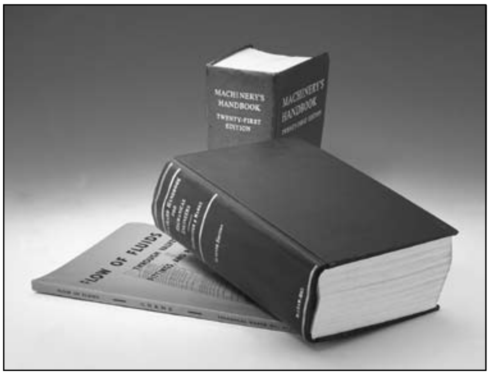
Technical Information

The information presented in this section is intended to assist designers in the proper selection of Autoclave Engineers' valves, fittings and tubing for fluid handling systems. This technical data does not represent product specifications but rather guidelines for direction in the proper application of the referenced equipment. These guidelines are general in nature because of the many process variables.

For severe service applications, selection of the appropriate valves, fittings and tubing is essential in order to optimize the service life of these products. Autoclave Engineers' technical staff is available to assist in the interpretation of this information.



Autoclave Engineers
Fluid Components
Division of Snap-tite, Inc.
www.autoclave.com

Technical and Application Information

Materials:

Widely varying conditions frequently require that valves, fittings and tubing be constructed of materials other than conventional stainless steel. Since many variables affect the corrosion resistance of metallic materials, it is Autoclave Engineers' policy not to recommend materials based on corrosion resistance for specific fluid applications. We can, however, suggest materials based on mechanical strength and also indicate materials generally used in a specific application. Other materials not listed in this section are also available.

Pressure:

Included in this section are the standard pressure ratings for several common materials for valves and fittings as well as tubing. Autoclave stocks a select quantity of special material tubing for immediate delivery.

Temperature:

Also contained in this section are pressure reduction factors at various temperatures for several materials. To obtain the maximum pressure rating at an elevated temperature, multiply the maximum pressure rating of the item at room temperature by the elevated temperature factor (% of RT).

High and low temperatures or high heat up and/or cool down rates can affect the capability of a metal-to-metal seal. When selecting a valve series, consideration should not only be given to static pressure rating, but also static and dynamic temperature conditions. Generally, the smaller the seal diameter of a metal-to-metal seal, the more reliable the seal will be.

Gas or Liquid Service:

Light gases such as hydrogen and helium are more difficult to seal than liquids. When selecting a valve series, consideration should be given to the fluid application and not just pressure and temperature requirements. The higher the rating of the valve or fitting, the less the likelihood of weepage problems with light gases. Tubing selections should also consider the service requirements, since thicker wall, smaller outside diameter tube sizes will produce a more reliable connection seal. Handling of fittings and tubing during installation will make a difference in sealability of light gases as well as liquids. Do not handle the tube or fitting in such a way as to damage the sealing surfaces. If it is process tolerable, a small amount of lubrication (or even process fluid) on the seal area during installation will help the sealing process. Refer to the Tools, Installation, Operation and Maintenance section for further information.

Valve Stem Packing Materials:

The considerations listed thus far should be applied when selecting a suitable valve stem packing material (Teflon, Teflon glass or Graphite yarn). Where possible, Teflon packing is the most reliable, low maintenance, packing choice; Teflon/glass is the second. While graphite yarn packing is a reliable packing material for the majority of extremely high temperature applications, some gases may permeate more readily through graphite yarn packing than through the Teflon packing in a valve with an extended stuffing box. The packing material must be kept below the maximum permitted temperature listed on page 5.

Valve Stem Seating:

Abrasive flow or high cycle service will require more frequent maintenance. Special materials and the proper valve series selection may extend service life. For example, if flow is not critical, a 30VM valve with an **N-Dura** stem will require less maintenance than an SW series valve used in a low pressure, high cycle, abrasive flow application. Although all application parameters cannot be considered in this section, the user can generally expect several thousand cycles in a liquid application and several hundred cycles for gas service. The packing gland may require adjustment, however, to achieve these results.

Pressure Cycling:

In medium and high pressure applications, static as well as dynamic (cyclic) pressure must be considered when selecting an appropriate valve series. If fatigue life is a concern, Autoclave Engineers can supply tubing which has been autofrettaged for improved fatigue resistance. For internally pressurized tubing, **autofrettaging** is a method by which the inner wall of the tube is precompressed to reduce the tube operating bore stresses. By applying sufficient internal pressure, greater than the maximum working pressure of the tube, the inner wall is plastically deformed by a controlled amount. The remaining outer portion of the wall acts elastically, and when the pressure is released, a positive compressive load at the bore will exist. As mentioned previously, the result is reduced bore stress and increased fatigue life. In addition to the autofrettaging method to increase cycle life, Autoclave offers HP-HC (high-pressure — high cycle) tubing, rated to 100,000 psi (6895 bar). This tubing can be substituted for our standard 60,000 psi (4137 bar) tubing providing longer life at 60,000 psi (4137 bar) operation.

Vacuum Service:

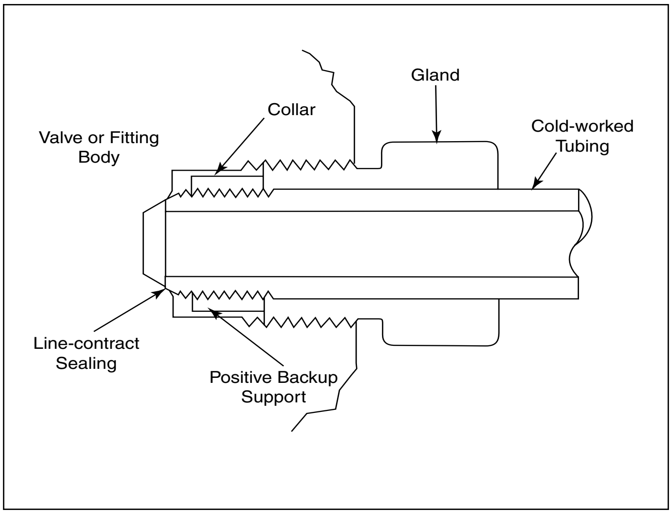
The high, medium and low pressure series of Autoclave Engineers' standard valves, fittings and tubing can be used in light vacuum services to 10^{-2} torr. For high vacuums to 10^{-5} or 10^{-6} torr, Autoclave Engineers' high pressure series is recommended. Extreme care and proper seal lubrication is required (as mentioned in the Gas or Liquid Service paragraph) to achieve these degrees of vacuum. The pump type and size will determine the final vacuum pressure.

Autoclave Engineers Medium & High Pressure Coned and Threaded Connections

Autoclave Engineers' Medium Pressure Coned and Threaded Connections

Features:

- Pressures to 43,000 psi (2965 bar)
- Uncompromised reliability under rigorous thermal and pressure cycling.
- Design is a more compact version of the original Autoclave Engineers High Pressure connections.
- Well suited to installations which require repeated assembly and disassembly with consistent reliability.
- Available in tube outside diameter sizes from 1/4"(6.35 mm) through 1-1/2" (38.10 mm) and bore sizes from .109"(2.77 mm) to .938"(23.83 mm).

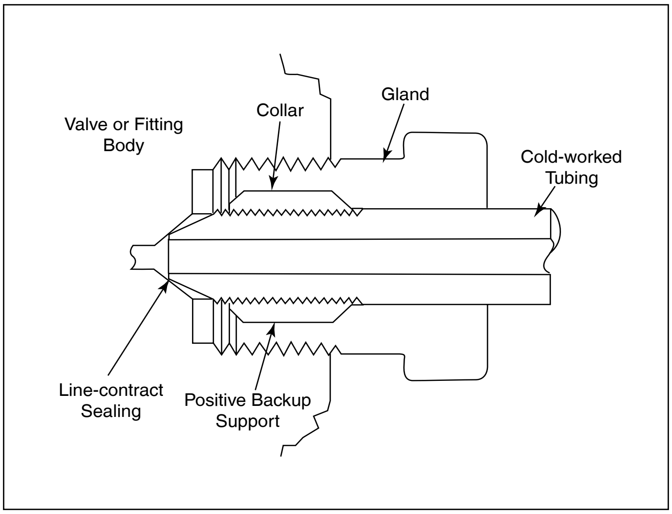


Differences in angles exaggerated for clarity.

Autoclave Engineers' High Pressure Coned and Threaded Connections

Features:

- Pressures to 60,000 psi (4137 bar)
- Increased pressure handling capabilities
- Uncompromised reliability under rigorous thermal and pressure cycling
- Well suited to installations which require repeated assembly and disassembly with consistent reliability.
- Available in tube outside diameter sizes of 1/4" (6.35mm), 3/8"(9.53mm) and 9/16"(14.27mm) and bore sizes of .083(2.11mm), .125"(3.18mm), .188"(4.78mm) and .250"(6.35mm).



Differences in angles exaggerated for clarity.

Technical Information - Coned and Threaded Connections

Design Considerations - Why Coning and threading?

High-pressure designs require a superior joining technique for valves, fitting and tubing. Conventional joining methods fall short of the reliability needed for pressures above 10,000 - 15,000 psi (690-1034 bar) and tube sizes above 1/4” outside diameter. Dissimilar angles between the body and the tube cone provide line contact sealing along the perimeter of a contact circle. The sealing contact area is therefore, maintained at its practical minimum for the given tube size and a reliable seal is produced due to high sealing stresses that occur at low sealing loads. When process tolerable, a small amount of lubricant (or even process fluid) on the seal area will help improve the reliability of the metal to metal seals, especially when light molecule gases are to be sealed. The metal to metal seal also eliminates the need for elastomers in the connections.

Positive backup support occurs with the collar threaded (left-handed) directly onto the tubing to form a positive integral retaining surface. This allows for a consistent connection make up that is required at higher pressures and temperatures. When the gland nut is threaded into the connection, the tubing is locked securely in place and the possibility for the ejection of the tubing from a properly assembled and used connection is extremely remote.

Remarks:

Since the glands and threaded collars can be removed from the tubing, properly lubricated Autoclave Medium-Pressure and High-Pressure connections can be disassembled and reassembled repeatedly without loss of relability. These connections are used with cold-worked valve and fitting bodies which can withstand many repeated sealings. Therefore, valves, fittings and accessories can be inserted or removed from the pressure system or the system can be altered or expanded in a fraction of the time and cost that may be imposed by welded, screwed, flared or other types of connections.

Vacuum Service:

Autoclave Medium-Pressure connections can be reliably used in light vacuum service to 10^{-2} torr. Autocalve High-Pressure connections are recommended for vacuum to 10^{-5} torr. Extreme care and proper seal lubrication are required to successfully achieve these levels of vacuum.

Pressure Cycling:

Since the metal to metal seal is pre-torqued to a specified value greater than the end load generated from the pressure, fatigue concerns of the connection due to pressure cycling are minimal.

Thermal Cycling:

Because of the threaded on collar design, Autoclave Medium and High-Pressure connections can take repeated thermal cycling under pressure with no loss in reliability. These connections can also handle a wider range of temperatures than swaged or bite type connections and are designed to maintain integrity from -423°F to 1200°F (-252°C to 649°C).

Pre-Rated Systems:

Valves, fittings and tubing with Autoclave Medium and High-Pressure connections provide a fully engineered, pre-rated system of components that are interchangeable from assembly to assembly. They are not over sensitive to abuse or careless assembly and no special gauges or tools are needed to check the connection. Weep holes are provided in every connection to permit fast visual inspection for leakage, and prevent pressure build up in the threads.

Materials:

Autoclaves’ standard gland and collar material is type 316 cold-worked stainless steel. This material provides high strength and good impact resistance over the temperature range mentioned above. A bonded dry film lubricant, to be used as an anti-galling agent, is available.

Pipe Thread Information

In some applications pipe threads may be preferred in place of standard Autoclave connections. Pipe threads for pressure seals are tapered or combination of taper and straight. A number of factors apply to pipe threads for high-pressure sealing. Thread form or the quality of the thread, which refers to the gauging or thread dimensions. Another is the actual machining of the thread producing the required finish to prevent thread galling.

Pipe threads can be used up to 15,000 psi (1034 bar) safely if proper installation procedures are followed. The following should be adhered to when using pipe threads.

NOTE: NPT (Pipe) connections

- NPT threads must be sealed using a high quality PTFE tape and/or PTFE paste product. Refer to thread sealant manufacturer’s instructions on how to apply thread sealant.
- Sealing performance may vary based on many factors such as pressure, temperature, media, thread quality, thread material, proper thread engagement and proper use of thread sealant.
- Customer should limit the number of times an NPT fitting is assembled and disassembled because thread deformation during assembly will result in deteriorating seal quality over time. When using only PTFE tape, consider using thread lubrication to prevent galling of mating parts.

Temperature limitations for pipe threads are based on material strength and thread sealant. Autoclave limits it’s pipe thread components to 0°F (17.8°C) to 400°F (204°C) and pressures as stated in the components sections.

Pressure/temperature Rating Guide

Information in this rating guide is furnished to approximate the pressure/temperature capabilities of Autoclave valves and fittings with various options.

To determine approximate ratings, the following factors should be considered:

• Refer to valve or fitting ordering pages for the base pressure rating of component at room temperature (R.T.).

• Refer to Technical Information section for pressure ratings of materials at elevated temperatures.

• Refer to appropriate tubing section for pressure ratings of standard Autoclave tubing at various temperatures to 800°F (427°C).

• Note maximum temperature ratings for Autocalve valves with various packing and stem options in table below.

• Note pressure/temperature curve on page 6 for type 316 stainless steel bodies and tubing.

• Note temperature information checklist on page 6.

Valve Stem	Stem Type			Packing Temperature: °F (°C)						
		Standard Teflon Packing		Standard Nylon-Leather		Optional Teflon Glass		Optional Graphite Yarn[1]		Optional Extended Stuffing Box
		Min	Max	Min	Max	Min	Max	Min	Max	
10V	Vee or Reg., Metal-to-Metal	-100 (-73)	450 (232)	NA	NA	-100 (-73)	600 (316)	0 (-17.8)	800[2] (427)	See page 2 of Extreme Temperature Series Needle Valve Section for information on extended stuffing box.
SW	Vee or Reg., Metal-to-Metal	-100 (-73)	450 (232)	NA	NA	-100 (-73)	600 (316)	0 (-17.8)	800[2] (427)	
10SM/20SM	Vee or Reg., Metal-to-Metal	-100 (-73)	450 (232)	NA	NA	-100 (-73)	600 (316)	0 (-17.8)	800 (427)	
30SC	Vee or Reg., Metal-to-Metal	-100 (-73)	450 (232)	NA	NA	-100 (-73)	600 (316)	NA	NA	
30VM	Vee or Reg., Metal-to-Metal	-100 (-73)	450 (232)	NA	NA	-100 (-73)	600 (316)	0 (-17.8)	800 (427)	
40VM	Vee or Reg., Metal-to-Metal	NA	NA	40 (4.4)	230 (110)	-100 (-73)	600 (316)	0 (-17.8)	800 (427)	
60VM	Vee or Reg., Metal-to-Metal	NA	NA	40 (4.4)	230 (110)	-100 (-73)	600 (316)	0 (-17.8)	800 (427)	
100VM	Vee Stem, Metal-to-Metal	NA	NA	40 (4.4)	230 (110)	NA	NA	NA	NA	
15Y	Vee or Reg., Metal-to-Metal	-100 (-73)	450 (232)	NA	NA	-100 (-73)	600 (316)	0 (-17.8)	800 (427)	
50Y	Vee or Reg., Metal-to-Metal	-100 (-73)	450 (232)	NA	NA	NA	NA	0 (-17.8)	800 (427)	
10VRMM	Micrometering	-100 (-73)	450 (232)	NA	NA	-100 (-73)	600 (316)	0 (-17.8)	800[2] (427)	
30VRMM	Micrometering	-100 (-73)	450 (232)	NA	NA	-100 (-73)	600 (316)	0 (-17.8)	800 (427)	
60VRMM	Micrometering	NA	NA	40 (4.4)	230 (110)	-100 (-73)	600 (316)	0 (-17.8)	800 (427)	
		(No Suffix Required)				(Add "TG" to Order Number)		(Add "GY" to Order Number)		

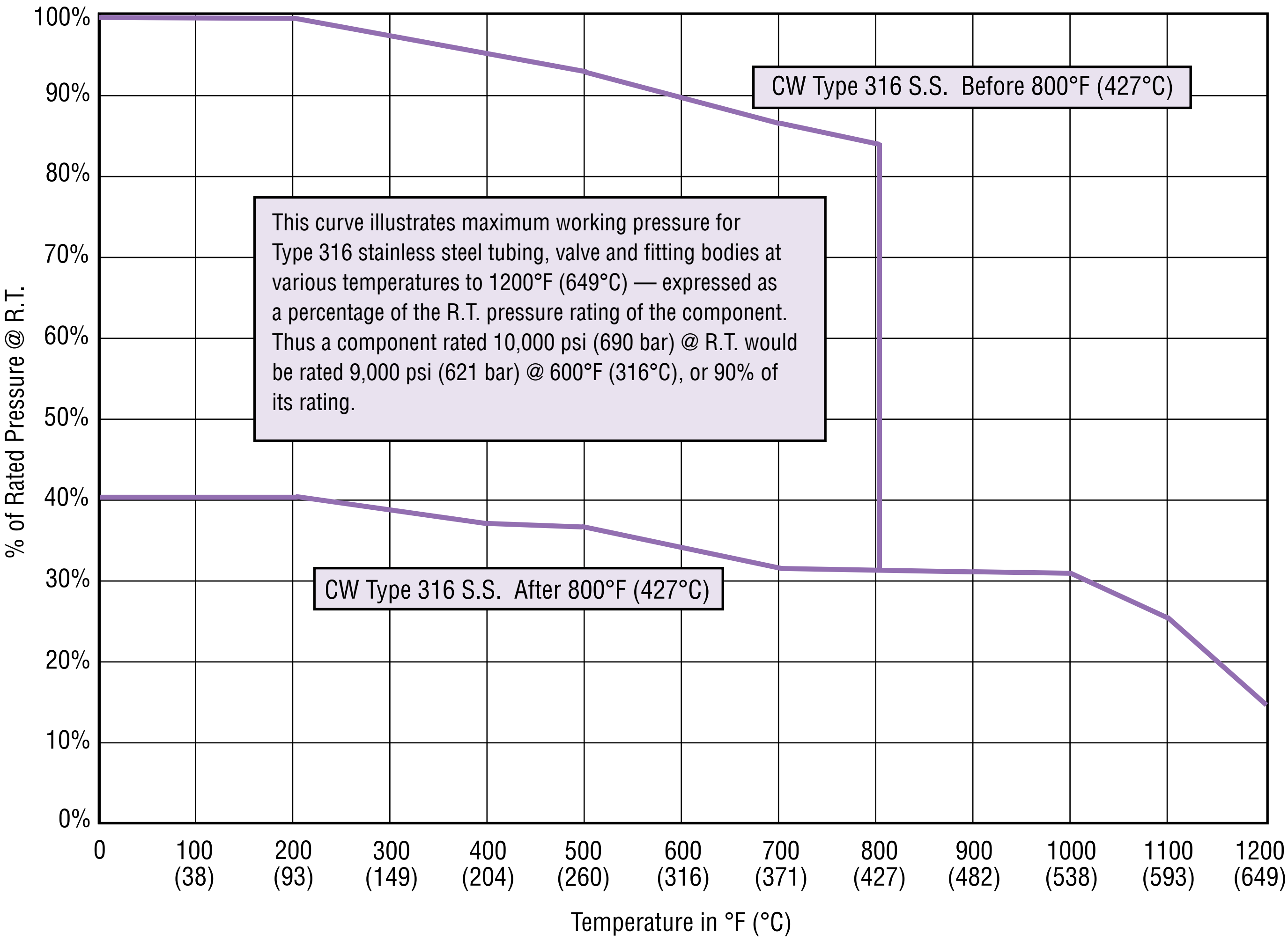
Caution: While testing has shown O-rings to provide satisfactory service life, both cyclic and shelf life may vary widely with differing service conditions, properties of reactants, pressure and temperature cycling and age of the O-ring. FREQUENT INSPECTION SHOULD BE MADE to detect any deterioration, and O-rings replaced as required.

Note:
1. Optional graphite-yarn packing not recommended for hydrogen or helium service.

2. Compression sleeve-type connections such as Autoclave Engineers' UniVersaLok, Autoclave Engineers' SpeedBite or other swaged or bite-type connections are not recommended for service above 650°F (343°C) or below 0°F (-17.8°C). For such applications, Autoclave Engineers recommends its medium pressure components with Autoclave Engineers Medium Pressure coned-and -threaded connections, offering excellent thermal cycling capability.

3. Pressure Limitations: Consult factory on 3/4 and 1 inch sizes.

Pressure/Temperature Rating Curve: 316 SS & 304 SS



Note:

Curves and ratings presented here are average values for reference only, and can be significantly affected by pressure and temperature characteristics of trim and packing materials. For unusual pressure/temperature requirements, please consult factory for recommended body, trim and packing specifications.

For pressure temperature information on components supplied in materials other than Type 316 stainless steel, refer to pages 9-10.

* Curve is valid for cold-worked Type 316 stainless steel components as long as operating temperature does not exceed 800°F (427°C). When exceeding this temperature, the cold worked effect is PERMANENTLY altered, and the components should be considered as annealed material, using 40% of its cold-worked rating for future operation of the components.

Temperature Information Checklist

	-423° to -100°F (-253° to -73°C)	-100° to 0°F (-73° to -17.8°C)	0° to 650°F (-17.8° to 343°C)	650° to 800°F (343° to 427°C)	800° to 1200°F (427° to 649°C)
Compression Type Connections	Not Recommended	Not Recommended	Recommended	Not Recommended	Not Recommended
Coned-and-Threaded Connections	Required	Required	Recommended	Required	Required
Extended Stuffing Box	Required (Teflon Packing)*	May be Required**	May be Required**	May be Required**	Required (Graphite-Yarn Packing)†

† Packing temperature not to exceed 800°F (427°C)
* Packing temperature not to go below -100°F (-73°C)

** Extended stuffing box required for operation below -100°F (-73°C) and above 450°F (232°C) (with Teflon packing) or 600°F (316°C) (with Teflon glass packing).

For prompt service, Autoclavce stocks select products. Consult factory.

Autocalve Engineers Valves, Fittings and Tubing

Valves & Fittings

Valve Series	Connection Type	Tube Size (in.)	Material vs. Pressure Rating psi (bar) @ Room Temperature *							
			316CW (Std.)	Hastelloy C276	Inconel 600	Inconel 625	Monel 400	Nickel 200	Titanium Gr2	Titanium 6AL4V
10V	W125	1/8	15,000 (1034)	11,000 (758)	11,000 (758)	11,000 (758)	9,900 (683)	6,000 (414)	7,500 (531)	11,000 (758)
	W250	1/4	15,000 (1034)	11,500 (793)	11,500 (793)	11,500 (793)	9,900 (683)	6,000 (414)	7,500 (531))	11,500 (793)
	W375	3/8	15,000 (1034)	7,500 (517)	7,500 (517)	7,500 (517)	6,300 (434)	3,800 (262)	4,800 (331)	7,500 (517)
	W500	1/2	10,000 (690)	5,500 (379)	5,500 (379)	5,500 (379)	4,600 (317)	2,700 (186)	3,400 (234)	5,500 (379)
SW	SW250	1/4	15,000 (1034)	9,600 (662)	7,700 (531)	12,500 (862)	6,300 (434)	3,800 (262)	4,800 (331)	11,500 (793)
	SW375	3/8	15,000 (1034)	7,500 (517)	7,500 (517)	7,500 (517)	6,300 (434)	3,800 (262)	4,800 (331)	7,500 (517)
	SW500	1/2	10,000 (690)	5,500 (379)	5,500 (379)	5,500 (379)	4,600 (317)	2,700 (186)	3,400 (234)	5,500 (379)
10SM	SF562CX10	9/16	10,000 (690)	10,000 (690)	9,300 (641)	10,000 (690)	6,600 (455)	4,000 (276)	6,600 (455)	10,000 (690)
	SF70CX10	3/4	10,000 (690)	10,000 (690)	9,300 (641)	10,000 (690)	6,600 (455)	4,000 (276)	6,600 (455)	10,000 (690)
	SF1000CX10	1	10,000 (690)	10,000 (690)	9,300 (641)	10,000 (690)	6,600 (455)	4,000 (276)	6,600 (455)	10,000 (690)
20SM	SF250CX	1/4	20,000 (1379)	12,200 (841)	9,300 (641)	15,000 (1034)	6,600 (455)	4,000 (276)	6,600 (455)	20,000 (1379)
	SF375CX	3/8	20,000 (1379)	12,200 (841)	9,300 (641)	15,000 (1034)	6,600 (455)	4,000 (276)	6,600 (455)	20,000 (1379)
	SF562CX20	9/16	20,000 (1379)	12,200 (841)	♦	15,000 (1034)	♦	♦	♦	20,000 (1379)
	SF750CX20	3/4	20,000 (1379)	12,200 (841)	♦	15,000 (1034)	♦	♦	♦	20,000 (1379)
	SF1000CX20	1	20,000 (1379)	12,200 (841)	♦	15,000 (1034)	♦	♦	♦	20,000 (1379)
30VM	F250C	1/4	30,000 (2068)	22,400 (1544)	17,300 (1193)	22,500 (1551)	13,000 (896)	8,200 (565)	15,200 (1048)	30,000 (2068)
	F375C	3/8	30,000 (2068)	22,400 (1544)	17,300 (1193)	22,500 (1551)	13,000 (896)	8,200 (565)	15,200 (1048)	30,000 (2068)
	F562C	9/16	30,000 (2068)	22,400 (1544)	17,300 (1193)	22,500 (1551)	13,000 (896)	8,200 (565)	15,200 (1048)	30,000 (2068)
40VM	F562C40	9/16	40,000 (2758)	23,500 (1620)	18,400 (1269)	27,000 (1862)	13,800 (951)	8,700 (600)	16,200 (1117)	40,000 (2758)
60VM	F250C	1/4	60,000 (4137)	35,900 (2475)	27,700 (1910)	35,900 (2475)	20,800 (1434)	13,100 (903)	24,300 (1675)	60,000 (4137)
	F375C	3/8	60,000 (4137)	35,900 (2475)	27,700 (1910)	35,900 (2475)	20,800 (1434)	13,100 (903)	24,300 (1675)	60,000 (4137)
	F562C	9/16	60,000 (4137)	35,900 (2475)	27,700 (1910)	35,900 (2475)	20,800 (1434)	13,100 (903)	24,300 (1675)	60,000 (4137)

* For ratings at elevated temperatures see P/T Rating Curves on pages 9 and 10.

♦ Use 10SM Series

Tubing, connection type and/or packing material may limit maximum temperature rating. See pages 5 and 6 for further temperature limitations.

Tubing (Seamless) - Low Pressure**

Valve Series	Tubing Size Outside x Inside Diameter Inches (mm)	Material vs. Pressure Rating psi (bar) @ Room Temperature ††*						
		316CW†	Hastelloy C276	Inconel 600	Inconel 625	Monel 400	Nickel 200	Titanium Gr2
Low Pressure	1/16 x 0.026 **(1.59 x 0.66)**	15,000 **(1034.20)**	15,000 **(1034.20)**	15,000 **(1034.20)**	15,000 **(1034.20)**	11,500 **(792.88)**	7,100 **(489.52**	11,500 **(792.88**
	1/8 x 0.052 **(3.19 x 1.32)**	15,000 **(1034.20)**	15,000 **(1034.20)**	15,000 **(1034.20)**	15,000 **(1034.20)**	12,000 **(827.36)**	7,200 **(496.41)**	12,000 **(827.36)**
	1/8 x 0.062 **(3.19 x 1.57)**	11,650 **(803.23)**	14,000 **(965)**	11,000 **(758.41)**	11,650 **(803.23)**	9,900 **(682.57)**	6,000 **(413.68)**	7,500 **(517.10)**
	1/8 x 0.069 **(3.19 x 1.75)**	9,950 **(686.02)**	11,000 **(758.41)**	10,600 **(730.83)**	11,500 **(792.88)**	9,300 **(641.26)**	5,300 **(365.42)**	6,650 **(458.49)**
	1/8 x 0.085 **(3.19 x 2.16)**	6,850 **(472.28)**	7,750 **(534.34)**	7,300 **(503.31)**	10,000 **(689.46)**	6,400 **(441.26)**	3,650 **(251.65)**	4,450 **(306.81)**
	1/4 x 0.125 **(6.35 x 3.18)**	11,650 **(803.23)**	11,500 **(792.88)**	11,500 **(792.88)**	12,500 **(861.83)**	9,900 **(682.57)**	6,000 **(413.68)**	7,500 **(517.10)**
	1/4 x 0.180 **(6.35 x 4.57)**	5,450 **(375.76)**	6,650 **(458.49)**	6,300 **(434.36)**	9,000 **(620.52)**	5,500 **(379.21)**	3,150 **(217.18)**	3,900 **(268.89)**
	1/4 x 0.194 **(6.35 x 4.93)**	4,600 **(317.15)**	5,200 **(358.52)**	4,900 **(337.84)**	7,200 **(496.41)**	4,300 **(296.47)**	2,450 **(168.92)**	3,050 **(210.29)**

Tubing (Seamless) - Low Pressure, continued on page 8

†† The tubing pressure rating in some instances is lower than the rating of the valve and fitting. Tubing connection type and/or packing material may limit maximum temperature rating. See pages 5 & 6 for further temperature limitations.

† Except low pressure series which is 316 annealed.
* For ratings at elevated temperatures see P/T Rating Curves on pages 9 & 10.
** Except Hastelloy C276 which is welded and drawn or seamless.

Tubing (Seamless) - Low Pressure** - continued

Valve Series	Tubing Size Outside x Inside Diameter Inches (mm)	Material vs. Pressure Rating psi (bar) @ Room Temperature ††*						
		316CW†	Hastelloy C276	Inconel 600	Inconel 625	Monel 400	Nickel 200	Titanium Gr2
Low Pressure	3/8 x 0.195 **(9.53 x 4.95)**	10,000 **(689.46)**	10,000 **(689.46)**	10,000 **(689.46)**	7,500 **(517.10)**	8,800 **(606.73)**	5,300 **(365.42)**	6,600 **(455.05)**
	3/8 x 0.250 **(9.53 x 6.35)**	7,500 **(517.10)**	7,500 **517.10)**	7,500 **(517.10)**	7,500 **(517.10)**	6,300 **(434.36)**	3,800 **(262.00)**	4,800 **(330.94)**
	3/8 x 0.277 **(9.53 x 7.04)**	5,450 **(375.76)**	6,150 **(424.02)**	5,800 **(399.89)**	7,500 **(517.10)**	5,100 **(351.63)**	2,900 **(199.942)**	3,600 **(248.21)**
	3/8 x 0.305 **(9.53 x 7.75)**	3,800 **(262.00)**	4,250 **(293.02)**	4,000 **(275.79)**	5,000 **(344.73)**	3,500 **(241.31)**	2,100 **(144.79)**	2,500 **(172.37)**
	1/2 x 0.375 **(12.70 x 9.53)**	5,500 **(379.21)**	5,500 **(379.21)**	5,500 **(379.21)**	5,500 **(379.21)**	4,600 **(317.15)**	2,700 **(186.16)**	3,450 **(237.87)**
	1/2 x 0.402 **(12.70 x 10.21)**	4,000 **(275.79)**	4,500 **(310.26)**	4,250 **(293.02)**	5,000 **(344.73)**	3,700 **(255.10)**	2,100 **(144.79)**	2,650 **(182.71)**

†† The tubing pressure rating in some instances is lower than the rating of the valve and fitting. Tubing connection type and/or packing material may limit maximum temperature rating. See pages 5 & 6 for further temperature limitations.

† Except low pressure sereis which is 316 annealed.
* For ratings at elevated temperatures see P/T Rating Curves on pages 9 & 10.
** Except Hastelloy C276 which is welded and drawn or seamless.

Tubing (Seamless) - Medium Pressure

Valve Series	Tubing Size Outside x Inside Diameter Inches (mm)	Material vs. Pressure Rating psi (bar) @ Room Temperature ††*						
		316CW	Hastelloy C276	Inconel 600	Inconel 625	Monel 400	Nickel 200	Titanium Gr2
Medium Pressure	1/4 x 0.109 **(6.35 x 2.77)**	20,000 **(1378.93)**	15,000 **(1034.20)**	8,450 **(582.60)**	15,000 **(1034.20)**	6,600 **(455.05)**	3,600 **(248.21)**	6,600 **(455.05)**
	3/8 x 0.203 **(9.53 x 5.16)**	20,000 **(1378.93)**	15,000 **(1034.20)**	8,450 **(582.60)**	15,000 **(1034.20)**	6,600 **(455.05)**	3,600 **(248.21)**	6,600 **(455.05)**
	9/16 x 0.312 **(14.29 x 7.92)**	20,000 **(1378.93)**	15,000 **(1034.20)**	8,450 **(582.60)**	15,000 **(1034.20)**	6,600 **(455.05)**	3,600 **(248.21)**	6,600 **(455.05)**
	9/16 x 0.359 **(14.29 x 9.12)**	10,000 **(689.46)**	10,000 **(689.46)**	5,175 **(356.80)**	12,000 **(827.36)**	4,150 **(286.13)**	2,225 **(153.41)**	5,925 **(408.51)**
	3/4 x 0.438 **(19.05 x 11.13)**	20,000 **(1378.93)**	15,000 **(1034.20)**	8,450 **(582.60)**	15,000 **(1034.20)**	6,600 **(455.05)**	3,600 **(248.21)**	6,600 **(455.05)**
	3/4 x 0.516 **(19.05 x 13.11)**	10,000 **(689.46)**	10,000 **(689.46)**	5,175 **(356.80)**	12,000 **(827.36)**	4,150 **(286.13)**	2,225 **(153.41)**	5,925 **(408.51)**
	1.00 x 0.562 **(25.40 x 14.27)**	20,000 **(1378.93)**	15,000 **(1034.20)**	8,450 **(582.60)**	15,000 **(1034.20)**	6,600 **(455.05)**	3,600 **(248.21)**	6,600 **(455.05)**
	1.00 x 0.688 **(25.40 x 17.48)**	10,000 **(689.46)**	10,000 **(689.46)**	5,175 **(356.80)**	12,000 **(827.36)**	4,150 **(286.13)**	2,225 **(153.41)**	5,925 **(408.51)**

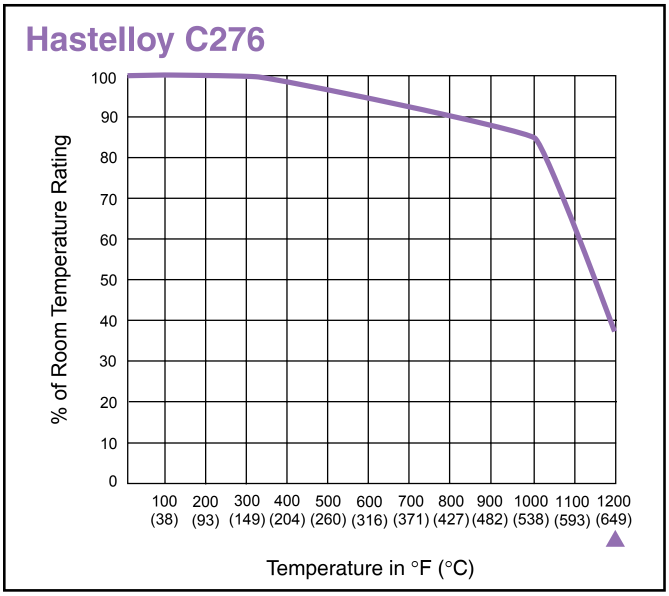
Tubing (Seamless) - High Pressure

Valve Series	Tubing Size Outside x Inside Diameter Inches (mm)	Material vs. Pressure Rating psi (bar) @ Room Temperature ††*						
		316CW	Hastelloy C276	Inconel 600	Inconel 625	Monel 400	Nickel 200	Titanium Gr2
High Pressure	1/4 x 0.083 **(6.35 x 2.11)**	60,000 **(4136.79)**	30,000 **(1934.98)**	21,300 **(1468.56)**	35,900 **(2475.18)**	17,025 **(1173.81)**	9,125 **(629.14)**	24,300 **(1675.40)**
	3/8 x 0.125 **(9.53 x 3.18)**	60,000 **(4136.79)**	30,000 **(1934.98)**	21,300 **(1468.56)**	35,900 **(2475.18)**	17,025 **(1173.81)**	9,125 **(629.14)**	24,300 **(1675.40)**
	9/16 x 0.188 **(14.27 x 4.78)**	60,000 **(4136.79)**	30,000 **(1934.98)**	21,300 **(1468.56)**	35,900 **(2475.18)**	17,025 **(1173.81)**	9,125 **(629.14)**	24,300 **(1675.40)**
	9/16 x 0.250 **(14.27 x 6.35)**	40,000 **(2757.86)**	23,000 **(1483.48)**	15,400 **(1061.78)**	27,000 **(1861.56)**	11,000 **(758.41)**	6,600 **(455.05)**	17,600 **(1213.46)**
	1 x 0.438 **(25.40 x 11.13)**	43,000 **(2964.70)**	23,000 **(1483.48)**	15,900 **(1096.25)**	28,000 **(1930.50)**	11,300 **(779.10)**	6,800 **(468.84)**	18,200 **(1254.83)**

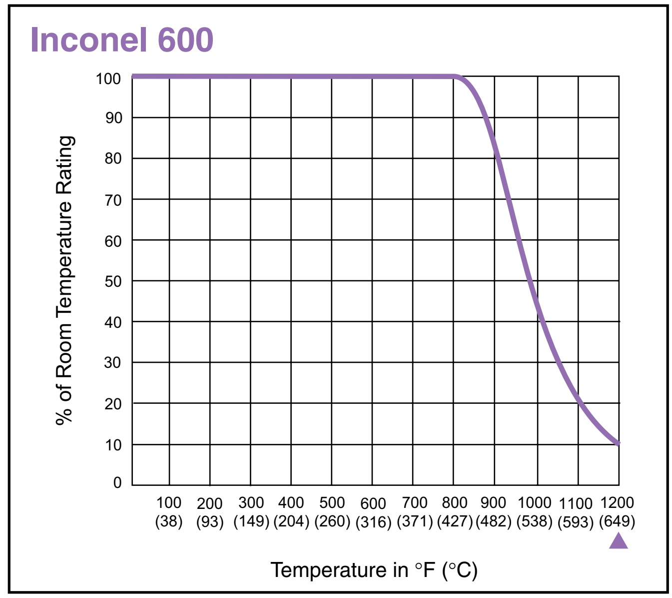
†† The tubing pressure rating in some instances is lower than the rating of the valve and fitting. Tubing connection type and/or packing material may limit maximum temperature rating. See pages 5 & 6 for further temperature limitations.

† Except low pressure series which is 316 annealed.
* For ratings at elevated temperatures see P/T Rating Curves on pages 9 & 10.

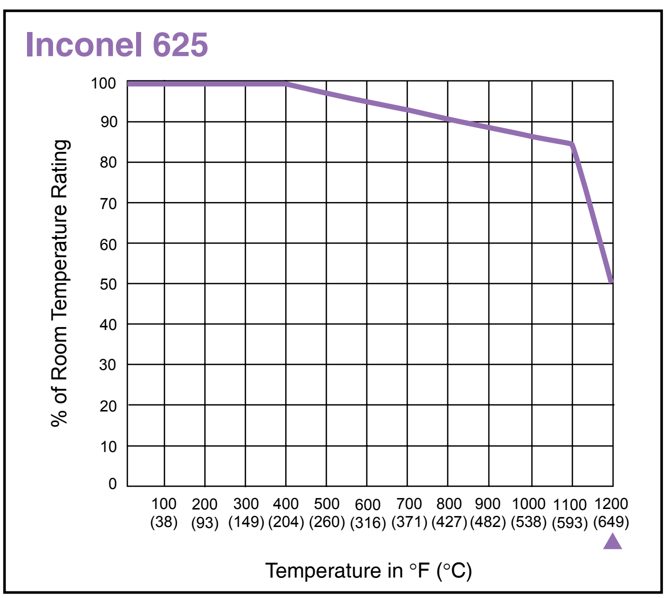
Pressure vs. Temperature Rating Curves



▲ Maximum Coincident Metal Temperature



▲ Maximum Coincident Metal Temperature



▲ Maximum Coincident Metal Temperature

Curves and ratings presented here are average values for reference only and can be significantly affected by pressure and temperature characteristics of trim materials, stem packing materials (or o-rings), and connection type. Other options such as an extended stuffing box will be required to achieve the maximum temperature rating. See pages 5 and 6 for further temperature limitations. For unusual pressure/temperature requirements, please consult factory for recommended body, trim and packing specifications.

To obtain the maximum pressure rating at an elevated temperature, multiply the maximum pressure rating of the item (in special material) at room temperature, by the elevated temperature factor (% of RT).

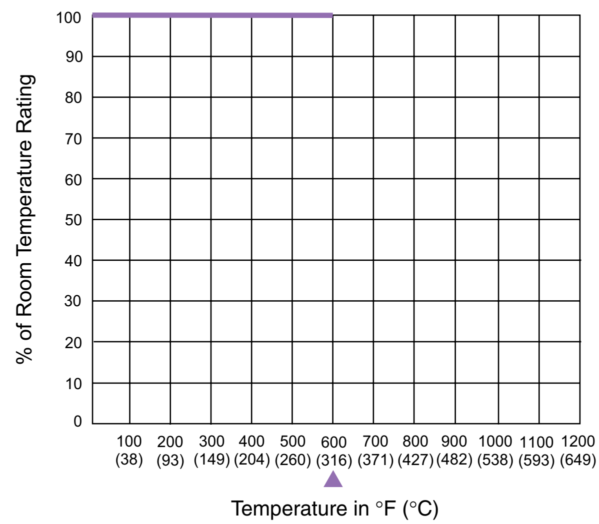
Example: What would be the pressure rating of a 30VM 1/4 inch valve constructed of Hastelloy C276 at 600°F (316°C)?

From the Material vs. Pressure rating chart on pages 7 & 8 for valves and fittings, the maximum pressure rating for a 30VM 1/4 inch valve constructed of Hastelloy C276 would be 22,400 psi (1544 bar).

To determine the approximate pressure rating at 600°F (316°C), the Pressure vs. Temperature Rating Curves will be used. A vertical line on the x-axis (Temperature) is traced at 600°F (316°C) [on the Hastelloy C276 graph], until it intersects the curve. A horizontal line is then drawn to the y-axis (% of rated pressure @ RT) and read as 93%. The room temperature rating of the Hastelloy C276 valve is multiplied by the temperature reduction factor (.93) 22,400 psi (1544 bar) to approximate the temperature corrected pressure of 20,800 psi (1434 bar).

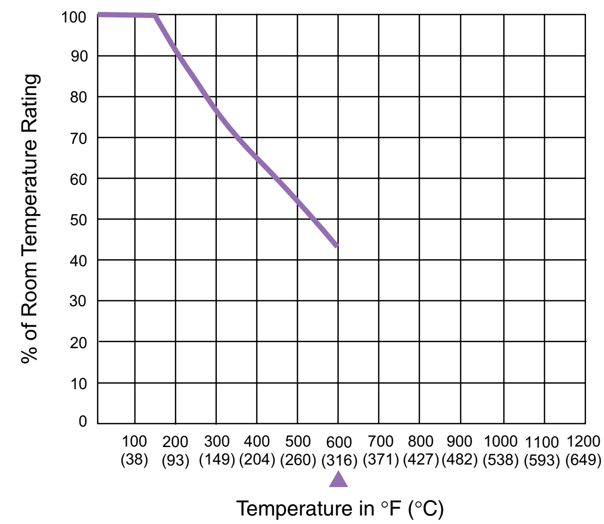
See page 5 for further packing temperature limitations.

Nickel 200



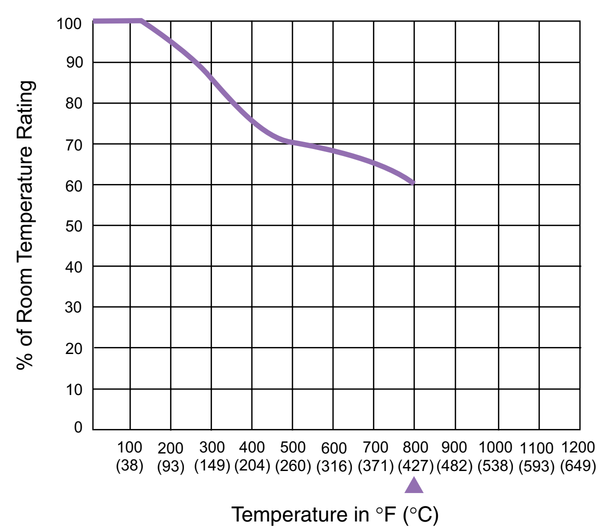
▲ Maximum Coincident Metal Temperature

Titanium Grade 2



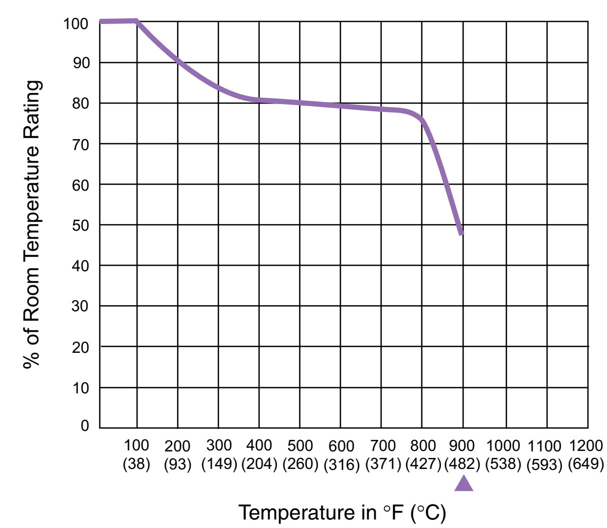
▲ Maximum Coincident Metal Temperature

Titanium 6AL4V



▲ Maximum Coincident Metal Temperature

Monel 400



▲ Maximum Coincident Metal Temperature

Curves and ratings presented here are average values for reference only and can be significantly affected by pressure and temperature characteristics of trim materials, stem packing materials (or o-rings), and connection type. Other options such as an extended stuffing box will be required to achieve the maximum temperature rating. See pages 5 and 6 for further temperature limitations. For unusual pressure/temperature requirements, please consult factory for recommended body, trim and packing specifications.

To obtain the maximum pressure rating at an elevated temperature, multiply the maximum pressure rating of the item (in special material) at room temperature, by the elevated temperature factor (% of RT).

Example: What would be the pressure rating of a 30VM 1/4 inch valve constructed of Titanium Grade 2 at 600°F (316°C)?

From the Material vs. Pressure rating chart on pages 7 & 8 for valves and fittings, the maximum pressure rating for a 30VM 1/4 inch valve constructed of Titanium Grade 2 would be 15,200 psi (1048 bar).

To determine the approximate pressure rating at 600°F (316°C), the Pressure vs. Temperature Rating Curves will be used. A vertical line on the x-axis Temperature) is traced at 600°F (316°C) [on the Titanium Grade 2 graph], until it intersects the curve. A horizontal line is then drawn to the y-axis (% of rated pressure @ RT) and read as 44%. The room temperature rating of the Titanium Grade 2 valve is multiplied by the temperature reduction factor (.44) 15,200 psi (1048 bar) to approximate the temperature corrected pressure of 6,688 psi (461 bar).

See page 5 for further packing temperature limitations.

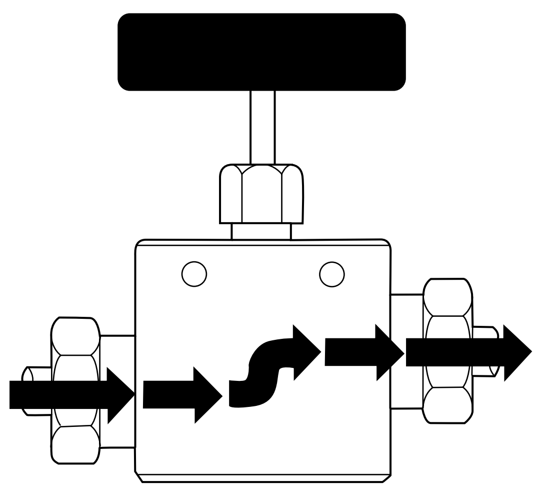
Technical Information - Flow Calculations

Liquids & Gases

Coefficient of flow (C_v)for a valve is the volume of water, in U.S gallons per minute at room temperature, which will flow through the valve with the stem fully open with a pressure drop of 1 psi (.069 bar) across the valve. C_v is the valve sizing factor that permits selection of the appropriate valve to meet flow requirements of a given fluid system

The flow capacity curves presented in the ordering pages for each series of Autoclave valves show the C_v for all series, sizes and stem types per number of turns of the stem. These curves also illustrate the relative flow patterns for a vee on-off stem and a regulating stem.

The C_v values shown on the valve ordering pages represent the full-open C_v for that valve. In determining estimated capacity, this C_v value should be used in the formulas which follow.



For 2 way angle patterns, increase Cv value 50%

Specific Gravity (Sg)
Typical Gases

Gas	SG@RT Relative to Air
Acetylene	0.897
Air	1.000
Ammonia	0.587
Argon	1.377
Butane	2.070
Carbon Dioxide	1.516
Ethylene	0.967
Helium	0.138
Hydrogen	0.0695
Methane	0.553
Nitrogen	0.966
Oxygen	1.103
Propane	1.562
Sulphur Dioxide	2.208

Specific Gravity (Sgf)
Typical Liquid

Liquid	SGF@RT Relative to Water
Acetone	0.792
Alcohol	0.792
Benzine	0.902
Gasoline	0.751
Gasoline, nat.	0.680
Kerosene	0.815
Pentane	0.624
Water	1.000

Flow Formulas

Liquids

☐ Flow, U.S. gal./min.

$$\mathbf{V} = \frac{C_V \sqrt{P_1 - P_2}}{\sqrt{S_{GF}}}$$

☐ Flow, lb./hr.

$$\mathbf{V} = 500\ C_V \sqrt{(P_1 - P_2)/S_{GF}}$$

Gases

☐ Flow, SCFH

$$\mathbf{Q} = \frac{42.2\ C_V \sqrt{(P_1 - P_2)(P_1 + P_2)}}{\sqrt{S_{GF}}}\ ^{*\dagger}$$

☐ Flow, SCFH (temperature corrected)

$$\mathbf{Q} = \frac{963\ C_V \sqrt{(P_1 - P_2)(P_1 + P_2)}}{\sqrt{S_G T_F}}\ ^{\dagger}$$

☐ Flow, lb./hr.

$$\mathbf{W} = 3.22\ C_V \sqrt{(P_1 - P_2)(P_1 + P_2)/S_G}\ ^{\dagger}$$

Saturated Steam

☐ Flow, lb./hr.

$$\mathbf{W} = 2.1\ C_V \sqrt{(P_1 - P_2)(P_1 + P_2)}\ ^{\dagger}$$

Super Heated Steam

☐ Flow, lb./hr.

$$\mathbf{W} = \frac{2.1\ C_V \sqrt{(P_1 - P_2)(P_1 + P_2)}}{(1 + 0.0007\ T_S)}\ ^{\dagger}$$

Formula Nomenclature

V = Flow, U.S. gallons per minute (GPM)
Q = Flow, standard cu.ft. per hr. (SCFH)
W = Flow, pounds per hour (lb./hr.)
P1 = Inlet pressure, psia (14.7 + psig)
P2 = Outlet pressure, psia (14.7 + psig)
Sgf = Liquid specific gravity (water = 1.0)
Sg = Gas specific gravity (air = 1.0)
Tf = Flowing temp., °R absolute (460 + °F)
Ts = Superheat in °F
Cv = Valve coefficient of flow, full open

** Effect of flowing temperatures on gas flow are minimal for temperatures between 30°F (-1.1°C) and 150°F (66°C). Correction should be included if temperatures are higher or lower.*

† Where outlet pressure P_2 is less than 1/2 inlet pressure P_1, the term:

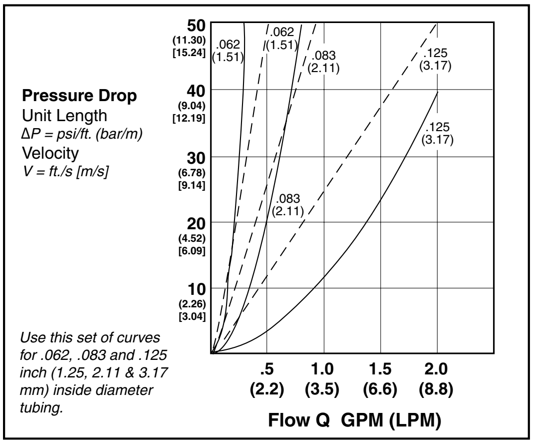
$$\sqrt{(P_1 - P_2)(P_1 + P_2)}\ \textit{becomes}\ 0.87\ P_1$$

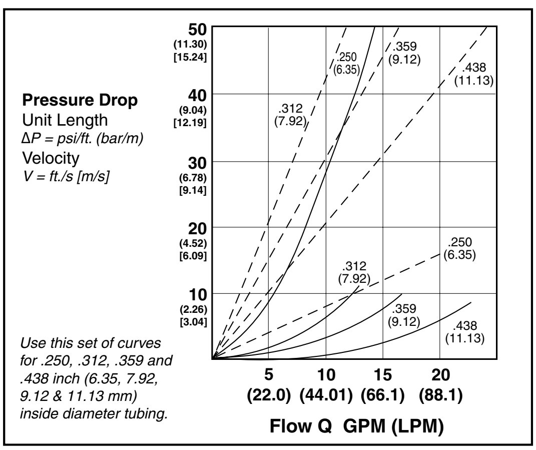
Note: Maximum Cv values in this catalog have been determined in accordance with the Fluid Controls Institute report FCI58-2. "Recommended Voluntary Standards for Measurement Procedure for Determining Control Valve Flow Capacity," including procedure, design of the test stand and evaluation of the data.

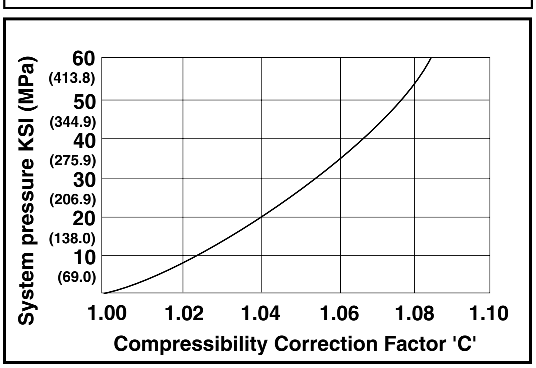
Tubing

Theoretical Pressure Drop & Fluid Velocity vs. Flow,
Autoclave Engineers Medium and High Pressure Tubing.
(Based on water @ RT)

Legend			
	———	Pressure drop	ΔP = psi/ft. (bar/m)
	— — —	Velocity	V = Ft./s (m/s)

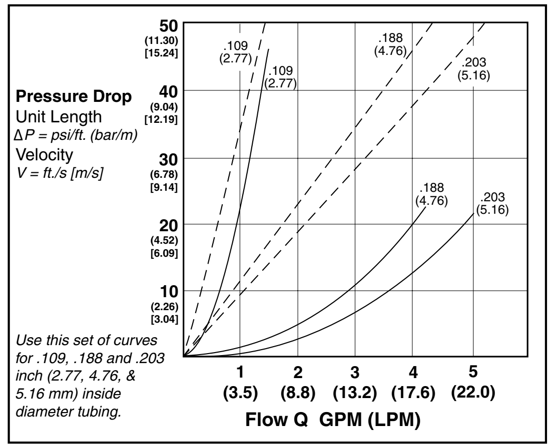


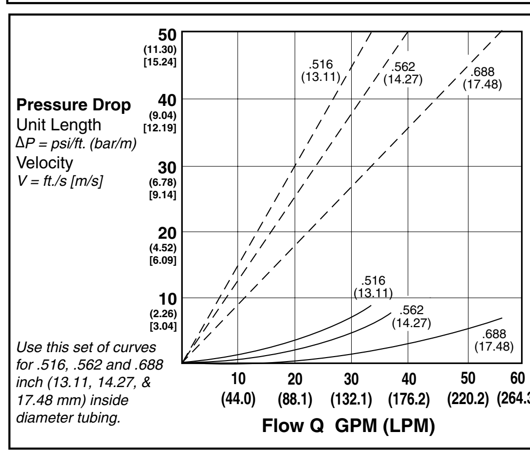




Note: Multiply pressure drop (ΔP/ft) from graph above by factor 'C' to correct for system pressure above atmospheric. Higher system pressure increases the fluid density resulting in higher system pressure loss.

Instructions: To determine the expected pressure drop, per foot of tube length, select the appropriate curves based on tube Inside Diameter. Follow the graph vertically at the design flow rate (X-axis) until it intersects the solid line, then move horizontally to read the expected pressure drop per foot (Y-axis). Multiply this by the total tube length to obtain the total pressure loss. See note below to correct for system pressures above atmospheric. To determine the average fluid velocity, repeat the above procedure, but use the dashed line. The pressure drop is for straight lengths of tube only.





Example: What would be the expected pressure drop and average fluid velocity at 1 gallon (4.4 liter) per minute of water through 100 feet (30.48 meters) of 3/8 outside diameter x .125 inside diameter tubing at 30,000 psi (2068 bar) will be used. This curve lists .125 inch (.317mm) inside diameter data.

From the x-axis (Flow "Q" GPM (LPM) at 1 GPM (3.5 LPM) a vertical line is drawn until it intersects the solid line labeled ".125 (3.17mm)".
A horizontal line is then traced to the y-axis)Pressure Drop/Unit Length) and is read 12 psi/ft. (2.71 bar/m).

Since the system pressure is 30,000 psi (2068 bar), a correction must be made to this value 12 psi/ft. (2.71 bar/m). The small graph in the lower left corner is used to determine this correction factor. A horizontal line on this graph is drawn from the y-axis System Pressure KSI (MPa) until it intersects the curve. It is then traced vertically to the x-axis (Compressibility Correction Factor 'C') and is read as 1.054.

To determine the total pressure drop, multiply the total tube length by the expected pressure drop per foot and by the correction factor 'C' (100) (12) (1.054) = 1,265 psi [(30.48m)(2.71 bar/m) (1.054)=87.10 bar].

The average fluid velocity is determined in a similar way except that on the original graph, the dashed line is used instead of the solid line. the average fluid velocity at 1 GPM (4.4 LPM) would be 25 ft/s (7.62 m/s). No correction needs to be made for elevated system pressures.

Technical Information - Conversion Tables

Temperature Equivalents

Fahrenheit °F	Celcius °C	Rankine°R	Kelvin°K
0	-18	460	255
32	0	492	273
-460	-273	0	0

Degrees Fahrenheit = °F

Degrees Celcius = 5/9 (°F - 32)

Degrees Kelvin = °C + 273.15

Degrees Rankine = °F + 459.67

Linear Equivalents

foot	inch	meter	centimeter	millimeter	micron	angstrom
1	12	0.3048	30.48	304.800	3.048x10^{5}	3.048x10^{9}
0.08333	1	0.0254	2.54	25.4	2.54x10^{4}	2.54x10^{8}
3.28083	39.37	1	100	1000	1x10^{6}	1x10^{10}
0.03281	0.3937	0.01	1	10	1x10^{4}	1x10^{8}
3.281x10^{-3}	0.03937	0.001	0.1	1	1000	1x10^{7}
3.281x10^{-6}	3.937x10^{-5}	1x10^{-6}	1x10^{-4}	1x10^{-3}	1	1x10^{4}
3.281x10^{-10}	3.937x10^{-9}	1x10^{-10}	1x10^{-8}	1x10^{-7}	1x10^{-4}	1

Pressure Equivalents

Pa	MPa	atm	bar	kg/cm^{2}	psi	inches Hg	Microns Hg
1	1x10^{-6}	9.8692x10^{-6}	1x10^{-5}	1.0197x10^{-5}	1.4504x10^{-4}	2.9530x10^{-4}	7.50059
1x10^{-6}	1	9.8692	10	10.1971	145.04	295.30	7.5006x10^{6}
101325	0.101325	1	1.01325	1.0332	14.696	29.921	760x10^{3}
100000	0.1	0.98692	1	1.01971	14.504	29.53	750.059x10^{3}
98066.5	0.098067	0.96784	0.98067	1	14.223	28.959	735.56x10^{3}
6894.757	6.8948x10^{-3}	0.06805	0.06895	0.07031	1	2.036	51.715x10^{6}
3386.389	3.3864x10^{-3}	0.03342	0.03386	0.03453	0.49116	1	2.54x10^{4}
0.133322	1.3332x10^{-7}	1.3158x10^{-6}	1.3332x10^{-6}	1.3595x10^{-6}	19.337x10^{-6}	39.37x10^{-6}	1

PSIG = lb./in.^{2} Gage

PSIG = lb./in.^{2} absolute

PSIA = PSIG plus atmospheric pressure

1Torr = 133.322Pa

Volume Equivalents

meter^{3}	foot^{3}	gallon*	liter	quart	inch^{3}	cc
1	35.31	264.2	1000	1056.8	61023	1x10^{6}
28.317x10^{-3}	1	7.4822	28.317	29.92	1728	28.317x10^{3}
3.785x10^{-3}	0.1337	1	3.785	4	231	3785
1x10^{-3}	0.03531	0.2642	1	1.057	61.023	1000
9.463x10^{-4}	0.03342	0.25	0.9463	1	57.75	946.25
1.638x10^{-5}	5.787x10^{-4}	43.29x10^{-4}	0.01639	0.01732	1	16.387
1x10^{-6}	35.31x10^{-6}	2.642x10^{-4}	1x10^{-3}	10.568x10^{-4}	0.06102	1

**U.S. Gallons*

US. gallon = 0.833 British Imperial gallon

British Imperial gallon = 1.201 US. gallon

US. gallon water = 8.345 pounds

British Imperial gallon water= 10.022 pounds

US. fluid ounce = 29.573 centimeters^{3}

British Imperial fluid ounce = 28.413 centimeters^{3}

Density Equivalents

pound/inch^{3}	pound/ft^{3}	pound/gallon^{3}	kg/meter*	gram/cm^{3}
1	1728	231	27.68x10^{3}	27.6797
5.787x10^{-4}	1	0.1337	16.018	0.01602
4.33x10^{-3}	7.48	1	119.8257	0.11983
3.613x10^{-5}	0.06243	8.3445x10^{-3}	1	.001
0.03613	62.43	8.3445	1000	1

**U.S. Gallons*

Fluid Flow Equivalents

*gal/hr	*gal/min	cu ft/hr	cu ft/min	liters/hr	liters/min	cc/min
1	0.01667	0.1337	2.228x10^{-3}	3.7848	0.06308	63.08
60	1	8.022	0.1337	227.1	3.7848	3784.8
7.48	0.1247	1	0.01667	28.32	0.472	472
448.8	7.48	60	1	1698.6	28.32	28.32x10^{3}
0.26418	4.403x10^{-3}	0.03531	5.886x10^{-4}	1	0.01667	16.67
15.8502	264.18x10^{-3}	2.11887	0.03531	60	1	1000
.01585	264.2x10^{-6}	2.1187x10^{-3}	35.3145x10^{-6}	.06	0.001	1

**U.S. Gallons*

Area Equivalents

ft^2	in^2	m^2	cm^2	mm^2
1	144	0.09291	929.034	$9.29x10^{4}$
$6.944x10^{-3}$	1	$6.451x10^{-4}$	6.4516	645.1625
10.7639	1550	1	$1x10^{-4}$	$1x10^{6}$
$1.0764x10^{-3}$	0.155	$1x10^{-4}$	1	100
$1.076x10^{-5}$	$1.55x10^{-3}$	$1x10^{-6}$	.01	1

Weight Equivalents

pound	ounce	kilogram	gram	grain
1	16	.45351	453.592	7000
0.0625	1	.02836	28.345	437.5
2.205	35.27	1	1000	$15.435x10^{3}$
$2.205x10^{-3}$	0.03527	0.001	1	15.435
$1.428x10^{-4}$	0.002285	$64.8x10^{-6}$	0.0648	1

Power Equivalents

kilowatt	horsepower*	ft lbs/sec	ft lbs/min	ft lbs/hr	Btu/sec	Btu/min	Btu/hr
1	1.341	738	44.280	$2.653x10^{6}$	0.948	56.9	3413
.7457	1	550	$33x10^{3}$	$1.99x10^{6}$	0.707	42.41	25.44
$13.55x10^{-4}$	$18.18x10^{-4}$	1	60	3600	$12.84x10^{-4}$	0.0771	4.62
$22.59x10^{-6}$	$0.303x10^{-4}$	0.01667	1	60	$21.41x10^{-6}$	$12.84x10^{-4}$	0.0771
$0.376x10^{-6}$	$0.505x10^{-6}$	$2.78x10^{-4}$	0.01667	1	$0.357x10^{-6}$	$21.41x10^{-6}$	$12.84x10^{-4}$
1.055	1.416	778	$46.7x10^{3}$	$2.802x10^{-6}$	1	60	3600
0.01759	0.02359	12.98	778	$46.7x10^{3}$	0.01667	1	60
$2.925x10^{-4}$	$3.933x10^{-4}$	0.2163	12.98	778	$2.778x10^{-4}$	0.01667	1

*U.S. Horsepower

US. horsepower = 1.014 metric horsepower

Metric. horsepower = 0.986 US. horsepower

Work or Energy Equivalents

kilowatt-hours	horsepower* hours	foot-pounds	inch-pounds	Btu	kilogram-meters	kilogram-calories	joules Newton meters
1	1.342	$2.655x10^{6}$	$31.86x10^{6}$	3415	$367.1x10^{3}$	860.238	$3.6x10^{6}$
.7457	1	$1.98x10^{6}$	$23.76x10^{6}$	2546.5	$273.546x10^{3}$	641.477	$2.685x10^{6}$
$0.376x10^{-6}$	$0.505x10^{-6}$	1	12	$1.286x10^{-3}$	0.13826	$3.239x10^{-4}$	1.3562
$0.313x10^{-7}$	$0.458x10^{-7}$	0.08333	1	$0.107x10^{-3}$	$11.522x10^{-3}$	$0.27x10^{-4}$	0.11302
$2.928x10^{-4}$	$3.929x10^{-4}$	778	9336	1	107.5	0.2519	1054.8
$2.717x10^{-6}$	$3.653x10^{-6}$	7.233	86.796	$9.302x10^{-3}$	1	$23.43x10^{-4}$	9.804
$1.161x10^{-3}$	$1.558x10^{-3}$	3088.26	37059.12	3.9683	427.32	1	4189.48
$2.774x10^{-7}$	$3.7229x10^{-7}$	0.7373	8.8476	$9.478x10^{-4}$	0.10194	$2.39x10^{-4}$	1

*U.S. Horsepower

Velocity Equivalents

cm/sec	meter/sec	meter/min	kilometer/hr	feet/sec	feet/min	mile/hr
1	0.01	0.6	0.036	0.03281	1.9685	0.02237
100	1	60	3.6	3.281	196.85	2.2369
1.667	0.01667	1	0.06	0.05468	3.281	.03728
27.78	0.2778	16.67	1	0.91134	54.681	0.62137
30.48	0.3048	18.29	1.0973	1	60	0.68182
0.508	$508x10^{-3}$	0.3048	0.01829	0.01667	1	0.01136
44.704	0.44704	26.82	1.6093	1.4667	88	1

Statute mile/hour = .8684 knot

Knot = 1.1516 mile/hour = 1.689 feet/second

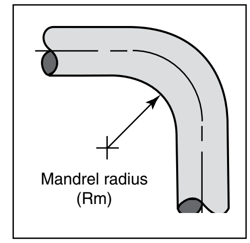
1 Statue Mile = 5280 feet

1 Nautical Mile = 6076 feet

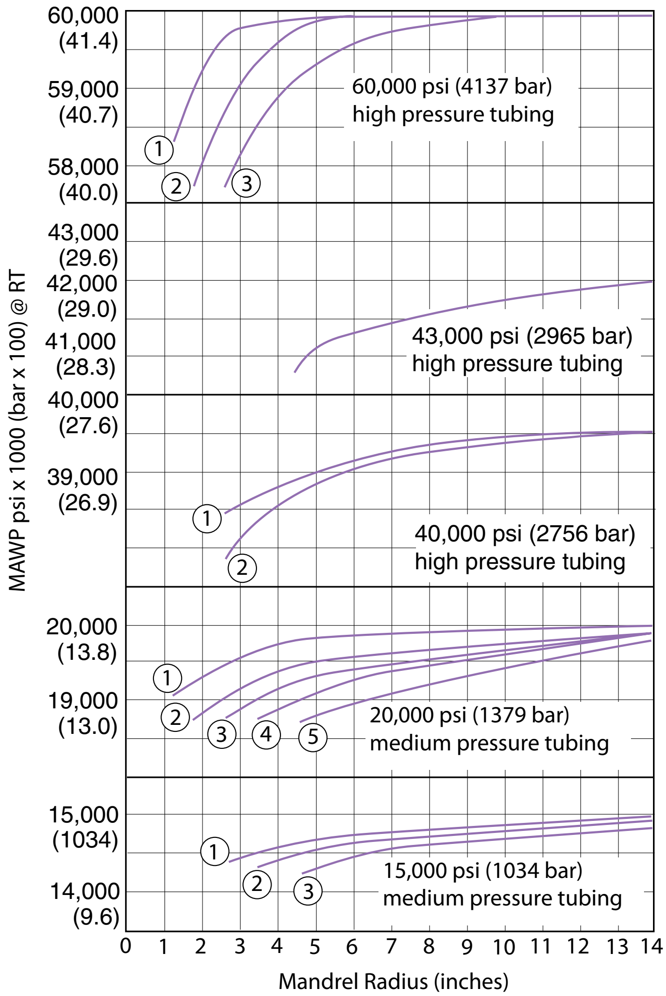
Technical Information - Pressure vs. Bend Radius

Tubing

Allowable Pressure vs. Bend (Mandrel) Radius



Autoclave Engineers Medium & High Pressure tubing (316 & 304 SS)



60,000 and 100,000 psi (4137 & 6895 bar)
High Pressure Tubing

	Size Inches	Rm (min.) inches (mm)
①	1/4 x .083	1.25 (31.8)
②	3/8 x .125	1.75 (44.5)
③	9/16 x .188	2.625 (66.7)

43,000 psi (2965 bar)
High Pressure Tubing

Size Inches	Rm (min.) inches (mm)
1 x .438	4.625 (117.5)

40,000 psi (2758 bar)
High Pressure Tubing

	Size Inches	Rm (min.) inches (mm)
①	9/16 x .250	2.625 (66.7)
②	9/16 x .312	

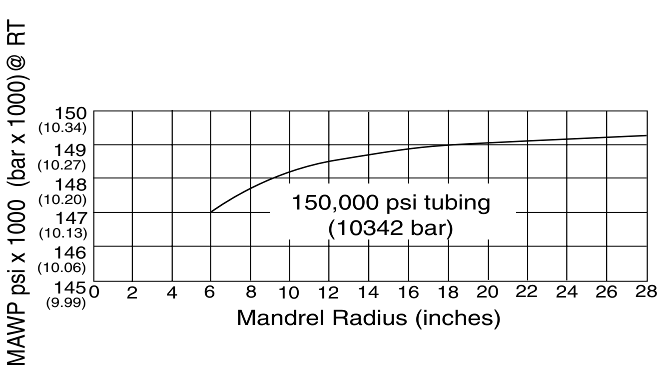
20,000 psi (1379 bar)
Medium Pressure Tubing

	Size Inches	Rm (min.) inches (mm)
①	1/4 x .109	1.25 (31.8)
②	3/8 x .203	1.75 (44.5)
③	9/16 x .312	2.625 (66.7)
④	3/4 x .438	3.5 (89.9)
⑤	1 x .562	4.625 (117.5)

15,000 psi (1034 bar)
Medium Pressure Tubing

	Size Inches	Rm (min.) inches (mm)
①	9/16 x .359	2.625 (66.7)
②	3/4 x .516	3.5 (89.9)
③	1 x .688	4.625 (117.5)

Autoclave Engineers Ultra High Pressure tubing (316SS)



150,000 psi (10342 bar)
Ultra High Pressure Tubing

Size Inches	Rm (min.) inches (mm)
5/16 x 1/16	6 (152.4)

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