thick (t)	Grade:	A-213 304	A-213 304L	A-213 316	A-213 316L
			Type:	Smls.	Smls.	Smls.	Smls.
			SE:	15000	12800	15600	12700
1 1/4	1.256	0.035		836	713	869	708
	1.256	0.049		1170	999	1217	991
	1.256	0.065		1553	1325	1615	1314
	1.256	0.083		1982	1692	2062	1679
	1.256	0.095		2269	1936	2360	1921
	1.256	0.120		2866	2446	2981	2427
	1.256	0.188		4490	3832	4670	3802
	1.256	0.250		5971	5096	6210	5056
1 1/2	1.506	0.035		697	595	725	590
	1.506	0.049		976	833	1015	826
	1.506	0.065		1295	1105	1347	1096
	1.506	0.083		1653	1411	1720	1400
	1.506	0.120		2390	2040	2486	2024
	1.506	0.188		3745	3196	3895	3171
	1.506	0.250		4980	4250	5179	4216
2	2.010	0.035		522	446	543	442
	2.010	0.049		731	624	761	619
	2.010	0.065		970	828	1009	821
	2.010	0.083		1239	1057	1288	1049
	2.010	0.120		1791	1528	1863	1516
	2.010	0.180		2687	2293	2794	2275
	2.010	0.188		2806	2394	2918	2376
	2.010	0.250		3731	3184	3881	3159
2 1/2	2.512	0.049		585	499	609	495
	2.512	0.065		776	662	807	657
	2.512	0.120		1433	1223	1490	1213
	2.512	0.188		2245	1916	2335	1901
	2.512	0.250		2986	2548	3105	2528
3	3.015	0.065		647	552	673	548
	3.015	0.083		826	705	859	699
	3.015	0.120		1194	1019	1242	1011
	3.015	0.188		1871	1596	1945	1584
	3.015	0.250		2488	2123	2587	2106

Table 3-9.

Maximum Allowable Working Pressure (PSIG)

A-249 Welded Stainless Steel Tubing with Welded, Brazed, Flared or Compression Fitting Ends (A = 0)

Nom. Tube Size	Max. OD	Min. Wall Thick (t)	Grade: Type:	A-249 304	A-249 304L	A-249 316	A-249 316L
				Welded	Welded	Welded	Welded
			SE:	12700	10900	13200	10800
1/4	0.254	0.018		1800	1545	1871	1531
	0.254	0.025		2500	2146	2598	2126
	0.254	0.029		2900	2489	3014	2466
	0.254	0.032		3200	2746	3326	2721
	0.254	0.044		4400	3776	4573	3742
	0.254	0.059		5900	5064	6132	5017
3/8	0.379	0.025		1675	1438	1741	1425
	0.379	0.032		2145	1841	2229	1824
	0.379	0.044		2949	2531	3065	2508
	0.379	0.059		3954	3394	4110	3363
1/2	0.504	0.025		1260	1081	1310	1071
	0.504	0.032		1613	1384	1676	1371
	0.504	0.044		2217	1903	2305	1886
	0.504	0.059		2973	2552	3090	2529
	0.504	0.075		3780	3244	3929	3214
	0.504	0.086		4334	3720	4505	3686
	0.504	0.108		5443	4671	5657	4629
3/4	0.754	0.032		1078	925	1120	917
	0.754	0.044		1482	1272	1541	1260
	0.754	0.059		1988	1706	2066	1690
	0.754	0.075		2527	2168	2626	2149
	0.754	0.086		2897	2486	3011	2464
	0.754	0.108		3638	3123	3781	3094
1	1.006	0.032		808	693	840	687
	1.006	0.044		1111	953	1155	945
	1.006	0.059		1490	1279	1548	1267
	1.006	0.075		1894	1625	1968	1610
	1.006	0.086		2171	1864	2257	1847
	1.006	0.108		2727	2340	2834	2319
	1.006	0.169		4267	3662	4435	3629
	1.006	0.225		5681	4876	5905	4831

Table 3-9. (Continued)

Nom. Tube Size	Max. OD	Min. Wall Thick (t)	Grade: Type:	A-249 304	A-249 304L	A-249 316	A-249 316L
				Welded	Welded	Welded	Welded
			SE:	12700	10900	13200	10800
1 1/4	1.256	0.032		647	555	673	550
	1.256	0.044		890	764	925	757
	1.256	0.059		1193	1024	1240	1015
	1.256	0.075		1517	1302	1576	1290
	1.256	0.086		1739	1493	1808	1479
	1.256	0.108		2184	1875	2270	1857
	1.256	0.169		3418	2933	3552	2906
	1.256	0.225		4550	3905	4729	3869
1 1/2	1.506	0.032		540	463	561	459
	1.506	0.044		742	637	771	631
	1.506	0.059		995	854	1034	846
	1.506	0.075		1265	1086	1315	1076
	1.506	0.108		1822	1563	1893	1549
	1.506	0.169		2850	2446	2963	2424
	1.506	0.225		3795	3257	3944	3227
2	2.010	0.032		404	347	420	344
	2.010	0.044		556	477	578	473
	2.010	0.059		746	640	775	634
	2.010	0.075		948	813	985	806
	2.010	0.108		1365	1171	1419	1161
	2.010	0.162		2047	1757	2128	1741
	2.010	0.169		2136	1833	2220	1816
	2.010	0.225		2843	2440	2955	2418
2 1/2	2.512	0.044		445	382	462	378
	2.512	0.059		597	512	620	507
	2.512	0.108		1092	937	1135	929
	2.512	0.169		1709	1467	1776	1453
	2.512	0.225		2275	1953	2365	1935
3	3.015	0.059		497	427	517	423
	3.015	0.075		632	542	657	537
	3.015	0.108		910	781	946	774
	3.015	0.169		1424	1222	1480	1211
	3.015	0.225		1896	1627	1970	1612

Table 3-10.

Maximum Allowable Working Pressure (PSIG)

A-269 Stainless Steel Tubing with Welded, Brazed, Flared or Compression Fitting Ends (A = 0)

Nom. Tube Size	Max. OD	Min. Wall Thick. (t)	Grade:	A-269 304	A-269 304	A-269 304L	A-269 304L	A-269 316	A-269 316	A-269 316L	A-269 316L
			Type:	Smls.	Welded	Smls.	Welded	Smls.	Welded	Smls.	Welded
			SE:	15000	12700	12800	10900	15600	13200	12700	10800
1/4	0.255	0.018		2118	1793	1807	1539	2202	1864	1793	1525
	0.255	0.025		2941	2490	2510	2137	3059	2588	2490	2118
	0.255	0.029		3412	2889	2911	2479	3548	3002	2889	2456
	0.255	0.032		3765	3187	3213	2736	3915	3313	3187	2711
	0.255	0.044		5176	4383	4417	3762	5384	4555	4383	3727
	0.255	0.059		6941	5877	5923	5044	7219	6108	5877	4998
3/8	0.380	0.025		1974	1671	1684	1434	2053	1737	1671	1421
	0.380	0.032		2526	2139	2156	1836	2627	2223	2139	1819
	0.380	0.044		3474	2941	2964	2524	3613	3057	2941	2501
	0.380	0.059		4658	3944	3975	3385	4844	4099	3944	3354
1/2	0.505	0.025		1485	1257	1267	1079	1545	1307	1257	1069
	0.505	0.032		1901	1610	1622	1381	1977	1673	1610	1369
	0.505	0.044		2614	2213	2230	1899	2718	2300	2213	1882
	0.505	0.059		3505	2968	2991	2547	3645	3084	2968	2524
	0.505	0.075		4455	3772	3802	3238	4634	3921	3772	3208
	0.505	0.086		5109	4326	4360	3712	5313	4496	4326	3678
	0.505	0.108		6416	5432	5475	4662	6672	5646	5432	4619
3/4	0.755	0.032		1272	1077	1085	924	1322	1119	1077	915
	0.755	0.044		1748	1480	1492	1270	1818	1539	1480	1259
	0.755	0.059		2344	1985	2001	1704	2438	2063	1985	1688
	0.755	0.075		2980	2523	2543	2166	3099	2623	2523	2146
	0.755	0.086		3417	2893	2916	2483	3554	3007	2893	2460
	0.755	0.108		4291	3633	3662	3118	4463	3776	3633	3090
1	1.005	0.032		955	809	815	694	993	841	809	688
	1.005	0.044		1313	1112	1121	954	1366	1156	1112	946
	1.005	0.059		1761	1491	1503	1280	1832	1550	1491	1268
	1.005	0.075		2239	1896	1910	1627	2328	1970	1896	1612
	1.005	0.086		2567	2174	2191	1865	2670	2259	2174	1848
	1.005	0.108		3224	2730	2751	2343	3353	2837	2730	2321
	1.005	0.169		5045	4271	4305	3666	5247	4439	4271	3632
	1.005	0.225		6716	5687	5731	4881	6985	5910	5687	4836

Note: Some sizes, grades and schedule combinations may not be commercially available.
Maximum allowable pressure may be limited by the fitting used.

Table 3-10. (Continued)

Nom. Tube Size	Max. OD	Min. Wall Thick. (t)	Grade:	A-269 304	A-269 304	A-269 304L	A-269 304L	A-269 316	A-269 316	A-269 316L	A-269 316L
			Type:	Smls.	Welded	Smls.	Welded	Smls.	Welded	Smls.	Welded
			SE:	15000	12700	12800	10900	15600	13200	12700	10800
1 1/4	1.255	0.032		765	648	653	556	796	673	648	551
	1.255	0.044		1052	891	898	764	1094	926	891	757
	1.255	0.059		1410	1194	1204	1025	1467	1241	1194	1015
	1.255	0.075		1793	1518	1530	1303	1865	1578	1518	1291
	1.255	0.086		2056	1741	1754	1494	2138	1809	1741	1480
	1.255	0.108		2582	2186	2203	1876	2685	2272	2186	1859
	1.255	0.169		4040	3420	3447	2936	4201	3555	3420	2909
	1.255	0.225		5378	4554	4590	3908	5594	4733	4554	3873
1 1/2	1.510	0.032		636	538	543	462	661	559	538	458
	1.510	0.044		874	740	746	635	909	769	740	629
	1.510	0.059		1172	992	1000	852	1219	1032	992	844
	1.510	0.075		1490	1262	1272	1083	1550	1311	1262	1073
	1.510	0.108		2146	1817	1831	1559	2232	1888	1817	1545
	1.510	0.169		3358	2843	2865	2440	3492	2955	2843	2417
	1.510	0.225		4470	3785	3815	3248	4649	3934	3785	3219
2	2.010	0.032		478	404	408	347	497	420	404	344
	2.010	0.044		657	556	560	477	683	578	556	473
	2.010	0.059		881	746	751	640	916	775	746	634
	2.010	0.075		1119	948	955	813	1164	985	948	806
	2.010	0.108		1612	1365	1376	1171	1676	1419	1365	1161
	2.010	0.162		2418	2047	2063	1757	2515	2128	2047	1741
	2.010	0.169		2522	2136	2152	1833	2623	2220	2136	1816
	2.010	0.225		3358	2843	2866	2440	3493	2955	2843	2418
2 1/2	2.510	0.044		526	445	449	382	547	463	445	379
	2.510	0.059		705	597	602	512	733	621	597	508
	2.510	0.108		1291	1093	1102	938	1342	1136	1093	929
	2.510	0.169		2020	1710	1724	1468	2101	1778	1710	1454
	2.510	0.225		2689	2277	2295	1954	2797	2367	2277	1936
3	3.010	0.059		588	498	502	427	612	517	498	423
	3.010	0.075		748	633	638	543	777	658	633	538
	3.010	0.108		1076	911	919	782	1119	947	911	775
	3.010	0.169		1684	1426	1437	1224	1752	1482	1426	1213
	3.010	0.225		2243	1899	1914	1630	2332	1973	1899	1615

Note: Some sizes, grades and schedule combinations may not be commercially available.
Maximum allowable pressure may be limited by the fitting used.

Table 3-11.

Maximum Allowable Working Pressure (PSIG)

ASTM B-88 Seamless Copper Water Tubing with Brazed, Flared or Compression Fitting Ends (A = 0)

Nom. Tube Size	Max. OD Drawn	Max. OD Annealed	Tube Type	Min. Wall Thick. (t)	Grade:	B-88	B-88
					Type:	Drawn	Annealed
					SE:	10300	4900
1/4	0.376	0.377	K	0.032		1726	819
	0.376	0.377	L	0.027		1479	702
	0.376	0.377	M	N/A		N/A	N/A
3/8	0.501	0.503	K	0.044		1809	858
	0.501	0.503	L	0.031		1275	605
	0.501	0.503	M	0.023		946	449
1/2	0.626	0.628	K	0.044		1448	687
	0.626	0.628	L	0.036		1185	562
	0.626	0.628	M	0.025		823	390
5/8	0.751	0.753	K	0.044		1207	573
	0.751	0.753	L	0.038		1042	495
	0.751	0.753	M	N/A		N/A	N/A
3/4	0.876	0.878	K	0.059		1387	659
	0.876	0.878	L	0.041		964	458
	0.876	0.878	M	0.029		682	324
1	1.127	1.129	K	0.059		1079	512
	1.127	1.129	L	0.045		823	391
	1.127	1.129	M	0.031		567	269
1 1/4	1.377	1.379	K	0.059		883	419
	1.377	1.379	L	0.049		733	348
	1.377	1.379	M	0.038		569	270
1 1/2	1.627	1.630	K	0.065		823	391
	1.627	1.630	L	0.054		684	325
	1.627	1.630	M	0.044		557	265
2	2.127	2.130	K	0.075		726	345
	2.127	2.130	L	0.063		610	290
	2.127	2.130	M	0.052		504	239
2 1/2	2.627	2.630	K	0.085		667	317
	2.627	2.630	L	0.072		565	268
	2.627	2.630	M	0.059		463	220

Table 3-11. (Continued)

Nom. Tube Size	Max. OD Drawn	Max. OD Annealed	Tube Type	Min. Wall Thick. (t)	Grade:	B-88	B-88
					Type:	Drawn	Annealed
					SE:	10300	4900
3	3.127	3.130	K	0.098		646	307
	3.127	3.130	L	0.081		534	254
	3.127	3.130	M	0.065		428	204
3 1/2	3.627	3.630	K	0.108		613	292
	3.627	3.630	L	0.090		511	243
	3.627	3.630	M	0.075		426	202
4	4.127	4.130	K	0.121		604	287
	4.127	4.130	L	0.099		494	235
	4.127	4.130	M	0.085		424	202
5	5.127	5.130	K	0.144		579	275
	5.127	5.130	L	0.113		454	216
	5.127	5.130	M	0.098		394	187
6	6.127	6.130	K	0.173		582	277
	6.127	6.130	L	0.126		424	201
	6.127	6.130	M	0.110		370	176
8	8.127	8.131	K	0.244		618	294
	8.127	8.131	L	0.180		456	217
	8.127	8.131	M	0.153		388	184

Note: If soldering or brazing drawn (straight) tubing use annealed allowable pressure.
Maximum allowable pressure may be limited by the fitting used.

Table 3-12.

Maximum Allowable Working Pressure (PSIG)

ASTM B-280 Seamless Copper Refrigeration Tubing with Brazed, Flared or Compression Fitting Ends

(A = 0)

Nom. Tube Size	Max.	Tubing Type	Min. Wall Thick. (t)	Grade:	B-280	B-280
				Type:	Drawn	Annealed
				SE:	10300	4900
	OD				(Straight)	(Coil)
1/4	0.252	Coil	0.027			1050
	0.251	Straight	0.023		1847	
5/16	0.314	Coil	0.029			905
3/8	0.377	Coil	0.029			754
	0.376	Straight	0.027		1479	
1/2	0.502	Coil	0.029			566
	0.501	Straight	0.031		1275	
5/8	0.627	Coil	0.031			485
	0.626	Straight	0.036		1185	
3/4	0.753	Coil	0.031			404
	0.751	Straight	0.038		1042	
7/8	0.878	Coil	0.041			458
	0.876	straight	0.041		964	
1 1/8	1.129	Coil	0.045			391
	1.127	Straight	0.046		841	
1 3/8	1.379	Coil	0.049			348
	1.377	Straight	0.049		733	
1 5/8	1.630	Coil	0.054			325
	1.627	Straight	0.054		684	
2 1/8	2.127	Straight	0.063		610	
2 5/8	2.627	Straight	0.072		565	
3 1/8	3.127	Straight	0.081		534	
3 5/8	3.627	Straight	0.090		511	
4 1/8	4.127	Straight	0.099		494	

Note: If soldering or brazing drawn (straight) tubing use annealed allowable pressure.
Maximum allowable pressure may be limited by the fitting used.

4. PIPE & TUBING FITTINGS – RATED WORKING PRESSURE

The tables in this section include data for typical pressure-temperature ratings for several types of pipe fittings commonly used in the agent distribution piping of special hazard fire suppression systems.

These tables may be used to assist the system designer in selection of pipe fittings.

CAUTION

The maximum allowable pressure ratings shall be verified with the fitting manufacturer for the type of fittings being used. In addition, any pipe fitting requirements specified in the suppression system equipment manufacturer's listed design manual and in the applicable NFPA Standards must be followed. If any discrepancy should exist between the fittings shown in this guide and the fittings specified in the equipment manufacturer's listed manual or in the applicable NFPA Standards, then the fitting requirements in the equipment manufacturer's manual and/or the applicable NFPA Standard shall take precedence.

Fittings shall have a minimum rated working pressure equal to or greater than the minimum piping design working pressure specified in Appendix A of this document for the agent being used.

The following tables provide values of maximum allowable working pressure for various types of fittings.

- Table 4-1: Malleable Iron Threaded Fittings
- Table 4-2: Grooved Fittings and Couplings
- Table 4-3: Forged Steel Threaded Fittings
- Table 4-4: Forged Carbon Steel Flanges
- Table 4-5: Ductile Iron Fittings
- Table 4-6: Stainless Steel Threaded Fittings
- Table 4-7: Carbon Steel Welded Fittings

Table 4-1.

Malleable Iron Threaded Fittings

(Reference: ANSI B16.3, 2016 edition.)

SERVICE TEMPERATURE DEGREES F.	FITTING CLASS	MAXIMUM RATED PRESSURE NPS FITTING SIZE		
		1/4" to 1"	1 1/4" to 2"	2 1/2" to 3"
-20 TO 150	150 lb. Class (PSIG)	300	300	300
-20 TO 150	300 lb. Class (PSIG)	2000	1500	1000

Note: 300 lb. Class street elbows are not recommended for pressures above 600 psi.

Table 4-1. (Continued)
(Reference: ANSI B16.39, 2014 edition.)

UNIONS & UNION FITTINGS			
CLASS		CLASS	CLASS
150		250	300
Non-shock Cold Water, Oil or Gas (PSIG)			
300		500	600

Table 4-2.
Grooved Fittings and Couplings

Manufacturer	Model	Pipe Sch.	NPS Pipe Size	Rated Working Pressure (PSI)
Victaulic	Style 001 90 Degree Elbow	40	2"-5"	500
	Style 002 Tee	40	2"-5"	500
	Style 003 45 Degree Elbow	40	2"-5"	500
	Style 006 End Cap	N/A	1-1/4" – 5"	500
	Style 101 90 Degree Elbow	40	1"-2-1/2"	365
	Style 102 Tee	40	1"-2-1/2"	365
	Style 103 45 Degree Elbow	40	1"-2-1/2"	365
	Style 177	40	2" - 8"	365
	Style 009N	40	1-1/4" - 8"	365
	Style 107N	40	4"	450
	Style 07 ("Zero Flex")	40	1" - 6"	500
	Style 75	40	1" - 4"	500
	Style 77	40	3/4" - 12"	500
	Style 107N	40	2" - 3"	600
	Style HP70	40	2" - 8"	750
	Style 177N	40	2" - 3"	840
	Style 743 Vic-Flange	40	2"- 12"	500
Grinnell	Figure 707 Heavy Duty Flexible Coupling		1-1/2"-6"	500
	Fig. 7000 Coupling		1-1/4" - 4"	500
	Fig. 7000 Coupling		5" - 8"	450
	Fig. 7001 Coupling		1" -12"	500
	Fig. 7401 Rigidlok		1-1/2" - 2-1/2"	750
	Fig. 7401 Rigidlok		3" - 4"	600
	Fig. 7401 Rigidlok		5" - 6"	500
	Fig. 7401 Rigidlok		8"	450
	Fig. 7401 Rigidlok		10", 12"	400

Note: Rated working pressures in table are the manufacturer's UL Listed and FM Approved pressure ratings

Table 4-3.

Forged Steel Threaded Fittings
(Reference: ANSI B16.11)

SERVICE TEMPERATURES DEGREES F.	MAXIMUM ALLOWABLE NON-SHOCK PRESSURE RATINGS (PSIG)		
	Class 2000	Class 3000	Class 6000
-20 to 150	2000 PSI or rating of Schedule 80 seamless pipe of equivalent material, whichever is less	3000 PSI or rating of Schedule 160 seamless pipe of equivalent material, whichever is less	6000 PSI or rating of XXS seamless pipe of equivalent material, whichever is less

Table 4-4.

Forged Steel Flanges with Standard Facings (Other Than Ring Joints)
(Reference: ANSI B16.5, 2017 Ed. Material ASTM A-105)

SERVICE TEMPERATURES DEGREES F.	MAXIMUM ALLOWABLE NON-SHOCK PRESSURE RATINGS (PSIG) @ PRIMARY SERVICE PRESSURE RATING						
-20 to 200	150 LB	300 LB	400 LB	600 LB	900 LB	1500 LB	2500 LB
	260	680	905	1,360	2035	3,395	5,655

Note: The pressure ratings of forged steel flanges are dependent on the type of gasket facing and the ASTM Grade of material used.

Table 4-5.

Ductile Iron Pipe Fittings

WORKING PRESSURES, NONSHOCK (PSIG)		
TEMPERATURE DEGREES F.	CLASS 150 FLANGED FITTINGS 1" – 6"	CLASS 300 THREADED FITTINGS ½" – 6"
-20 TO 150	250	500

Table 4-6.
Stainless Steel Threaded Fittings
(Reference: ASTM A-16.2, ANSI B16.11)

TEMPERATURE DEGREES F.	WORKING PRESSURE RATING NON-SHOCK (PSIG)			
	Class 150 1/8" – 4" NPT	Class 2000 1/8" – 4" NPT	Class 3000 1/8" – 4" NPT	Class 6000 1/8" – 4" NPT
-20 to 150	300	2000 PSI or rating of the connected Schedule 80 seamless pipe of equivalent material, whichever is less	3000 PSI or rating of the connected Schedule 160 seamless pipe of equivalent material, whichever is less	6000 or rating of the connected XXS seamless pipe of equivalent material, whichever is less

Table 4-7A.
Standard Weight – Carbon Steel Butt-Weld Fittings
(Reference: ANSI B16.9)

SIZE OF FITTING INCHES	*WALL THICKNESS INCHES	**WORKING PRESSURE - PSIG AT THE FAHRENHEIT TEMPERATURES INDICATED)
		-20 to 650 °F
1/2"	0.109	1695
3/4"	0.113	1455
1"	0.133	1575
1 - 1/4"	0.140	1065
1 - 1/2"	0.145	1005
2"	0.154	900
2 - 1/2"	0.203	1215
3"	0.216	1095
3 - 1/2"	0.226	1020
4"	0.237	975
5"	0.258	885
6"	0.280	840
8"	0.322	765

Note: * Nominal wall thickness that corresponds to Schedule 40 steel pipe.

**The pressure rating will be the lesser of the working pressure of the fitting and the working pressure of the ASTM seamless pipe used.

Table 4-7B.

Extra Strong – Carbon Steel Butt-Weld Fittings
(Reference: ANSI B16.9)

SIZE OF FITTING INCHES	*WALL THICKNESS INCHES	**WORKING PRESSURE - (PSIG AT THE FAHRENHEIT TEMPERATURES INDICATED)
		-20 to 650 °F.
1/2"	0.147	3030
3/4"	0.154	2595
1"	0.179	2610
1 - 1/4"	0.191	1935
1 - 1/2"	0.200	1815
2"	0.218	1665
2 - 1/2"	0.276	1935
3"	0.300	1770
3 - 1/2"	0.318	1665
4"	0.337	1590
5"	0.375	1470
6"	0.432	1470
8"	0.500	1350

Note: *Nominal wall thickness that corresponds to Schedule 80 steel pipe.

** The pressure rating will be the lesser of the working pressure of the fitting and the working pressure of the ASTM seamless pipe used.

Table 4-7C.

Forged Steel Socket-Weld Fittings
(Reference: ANSI B16.11)

TEMPERATURE DEGREES F	WORKING PRESSURE RATING NON-SHOCK (PSIG)	
	Class 3000 1/8" - 4" NPT	Class 6000 1/8" - 4" NPT
-20 to 650	3000 PSI or rating of Schedule 160 seamless pipe of equivalent material, whichever is less	6000 PSI or rating of XXS seamless pipe of equivalent material, whichever is less

4.1. Compression-Type Tube Fittings

Tube fittings are rated to the maximum working pressure of tubing as shown in tables 3-7, 3-8, 3-9, 3-10, 3-11, and 3-12 of this document. Compression fittings that have NPT (female or male) pipe threads are an exception and the fitting manufacturer shall be consulted.

The manufacturer of compression fittings being considered for use, should be consulted prior to the use of the fittings with hard drawn copper tubing. Most manufacturers require copper tubing be “soft annealed” copper to ensure safe, reliable, leak-free connections. In addition, the metal tubing material should be softer than the fitting material. (For example: stainless steel tubing should not be used with brass fittings.)

Consult the manufacturer of the fittings for compatibility of the fitting with the tubing material as well as the maximum working pressure.

5. PIPE DESIGN GUIDELINES FOR CLOSED SECTIONS OF PIPE

5.1. Introduction

Fire extinguishing systems often include valve arrangements which introduce closed sections of pipe. Such “closed sections of pipe” most commonly, but not exclusively, are located between the agent containers and stop valves or lockout valves. In such arrangements, extinguishing agent may be trapped between the agent container valve and the stop or lockout valve⁹. If the temperature of the trapped agent rises, the pressure of the trapped agent will likewise rise. Of particular concern is the scenario where liquid agent is trapped. Very high pressures exceeding the strength of the pipe are possible.

Because of this possibility, many of the NFPA Fire Extinguishing System Standards require pressure relief devices to be installed in these “closed” pipe sections. The relief devices are intended to prevent over pressurization and consequent damage or rupture of the pipe.

The pressure relief devices must be designed to operate at higher than the **maximum pressure expected in the pipe section during a system discharge**. The operating range of these relief devices is specified in the NFPA Standards or the equipment Manufacturer’s Listed Design Manual.

5.2. Design Guidelines

The following guidelines are given for the design of “closed sections of pipe” that are equipped with pressure relief devices. In cases where applicable NFPA standards or Equipment Manufacturer’s Listed Design Manuals give guidance for the design of closed sections of pipe and the required pressure relief devices, such guidance must be followed.

1. Select the proper pressure relief device as specified in the applicable NFPA Standard, the manufacturer’s design manual, and/or other applicable codes or standards.
2. The maximum allowable working pressure of the pipe must be equal to or greater than the maximum operating pressure of the pressure relief device.
3. From the pipe tables in Section 3 select the desired type pipe that has a maximum allowable working pressure equal to or greater than the maximum operating pressure of the pressure relief device. **DO NOT USE** pipe tables in Section 2 for this purpose.

⁹ Some manufacturers provide special valves which are designed to prevent entrapment of extinguishing agent.

6. DISCHARGE PIPING FIELD PRESSURE TEST

Pneumatically pressure testing closed pipe systems at high pressures is extremely dangerous. The energy stored per unit volume of compressed gas is very high. The high pressure could potentially cause a rupture of the piping system and introduce dangerous projectiles into the area creating a risk to both personnel and surroundings. Such testing is NOT recommended. In the event that an owner wishes to assume the risk to personnel and property inherent in such testing and requires such a test, personnel should be evacuated from all areas through which the pipe runs prior to pressure testing.

CAUTION

Do not apply pressure to the discharge piping while the pipe is connected to the discharge outlet of any automatically operating discharge valve. Applying pressure to the discharge outlet of a cylinder valve may cause the valve to open and discharge the contents of the agent storage container potentially causing injury or death to personnel or damage to property.

CAUTION

Water should not be used to pressure test a clean agent, halon, or CO₂ system as water can never be fully removed from the system piping. Any water remaining in the system piping during a system discharge can freeze or interact with the discharging agent, potentially disrupting the discharge.

6.1. Pressure Tests

The provisions of the Power Piping Code (PPC), ASME B31.1, do not directly apply to NFPA fire suppression systems such as clean agent and carbon dioxide systems. Nonetheless, the guidance provided in the PPC is worth considering in assessing pressure testing of pipes.

Consider the following:

1. B31.1, edition 2018 137.3.2 requires hydrostatic testing of non-boiler external piping but specifically excludes this requirement for pipe open to the atmosphere. Much of the pipe in a gaseous agent system is open to the atmosphere. Thus, even if B31.1 were to be applied, most of the gaseous agent system pipe would be excluded from the required hydro test.
2. B31.1 further states that, except for pressures not exceeding 25 PSIG (175 kPa), pneumatic testing shall not be used unless the owner specifies pneumatic testing or permits its use as an alternative. (Note: ASME B31.1 refers to the low pressure (25 psi) pneumatic testing as a “preliminary pneumatic test”.)
3. Notwithstanding the foregoing considerations, in the “Required Pneumatic Test Pressure” section of the PPC it is stated that the pneumatic test pressure shall be not less than 1.2 nor more than 1.5 times the design pressure of the piping system.
4. For gaseous fire suppression systems, including both clean agent and carbon dioxide systems, with relatively high maximum working pressures, pneumatic test pressures of not less than 1.2 times the design pressure of the piping system in a closed piping system **could be considered severely high and extremely dangerous**.

6.2. Validation of Pipe Integrity

Various NFPA Standards which apply to fire extinguishing systems have specific requirements for commissioning of the systems, including checks of the system pipe.

If further validation of the integrity of the piping system is required, the following suggestions can be safely accomplished:

1. Most pipe manufacturers and suppliers when asked will supply a “CERTIFIED MATERIAL TEST REPORT.” Test reports typically state the type, sizes and schedules of purchased pipe and the pressure that the pipe was hydrostatically tested to prior to shipment. This type of certificate should validate the customer’s concerns of pipe material integrity.
2. If manifolds, pipe headers or piping segments are being made by a piping fabricator, require that a hydrostatic test be performed, the piping dried internally, and a certificate of conformance be supplied as part of your contract.

6.3. NFPA 2001 Pressure Test

NFPA 2001 which applies to clean agent systems mandates a pressure test of the installed pipe system. The standard requires that the piping system be tested to at least 40 psi (276 kPa) in a closed-circuit using nitrogen or other dry gas. After removing the source of pressurizing gas, the pressure in the pipe shall not be less than 80 percent of the test pressure after 10 minutes.

To meet the requirement of NFPA 2001 to pressure test the installed piping systems, the following steps are suggested:

CAUTION

Personal Protective Equipment and evacuation of non-essential personnel from areas in which the pipe under test is located are basic precautions to be taken during pneumatic pressure testing of installed piping systems.

1. Ensure all nozzles are removed and replaced with suitable caps.
2. Disconnect pressure trips, pressure switches, cylinders, and any other pressure operated devices from the pipe system and seal the pipe openings thus created with suitable plugs or caps. Install anti-recoil devices on cylinder outlets.
3. Evacuate all personnel who are not directly involved in the testing from areas through which the pipe runs.
4. Inform participants that the test is beginning.
5. Begin pressurizing system with nitrogen or other dry gas.
6. If visible or audible leaks are detected, stop the test, remove the pressure from the pipe, and fix the leaks.
7. If no visible or audible leaks are detected, continue bringing the pressure slowly to 40 psi and hold while making a visual inspection for leaks.

8. If any leaks are found, the system must be shut down, the pipe depressurized, reworked, and procedure repeated starting at the top of this Test Procedure Checklist.
9. If no audible or visible leaks are detected, remove source of pressurizing gas. Record the pressure in the pipe. After 10 minutes check and record the pressure reading. (The pressure in the pipe shall not be less than 80 percent of the test pressure after 10 minutes.)

Acceptance Criteria

Test will be considered satisfactory when the pressure in the pipe maintains at least 80 percent of the test pressure at the end of 10 minutes. Results of this test are to be transferred to Contractor's Material and Test Certificate, System Acceptance Test Report, or similar document.

Test Records Data

Test shall be documented as part of the system commissioning report.

Further Information

For further detail, see the FSSA Online Training Course Module: "Piping Pressurization and Puff Testing" and NFPA 2001.

6.4. NFPA 12 Requirements

NFPA 12, Standard on Carbon Dioxide Extinguishing Systems, does not require pressure testing of system piping. A full discharge test is required for every system. System manufacturers may have specific requirements for leak testing of system pipe to be done prior to the full discharge test.

7. PIPE SUPPORTS AND HANGERS

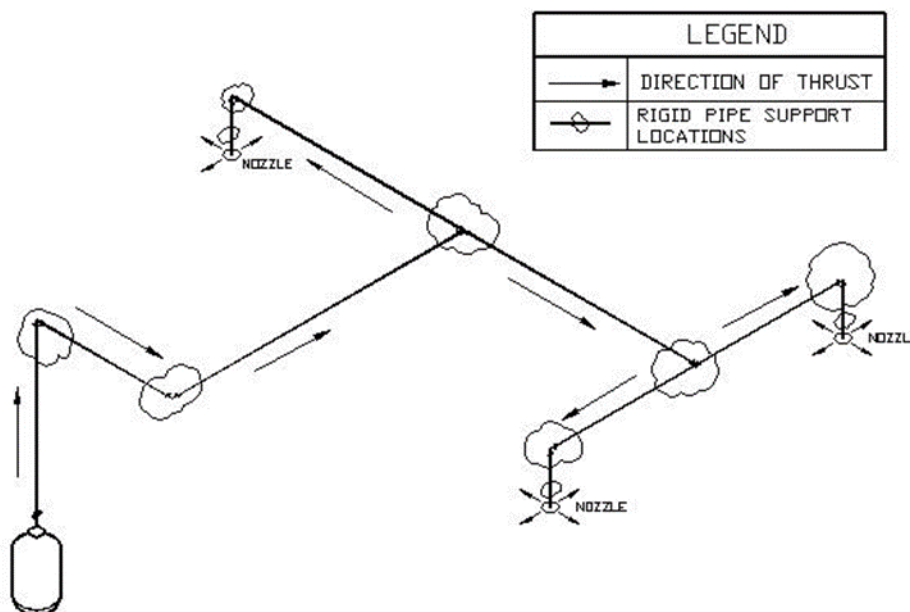
This section provides general information and guidelines for the selection and application of pipe supports and/or hangers for special hazard fire suppression systems. Pipe supports and hangers shall be capable of supporting the pipe in all conditions of operation, including thrusts created by system discharge.

These general guidelines are not intended to provide all information necessary to determine equipment and material requirements for specific installations or applications. Specific installation guidelines as provided by the manufacturer of pipe supports and/or pipe support systems shall be followed.

The design examples provided in this section are typical of installations in the industry. Load calculations have not been performed for any examples shown.

1. Conventional hanger design which is generally accepted as good practice, using standard stock or production units, as manufactured by recognized manufacturers, shall be used whenever possible.
2. All piping must be solidly anchored to rigid fixed structure (wall studs, concrete wall, roofing structure, floors, or columns) by angle iron brackets, channels / struts or equivalent brackets. Particular attention must be paid to the bracing of all changes in piping direction, nozzle piping and header piping. As a minimum, rigid pipe supports shall be provided at all locations where piping changes direction (See Figure 7-1).

Figure 7-1. – Sample Piping Layout



Notes:

1. Actual number of braces will depend upon piping and nozzle arrangement.
2. Nozzles with different orifice orientation may require different types of bracing to counter thrusts due to direction of agent discharge (Example: 360°, 180°, and orifices angled off the horizontal).
3. Pipe support components shall be steel and adequate to support the pipe in response to movements created by changing thermal conditions, and to allow for free and ample movement for contraction except where anchored, thereby preventing excessive stress.
4. Thermal expansion and contraction of long runs of pipe can introduce stress in the pipe unless provision is made to permit longitudinal movement. Expansion loops can usually be incorporated in the pipe design to permit the required longitudinal movement to prevent excessive stress. Where conditions are such that expansion loops cannot be incorporated as required, manufactured expansion joints compatible with the agent and having suitable strength may be employed.
5. Where rod type hangers are permitted for intermediate support between rigid supports, they shall be steel clevis or steel band hangers of the proper size for the supported pipe and with solid bar-type hanger rod. Hanger rods shall not be subjected to stresses due to bending.
6. Grooved pipe, fittings, and couplings must be supported and anchored exactly per the manufacturer's specification. Installation shall be such as to allow for contraction over the anticipated temperature range and pressure thrusts. Consideration should be given to provide a minimum of two hangers per length of grooved pipe to avoid injury or accident during installation or maintenance of piping. No grooved pipe length should be left unsupported between any two couplings.

7. Cast iron supports, conduit clamps or “C” clamps shall not be used to support piping. All parts of the supporting equipment shall be fabricated, assembled and installed so that they will not be disengaged by movement of the supported pipe. Drilling of, welding, or the use of beam clamps are acceptable means of attaching hangers to the building structure. A pipeline is not to be supported from another pipeline.
8. All pipe supports shall be installed to avoid interference with other piping, hangers, electrical conduit, and supports or building structure and equipment.
9. Supports shall be sufficiently close together to avoid excessive bending stresses from concentrated loads between supports. (Refer to Table 7-1, Maximum Horizontal Spacing Between Pipe Supports for Screwed, Welded, or Grooved Pipe with Rod Diameters and Table 7-2, Maximum Horizontal Spacing Between Tubing Supports with Rod Diameters.)
10. When using concrete inserts or power-driven studs, the manufacturer’s specifications must be followed. Consideration should be given to minimum and maximum engagement depths, edge distances, minimum spacing of anchors in the concrete and the quality of the concrete.
11. When using channel / strut refer to manufacturer information for limitations.
12. Consideration shall be given to providing ring inserts to resist galvanic corrosion when piping and hanger rings or U-bolts are of dissimilar metals.
13. For guidelines on the application of seismic bracing and supports refer to the following documents:
 - MSS SP-127-2001 Bracing for Piping Systems Seismic – Wind – Dynamic Design, Selection, Application – Latest Edition
 - NFPA 13 Standard for the Installation of Sprinkler Systems – Latest Edition
 - State and Local Building Codes – Latest Edition

7.1. Rigid Pipe Hangers

Following are eighteen (18) examples of rigid pipe hangers. Specific installation guidelines, as provided by the manufacturer of pipe supports and/or pipe support systems, shall be followed.

Figure 7-2 - Typical Rigid Support

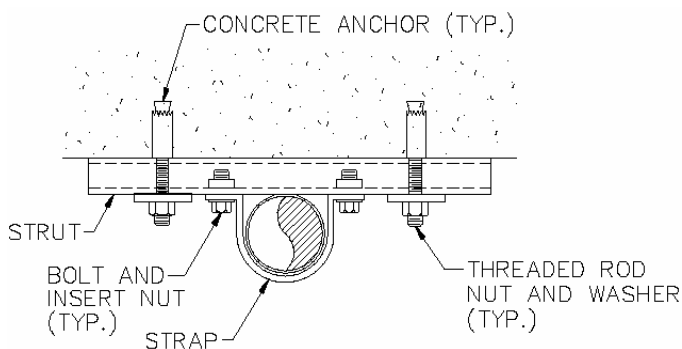


Figure 7-3 - Typical Rigid Support

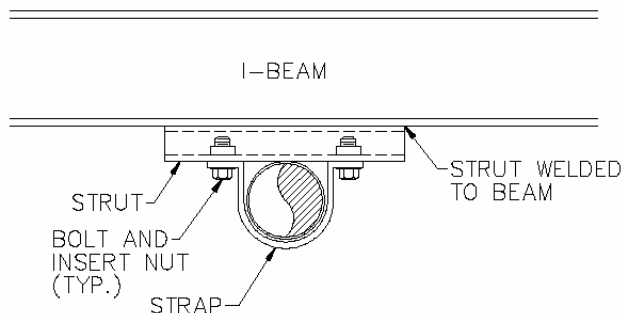


Figure 7-4 - Typical Rigid Support

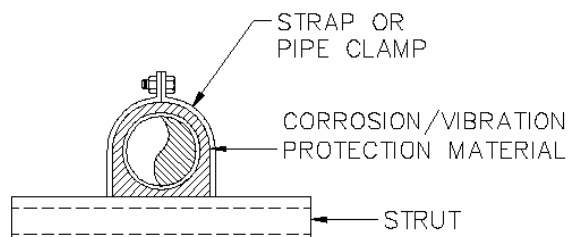


Figure 7-5 - Typical Rigid Support

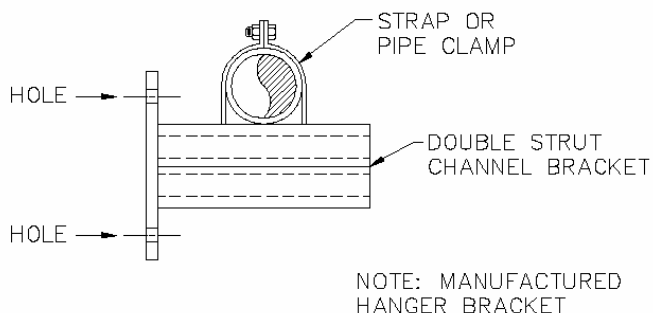


Figure 7-6 - Typical Rigid Support

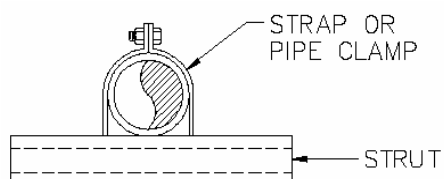


Figure 7-7 - Typical Rigid Support

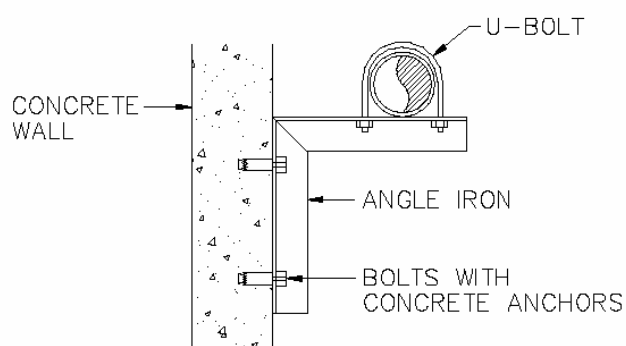


Figure 7-8 - Typical Rigid Support

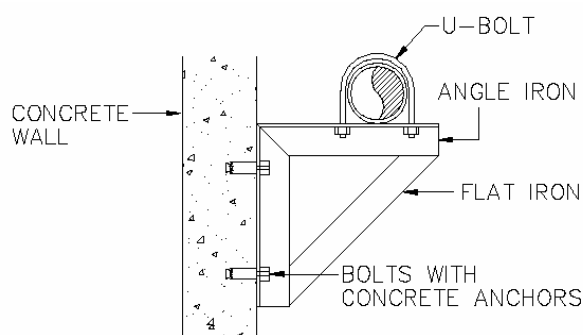


Figure 7-9 - Typical Rigid Support

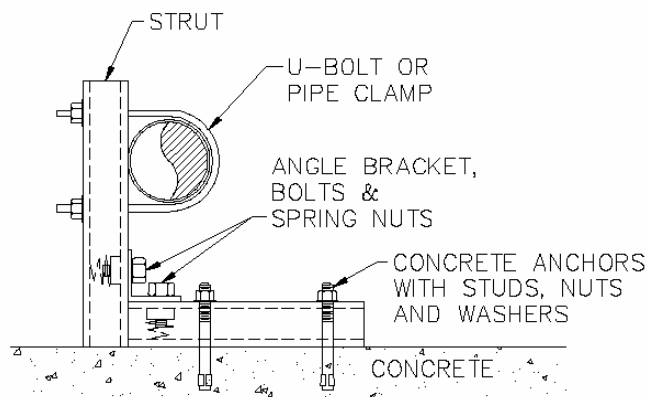


Figure 7-10 - Typical Rigid Support

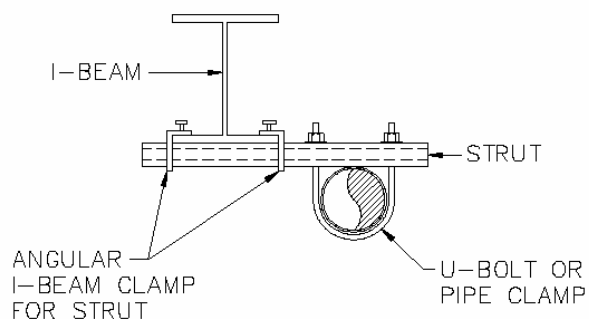


Figure 7-11 - Typical Rigid Support

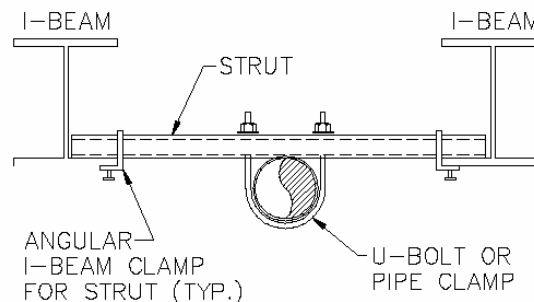


Figure 7-12 - Typical Rigid Support

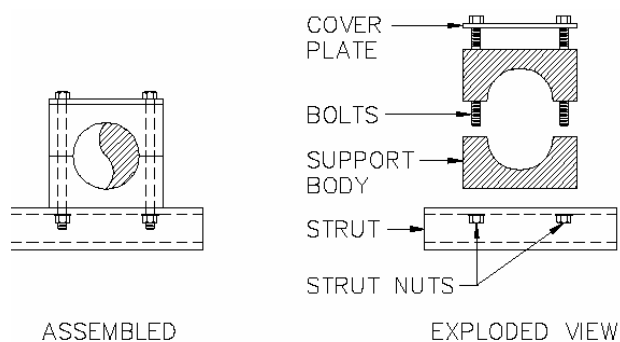


Figure 7-13 - Typical Rigid Support

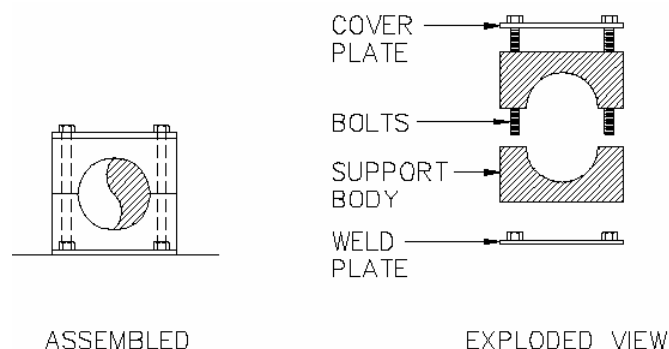
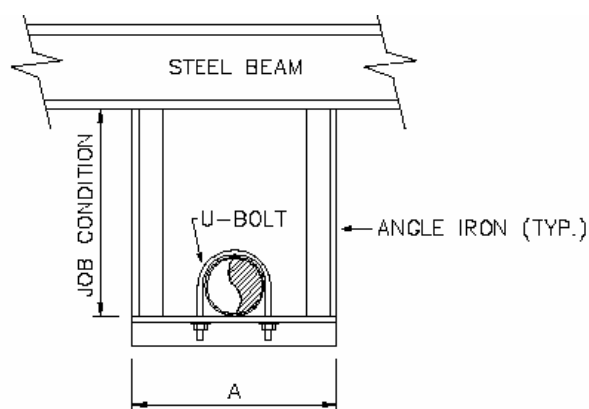


Figure 7-14 - Typical Rigid Support



PIPE SIZE	A DIM	ANGLE IRON SIZE	U-BOLT DIA.
1", 1 1/4", 1 1/2" & 2"	8"	1 1/2" x 1 1/2" x 1/4"	3/8"
2 1/2", 3" & 4"	12"	3" x 3" x 1/4"	1/2"
5" & 6"	16"	3 1/2" x 3 1/2" x 3/8"	5/8"

Figure 7-15 - Typical Rigid Support

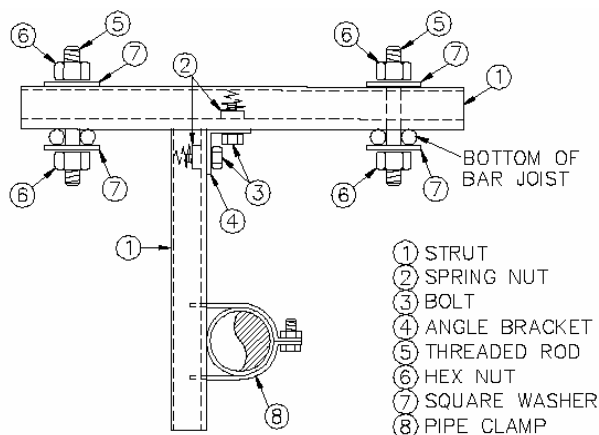


Figure 7-16 - Typical Rigid Support

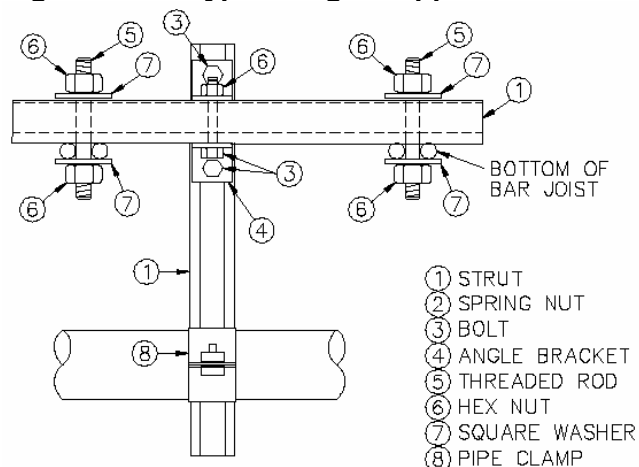


Figure 7-17 - Typical Rigid Support

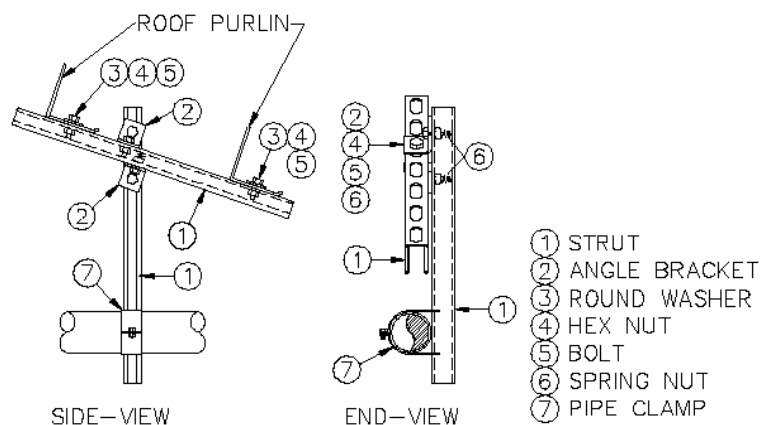


Figure 7-18 - Typical Rigid Support

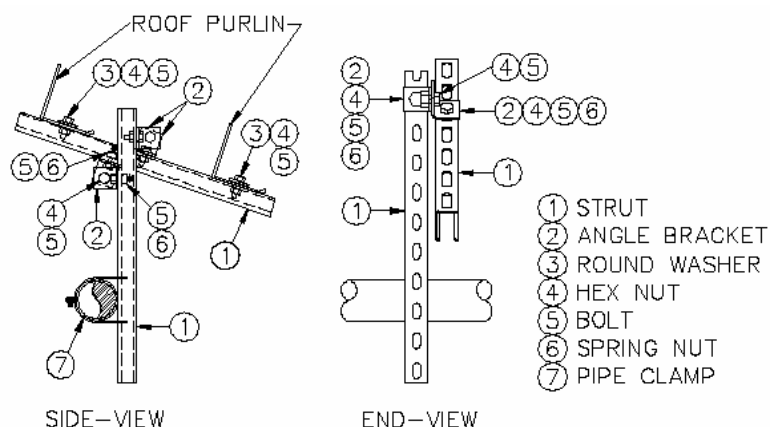
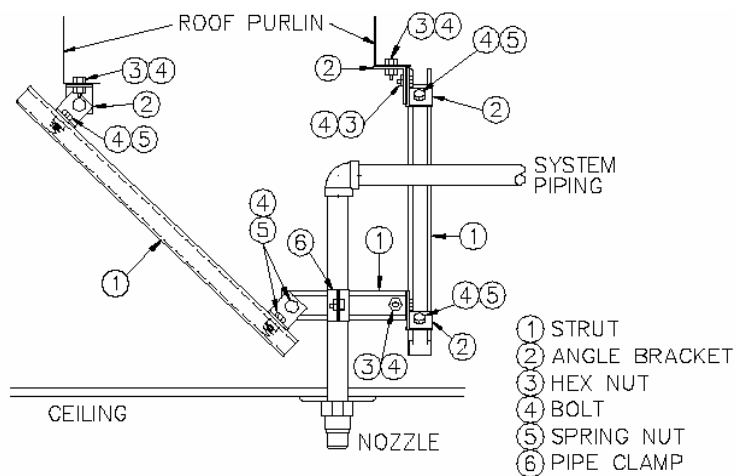


Figure 7-19 - Typical Rigid Support



7.2. Intermediate Pipe Hangers

Following are eleven (11) examples of intermediate pipe hangers. Specific installation guidelines, as provided by the manufacturer of pipe supports and/or pipe support systems, shall be followed.

Figure 7-20 - Typical Intermediate Support

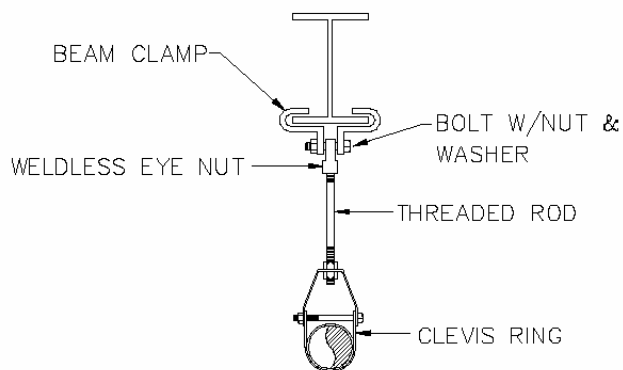


Figure 7-21 - Typical Intermediate Support

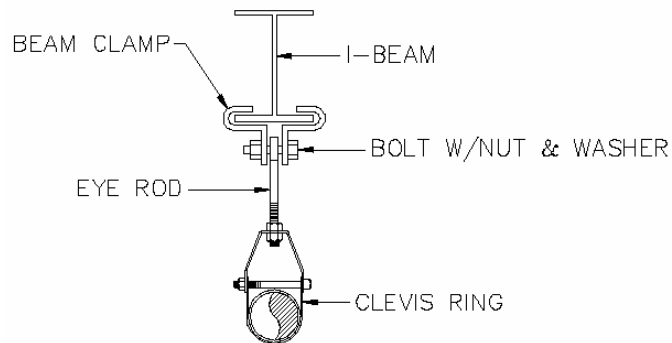


Figure 7-22 - Typical Intermediate Support

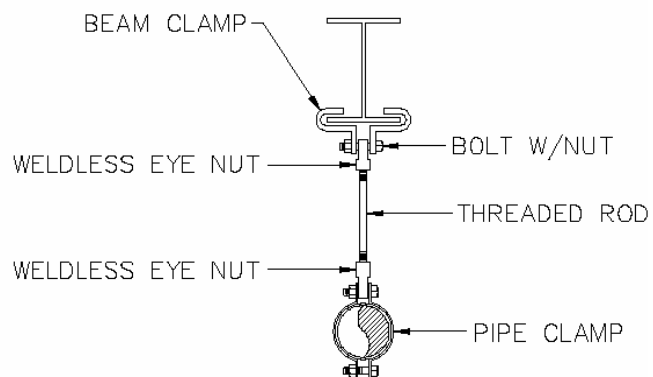


Figure 7-23 - Typical Intermediate Support

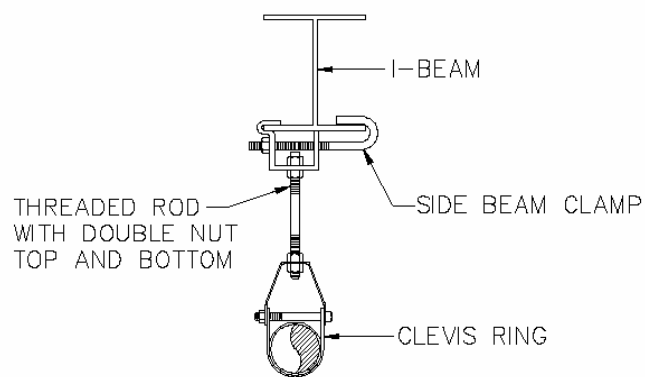


Figure 7-24 - Typical Intermediate Support

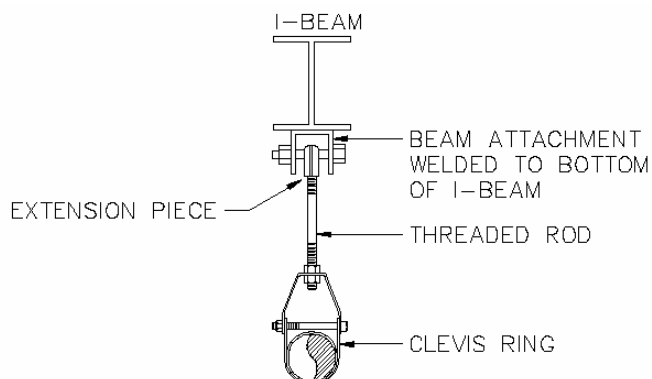


Figure 7-25 - Typical Intermediate Support

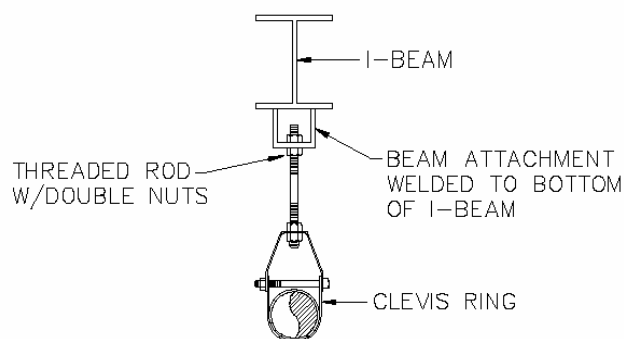


Figure 7-26 - Typical Intermediate Support

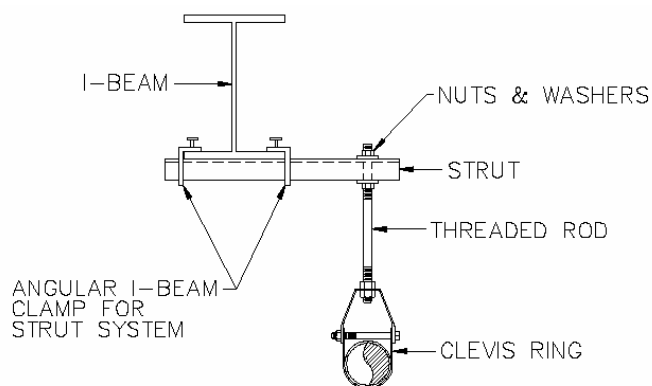


Figure 7-27 - Typical Intermediate Support

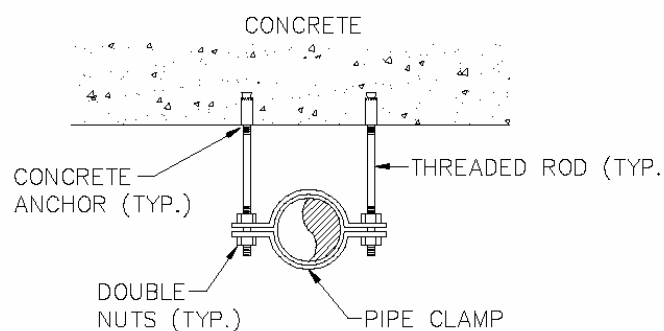


Figure 7-28 - Typical Intermediate Support

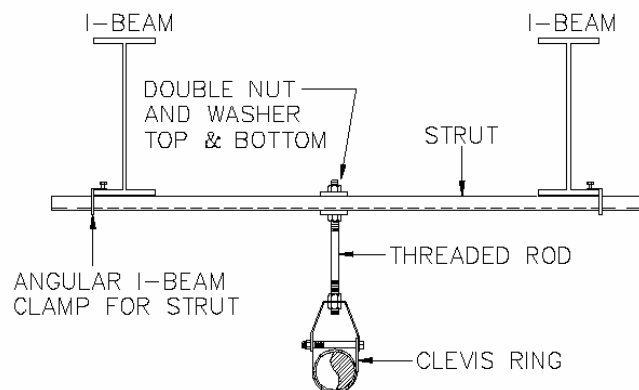


Figure 7-29 - Typical Intermediate Support

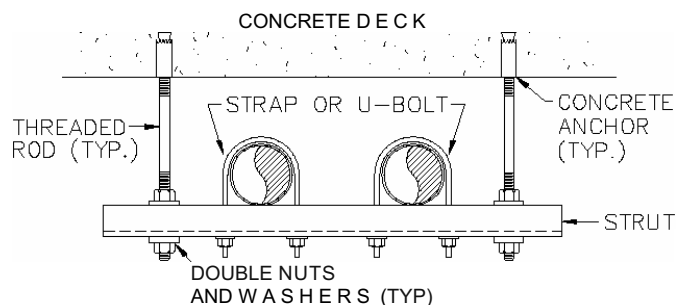


Figure 7-30 - Typical Intermediate Support

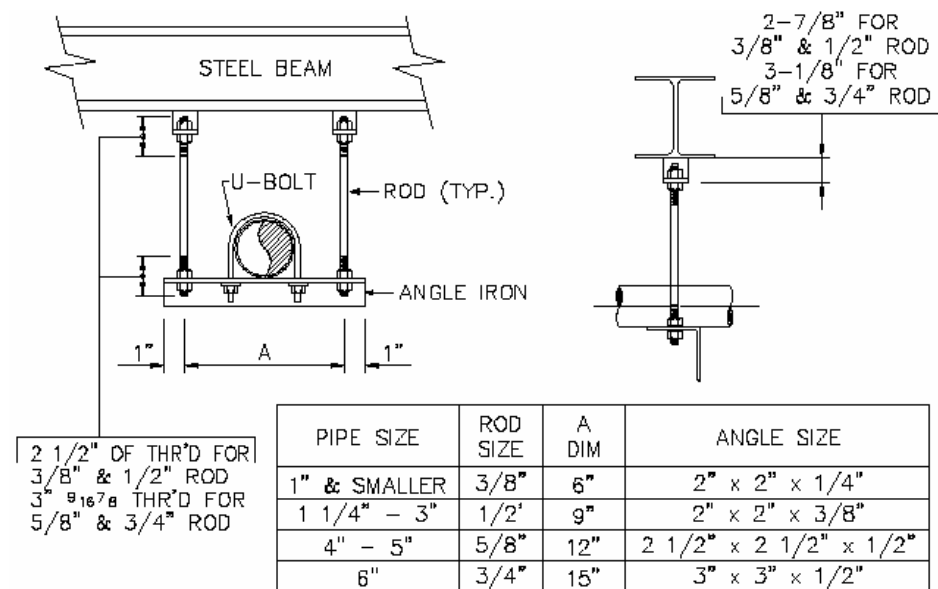


Table 7-1.

Maximum Horizontal Spacing between Pipe Supports
For Screwed, Welded, or Grooved Pipe with Rod Diameters
(Reference: MSS SP-58-2009)

Pipe Size (inches)	Distance Between Supports (feet)	Rod Diameter (inches)
1/4"	7	3/8
1/2"	7	3/8
3/4"	7	3/8
1"	7	3/8
1 1/4"	7	3/8
1 1/2"	9	3/8
2"	10	3/8
2 1/2"	11	1/2
3"	12	1/2
4"	14	5/8
5"	16	5/8
6"	17	3/4
8"	19	3/4

Note: "C" Clamps are not acceptable to support rod hangers

Table 7-2.

Maximum Horizontal Spacing between Tubing Supports with Rod Diameters
(Reference: MSS SP-58-2009)

Tubing Size (inches)	Distance Between Supports (feet)	Rod Diameter (inches)
1/4"	5	3/8
1/2"	5	3/8
3/4"	5	3/8
1"	6	3/8
1 1/4"	7	3/8
1 1/2"	8	3/8
2"	8	3/8
2 1/2"	9	1/2
3"	10	1/2
4"	12	1/2
5"	13	1/2
6"	14	5/8
8"	16	3/4

APPENDIX A: PIPE FOR CARBON DIOXIDE FIRE EXTINGUISHING SYSTEMS

This appendix provides a summary of NFPA 12 pipe and fitting requirements for Carbon Dioxide Fire Extinguishing Systems. Refer to NFPA 12 current edition for more detail.

Some manufacturers of carbon dioxide fire extinguishing systems have additional piping system requirements which must be followed. Always consult the system manufacturer's installation requirements.

NFPA Standard 12 on Carbon Dioxide Fire Extinguishing Systems Edition 2015 requires pipe to be made of metallic non-combustible material having characteristics such that the pipe's performance under stress can be reliably predicted. NFPA 12 specifically permits the pipe types and schedules shown in Table A-1.

Table A-1.

CO ₂ Storage		
High Pressure		
Steel Pipe: ASTM A53 seamless or electric welded, Grade A or B; or ASTM A106, Grade A, B, or C.	¾ inch and smaller Schedule 40 1 inch through 4 inch Schedule 80	NOTE: Furnace butt weld ASTM A-53 pipe is <i>prohibited</i> for high pressure storage
Stainless Steel Pipe: TP304 or TP316 with threaded connections or TP304, TP316, TP304L, or TP316L with welded connections.		
Low Pressure		
Steel Pipe: ASTM A53 seamless or electric welded, Grade A or B; or ASTM A106, Grade A, B, or C.	¾ inch through 8 inch Schedule 40	NOTE: Furnace butt weld ASTM A-53 pipe is permitted for low pressure storage
Stainless Steel Pipe: TP304 or TP316 with threaded connections or TP304, TP316, TP304L, or TP316L with welded connections.		

Cast iron pipe is prohibited in carbon dioxide systems.

ASTM A-120 pipe is prohibited in carbon dioxide systems.

If a pipe or tubing is not shown in Table A-1, it may be used in carbon dioxide systems only if it is made of metallic non-combustible material having characteristics such that the pipe's performance under stress can be reliably predicted. The wall thickness of the pipe or tubing must be calculated in accordance with ASME B31.1 using an internal pressure of 2800 psi for high pressure storage systems and 450 psi for low pressure storage systems. The Tables in Section 3 of this document may be used to determine the required thickness for such piping.

Table A-2. - NFPA Standard 12 Pipe Fitting Specifications

Application	Pipe Size	Permitted Fitting
High Pressure CO ₂ fittings (standard)	Through 2 inch	Class 300 malleable iron (M.I.)
	Larger than 2 inch	Forged Steel
	1/8 through 4 inch	Stainless steel Type 304 or 316 wrought or forged per ASTM A182
HP CO ₂ Flanged Joint upstream of any stop valves	All	Class 600
HP CO ₂ Flanged Joint downstream of any stop valves	All	Class 300 Note: threaded unions must be equivalent to minimum Class 2000 forged steel
Low Pressure CO ₂ fittings (standard)	Through 3 inch	Class 300 malleable iron (M.I.) or ductile iron (D.I.)
	Larger than 3 inch	Forged steel
	1/8 through 4 inch	Stainless steel Type 304 or 316 threaded connections wrought or forged per ASTM A182 Class 2000
	1/8 through 4 inch	Stainless steel Type 304 or 316 or 304L or 316L welded connections wrought or forged per ASTM A182 Class 2000
Low Pressure CO ₂ Flanged joints	All	Class 300
Bushings (high or low pressure storage) Note: Flush bushings shall NOT be used	One pipe size reduction	3000 lb steel bushing required
	More than one pipe size reduction	Follow requirements for standard fittings.
Mechanical Grooved Coupling and Fittings	All	Must be SPECIFICALLY LISTED FOR THE TYPE OF CARBON DIOXIDE SYSTEM SERVICE (i.e., High Pressure or Low Pressure)

APPENDIX B: References

B.1 Publications

1. ASME B31.1 – 2018 Edition, Power Piping Code
2. ASME B16.3 – 1998 Edition, Malleable Iron Threaded Fittings
3. ASME B16.11 – 1996 Edition, Forged Steel Fittings – Socket-Welding and Threaded
4. National Fire Protection Association Standards
 - a. NFPA-12: Standard on Carbon Dioxide Extinguishing Systems, 2018 Edition
 - b. NFPA-12A: Standard on Halon 1301 Fire Extinguishing Systems, 2015 Edition
 - c. NFPA-17: Standard on Dry Chemical Extinguishing Systems, 2017 Edition
 - d. NFPA 750: Standard on Water Mist Fire Protection Systems, 2015 Edition
 - e. NFPA 2001: Standard on Clean Agent Fire Extinguishing Systems, 2018 Edition
5. American Society for Testing and Materials (ASTM) Standard Specifications for:
 - a. ASTM A53: Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 - b. ASTM A106: Seamless Carbon Steel Pipe for High-Temperature Service
 - c. ASTM A178: Electric-Resistance-Welded Carbon Steel Tubes
 - d. ASTM A179: Seamless Cold Drawn Low-Carbon Steel Heat Exchanger and Condenser Tubes
 - e. ASTM A213: Seamless Ferritic and Austenitic Alloy – Steel Boiler, Super heater, and Heat Exchanger Tubes
 - f. ASTM A249: Welded Austenitic Steel Boiler, Super heater, Heat Exchanger, and Condenser Tubes
 - g. ASTM A269: Seamless and Welded Austenitic Stainless Steel Tubing for General Service
 - h. ASTM A312: Seamless and Welded Austenitic Stainless Steel Pipe
 - i. ASTM B88: Seamless Copper Water Tube
 - j. ASTM B280: Seamless Copper Tube for Air Conditioning and Refrigeration Service
6. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.
 - a. MSS SP-58-2009: Pipe Hangers and Supports – Materials, Design, Manufacture, Selection, Application and Installation

To order copies of the referenced publications, contact:

- a. ASME International
22 Law Drive
P.O. Box 2900
Fairfield, NJ 07007-2900
Phone: 800-843-2763
973-882-1167
Fax: 973-882-1717
Website: www.asme.org

- b. NFPA Standards
National Fire Protection Association
11 Tracy Drive
Avon, MA 02322-9908
Phone: 800-344-3555
Fax: 800-593-6372
Website: www.nfpa.org

- c. ASTM Standards
American Society for Testing and Materials
100 Bar Harbor Drive
West Conshohocken, PA 19428-2959
Phone: 610-832-9585
Website: www.astm.org

- d. Manufacturers Standardization Society
127 Park Street, N.E. Vienna,
VA 22180
Phone: 703-281-6613
Website: www.msshq.org



Fire Suppression Systems Association

3601 East Joppa Road
Baltimore, Maryland 21234
Phone: (410) 931-8100
Fax: (410) 931-8111
www.fssa.net