PSI

LINED PIPING SYSTEMS

Design Manual for Lined Piping Systems

CRANE

ChemPharma Flow Solutions

www.cranechempharma.com

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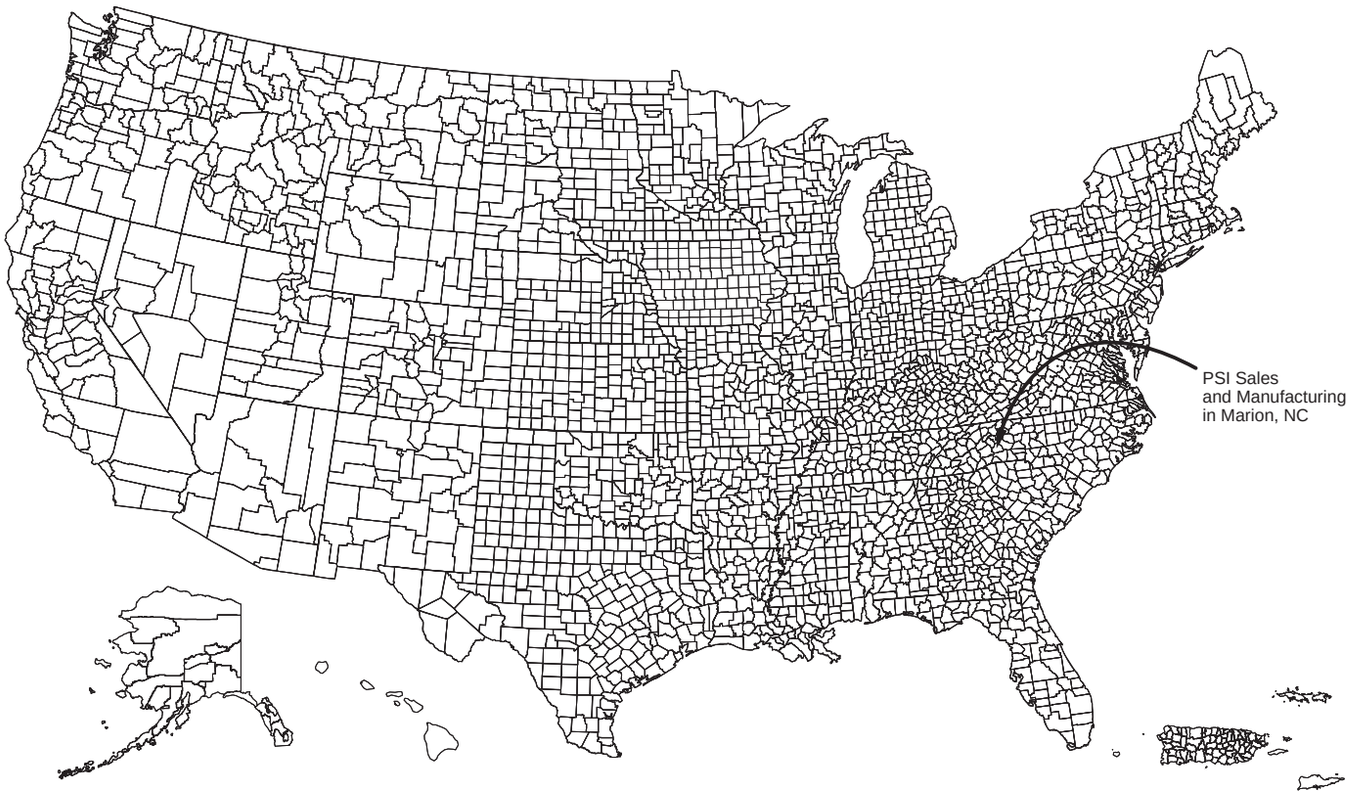
Terminology and Standards

PTFE	Polytetrafluoroethylene, manufactured by DuPont under the trade name Teflon®, is the only PTFE used by PSI.
PFA	Perfluoroalkoxy, manufactured by DuPont under the trade name of Teflon®.
PVDF	Polyvinylidene Fluoride, manufactured by Arkema under the name Kynar® and Kynar Flex®.
PP	Polypropylene
ETFE	Ethylenetetrafluoroethylene, manufactured by DuPont under the trade name Tefzel®, is the only ETFE used by PSI.
NPS	Nominal Pipe Size
DI	Cast ductile iron
FS	Forged steel
CS	Cast steel
Full Vacuum	29.6 inches of mercury
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
F1545	ASTM consolidated plastic lined piping standards
A395	ASTM standard pertaining to ferritic ductile iron
A105	ASTM standard pertaining to forged steel
A216	ASTM standard pertaining to cast steel (grade WCB)

INDUSTRY STANDARD LINER COLORATION

PTFE	White
PVDF	Black as standard. Available unpigmented.
PP	Orange as standard. Available unpigmented.
PFA	Natural - off white
ETFE	Natural - shiny, milky white

Sales and Distribution



Our Distribution Network:

PSI has a well-established network of stocking and fabricating distributors throughout North America. This extensive network of distribution channels offers our customers local and personalized service, regardless of location.

PSI distributors are not just order takers. Many of them have over 35 years of lined pipe experience and all are experienced in the technology of fluid handling and how plastic lined pipe can be used to solve fluid handling problems safely and economically. All of our distributors are dedicated to providing unmatched customer service. Additional involvement with, and experience in related products results in a team of professionals able to assist in any specialized project.

To find a local distributor, log onto www.cranechempharma.com or contact our Customer Service Center at (828) 724-2430.

Engineering support is available in the form of bill-of-material take-offs, technical service, and testing. We can also provide in-house or on-site product and/or fabrication training and certification.

Liner Materials

PTFE (Polytetrafluoroethylene)
PTFE, the most commonly used fluoropolymer, has excellent high-temperature corrosion resistance to virtually all chemicals except elemental fluorine and molten alkali metals. In addition, PTFE possesses unusual non-stick properties which can reduce or eliminate the buildup of deposits on the pipe walls. Service temperatures in pressure piping systems range from -20°F (-29°C) to 450°F (230°C).

PFA (Perfluoroalkoxy)
PFA exhibits chemical resistance virtually identical to PTFE. Suitable for service from 0°F to 450°F, PFA is a fluorinated thermoplastic known for its ultra-pure capabilities. PFA provides superior creep resistance at high temperature, excellent low temperature toughness and exceptional flame resistance.

ETFE (Tefzel®, ethylene tetrafluoroethylene)
Tefzel® combines mechanical toughness with outstanding chemical resistance that approaches Teflon®. Effective from -20°F to 300°F, Tefzel is easily processed and known for its high energy radiation resistance.

PVDF (Polyvinylidene Fluoride)
PVDF has excellent resistance to many chemicals, including halogens and strong oxidants. PVDF exhibits excellent abrasion and permeation resistance. As PSI uses both the homopolymer (6" - 8" fittings) and copolymer resins (1" - 8" pipe, 1" - 4" fittings), the PVDF lined system is rated from 0°F (-29°C) to 275°F (135°C). Because PVDF is only partially fluorinated, its chemical resistance is affected by temperature and concentration of liquids and gases.

PP (Polypropylene)
The PP homopolymer PSI uses has good corrosion resistance, low moisture absorption, and good mechanical properties. Since its chemical resistance is greatly affected by the concentration and temperature of the conveyed fluid, its use in pressure piping systems is generally limited from 0°F (-16°C) to 225°F (107°C).

Note: 1" - 12" PP pipe liner is Type II copolymer.
1" - 4" MultiPlane pipe and 1" - 12" PP fittings liner is Type I homopolymer.

PLASTIC LINER DATA

Liner Characteristics	PTFE	PFA	PP	PVDF (homopolymer)	PVDF (copolymer)	ETFE
Service Temperature Range, °F[1]	-20°F to 450°F	0°F to 450°F	0°F to 225°F	0°F to 275°F	-20°F to 275°F	-20°F to 300°F
Liner Color	White	Natural	Orange[3]	Black[3]	Black[3]	Natural
Color of Liner Identification Band	White with Black Lettering[2]	Gray with Black Lettering	Orange w/ Black Lettering	Black w/ White Lettering	Black w/ White Lettering	Gray w/ White Lettering
Coefficient of Thermal Expansion of Pipe Liner Prior to Lining, in./in./°F	5.5×10^{-5}	7.8×10^{-5}	4.8×10^{-5}	6.6×10^{-5}	7.8×10^{-5}	7.4×10^{-5}
Thermal Conductivity ("K" Factor) of Liner, BTU-in./hr.-sq. ft.-°F	1.7	1.3	0.8	0.9	1.18	1.65
Tensile Strength of Liner at Yield, psi	3,000 - 4,000	3,800 - 4,500	4,000 - 4,500	5,000 - 6,000	4,500 - 5,500	6700
Elongation of Liner at Yield, %	250 - 350	300 - 350	10 - 13	8 - 10	10 - 20	150 - 300
Compressive Strength of Liner at Yield, psi	1,700	3,500	5,500 - 8,000	10,000 - 16,000	5000 - 8500	2,500
Specific Gravity of Liner	2.14 - 2.19	2.12 - 2.17	0.90 - 0.92	1.75 - 1.78	1.76 - 1.78	1.70 - 1.72

PTFE = polytetrafluoroethylene
PFA = perfluoroalkoxy
PP = polypropylene
PVDF = polyvinylidene fluoride
ETFE = ethylene tetrafluoroethylene

[1]Max. allowable temperature depend on the specific contact chemicals.
[2]10" - 12" non-vacuum pipe and fittings band is red with black letters.
[3]Available unpigmented as a special option.

PSI ANSI/ASTM Standards

Pipe and fittings manufactured by PSI are in full compliance with:

ASTM F1545, Standard Specification for Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges

This specification covers all aspects of Plastic Lined Piping Products including:

- Approved ASTM designations of resin used to manufacture liner
- Approved ASTM designations of materials of construction of housings and flanges
- Minimum dimensional requirements
- Required qualification testing and proof-testing procedures

PSI products also meet the following specifications/requirements:

Liners:	PTFE — Polytetrafluoroethylene ASTM D4894, D4895 PFA — Perfluoroalkoxy ASTM D3307 PVDF — Polyvinylidene Fluoride ASTM D3222, D5575 PP — Polypropylene Type I, Type II Copolymer ASTM D4101
Pipe:	1" through 4" size, Schedule 40 Carbon Steel per ASTM A587 ERW 6" through 8" size, Schedule 40 Carbon Steel per ASTM A53, Grade B Type E ERW 10" size, Schedule 30 Carbon Steel per ASTM A53, Grade B Type E ERW 12" size, Schedule 20 Carbon Steel per ASTM A53, Grade B Type E ERW
Flanges:	Lap-joint, 1" through 12" size, Ductile Iron ASTM A395, dimensions per ANSI B16.42 Class 150 Lap-joint, 1" through 12" size, Forged Steel ASTM A105, dimensions per ANSI B16.5 Class 150 Note: PP and PVDF-lined fittings are normally supplied with fixed flanges
Fitting Types:	Fabricated Carbon Steel: components per ASTM A587, A53 & A234 as specified on individual drawings. Dimensions per ANSI 16.5 Class 150. Flanges rotating lap joint or fixed as specified above. Ductile Iron Casting (60-40-18) per ASTM A395. Cast Steel per ASTM A216 Gr. WCB. Standard fittings dimensions per ANSI B16.5 Class 150.
Fabrication Tolerances:	Pipe and Fittings

Dimension	**Tolerance, in.**
Length and Centerline Dimensions	± 1/8"
Fixed Flange Bolt Hole Alignment	± 1/16"
Flange Perpendicularity (with Pipe Centerline)	3/32 in/ft of nom. pipe diameter

Inspection and Quality Control

- Each lined pipe and fitting shall be subjected to a 18,000-volt electrostatic and/or hydro testing, per ASTM 1545, as part of the finish inspection. A visible or audible spark at the probe from an electrical contact to the housing or evidence of leakage at a vent hole indicates the presence of a defect in the liner and shall be cause for rejection.

Note: The electrostatic test is standard. The hydrostatic test is available at an additional cost

- The sealing surface of the liner shall be free of any defects that would impair the sealing effectiveness. Any imperfection will not exceed 10% of the flare thickness.
- Wooden end protectors are used to protect the plastic faces of flanged pipe and fittings. End protectors should stay in place until just prior to installation.
- Flanged pipe and fittings are labeled with a PSI sticker located on the wooden end protectors, which identifies the plastic liner type, the flange material, and spool length.
- A colored plastic band is placed on all pipe and fittings to identify the PSI material and the liner type on the exterior of the pipe.
- Plastic caps will be used to protect the ends on field flare product.

RELATIONSHIPS, BY LINING MATERIAL, BETWEEN VACUUM RATING AND TEMPERATURE FOR STANDARD LINED PIPE

Diameter – Inches (Nominal)	1	1 1/2	2	3	4	6	8	10	12
PTFE									
FULL VACUUM RATED									
Liner Thickness (in.)	.130	.150	.160	.160	.160	.275	.310	.320	.425
Vacuum (in. Hg)	Full	Full	Full	Full	Full	Full	Full	Full	Full
Temperature (˚F)	450	450	450	450	450	450	450	450	450
NON VACUUM RATED									
Liner Thickness (in.)	- -	- -	- -	- -	- -	- -	- -	.200	.200
Vacuum (in. Hg)								Non Vacuum	Non Vacuum
PP									
Liner Thickness (in.)	.135	.160	.175	.175	.210	.220	.220	.320	.380
Vacuum (in. Hg)	Full	Full	Full	Full	Full	Full	Full	Full	Full
Temperature (˚F)	225	225	225	225	225	225	225	225	225
PFA									
Liner Thickness (in.)	.113	.114	.114	.130	.150	.145	.140		
Vacuum (in. Hg)	Full	Full	Full	Full	Full	Non Vacuum	Non Vacuum	- -	- -
Temperature (˚F)	450	450	450	450	450				
PVDF									
Liner Thickness (in.)	.125	.125	.125	.125	.145	.160	.185		
Vacuum (in. Hg)	Full	Full	Full	Full	Full	Full	Full	- -	- -
Temperature (˚F)	275	275	275	275	275	275	275		

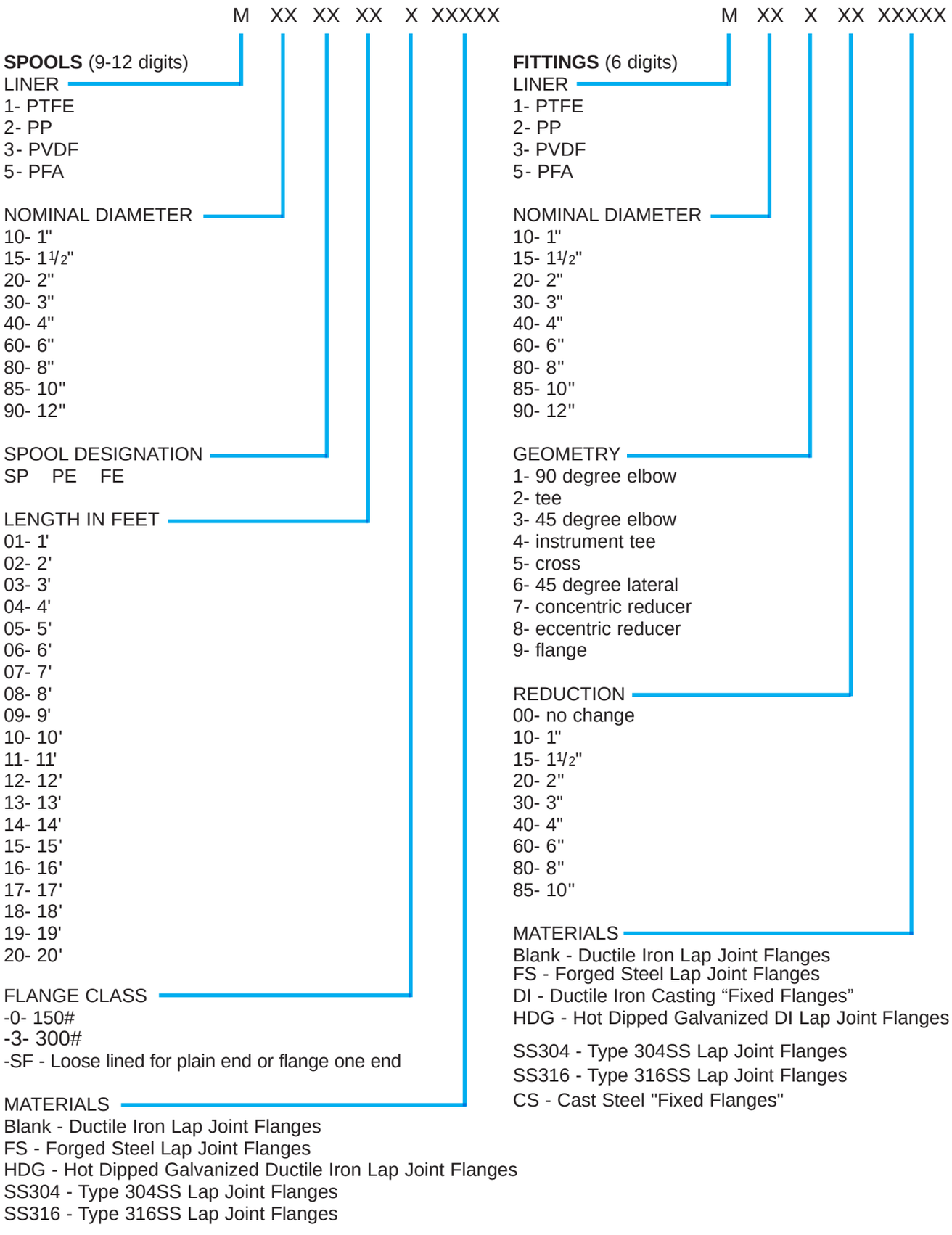
Note 1: All vacuum data reflects testing done per ASTM F1545.

Note 2: 1" - 8" fittings meet or exceed pipe liner thickness and vacuum ratings for same size and liner material. Vacuum ratings for some 10" and larger fittings may have vacuum limitations. Consult factory.

Note 3: Vacuum ratings may not apply for special angle elbows, sight flow indicators and laterals, crosses and eccentric reducers that are 6" and above. Consult factory.

Note 4: Certain chemicals may affect vacuum ratings. Consult factory.

PSI Part Numbering System

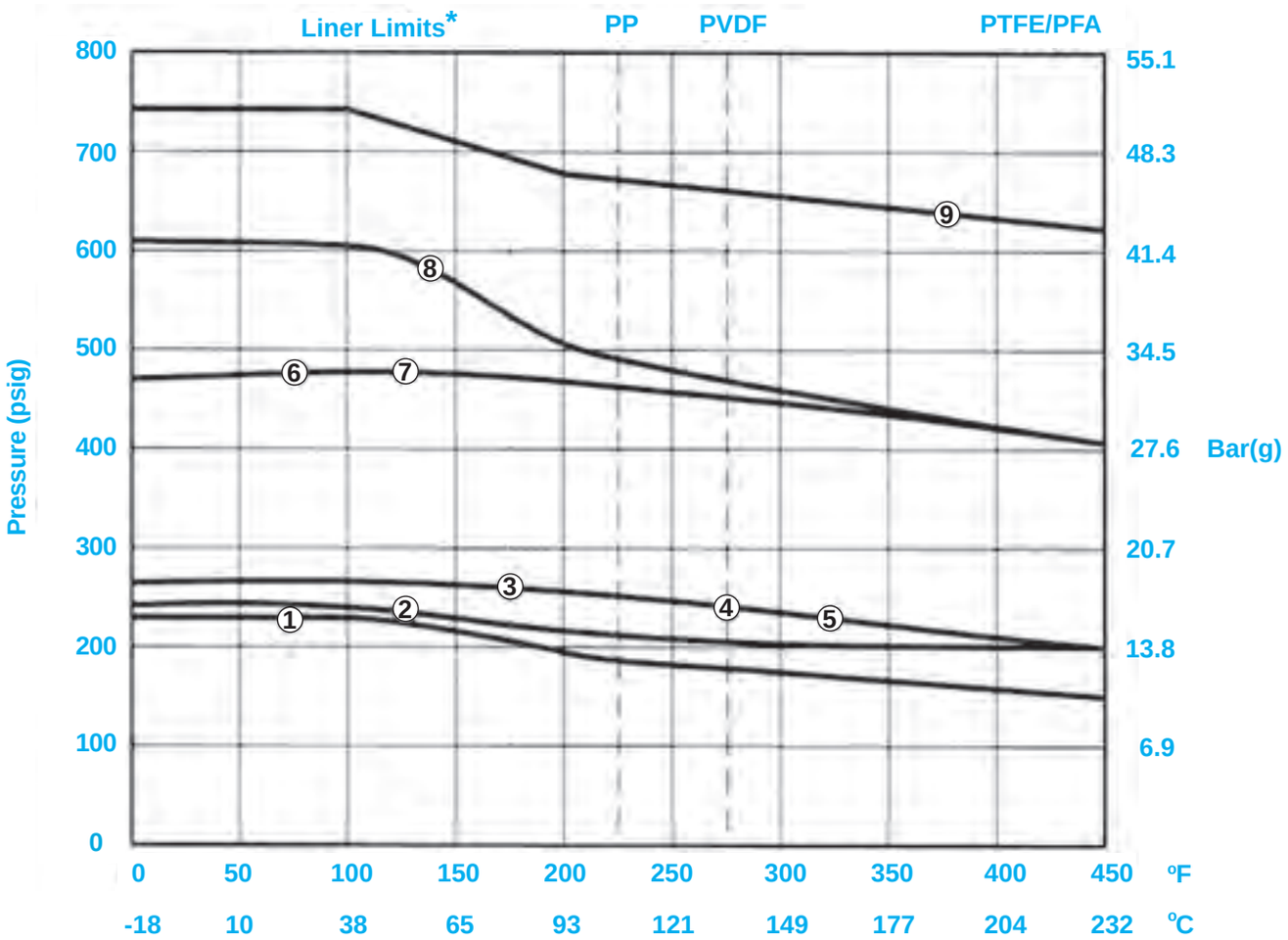


Pressure/Vacuum Capabilities of Pipe and Fittings

The pressure/temperature ratings of 1" to 12" PSI Plastic-Lined Piping Products conform to standard ANSI codes and specifications per the appropriate metallurgy. See Figure 1. The pressure/temperature ratings for lined piping with ANSI B16.5 Class 300 flanges are adjusted to account for plastic raised faces on pipe and fittings, and are lower than actual ANSI B16.5 Class 300 pressure/temperature ratings.

PVDF (1" - 8") and PP (1" - 12") pipe and fittings have been full vacuum rated at their maximum service temperature and can be used at full vacuum within their operating temperature ranges. Standard 1" - 12" PTFE pipe and fittings are available to provide Full Vacuum / 450°F performance, if so specified. Some pipe and fittings may have a reduced vacuum rating. 1" - 4" PFA-lined pipe and fittings are rated for full vacuum to 450 F. 6" and 8" PFA-lined pipe and fittings are non-vacuum rated.

Figure 1: Working pressures for PSI plastic-lined pipe and fittings (includes PTFE-lined stainless steel pipe)



Curves

1. Class 150 stainless steel (Steel Flanges) (Type 304L) ANSI B16.5.
2. Class 150 ductile iron/plastic lined ANSI B16.42.
3. Class 150 cast steel/plastic lined ANSI B16.5.
4. Class 150 stainless steel/plastic (Steel Flanges) lined ANSI B16.5.
5. Class 150 carbon steel ANSI B16.5.
6. Class 300 cast steel/plastic lined.
7. Class 300 stainless steel/plastic (Steel Flanges) lined.
8. Class 300 stainless steel (Steel Flanges) (Type 304L) ANSI B16.5.
9. Class 300 cast steel ANSI B16.5.

*Maximum temperatures may be reduced depending on the aggressiveness of the fluid being handled.

Note 1: All vacuum data reflects testing done per ASTM F1545.

Note 2: 1" - 8" fittings meet or exceed pipe liner thickness and vacuum ratings for same size and liner material. Vacuum ratings for some 10" and larger fittings may have vacuum limitations. Consult factory.

Note 3: Vacuum ratings may not apply for special angle elbows, sight flow indicators and laterals, crosses and eccentric reducers that are 6" and above. Consult factory.

Note 4: Certain chemicals may affect vacuum ratings. Consult factory.

Lokline™ Process for Factory and Field Flare Piping

PSI steel pipe and plastic liner act as one integral piece. Combining dissimilar materials with very different rates of thermal expansion, our precision lining process locks the isostatically molded liner into the pipe housing, making it full-vacuum rated throughout the temperature range.

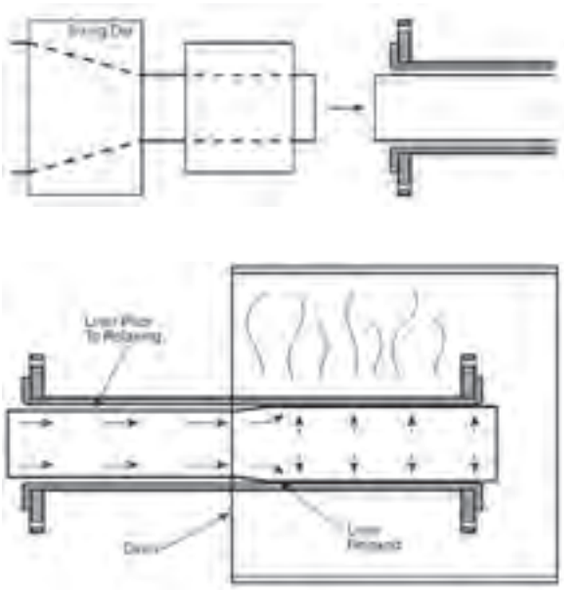
The lining process positively locks the plastic liner in the metal pipe housing while effectively relieving stresses that could cause unwanted liner movement in service.

Lining Process:

- Incoming lots of resin are analyzed in our Quality Assurance laboratory for conformance to established raw material specifications.
- The liner is processed under controlled conditions to a size somewhat larger than the I.D. of the steel housing into which it will be installed. It is then thoroughly inspected for conformance to design specifications. Next, the liner is subjected to a battery of quality tests designed to ensure liner integrity.
- The liner is then drawn through a sizing die at carefully controlled draw rates which results in a calculated reduction in the oustide diameter.
- A programmed heating cycle relaxes the liner inside the steel housing, resulting in a snug liner fit. Design allowances are incorporated in this procedure to eliminate undesirable stresses in the finished product.
- Both liner ends of the pipe spool are then flared. Temperature, time and pressure are carefully monitored.
- The finished pipe is then tested in accordance with ASTM F1545 standards.

The PSI lining process provides lined pipe with dimensional stability under vacuum, pressure, and thermal cycling conditions, which prevents liner buckling and cracked flares within operational limits.

Drawing and Sizing



PSI Field Flare Pipe

Field Flare (FF) pipe is available Flange x Plain End or Plain End x Plain End pipe with movable liner for distributor or end-user fabrication[1] with the following features:

- PSI manufactures Field Flare pipe utilizing the the same lining process as factory-finished pipe, but the process is modified to result in a movable liner.
- The liner can be removed from the pipe, allowing the fabricator a wide variety of flange options, including the PSI field flare flange, all types of weld flanges, and lap joint flanges.
- PSI Field Flare pipe has the same performance characteristics as the factory-finished pipe, including full vacuum capability.
- Available in PTFE, PP, PVDF, and PFA in the same sizes as factory-finished spools.
- Housings are available in CS or SS.

1 - Special fabrication tooling and training required.

Lined Pipe and Fittings

LINED PIPE

Pipe Sizes PSI plastic-lined metal systems are available from 1/2" through 12". All types of PSI plastic-lined pipe can easily be field fabricated.

Housing Materials Various metals (carbon steel, 304 and 316 stainless steel including "L" grades, and other alloys) are available.

Flanges ANSI Class 150 and Class 300, as well as DIN rotating flanges are available in a variety of materials. Ductile iron is the standard flange material. Hot dipped galvanized, stainless and forged steel can be substituted with pricing on request.

Vent Extensions (1/8" or 1/4" half couplings can be welded over ventholes prior to lining.)

Consider For:

1. Sacrificial nipples for use in Halogen services. Extremely small in molecule size, Chlorine, Bromine and Fluorine have a tendency to permeate through the plastic liner and form acids at the vent hole where they see moisture. Vent extensions transfer the acid attack from the body of the pipe to the remote nipple end, thereby extending pipe life.
2. Extensions to route permeated gasses past pipe insulation.
3. Dual containment leak sensor ports.
4. Vacuum taps

Coating Systems: Gray two-part epoxy primer is standard. If special paint or blast profile is required, this can be applied at the factory with pricing on application.

PSI LINED PIPE DIMENSIONS

	Steel Pipe		Liner Thickness, in.				Weight (lbs.)	
Nominal Size	O.D.	Wall	PTFE	PP	PVDF	PFA	First Foot	Ea. Add'l. Foot
1	1.315	.133	.130	.135	.125	.113	7	2
1 1/2	1.900	.145	.150	.160	.125	.114	9	3
2	2.375	.154	.160	.175	.125	.114	15	4
3	3.500	.216	.160	.175	.125	.130	26	8
4	4.500	.237	.160	.210	.145	.150	38	12
6	6.625	.280	.275	.220	.160	.145	60	21
8	8.625	.322	.310	.220	.185	.140	94	32
10 (FVR)	10.750	.307	.320	.320	—	—	128	39
10 (NVR)			.200	—	—	—	125	36
12 (FVR)	12.750	.250	.425	.380	—	—	180	50
12 (NVR)			.200	—	—	—	176	36

I.D. of lined pipe = Pipe OD - (pipe wall thickness x 2) - (liner thickness x 2)

FVR = Full Vacuum Rated Liner
NVR = Non-Vacuum Rated Liner

Also Available as an Option:

- 304/316 stainless steel (including "L" grade) lined pipe with stainless or hot-dipped galvanized flanges.
- Vent couplings
- Jacketed construction
- 300# flanges
- DIN flanges

STEEL PIPE DIMENSIONS

		Nominal Wall Thicknesses, in.		
Nominal Pipe Size	Outside Dia.	Sched. 20	Sched. 30	Sched. 40
1	1.315	—	—	.133
1 1/2	1.900	—	—	.145
2	2.375	—	—	.154
3	3.500	—	—	.216
4	4.500	—	—	.237
6	6.625	—	—	.280
8	8.625	—	—	.322
10	10.750	—	.307	—
12	12.750	.250	—	—

LINED FITTINGS

A complete line of standard and custom flanged fittings, lined with PTFE, ETFE, PFA, PVDF and PP is available. Certain sizes and geometries may not be available in all liners. Please consult the factory. PP/PVDF/PFA fittings normally have fixed flanges.

Many Class 300 fittings are available in two lay lengths. Most PTFE-lined fittings are standard ANSI Class 150 housings with Class 300 flanges. Some Class 300 flanged PTFE lined fittings are available with ANSI 300 centerline-face dimensions. PP and PVDF ANSI 300 fittings have ANSI 300 lb lay lengths.

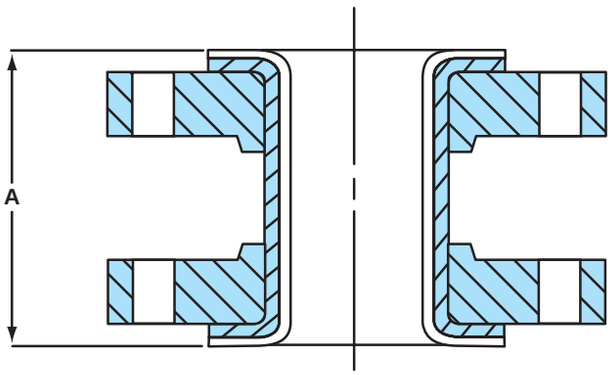
Please note: the increased number of bolt holes on the 150# lay length style may make fit up difficult. Tapped holes have been incorporated to accommodate.

Please offset tapped holes during installation to allow correct torquing.

Pipe Spools and Distance Pieces

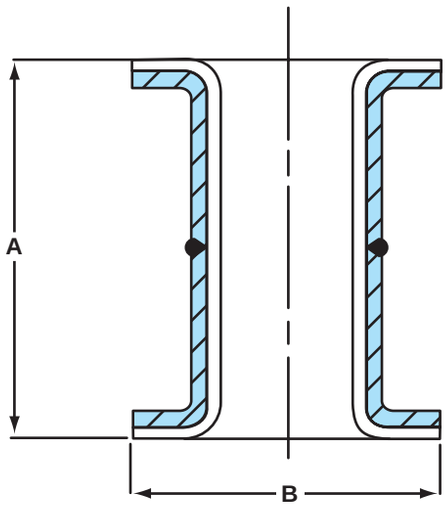
Minimum Length of Pipe Spools with ANSI 150# Dimensions

Part #	Nom. Pipe Size	Minimum Length - A
M10SPXX-X	1	3
M15SPXX-X	1 1/2	3 3/8
M20SPXX-X	2	3 1/2
M30SPXX-X	3	4
M40SPXX-X	4	4 3/8
M60SPXX-X	6	5 1/2
M80SPXX-X	8	6 1/2
M85SPXX-X	10	8 1/2
M90SPXX-X	12	8 1/2

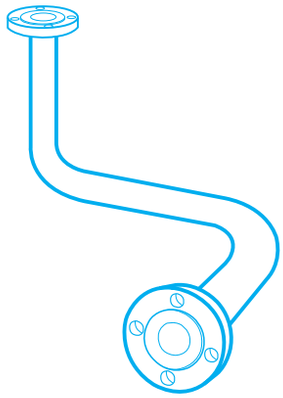


Distance Piece

Part #	Size	B	Weight #/in.	Minimum Length - A	Maximum Length - A
M10DP-XX	1	2	.17	3	3
M15DP-XX	1 1/2	2 7/8	.25	3	3
M20DP-XX	2	3 5/8	.35	3	3 1/2
M30DP-XX	3	5	.70	3	4
M40DP-XX	4	6 3/16	1.00	3	4 3/8
M60DP-XX	6	8 3/8	1.75	3	5 1/2
M80DP-XX	8	10 1/2	2.75	3	6 1/2
M85DP-XX	10	12 5/8	16.00	3	8 1/2
M90DP-XX	12	14 5/8	21.50	3	8 1/2



Multi-Plane™ Lined Pipe



- Available in PTFE, Polypropylene, and PVDF
- Eliminates flange connections at elbows.
- Up to 3 compound bends (3D) in a single piece of pipe
- Sections are bent at any angle up to 90° with a tolerance of ±1°.
- Reduces pressure drop across the bend and reduces energy costs.
- Longer bend radius (3 diameters vs. 1.5 diameters).

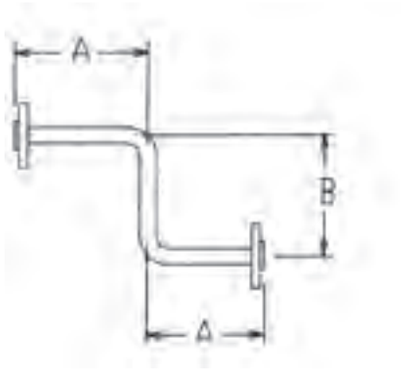
The Bending Process

Although the concept behind bent pipe is simple, successfully bending plastic-lined pipe is not. It is considerably more difficult than bending unlined pipe. As for loose-lined pipe, it is virtually impossible to bend without distorting the liner. The liner in PSI Plastic-Lined Pipe is locked into position and resists distortion.

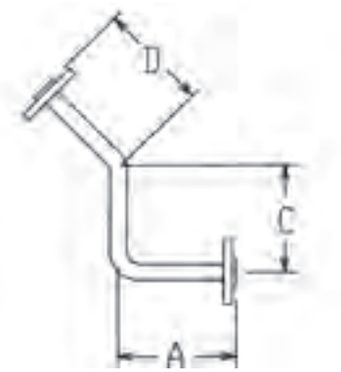
PSI uses special bending equipment and proprietary manufacturing techniques to provide bends in any angle up to 90° and compound bends on a single section of pipe. Our bent pipe is a high-quality product with dimensional tolerances of ± 0.125" (3.2mm), even on pieces with multiple bends. Due to the complexity of the bending operation, field bending of lined pipe is not available. Bent pipe can be supplied with Class 150 or Class 300 rotatable flanges.

When considering bent pipe, it's important to carefully examine directional changes in a system to determine whether the centerline-to-face or centerline-to-centerline dimensional requirements of bent pipe can be met within the parameters of the initial design. If not, design adjustments may be required.

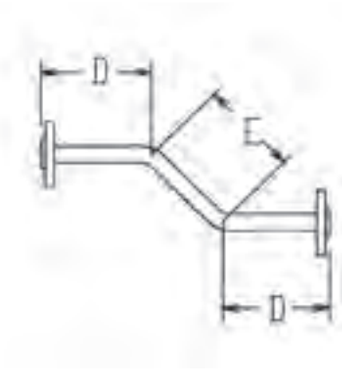
Minimum Lengths Required for PSI Bent Plastic Lined Pipe



90° Bends



90° & 45° Bends



45° Bends

Pipe Size	A	B	C	D	E
1	6 1/8	11 3/8	8 1/2	4 1/4	6 3/4
1 1/2	9 3/16	15 3/16	12 1/2	6 7/16	9 3/4
2	11 1/4	18 1/4	14 5/8	8	10 3/4
3	15	26 11/16	22	10	15 3/4
4	19 3/4	36 1/2	29 1/2	12 7/8	22 1/2

Tolerances

Center-center and center-face dimensions = +/- 1/8"

Bend angle = +/- 1°

Note: Angle can be within 1 degree of specified angle. If there is a long run of straight pipe after the bend, this can result in the center of the next bend or the face of the flare being offset an inch or more from what was intended. In most cases, this can be compensated for in the field installation. In the case of bolting bent lined pipe to flanged equipment that is in a permanent fixed location, the offset may present an installation problem.

Spacers - Ring and Full-Face

SOLID PLASTIC SPACERS

Part #	Size	Ring A	I.D., B		Full Face D	Bolt Holes		Bolt Circle
			PP/PVDF	PTFE		No.	Size	
Consult Factory	1	2 5/8	11/16	1	4 1/4	4	5/8	3 1/8
Consult Factory	1 1/2	3 3/8	1 5/16	1.5	5	4	5/8	3 7/8
Consult Factory	2	4 1/8	1 3/4	2	6	4	3/4	4 3/4
Consult Factory	3	5 3/8	2 11/16	3	7 1/2	4	3/4	6
Consult Factory	4	6 7/8	3 5/8	4	9	8	3/4	7 1/2
Consult Factory	6	8 3/4	5 9/16	6	11	8	7/8	9 1/2
Consult Factory	8	11	7 1/2	8	13 1/2	8	7/8	11 3/4
Consult Factory	10	13 3/8	9 11/16	10	16	12	1	14 1/4
Consult Factory	12	16 1/8	12	12	19	12	1	17

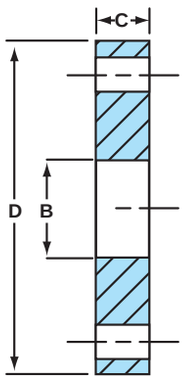
Note: "C" dimension to be specified by customer.

Armored spacers are solid plastic spacers with steel outer casing.

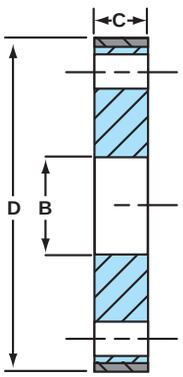
Solid plastic spacers are also available as orifice, blind. Please consult factory for additional information.

Max. Length = 3"

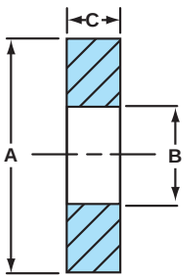
10" and 12" solid polypropylene spacers are made with glass-filled resin and are not recommended for hydrofluoric acid or sodium hydroxide service.



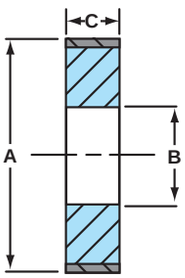
Full Face Spacer



Armored Full Face Spacer



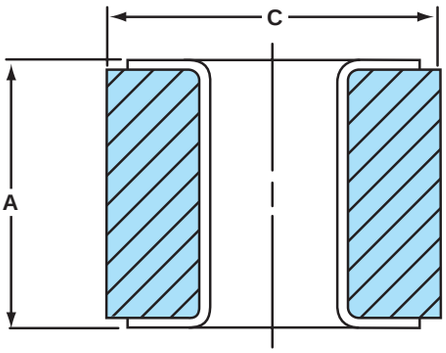
Ring Spacer



Armored Ring Spacer

LINED RING SPACER (PTFE-LINED, ONLY)

Part #	Size	C	Weight lb./in.
M10AS-XX	1	2 5/8	1.25
M15AS-XX	1 1/2	3 3/8	1.88
M20AS-XX	2	4 1/8	2.63
M30AS-XX	3	5 3/8	4.25
M40AS-XX	4	6 7/8	5.63
M60AS-XX	6	8 3/4	8.63
M80AS-XX	8	11	11.75
M85AS-XX	10	13 3/8	16.00
M90AS-XX	12	16 1/8	21.50



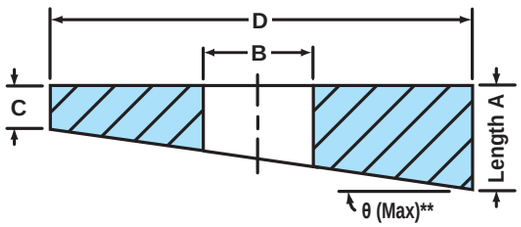
Minimum Length - A: 1/2" for 1" - 6" sizes.
1" for 8" - 12" sizes.

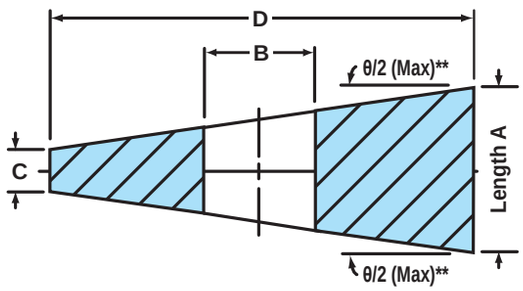
Maximum Length - A: 3" in all sizes

Solid Plastic Spacers

SOLID PLASTIC TAPERED SPACERS

Part #	Nominal Size	D	B		Single or double taper θ (max)	Minimum Length - A	Maximum Length - A
			PP/PVDF	PTFE			
Consult Factory	1	2 5/8	11/16	1	10°	1/2	3
Consult Factory	1 1/2	3 3/8	1 5/16	1.5	10°	1/2	3
Consult Factory	2	4 1/8	1 3/4	2	10°	1/2	3
Consult Factory	3	5 3/8	2 11/16	3	10°	1/2	3
Consult Factory	4	6 7/8	3 5/8	4	10°	1/2	3
Consult Factory	6	8 3/4	5 9/16	6	10°	1/2	3
Consult Factory	8	11	7 1/2	8	10°	1/2	3
Consult Factory	10	13 3/8	9 11/16	10	10°	1/2	3
Consult Factory	12	16 1/8	12	12	10°	1/2	3

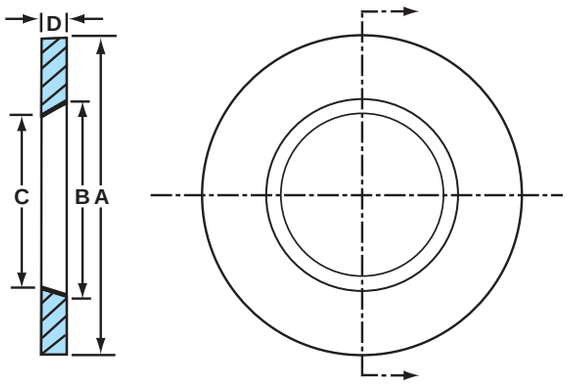




"A" and C" dimension to be supplied by customer
** Angle to be specified by customer.

SOLID PLASTIC TAPERED BORE SPACERS

Part #	Size	A	B	C	D
Consult Factory	1	2.63	Consult Factory		.50
Consult Factory	1 1/2	3.38			.50
Consult Factory	2	4.13			.50
Consult Factory	3	5.38			.50
Consult Factory	4	6.88			.50
Consult Factory	6	8.75			1.00
Consult Factory	8	11.00			1.00
Consult Factory	10	13.38			1.25
Consult Factory	12	16.12			1.25



Available in PTFE, PP, and PVDF

10" and 12" solid polypropylene spacers are made with glass-filled resin and are not recommended for hydrofluoric acid or sodium hydroxide service.

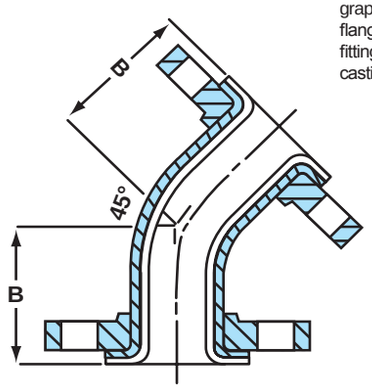
Elbows

45 DEGREE ELBOWS

Part #	Size	B (150 lb. Flanged)	B (300 lb Flanged)*	Wt.
M10300	1	1 3/4	2 1/4	4.5
M15300	1 1/2	2 1/4	2 3/4	7.0
M20300	2	2 1/2	3	10.5
M30300	3	3	3 1/2	21.5
M40300	4	4	4 1/2	37.0
M60300	6	5	5 1/2	63.0
M80300	8	5 1/2	6	110.0
M85300	10	6 1/2	- -	160.0
M90300	12	7 1/2	- -	205.0

* PP/PVDF available in 1" - 6" only

Note: Representative graphics show rotating flanges. PP/PVDF/PFA fittings are normally castings with fixed flanges.



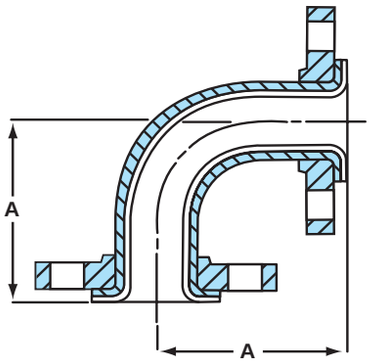
45° Elbow

90 DEGREE ELBOWS

Part #	Size	A (150 lb. Flanged)	A (300 lb Flanged)*	Wt.
M10100	1	3 1/2	4	5.0
M15100	1 1/2	4	4 1/2	8.5
M20100	2	4 1/2	5	14.0
M30100	3	5 1/2	6	26.0
M40100	4	6 1/2	7	41.0
M60100	6	8	8 1/2	75.0
M80100	8	9	10	125.0
M85100	10	11	- -	200.0
M90100	12	12	- -	245.0

PTFE-lined 300 lb flanged 90 deg elbows are available with 150 lb lay lengths in 1" - 6" sizes, only.

* PP/PVDF available in 1" - 6" only

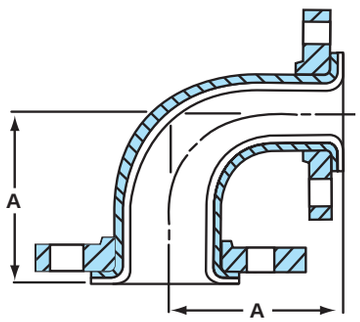


90° Elbow

REDUCING 90 DEGREE ELBOWS (150 lb, only)

Part #	Size	A	Wt.
M15110	1 1/2 x 1	4	7.0
M20110	2 x 1	4 1/2	9.3
M20115	2 x 1 1/2	4 1/2	11.8
M30120	3 x 1	5 1/2	14.9
M30115	3 x 1 1/2	5 1/2	16.9
M30120	3 x 2	5 1/2	19.0
M40110	4 x 1	6 1/2	22.10
M40115	4 x 1 1/2	6 1/2	24.8
M40120	4 x 2	6 1/2	26.5
M40130	4 x 3	6 1/2	33.0
M60120	6 x 2	8	44.0
M60130	6 x 3	8	45.0
M60140	6 x 4	8	52.0
M80140	8 x 4	9	86.0
M80160	8 x 6	9	89.0

Reducing 90 deg. elbows not available in PTFE.



90° Reducing Elbow

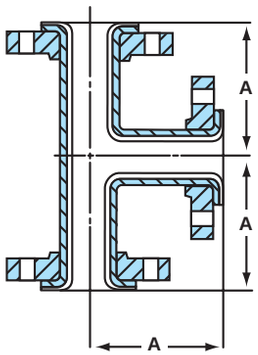
NOTE: 10" and 12" Polypropylene-lined fittings are made with glass-filled resin and are not recommended for hydrofluoric acid or sodium hydroxide service

Tees and Instrument Tees

STANDARD TEE

Part #	Size	A	Wt.
M10200	1	3 1/2	10.0
M15200	1 1/2	4	14.0
M20200	2	4 1/2	19.0
M30200	3	5 1/2	39.0
M40200	4	6 1/2	67.0
M60200	6	8	120.0
M80200	8	9	180.0
M85200	10	11	219.0
M90200	12	12	318.0

PP/PVDF tees are available 300 lb flanged with 300 lb lay lengths in 1" - 6"



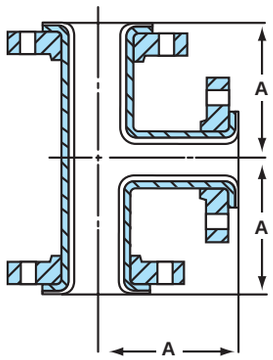
Standard Tee

REDUCING TEE*

Part #	Size	A	Wt.
M152XX	1 1/2	4	12.2
M202XX	2	4 1/2	17.0
M302XX	3	5 1/2	33.0
M402XX	4	6 1/2	57.0
M602XX	6	8	102.0
M802XX	8	9	167.0
M852XX	10	11	260.0
M902XX	12	12	290.0

* Weights shown are one step reduction.

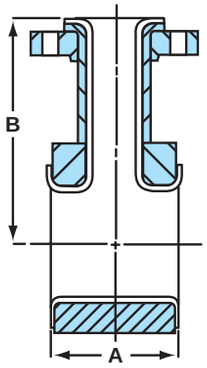
PP/PVDF reducing tees are available 300 lb flanged with 300 lb lay lengths in 1.5" - 4"



Reducing Tee

INSTRUMENT TEES, 150 LB FLANGED

1" Branch					1 1/2" Branch				2" Branch			
Part #	Size	A	B 150#	Wt.	Size	A*	B 150#	Wt.	Size	A	B 150#	Wt.
M104XX	1 x 1	2	3 1/2	3.7	–	–	–	–	–	–	–	–
M154XX	1 1/2 x 1	2	4	5.1	1 1/2 x 1 1/2	3*	4	8.3	–	–	–	–
M204XX	2 x 1	2	4 1/2	6.6	2 x 1 1/2	3*	4 1/2	11.0	2 x 2	4	4 1/2	17.0
M304XX	3 x 1	2	5 1/2	9.2	3 x 1 1/2	3*	5 1/2	16.0	3 x 2	4	5 1/2	21.0
M404XX	4 x 1	2	6 1/2	13.3	4 x 1 1/2	3*	6 1/2	22.0	4 x 2	4	6 1/2	31.0
M604XX	6 x 1	2	8	17.4	6 x 1 1/2	3*	8	29.0	6 x 2	4	8	38.8
M804XX	8 x 1	2	9	23.6	8 x 1 1/2	3*	9	38.1	8 x 2	4	9	53.0
M854XX	10 x 1	2	11	38.1	10 x 1 1/2	3*	11	53.0	10 x 2	4	11	67.0
M904XX	12 x 1	2	12	50.0	12 x 1 1/2	3*	12	65.2	12 x 2	4	12	80.0



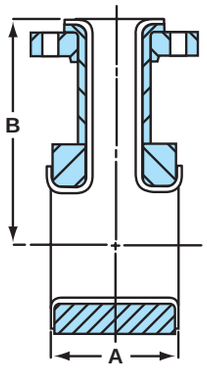
Instrument Tee

* For PP/PVDF Instrument Tees With 1 1/2" Branch, "A" Dimension is 4"

INSTRUMENT TEES, 300 LB FLANGED

1" Branch						1 1/2" Branch			
Part #	Size	A	B (PTFE)	B (PP/PVDF)	Wt.	Size	A	B (PTFE, Only)	Wt.
M102XX	1 x 1	2	4	4	3.7	- -	- -	- -	- -
M152XX	1 1/2 x 1	2	4 1/2	4 1/2	5.1	1 1/2 x 1 1/2	3	4 1/2	8.3
M202XX	2 x 1	2	5 9/16	5	6.6	2 x 1 1/2	3	5 9/16	11.0
M302XX	3 x 1	2	6 5/16	6	9.2	3 x 1 1/2	3	6 5/16	16.0
M402XX	4 x 1	2	7 1/16	7	13.3	4 x 1 1/2	3	7 1/16	22.0
M602XX	6 x 1	2	8 1/16	8 1/2	17.4	6 x 1 1/2	3	8 1/16	29.0
M802XX	8 x 1	2	9 5/16	- -	23.6	8 x 1 1/2	3	9 5/16	38.1

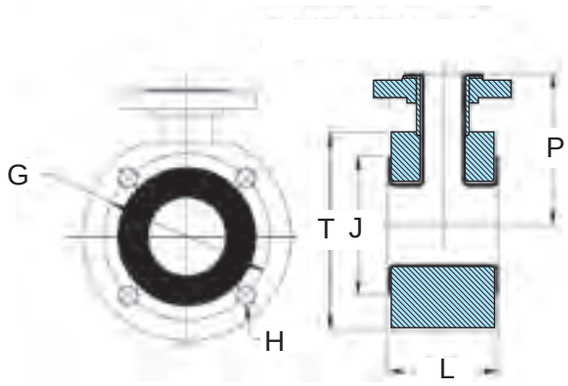
NOTE: 10" and 12" Polypropylene-lined fittings are made with glass-filled resin and are not recommended for hydrofluoric acid or sodium hydroxide service



Instrument Tee

Note: Representative graphics show rotating flanges. PP/PVDF/PFA fittings are normally castings with fixed flanges.

Lugged Body Instrument Tees



Instrument Tee Size	Branch Size	Part #	L	P	T	J	"H" Holes No. and Size	"G" Bolt Circle Diameter
1	1	M10410LFS	2	3 1/2	4 1/4	2	(4) 1/2 - 13	3 1/8
1.5	1	M15410LFS	2	4	5	2 7/8	(4) 1/2 - 13	3 7/8
	1.5	M15415LFS	4					
2	1	M20410LFS	2	4 1/2	6	3 5/8	(4) 5/8 - 11	4 3/4
	1.5	M20415LFS	4					
	2	M20420LFS	4					
3	1	M30410LFS	2	5 1/2	7 1/2	5	(4) 5/8 - 11	6
	1.5	M30415LFS	4					
	2	M30420LFS	4					
4	1	M40410LFS	2	6 1/2	9	6 3/16	(8) 5/8 - 11	7 1/2
	1.5	M40415LFS	4					
	2	M40420LFS	4					
6	1	M60410LFS	2	8	11	8 1/2	(8) 3/4 - 10	9 1/2
	1.5	M60415LFS	4					
	2	M60420LFS	4					
8	1	M80410LFS	2	9	13 1/2	10 5/8	(8) 3/4 - 10	11 3/4
	1.5	M80415LFS	4					
	2	M80420LFS	4					
10	1	M85410LFS	2	11	16	12 3/4	(12) 7/8 - 9	14 1/4
	1.5	M85415LFS	4					
	2	M85420LFS	4					
12	1	M90410LFS	2	12	19	15	(12) 7/8 - 9	17
	1.5	M90415LFS	4					
	2	M90420LFS	4					

Available in PTFE / PP / PVDF (PVDF not available in 10"/12")
PTFE lugged body instrument tees are supplied with a rotating branch flange
PP/PVDF branch flanges are fixed

NOTE: 10" and 12" Polypropylene-lined fittings are made with glass-filled resin and are not recommended for hydrofluoric acid or sodium hydroxide service

PTFE-Lined Short Stack Tees and Crosses

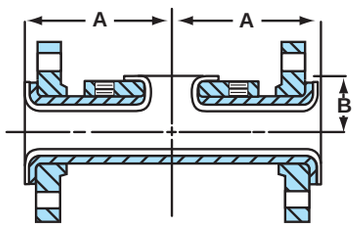
CARBON STEEL SHORT STACK CROSS

Part #	Size	A	B	Wt.
M102SS	1	3 1/2	1	9.0
M152SS	1 1/2	4	1 3/16	15.0
M202SS	2	4 1/2	2	21.5
M302SS	3	5 1/2	2 3/4	37.0
M402SS	4	6 1/2	3 1/4	60.0
M602SS	6	8	4 5/16	97.0
M802SS	8	9	5 5/16	160.0

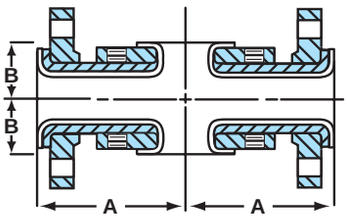
CARBON STEEL SHORT STACK TEE

Part #	Size	A	B	Wt.
M105SS	1	3 1/2	1	8.5
M155SS	1 1/2	4	1 3/16	12.2
M205SS	2	4 1/2	2	18.5
M305SS	3	5 1/2	2 3/4	33.0
M405SS	4	6 1/2	3 1/4	51.0
M605SS	6	8	4 5/16	85.0
M805SS	8	9	5 5/16	150.0

C.S. Short Stack Tees and Crosses are PTFE-Lined, only.
10" / 12" - Consult Factory



Short Stack Tee
(tapped holes straddle C_L)



Short Stack Cross

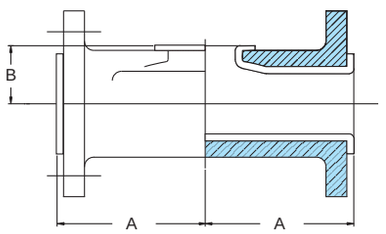
DUCTILE IRON SHORT STACK CROSS

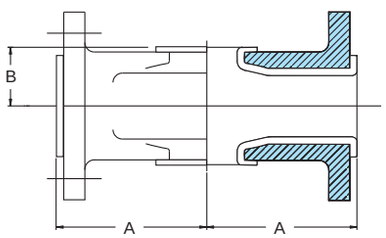
Part #	Size	A	B	Wt.
M102SS	1	3 1/2	1 3/16	9.0
M152SS	1 1/2	4	1 15/32	15.0
M202SS	2	4 1/2	1 11/16	21.5
M302SS	3	5 1/2	2 3/16	37.0
M402SS	4	6 1/2	2 11/16	60.0
M602SS	6	8	3 11/16	99.0
M802SS	8	9	4 15/16	163.0
M852SS	10	11	6	270.0
M902SS	12	12	7 1/32	310.0

DUCTILE IRON SHORT STACK TEE

Part #	Size	A	B	Wt.
M105SS	1	3 1/2	1 3/16	9.0
M155SS	1 1/2	4	1 15/32	11.5
M205SS	2	4 1/2	1 11/16	19.5
M305SS	3	5 1/2	2 3/16	33.0
M405SS	4	6 1/2	2 11/16	54.0
M605SS	6	8	3 11/16	85.0
M805SS	8	9	4 15/16	150.0
M855SS	10	11	6	245.0
M905SS	12	12	7 1/32	280.0

D.I. Short Stack Tees and Crosses are PTFE-Lined, only.



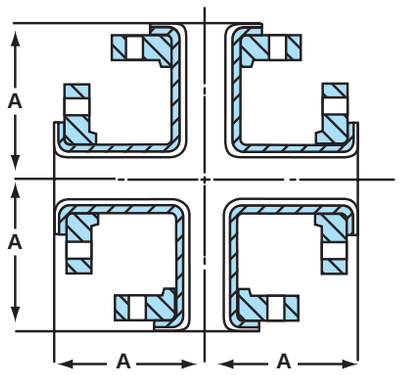


Crosses / Laterals / Strainer Tees

STANDARD CROSS

Part #	Size	A	Wt.
M10500	1	3 1/2	11.5
M15500	1 1/2	4	19.5
M20500	2	4 1/2	26.0
M30500	3	5 1/2	49.5
M40500	4	6 1/2	87.5
M60500	6	8	147.0
M60500	8	9	220.0

PTFE-lined crosses are available with 300 lb flanges in 1" - 6", only, with 150 lb lay lengths.

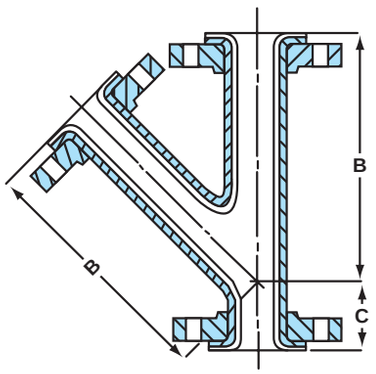


Standard Cross

Note: Representative graphics show rotating flanges. PP/PVDF/PFA fittings are normally castings with fixed flanges.

45˚ LATERAL

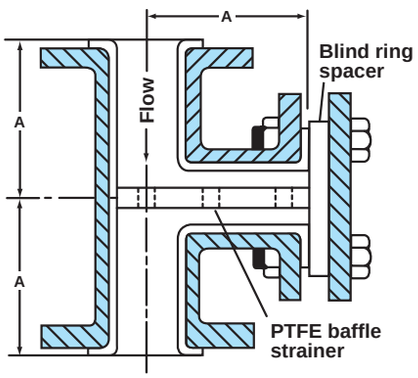
Part #	Size	B 150#	C 150#	Wt.
M10600	1	5 3/4	1 3/4	11.4
M15600	1 1/2	7	2	17.7
M20600	2	8	2 1/2	25.0
M30600	3	10	3	52.8
M40600	4	12	3	96.8
M60600	6	14 1/2	3 1/2	145.0
M80600	8	17 1/2	4 1/2	219.0



45° Lateral

STRAINER TEE

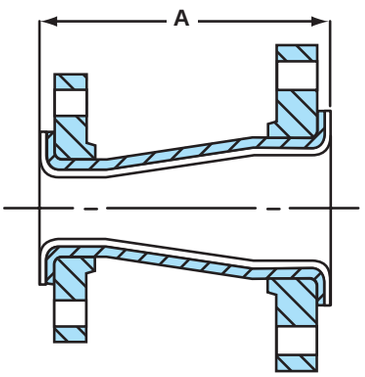
Part #	Size	A	Wt.
Consult Factory	1	3 1/2	12.4
Consult Factory	1 1/2	4	17.5
Consult Factory	2	4 1/2	33.1
Consult Factory	3	5 1/2	49.3
Consult Factory	4	6 1/2	82.8
Consult Factory	6	8	152.5
Consult Factory	8	9	233



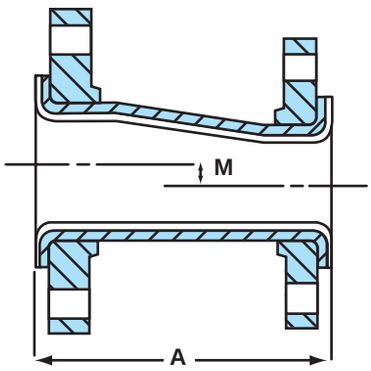
Strainer Tee

Concentric / Eccentric Reducers

Part #	Size	Conc. Red. Liner Avail.	A	M (Ecc Red.)	Ecc. Red. Liner Avail.	Wt.
M10X05	1 x 1/2	T	4 1/2	Ecc. Red. N/A		6.5
M10X75	1 x 3/4	T	4 1/2	Ecc. Red. N/A		7.0
M15X10	1 1/2 x 1	TPK	4 1/2	1/4	TPK	6.5
M20X10	2 x 1	TPK	5	1/2	TPK	9.0
M20X15	2 x 1 1/2	TPK	5	1/4	TPK	10.5
M30X10	3 x 1	TPK	6	1	PK	14.0
M30X15	3 x 1 1/2	TPK	6	3/4	TPK	16.0
M30X20	3 x 2	TPK	6	1/2	TPK	17.0
M40X10	4 x 1	TPK	7	1 1/2	PK	22.0
M40X15	4 x 1 1/2	TPK	7	1 1/4	TPK	25.0
M40X20	4 x 2	TPK	7	1	TPK	28.0
M40X30	4 x 3	TPK	7	1/2	TPK	29.0
M60X30	6 x 1	P	9	2 1/2	P	36.0
M60X15	6 x 1 1/2	P	9	1 1/4	PK	42.0
M60X20	6 x 2	TPK	9	2	TPK	42.0
M60X30	6 x 3	TPK	9	1 1/2	TPK	44.0
M60X40	6 x 4	TPK	9	1	TPK	50.0
M80X10	8 x 1	P	11	3 1/2	P	46.0
M80X20	8 x 2	PK	11	3	P	63.0
M80X20	8 x 3	PK	11	2 1/2	P	70.0
M80X40	8 x 4	TPK	11	2	TPK	76.0
M80X60	8 x 6	TPK	11	1	TPK	83.0
M85X40	10 x 4	TP	12	Ecc. Red. N/A		97.0
M85X60	10 x 6	T	12	Ecc. Red. N/A		105.0
M85X80	10 x 8	T	12	1	P	131.0
M90X60	12 x 6	T	14	Ecc. Red. N/A		170.0
M90X80	12 x 8	T	14	Ecc. Red. N/A		175.0
M90X85	12 x 10	T	14	1	P	180.0



Concentric Reducer



Eccentric Reducer

Note: Representative graphics show rotating flanges. PP/PVDF/PFA fittings are normally castings with fixed flanges.

PTFE-lined reducers, depending on the size, may be available with fixed x rotate or fixed by fixed flanges, only. Consult factory.

X - Type of Reducer. 7 = Concentric, 8 = Eccentric

Liner Availability Code:

T = PTFE
P = Polypropylene
K = PVDF

Example: "PK" means that size is only available with polypropylene and PVDF liners.

1 1/2" and larger sizes are available with PFA liner (some sizes are rotationally lined).

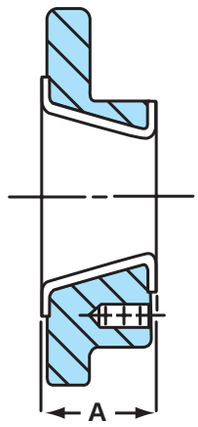
PTFE lined reducers may be fixed x rotate or fixed x fixed. Consult factory

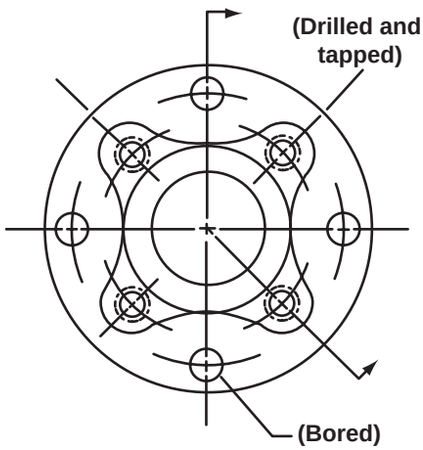
Available with 300 lb flanges - consult factory.

NOTE: 10" and 12" Polypropylene-lined fittings are made with glass-filled resin and are not recommended for hydrofluoric acid or sodium hydroxide service

PTFE-Lined DI Reducing Flanges

Part #	Size	A (±1/8)	Bolt* Orientation (Sets Straddling C_L)	Wt.
110905	1 x 1/2	1 5/8	1	2.8
110975	1 x 3/4	1 5/8	1	3.0
115910	1 1/2 x 1	1 9/16	1	4.3
120910	2 x 1	1 9/16	1	6.0
120915	2 x 1 1/2	1 9/16	1	6.3
130910	3 x 1	1 5/8	1	11.5
130915	3 x 1 1/2	1 5/8	1	12.8
130920	3 x 2	1 3/4	1	10.5
140910	4 x 1	1 7/8	2	15.8
140915	4 x 1 1/2	1 5/8	2	15.5
140920	4 x 2	2	2	14.5
140930	4 x 3	1 3/4	2	13.8
160915	6 x 1 1/2	1 7/8	2	24.5
160920	6 x 2	1 7/8	2	26.3
160930	6 x 3	1 3/4	2	22.3
160940	6 x 4	2 1/8	1	22.0
180940	8 x 4	2	1	38.5
180960	8 x 6	2	1	36.3
185940	10 x 4	2 7/16	2	62.0
185960	10 x 6	2 7/16	2	58.5
185980	10 x 8	2 7/16	2	50.5

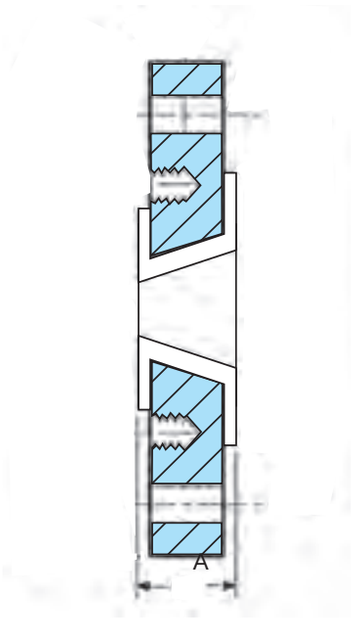




* 1 - One set bolt holes straddle C_L
* 2 - Both sets bolt holes straddle C_L

Carbon Steel Reducing Flanges

Part #	Size	A (±1/8)	Bolt* Orientation (Sets Straddling C_L)	Wt.
M10905FS	1 x 1/2	1 1/2	1	6.0
M10975FS	1 x 3/4	1 1/2	1	6.0
M15910FS	1 1/2 x 1	1 1/2	1	6.0
M20910FS	2 x 1	1 1/2	2	8.0
M20915FS	2 x 1 1/2	1 1/2	1	8.5
M30910FS	3 x 1	1 1/2	2	14.5
M30915FS	3 x 1 1/2	1 1/2	2	14.0
M30920FS	3 x 2	1 1/2	1	13.0
M40910FS	4 x 1	2	2	29.0
M40915FS	4 x 1 1/2	2	2	28.0
M40920FS	4 x 2	1 1/2	2	20.0
M40930FS	4 x 3	1 1/2	2	19.0
M60910FS	6 x 1	2	2	38.0
M60915FS	6 x 1 1/2	2	2	34.0
M60920FS	6 x 2	2	2	31.0
M60930FS	6 x 3	2	2	30.0
M60940FS	6 x 4	1 1/2	2	26.0
M80930FS	8 x 3	2	2	60.0
M80940FS	8 x 4	2	2	50.0
M80960FS	8 x 6	1 1/2	2	39.0
M85930FS	10 x 3	2	2	89.0
M85940FS	10 x 4	2	2	85.0
M85960FS	10 x 6	2	2	77.0
M85980FS	10 x 8	2	2	75.0
M90960FS	12 x 6	2	2	115.0
M90980FS	12 x 8	2	2	100.0
M90985FS	12 x 10	2	2	95.0



* 1 - 1 set of bolt holes straddle the centerline.
* 2 - both sets of bolt holes straddle the centerline.

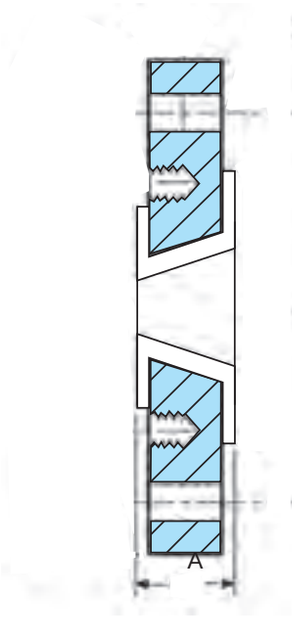
This style of reducing flange is available with PTFE, PP, or PVDF liner. PVDF Not Available in 10"/12".

Available with 300 lb bolt patterns - consult factory

NOTE: 10" and 12" Polypropylene-lined fittings are made with glass-filled resin and are not recommended for hydrofluoric acid or sodium hydroxide service

Carbon Steel Reducing Flanges, Non-Standard Sizes

Size	A (±1/8)	Bolt* Orientation (Sets Straddling C_L)
1 1/2 x 1/2	13/16	1
1 1/2 x 3/4	13/16	1
1 1/2 x 1 1/4	13/16	1
2 x 1/2	7/8	1
2 x 3/4	7/8	1
2 x 1 1/4	7/8	1
2 1/2 x 1	1	2
2 1/2 x 1 1/2	1	1
2 1/2 x 2	1	1
3 x 1 1/4	1 3/16	1
3 x 2 1/2	1 3/16	1
5 x 2	1 3/16	2
5 x 3	1 3/16	2
6 x 3/4	1 1/4	2
8 x 1	1 3/8	2
8 x 1 1/2	1 3/8	2
8 x 2	1 3/8	2
10 x 1	1 7/16	2
10 x 1 1/2	1 7/16	2
10 x 2	1 7/16	2
12 x 1	1 1/2	2
12 x 1 1/2	1 1/2	2
12 x 2	1 1/2	2
12 x 3	1 1/2	2
12 x 4	1 1/2	2



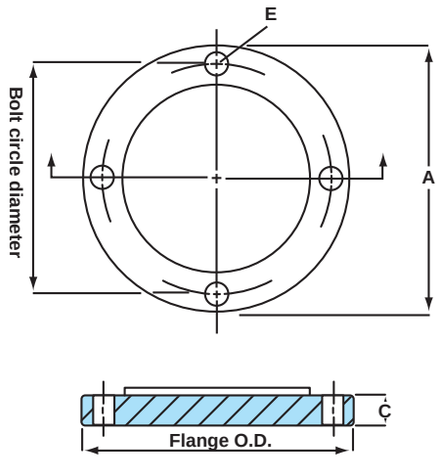
PTFE-Lined, Only

This style of reducing flange is available in sizes up to 30" diameter, and/or with 300 lb drill patterns, and/or with a non-taper straight-through bore.

Blind Flanges / Spectacle Blind Flanges

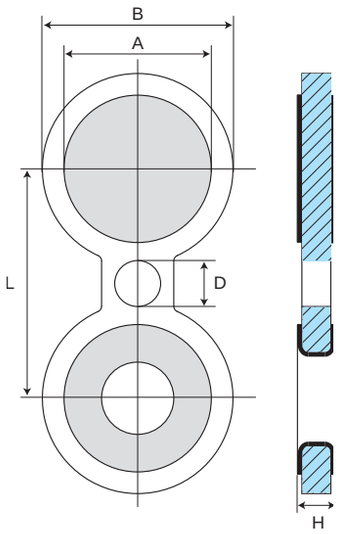
BLIND FLANGES

Size	A	C	Bolt Holes, E	
			No.	Size
1	4 1/4	9/16	4	5/8
1 1/2	5	11/16	4	5/8
2	6	3/4	4	3/4
3	7 1/2	15/16	4	3/4
4	9	15/16	8	3/4
6	11	1	8	7/8
8	13 1/2	1 1/8	8	7/8
10	16	1 3/16	12	1
12	19	1 1/4	12	1



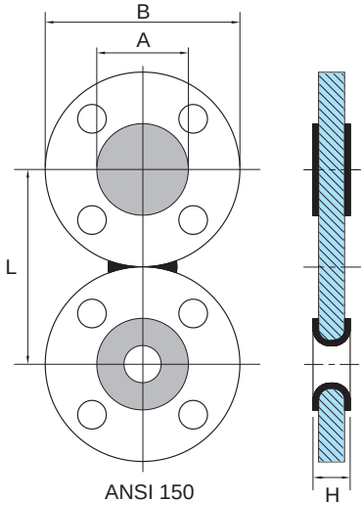
SPECTACLE BLIND FLANGES - RING STYLE

Size	A	B	D	H	L
1	2	2 1/2	5/8	3/4	3 1/8
1.5	2 7/8	3 1/4	5/8	7/8	3 7/8
2	3 5/8	4	3/4	7/8	4 3/4
3	5	5 1/4	3/4	1 1/8	6
4	6 3/16	6 3/4	3/4	1 1/8	7 1/2
6	8 1/2	8 5/8	7/8	1 1/8	9 1/2
8	10 5/8	10 7/8	7/8	1 1/4	11 3/4
10	12 3/4	13 1/4	1	1 3/8	14 1/4
12	15	16	1	1 3/8	17



SPECTACLE BLIND FLANGES - FULL FACE STYLE

Size	A	B	H	L
1	2	4 1/4	13/16	4 1/4
1.5	2 7/8	5	15/16	5
2	3 5/8	6	1	6
3	5	7 1/2	1 3/16	7 1/2
4	6 3/16	9	1 3/16	9
6	8 1/2	11	1 1/4	11
8	10 5/8	13 1/2	1 3/8	13 1/2
10	12 3/4	16	1 3/8	16
12	15	19	1 1/2	19

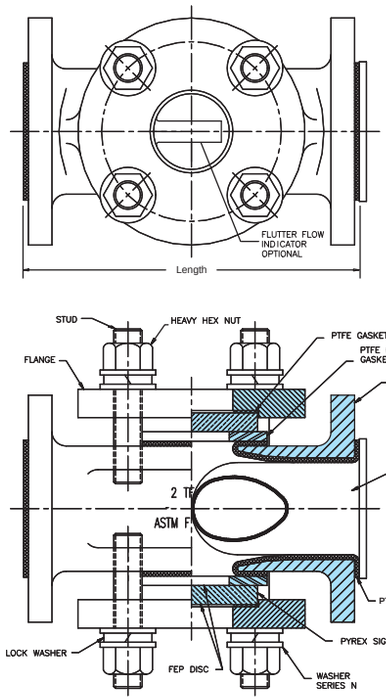


ANSI 150
Flange Bolt
Drilling

PTFE-Lined Sight Glass Indicators

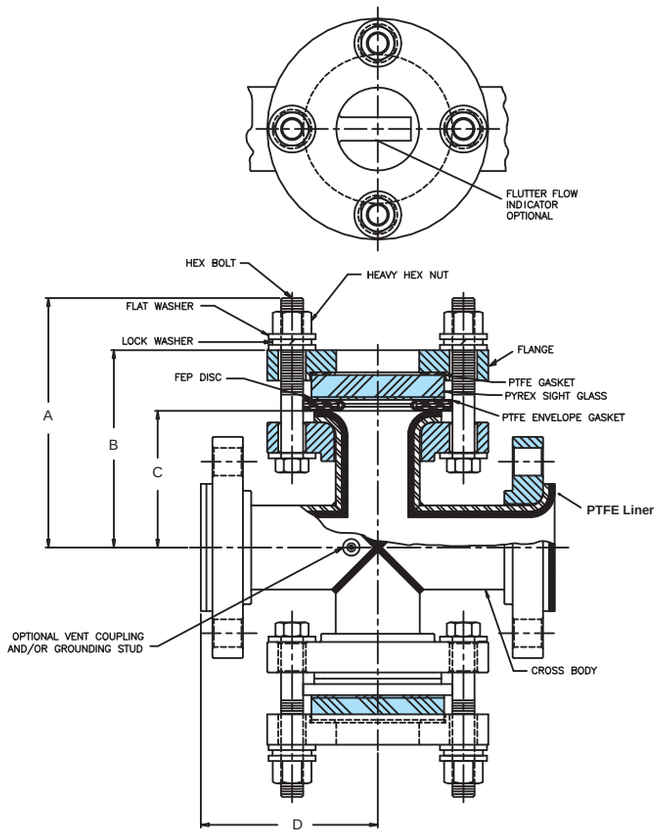
DI SIGHT GLASS INDICATORS

Size	Length
1	7
1 1/2	8
2	9
3	11
4	13
6	16



FABRICATED SIGHT GLASS INDICATORS

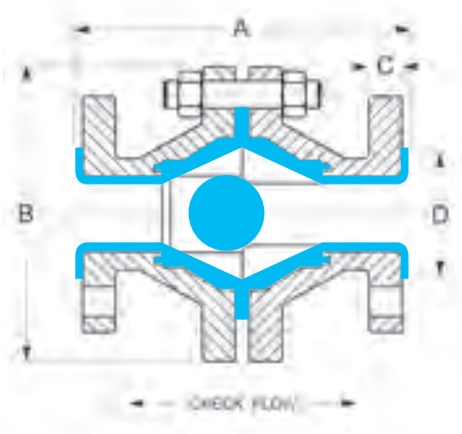
Size	A	B	C	D
1	4.806	3.914	2.605	3 1/2
1 1/2	5.575	4.475	3.103	4
2	5.857	4.924	3.490	4 1/2
3	7.035	6.102	4.299	5 1/2
4	7.572	6.764	4.954	6 1/2
6	9.354	8.425	6.330	8



Model 770 Ball Check Valve

DIMENSIONS

Valve Size	A	B	C	D	Valve Wt., Lbs.	Ball Wt., Lbs.
1"	6"	5"	0.438"	2"	12	0.079
1.5"	7"	6.5"	0.563"	2.875"	22	0.268
2"	7"	7.25"	0.625"	3.625"	29	0.544
3"	8"	9"	0.75"	5"	49	1.759
4"	10.5"	11.5"	0.938"	6.125"	82	3.722
6"	15.5"	17.25"	1"	8.375"	190	18.69
8"	19.688"	17.25"	1.125"	10.5"	266	18.69



1 . Flange Dimensions:
Bolt circle and flange bolt hole sizes per ANSI Class 150 dimensions.

2. Materials:
Body: Cast Ductile Iron (60-40-18) per ASTM A395.
Liner Availability: PFA (1"-8"), PVDF (1"-4"), or PP (1"-8").
Ball: Solid PTFE (1"-8" Solid).
Hardware: Studs per ASTM A193 Gr. B7, Nuts per SAE J995 Gr. 8. All hardware is zinc-p.

3. Permanent name plates show sizes, liner material, and flow direction.

4. Pressure Rating: Full-Vacuum to 150 psi.

5. Temperature Rating:
PFA: 0° F to 450° F
PVDF: -20° F to 275° F
PP: 0° F to 225° F

6. Cv value is the flow (GPM) through the valve at a pressure drop of 1 psi. Media is water at 60° F.

7. 8" Ball Check Valve consists of a 6" valve with two 8" x 6" reducing flanges.

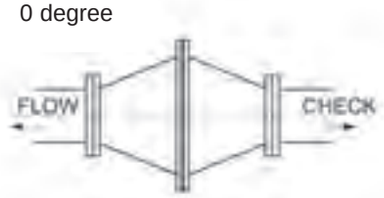
8. Model 770 Ball Check Valve can be installed vertically or horizontally. See Model 770 Ball Check Valve Ball sealing force data sheet.

SEALING and FLOW DATA

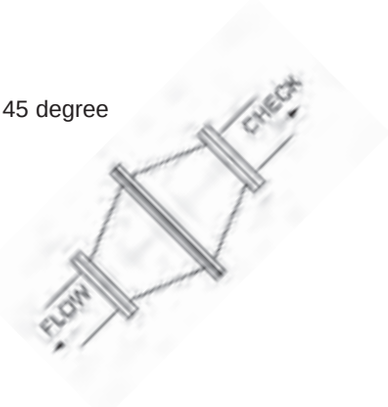
Flow required to force ball into seat at various inclinations (Solid Ball)

	Gallon/Minute			Velocity in Feet/Second			to Unseat DP	
Size	0°	45°	90°	0°	45°	90°	180°	CV
1"	1.3	8.3	12.5	.6	3.6	6	.114	30
1.5"	5.9	23	30	.94	4.1	5.45	.159	75
2"	7	52	80	.76	5.5	8.69	.196	150
3"	16	71	105	.73	3.4	5	.273	250
4"	31	121	160	.86	3.5	4.47	.367	400
6–8"	60	170	210	.74	2.08	2.6	.520	550

0 degree



45 degree



90 degree

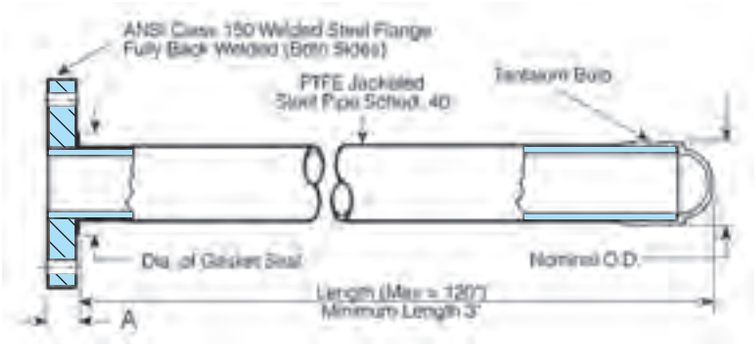
Thermowell Baffles

THERMOWELL BAFFLE

Dimensional Data						
Part #	NPS	Flange Size	Gasket Seal Dia.	A	Nominal O.D.	Max. Unsupported Length, Ft.
Consult Factory	1/2	1	1 3/4	11/16	1	3
Consult Factory	1	1 1/2	2 3/4	13/16	1 15/32	4
Consult Factory	1 1/2	2	3 1/2	7/8	2 1/16	5
Consult Factory	2	3	5	1 1/16	2 9/16	6

Recommended maximum length for mild agitation is shown as a general guide for liquids having about the same density and viscosity as water. For longer lengths or more severe operating loads (density, viscosity and velocity of fluid at the pipe), a larger size or internal bracing should be employed. Exceeding the maximum recommended service temperature and/or pressure or maximum recommended unsupported length can result in premature failure and possible personnel and equipment hazard.

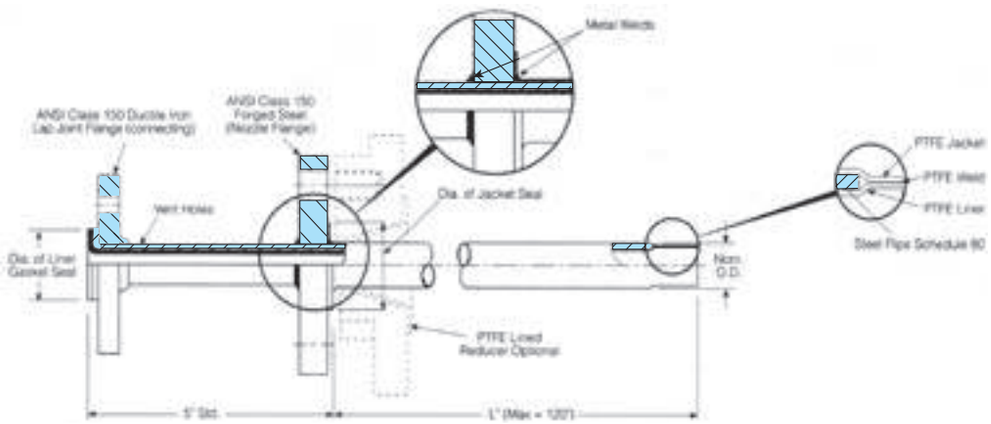
Notes: Maximum Length = 10 ft.



Reinforced Dip Pipes and Spargers

REINFORCED DIP PIPE

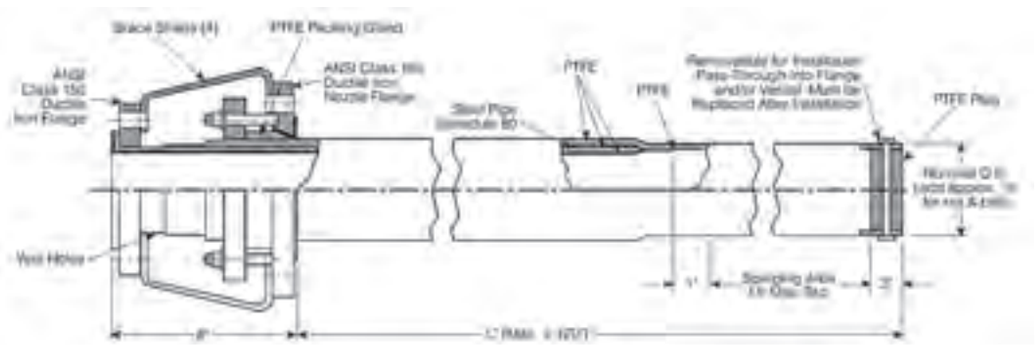
Size	Pipe and Connecting Flange Size	Nozzle Flange Size	Min. Diameter of Jacket Gasket Seal	Diameter of Liner Gasket Seal	Nominal OD	Max. Recommended Unsupported Length (Ft.)
1/2	1/2	1	1 7/8	1 3/8	1	3
1	1	1 1/2	2 3/4	2	1 7/16	4
1 1/2	1 1/2	2	3 1/2	2 7/8	2 1/64	5
2	2	3	4 3/8	3 5/8	2 1/2	6
3	3	4	5 7/16	5	3 5/8	8



Single flange dip pipes are also available. Nozzle flange is always one size larger than the dip pipe size. The flare diameter is standard for the nominal dip pipe size, not the nozzle flange size.

REINFORCED SPARGER

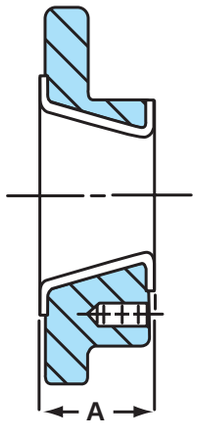
Pipe and Connecting Flange Size	Nozzle Flange Size	Min. Diameter of Jacket Gasket Seal	Nominal OD	Max. Recommended Length
1	2	1 7/8	1 15/16	4
1 1/2	3	2 3/4	2 9/16	5
1 1/2	4	3 1/2	2 33/64	5
2	4	4 3/8	3	6
3	6	5 7/16	4 1/8	8

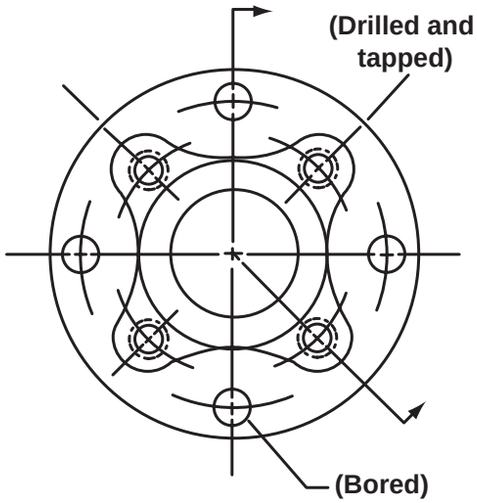


Note: Nozzle flange sizes on reinforced dip pipes and spargers are limited to those shown. To connect to other size nozzles, special ID reducing flanges (see following page) can be installed between the dip pipe / sparger and the vessel nozzle.

Special ID Reducing Flanges for Dip Pipes

Size	Actual Smallest ID	A
1 x 1/2	13/32	1 5/8
1 x 3/4	5/8	1 5/8
1 1/2 x 1	1 1/8	1 9/16
2 x 1	1 1/8	1 9/16
2 x 1 1/2	1 5/8	1 9/16
2 1/2 x 2	2 1/8	1 9/16
3 x 1	1 1/8	1 5/8
3 x 1 1/2	1 5/8	1 5/8
3 x 2	2 1/8	1 3/4
3 x 2 1/2	2 3/16	1 5/8
4 x 1	1 1/8	1 7/8
4 x 1 1/2	1 5/8	1 5/8
4 x 2	2 1/8	2
4 x 3	2 25/32	1 3/4
5 x 4	3 3/4	1 5/8
6 x 1 1/2	1 5/8	1 7/8
6 x 2	2 1/8	1 7/8
6 x 3	2 31/32	1 3/4
6 x 4	3 3/4	2 1/8
6 x 5	4 25/32	1 3/4
8 x 4	3 29/32	2
8 x 6	5 25/32	2
10 x 4	4 1/16	2 7/16
10 x 6	5 29/32	2 7/16
10 x 8	7 11/16	2 7/16





These reducing flanges are PTFE-Lined, only

Solid PTFE Dip Pipes and Spargers

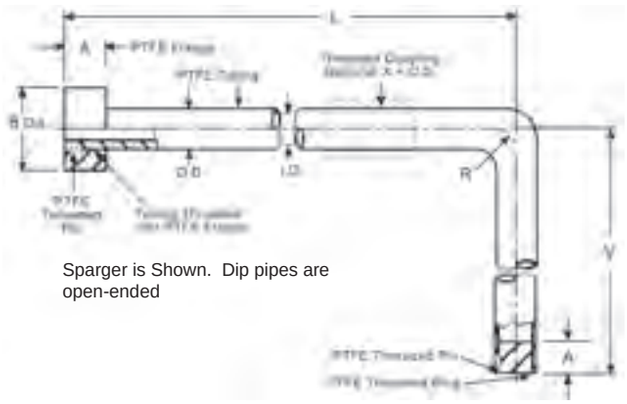
Tubing Size		PTFE Flange and Plug Thickness, A	PTFE Flange O.D., B	Bend Radius, R	Coupling OD, X
O.D.	I.D.				
1 1/4	1/2	1	Specified by Customer	2	2 1/8
1 3/8	3/4	1		2	2 1/4
1 3/4	1	1 1/2		3	2 5/8
2 1/4	1 1/2	2		4	3 3/8
3	2	2 1/2		8	4 3/8

L, V, and Z dimensions are specified by the customer.

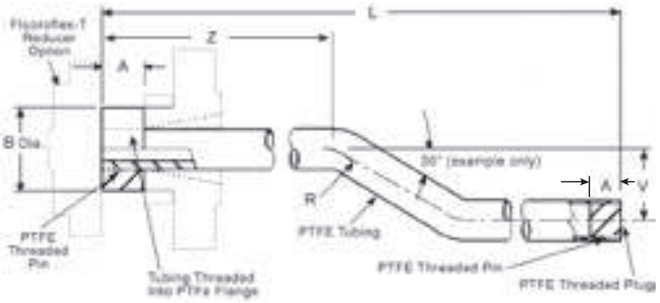
Part Number Code:

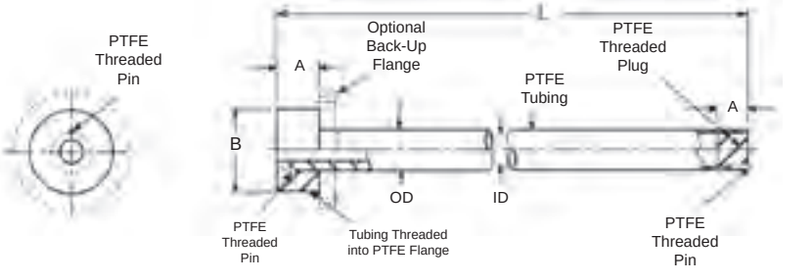
R6 X X X X X - L - V - C

- PTFE
- Style
  - 5 = Dip Pipe
  - 7 = Sparger
- Shape
  - 0 = Straight
  - 1 = 1 bend 90°
  - 2 = 1 bend 45°
  - 6 = 2 bends 30°
  - 7 = 2 bends 45°
  - 8 = 2 bends 90°
- Tubing Size
  - 1 = 1 1/4" OD x 1/2" ID
  - 2 = 1 3/8" OD x 3/4" ID
  - 3 = 1 3/4" OD x 1" ID
  - 4 = 2 1/4" OD x 1 1/2" ID
  - 5 = 3" OD x 2" ID
- PTFE Flange Dia. "B"
  - 1 = 2" (when connecting to a 1" Flange)
  - 2 = 2 7/8" (when connecting to a 1.5" Flange)
  - 3 = 3 5/8" (when connecting to a 2" Flange)
  - 4 = 5" (when connecting to a 3" Flange)
  - 5 = 6 3/16" (when connecting to a 4" Flange)
  - (Other diameters available on request)
- Back-up Flange
  - 0 = None
  - 1 = Back-up Flange
  - 2 = PTFE Flange to be removable
- Length Callout



Sparger is Shown. Dip pipes are open-ended



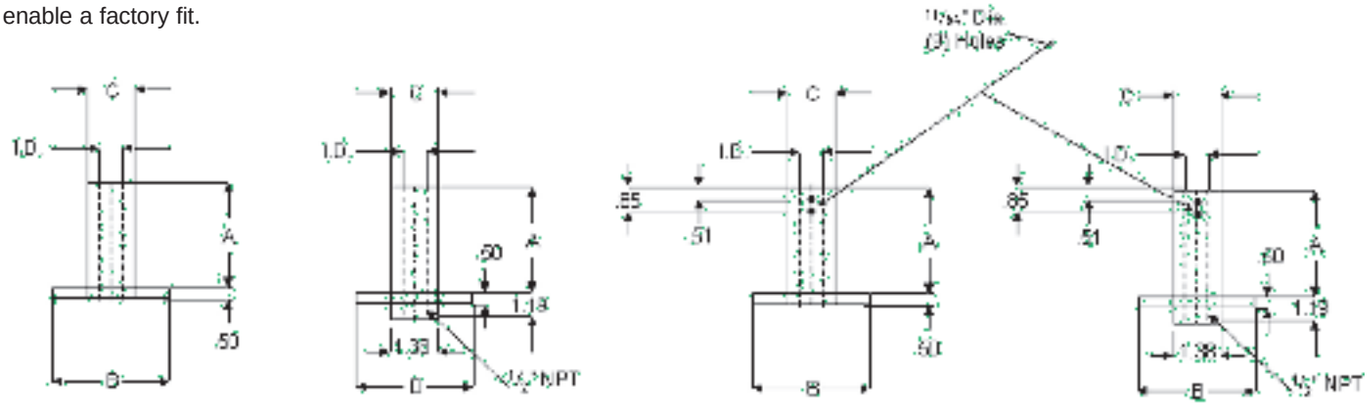


Sparger is Shown. Dip pipes are open-ended

PTFE Mixing Tee Nozzles

Acid mixing tees are used to introduce acid to the system. The solid PTFE nozzle is specially designed to disperse the acid uniformly into the process. Various nozzle sizes are available for different outlet diameters. Optional open-ended constructions are also available. The tees are made in 1" through 8" sizes for standard and reducing tees, and are available on special request. The PTFE mixing nozzle is also used with plastic lined tees. When selecting a tee, be sure the heat of reaction does not exceed the temperature rating of the plastic liner.

Note: Mixing tee nozzles purchased separately may not always fit in an existing tee, depending on size and construction. Mixing tees and nozzles should be purchased together to enable a factory fit.

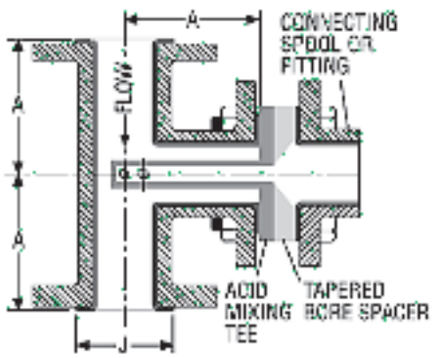


Detail 1 Detail 2 Detail 3 Detail 4

Part No.:

WM0WM00000_ _0 WM0XM00000_ _0 WM0YM00000_ _0 WM0ZM00000_ _0

Size Code ___



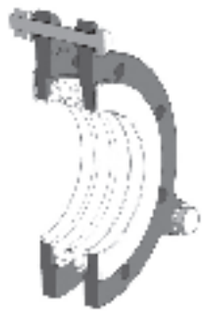
For Standard Tees					
Size Code	Size	A	B	C	I.D.
10	1	3 1/2	2 5/8	9/16	1/4
B0	1 1/2	4	3 3/8	1 1/5	1/2
20	2	4 1/2	4 1/8	1 3/8	7/8
30	3	5 1/2	5 3/8	2 1/2	1 1/2
40	4	7 3/8	6 7/8	2 1/2	1 1/2
60	6	9 3/8	8 3/4	2 1/2	1 1/2
80	8	11	11	2 1/2	1 1/2
C0	2 1/2	5	4 7/8	1 3/4	1

For Reducing Tees					
Size Code	Size	A	B	C	I.D.
B1	1 1/2 x 1	4	2 5/8	9/16	1/4
21	2 x 1	4 1/2	2 5/8	9/16	1/4
2B	2 x 1 1/2	4 1/2	3 3/8	1 1/8	1/2
31	3 x 1	5 1/2	2 5/8	9/16	1/4
3B	3 x 1 1/2	5 1/2	3 3/8	1 1/8	1/2
32	3 x 2	5 1/2	4 1/8	1 3/8	7/8
4B	4 x 1 1/2	7 3/8	3 3/8	1 1/8	1/2
42	4 x 2	7 3/8	4 1/8	1 3/8	7/8
43	4 x 3	7 3/8	5 3/8	2 1/2	1 1/2
62	6 x 2	9 3/8	4 1/8	1 3/8	7/8
63	6 x 3	9 3/8	5 3/8	2 1/2	1 1/2
64	6 x 4	9 3/8	6 7/8	2 1/2	1 1/2
81	8 x 1	11	2 5/8	9/16	1/4
8B	8 x 1 1/2	11	2 3/8	1 1/8	1/2
82	8 x 2	11	4 1/8	1 3/8	7/8
84	8 x 4	11	6 7/8	2 1/2	1 1/2
86	8 x 6	11	8 3/4	2 1/2	1 1/2
41	4 x 1	7 3/8	2 5/8	9/16	1/4
6B	6 x 1 1/2	9 3/8	3 3/8	1 1/8	1/2
C1	2 1/2 x 1	5	2 5/8	9/16	1/4
CB	2 1/2 x 1 1/2	5	3 3/8	1 1/8	1/2
C2	2 1/2 x 2	5	4 1/8	1 3/8	7/8
61	6 x 1	9 3/8	2 5/8	9/16	1/4

Expansion Joints of Teflon®

2-Convolutions

Available Movement (Depending on Size):
Axial = 1/4” - 1”
Lateral = 1/16” - 15/32”
Angular = 5 - 16 Degrees

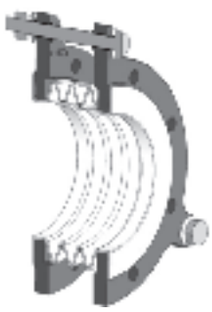


R6904

E6904

3-Convolutions

Available Movement (Depending on Size):
Axial = 1/2” - 1 3/8”
Lateral = 3/16” - 1”
Angular = 9 - 24 Degrees

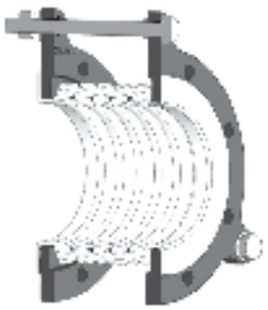


R6905

E6905

5-Convolutions

Available Movement (Depending on Size):
Axial = 7/16” - 1 5/8”
Lateral = 5/16” - 1”
Angular = 17 - 39 Degrees



R6906

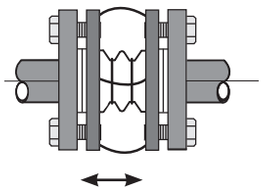
E6906

Why Use Expansion Joints?

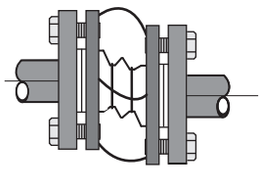
Expansion joints are used to compensate for movement, misalignment, and/or vibration in a piping system. Generally the more convolutions a joint has, the greater range of motion and lower pressure handling capacity it will have. The expansion joint must never be subjected to twist about the centerline.

Available with limit bolts or cables. Flanges are ductile iron or stainless steel. Size availability through 24".

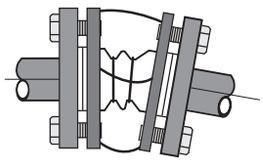
Please refer to our complete Expansion Joint Design Manual for details



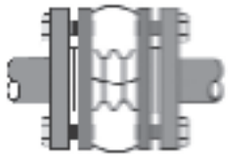
Axial Compression and Extension



Misalignment or Offset



Angular Deflection



Vibration

Flange Bolt Torquing

When assembling flange connections, always use a full complement of clean, new high strength A193-B7 bolting. If using stainless steel bolting, the bolts should be A193 Gr . B8M Class 2A and nuts should be A193 Gr . B8M Class 2B. If other bolting materials are used, the end user must ensure that the new bolting material strength properties exceed the calculated bolt stress values to be generated in making the piping connection.

1) Always use flat washers on both sides of the connection.

2) Tighten the flange bolts with a calibrated torque wrench. The recommended bolt torque values are shown in the tables on the reverse of this card. Note: For zinc-plated bolts, or with anti-seize compounds, the torque values will be different. Please contact PSI for more information.

3) Tighten the flange bolts with a torque wrench, using a “crisscross” pattern that alternately tightens the bolts located 180 degrees apart.

4) Using this pattern, tighten the bolts in 20% increments of the final bolt torque until 80% of final bolt torque has been achieved.

5) For tightening to the final torque values, tighten bolts sequentially clockwise once around the flange. This will help ensure that the bolts are evenly stressed.

6) Care should be taken to avoid over-torquing, which can cause damage to the plastic sealing surfaces.

NOTE: When bolting together dissimilar materials, always tighten to the lowest recommended torque of the components in the joint. Using higher torques may cause excessive deformation of the “softer” material in the joint. Install a 1/2" thick spacer between PSI plastic-lined pipe or fittings and other plastic-lined components, particularly valves, if the diameters of the raised plastic faces are different. Belleville washers are not recommended for use with PTFE-lined products.

Retorquing

A retorque should be applied a minimum of 24 hours after the initial torque or after the first thermal cycle. This allows for seating of the plastic and for relaxation of the bolts. If the system is to perform at elevated temperatures, it is recommended that hot water be circulated at the maximum operating temperature of the process (if possible) for a minimum of 24 hours. This allows for the pipe system to experience one thermal cycle. After cool-down, retorquing of the system

Retorquing (continued)

should be done. Torquing should only be done on the system in the ambient, cooled state, never while the process is at elevated temperature, or excessive force could be applied to the plastic faces. Never disassemble a flange joint in a hot system. Wait until the system has booled to ambient temperature.

Hydrotesting

Normally, after initial torque and retorque, a hydrotest should be performed following ANSI requirements. Experience has shown that if the above procedure has been followed very few, if any, of the flange joints may fail the hydrotest. If a flange joint does leak, first check the torque values, then tighten in 10% increments over the specified bolt torques until sealed. However, if 150% of the specified torque value is reached and the flange joint still leaks, stop and disassemble the flange joint. Something else is probably wrong such as a scratched plastic face.

Only after the hydrotest has been successfully completed and any leaks corrected, can the pipeline be signed off and commissioned.

Annual retorquing

Retorquing should be done at least annually thereafter especially if the process line experiences elevated temperatures or extreme ambient temperature situations. Torquing should only be done on the system in the ambient, cooled state, never while the process is at elevated temperature or excessive force could be applied to the plastic faces.

Pressure Testing

Hydrostatic Test

Pipe and fittings manufactured by PSI can be tested at the pressures recommended by ASME B31.3.

The fluid used for the hydrostatic test is typically water. Another suitable non-toxic liquid can be substituted if there is the risk of damage due to the adverse effects of having water in the system. The system should be tested at a pressure not less than 1.5 times the design pressure. If the design temperature is above the test temperature then the required test pressure is calculated by the following equation:

$$P_t = \frac{(1.5\ PS_t)}{S}$$

Where
P_t = minimum hydrostatic test gauge pressure
P = internal design gauge pressure
S_t = stress value at test temperature
S = stress value at design temperature

Typically, for the pressures and temperatures in which plastic-lined pipe is used, the above calculation reduces to:

$$P_t = 1.5\ P$$

We recommend that the system be retorqued after the first thermocycle. If the hydrostatic test is performed at the expected operating temperature (a “hot hydrotest”) then the hydrotest can constitute the first thermocycle and the recommended retorquing can occur after the pressure test.

Pneumatic Leak Test

This pressure test is performed in some situations where the presence of any water in the system is forbidden. The test is very dangerous due to the stored energy of the compressed gas. ASME B31.3 refers to the dangers of performing this test and provides safety considerations in the standard.

For a pneumatic pressure test, a pressure relief device must be in the system. This relief device should be set at the test pressure plus either 50 psi or 10% of the test pressure, whichever is lower. The gas used for the pneumatic test, if not air, can be any nonflammable and non-toxic gas. The test pressure required for this test is 110% of the design pressure.

To perform the pneumatic leak test, begin by increasing the pressure until a gauge pressure of 25 psi is attained. At this point, a preliminary check for leaks must be made. After the initial check, the pressure should be incrementally increased, holding the pressure at each increment long enough to equalize the piping strains. Once the test pressure is reached, the pressure is then reduced to the design pressure before examining for leakage.

Alternative Leak Test

If a hydrostatic pressure test is undesirable due to the possible chemical reactions with water and a pneumatic test in undesirable due to the potential hazards, then an alternative leak test can be used. This test is not applicable to plastic lined pipe because it relates to welded systems.

Initial Service Leak Test

This test is applicable only to systems, which meet the following requirements:

- The fluid handled is nonflammable, non-toxic, and not damaging to human tissues.
- The design gauge pressure does not exceed 150 psi.
- The design temperature is between -20°F and 366°F.

In this test, the test fluid is the service fluid. It is rare that this test is used with plastic-lined pipe. ASME B31.3 should be considered if more information concerning this test is required.

Other Tests

Another option, which is not included in ASME B31.3, is the “halogen test with Freon”. This test will find leaks in the piping system, but it does not meet the code.

The above is a description of some pressure test methods. In general, most systems are hydrostatically tested as described in the ASME standard. If the hydrostatic test is impractical, then the pneumatic test can be substituted, however, extreme caution must be observed during this potentially hazardous test.

Bolt Torque Requirements

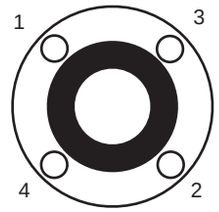
ANSI Class 150 Systems Lightly Oiled A193 Gr. B7 Bolts and A194 2H Nuts								
Pipe Size	Bolt Torque (ft-lb per Bolt)							
	PP		PVDF		PTFE		PFA	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1	13	17	17	21	8	13	12	17
1.5	31	41	41	50	19	31	28	41
2	65	85	85	104	39	65	59	85
3	103	134	134	165	62	103	93	134
4	67	88	88	108	40	67	61	88
6	124	161	161	199	75	124	112	161
8	167	217	217	267	100	167	150	217
10	157	204	--	--	94	157	--	--
12	193	251	--	--	116	193	--	--

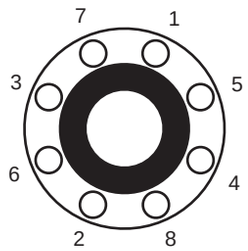
ANSI Class 300 Systems Lightly Oiled A193 Gr. B7 Bolts and A194 2H Nuts								
Pipe Size	Bolt Torque (ft-lb per Bolt)							
	PP		PVDF		PTFE		PFA	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1	17	22	22	27	10	17	15	22
1.5	47	61	61	75	28	47	42	61
2	33	42	42	52	20	33	29	42
3	62	80	80	99	37	62	56	80
4	81	105	105	130	49	81	73	105
6	83	108	108	132	50	83	75	108
8	130	169	169	207	78	130	117	169
10	135	175	--	--	81	135	--	--
12	186	242	--	--	112	186	--	--

Note: These maximum torques are only valid for LIGHTLY OILED A193 B7 bolts. Lightly oiled is considered lubrication with WD-40 or equivalent. Please contact us for guidance on torques for other bolting/lubrication systems.

Note: The maximum recommended torque values are suggested for lined systems operating at or near the maximum recommended pressures and temperatures. Systems operating under less severe conditions can in general experience leak-free performance using lower torque values. Additionally, anytime gaskets or spring type washers are used, we suggest using the minimum recommended torque value and that the torque be increased only to obtain satisfactory sealing. For systems that will require frequent disassembly, we suggest using the minimum recommended torque value initially to avoid distortion of the plastic face.

Always tighten bolts in crisscross pattern





Note: For specialty items rotationally-lined with Tefzel® ETFE, use values for PVDF.

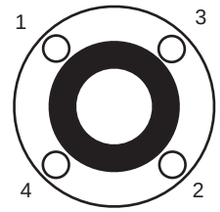
Bolt Torque Requirements

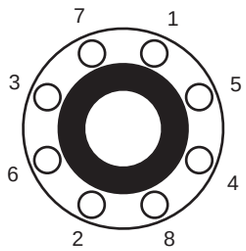
ANSI Class 150 Systems PTFE-Coated A193 Gr. B7 Bolts and A194 2H Nuts								
Pipe Size	Bolt Torque (ft-lb per Bolt)							
	PP		PVDF		PTFE		PFA	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1	8	10	10	13	5	8	7	10
1.5	19	25	25	30	11	19	17	25
2	39	51	51	62	23	39	35	51
3	62	80	80	99	37	62	56	80
4	40	53	53	65	24	40	36	53
6	75	97	97	119	45	75	67	97
8	100	130	130	160	60	100	90	130
10	94	123	--	--	57	94	--	--
12	116	150	--	--	69	116	--	--

ANSI Class 300 Systems PTFE-Coated A193 Gr. B7 Bolts and A194 2H Nuts								
Pipe Size	Bolt Torque (ft-lb per Bolt)							
	PP		PVDF		PTFE		PFA	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1	10	13	13	16	6	10	9	13
1.5	28	37	37	45	17	28	25	37
2	20	25	25	31	12	20	18	25
3	37	48	48	59	22	37	33	48
4	49	63	63	78	29	49	44	63
6	50	65	65	79	30	50	45	65
8	78	101	101	124	47	78	70	101
10	81	105	--	--	49	81	--	--
12	112	145	--	--	67	112	--	--

ANSI Class 150 Systems Zinc Plated A193 Gr. B7 Bolts and A194 2H Nuts								
Pipe Size	Bolt Torque (ft-lb per Bolt)							
	PP		PVDF		PTFE		PFA	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1	19	25	25	31	12	19	17	25
1.5	46	59	59	73	27	46	41	59
2	94	123	123	151	57	94	85	123
3	149	194	194	239	90	149	134	194
4	98	127	127	157	59	98	88	127
6	180	234	234	288	108	180	162	234
8	242	314	314	387	145	242	217	314
10	228	296	--	--	137	228	--	--
12	280	364	--	--	168	280	--	--

Always tighten bolts in crisscross pattern





Note: For specialty items rotationally-lined with Tefzel® ETFE, use values for PVDF.

Bolt and Stud Length Requirements

F x F = Fixed x Fixed
F x R = Fixed x Rotatable
R x R = Rotatable x Rotatable

ANSI Class 150 bolt and stud length requirements (All dimensions in inches)						
Flange Size	Stud Length			Bolt Length		
	F x F	F x R	R x R	F x F	F x R	R x R
1	3	3 1/4	3 1/4	2 1/2	2 3/4	2 3/4
1 1/2	3 1/4	3 1/2	3 1/2	2 3/4	3	3
2	4	4	4 1/4	3 1/4	3 1/4	3 1/2
2 1/2	4	N/A	N/A	3 1/2	N/A	N/A
3	4 1/4	4 1/2	4 1/2	3 1/2	3 3/4	4
4	4 1/4	4 1/2	4 1/2	3 1/2	3 3/4	4
6	5	5	5 1/4	4 1/4	4 1/4	4 1/2
8	5	5 1/4	5 1/2	4 1/4	4 1/2	4 3/4
10	5 1/2	5 3/4	6	4 1/2	4 3/4	5 1/4
12	5 1/2	5 3/4	6 1/4	4 3/4	5	5 1/2

ANSI Class 300 bolt and stud length requirements (All dimensions in inches)						
Flange Size	Stud Length			Bolt Length		
	F x F	F x R	R x R	F x F	F x R	R x R
1	3 1/2	3 3/4	3 3/4	3	3 1/4	3 1/4
1 1/2	4	4 1/4	4 1/2	3 1/2	3 3/4	3 3/4
2	4	4	4 1/4	3 1/4	3 1/2	3 3/4
3	4 3/4	5 1/4	5 1/4	4 1/4	4 3/4	4 3/4
4	5	5 1/2	5 1/2	4 1/2	5	5
6	5 1/2	5 3/4	6	4 3/4	5 1/4	5 1/4
8	6 1/4	7	7	5 1/4	5 3/4	6 1/4
10	7	7 1/4	7 3/4	6	6 1/4	6 3/4
12	7 3/4	8	8 1/4	6 1/2	6 3/4	7

Note: Bolt/Stud lengths for both Class 150 and 300 are calculated to include two threads past the nut, then rounded to the nearest 1/4", to result in a commercially available length. Lengths include flat washers on both sides.

Storage and Maintenance

To obtain maximum performance from plastic-lined piping products, it is important that the flared or molded end faces of the plastic are protected from damage during storage, handling and installation. The following should be considered when handling Plastic-Lined Piping Products.

- Store indoors or under cover.
- Products are shipped with a high performance, two component, epoxy primer protective coating. This coating in only a primer and is not meant for outdoor exposure without a suitable topcoat. Protective end caps are not designed for prolonged outdoor exposure.
- The protective end caps on all pipe and fittings should be left in place until the pipe is ready to be installed. Do not damage the plastic sealing faces when removing the end caps.
- Avoid rough handling of plastic-lined pipe in temperatures below 40°F. Plastic becomes brittle in low temperatures, and is more susceptible to cracking during rough handling.
- Never put the lifts of a forklift inside of the pipe to transport. This can damage the plastic liner.
- The following temperature guidelines should be followed for plastic-lined piping products:

  Do not store plastic-lined pipe in temperatures below 0°F. Avoid storing plastic-lined piping products where they will be exposed to ultraviolet light for long periods of time.

- The center of gravity of bent lined pipe may not be readily apparent. Be sure to handle carefully.

Safety precautions for plastic-lined pipe

Plastic-lined pipe can be fabricated on-site by properly certified personnel. When field fabricating, adequate ventilation (such as exhaust fans) should be used. Overheating of the plastic can cause it to degrade and generate vapors.

Avoid breathing vapors. Vapors can cause severe irritation to skin, eyes, and respiratory tract. When field fabricating, never heat the plastic with a torch or open flame.

Painting Plastic-Lined Piping Products

All pipe, fittings, and valves supplied by PSI have a gray protective coating applied to minimize oxidation during shipping and handling. Refer to NACE guidelines and recommendations for sandblasting and selection of an appropriate primer and topcoat suitable for your plant environmental conditions.

It is important that the raised plastic face on all plastic-lined piping components is protected from damage during sandblasting and painting. Make sure that the protective end caps remain in place at all times during these operations, and direct the sandblasting away from the face of the flange. As an extra precaution, you may want to remove the protective end cap, apply protective tape over the plastic face, and then replace the cap before sandblasting and painting. If the exterior of the pipe is to be treated with a head curable protective coating, exercise caution during the heating process. Never apply heat in excess of the liner's maximum temperature rating.

Vent holes on PTFE-lined pipe and PTFE-lined fittings should not be plugged with paint. The collars and holes are part of the venting system needed to prevent possible gas buildup behind the liner and possible liner collapse. Pipe, fittings and valves can be special ordered without paint, but longer lead times are necessary.

*LINED PIPE AND FITTINGS TO BE STORED UNDER COVER UNTIL THE TIME OF INSTALLATION.

Pressure Drop Information

Per 100 Feet of Straight PSI Plastic-Lined Pipe

INSTRUCTIONS FOR USE

1) You must know the flowrate in gallons per minute (gpm), or the velocity in feet per second (fps).
2) If you know the velocity in fps, go directly to the charts and locate the pressure drop for the velocity and line size you are working with.
3) If you don't know the velocity, but know the flowrate in gpm, follow the example below to determine velocity in fps:

Size	CF
1"	.6933
1.5"	.2433
2"	.1322
3"	.0543
4"	.0300
6"	.0132
8"	.0073
10"	.0045
12"	.0031

Note: CF factors were determined using the average ID's of PSI lined pipe for PTFE, PP, and PVDF liners.

Example:

What is the pressure drop in 2" pipe at 60 gpm? First multiply 60 gpm x .1322 (CF factor for 2" pipe) to get a velocity of 7.93 feet per second. Look up the pressure drop for that velocity and line size in the charts. The pressure drop is approx. 4.5 psi per 100 ft. of straight pipe.

If the resultant pressure drop is too high for your needs, repeat the procedure for the next higher line size, until you get a pressure drop that is suitable. Conversely, a smaller line size will result in higher pressure drop for a given flowrate.

Pressure drops were determined using the Darcy equation. Average lined pipe I.D.'s were used together with friction factors obtained from the Moody Diagram. Per a study made by Battelle Institute, the friction factors were derived using relative roughness factors for perfectly smooth pipes.

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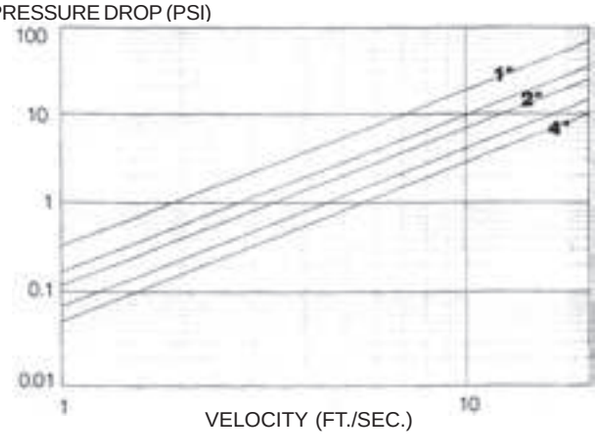
FITTINGS

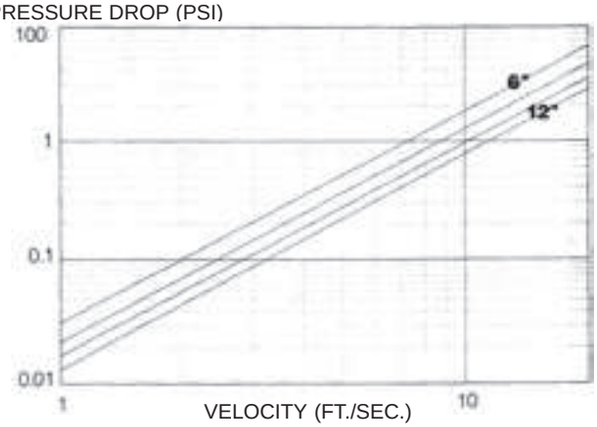
For pressure drops in fittings, please refer to a Piping Handbook giving that information for unlined components in equivalent feet of pipe. Then use the pressure drop chart for PTFE lined pipe.

PTFE Lined Pipe Pressure Drop
Water at 60°F

PRESSURE DROP (PSI)



PRESSURE DROP (PSI)



Note: The information on this page is intended to give a general idea of pressure drop for plastic-lined pipe. For actual pressure drop calculations used to size pumps or piping, use published formulas from recognized sources, such as Crane Technical Paper 410, which is also available as software.

Heat Tracing

Many products freeze or become viscous when exposed to ambient temperatures. Other polymerize, react, or become corrosive when exposed to ambient temperatures (e.g., condensation of a permeating vapor through a PTFE liner). Successful storage and transfer of such products, in most cases, requires that the piping and associated equipment be heat traced. Throughout the industry, steam, fluid, and electric heat tracing systems are widely used. All are intended for the same purpose of pipe heating, but each has its own design considerations and limitations.

The potential problem with heat tracing plastic lined pipe is overheating of the plastic liner. In PTFE lined pipe, localized heating can cause increased permeation, resulting in a single lobe collapse of the liner. Each liner has a maximum service temperature; however, some aggressive chemicals can reduce the temperature limits of the plastic. The following outlines the maximum service temperatures for the liners, recommended heat tracing methods for each liner, design considerations for each heat tracing method, and relative strengths and limitations for each heating system.

Available Liners	Maximum Temperature °F (°C)	Recommended Heat Tracing
Polypropylene (PP)	225 (107)	steam**, fluid, electric
Polyvinylidene Fluoride (PVDF)	275 (135)	steam, fluid, electric
Polytetrafluoroethylene (PTFE)	450 (232)	steam, fluid, electric
Perfluoroalkoxyflurocarbon (PFA)	450 (232)	steam, fluid, electric

**Since useful steam temperatures are above the recommended temperature for PP, a special designed isolated tracing system must be used to limit the tracer temperature to prevent overheating of the liner.

Note: Maximum Liner Service Temperature can decrease because of the service application; check Chemical Resistance data for recommended temperature of each liner for the application in question.

General Design Consideration for Heat Tracing Plastic-Lined Pipe

1. Pipe Size
2. Liner Type
   a. Maximum Liner Temperature
   b. Decrease of Liner Service Temperature Due to Service

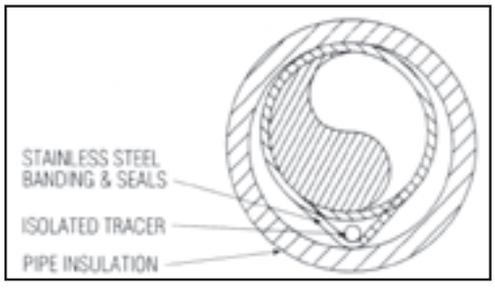
Application (per Chemical Resistance Guide)

1. Insulation Type
2. Insulation Thickness
3. Temperature to be Maintained
4. Ambient Conditions
   a. High and Low Temperatures
   b. Wind Speed

Steam Tracing : Special Design Considerations

1. Steam Pressure and Temperature
2. Since useful steam temperatures are above the recommended temperature for PP, a specially designed isolated tracking system must be designed to limit the tracer temperature to prevent overheating of the liner.
3. Advantages
   a. Often available as surplus in plant operations
   b. Good for heat up and temperature maintenance
   c. Can be used in explosive risk areas
4. Disadvantages
   a. Useful temperature range: 200°F-350°F
   b. Temperature control difficult
   c. High installation and day-to-day maintenance

Recommended steam tracing technique

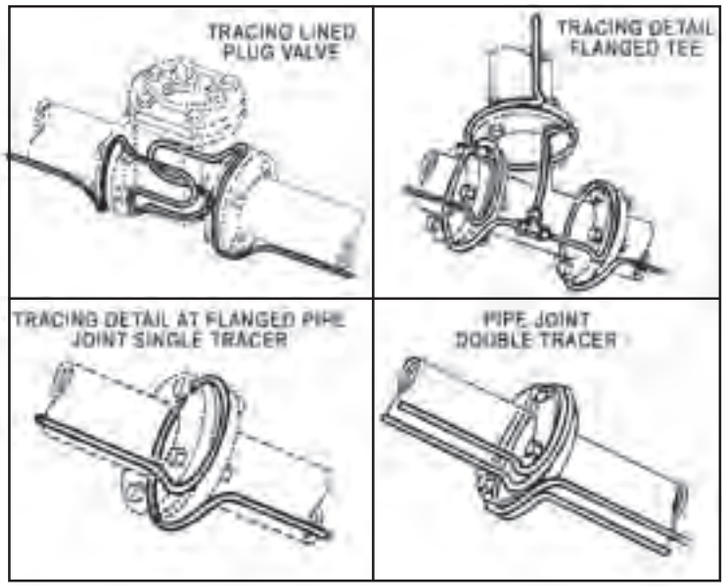


Heat Tracing

Fluid Tracing: Special Design Considerations

1. Inlet Fluid Media Temperature and Pressure
2. Fluid Media: Density, Specific Heat Viscosity
3. Maximum Allowable Fluid Pressure Drop and Outlet Temperature
4. Advantages
   a. Good for close temperature control
   b. Very good for cooling application
   c. Less susceptible to low temperature problems during system shutdown
5. Disadvantages
   a. Tracing fluids typically have a low heat capacity
   b. Environmental concerns with possible leaks
   c. Many tracing fluids are very expensive and require occasional regeneration

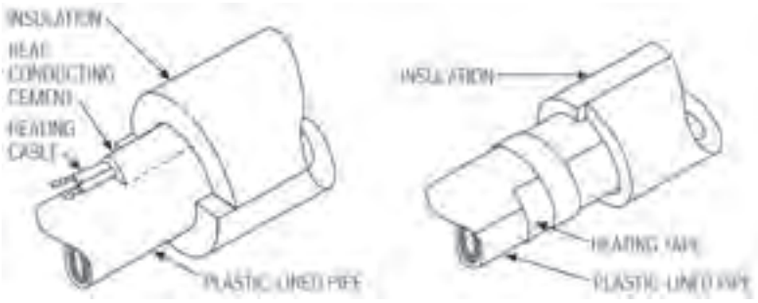
Recommended tracing configurations for joints, fittings and valves.



Electric Tracing: Special Design Considerations

1. Available Voltage
2. Hazardous Area Limitations
3. Do not use an electric heating cable with a T-Rating above the recommended liner temperature for the application in question.
4. Advantages
   a. Readily available in any plant facility
   b. Very low heat output capabilities
   c. Very good temperature control capabilities
5. Disadvantages
   a. Restricted in flammable/hazardous areas
   b. If sized for temperature maintenance, electric heat tracing provides slow heat up to the maintenance temperature

Electrical tracing methods and configurations



When heat tracing plastic line pipe, the maximum liner temperature and any decrease of this temperature due to the service application must be considered. Each heat tracing method has its own strengths and limitations and are all recommended for plastic lined pipe. However, when steam heat tracing Polypropylene (PP) a specially designed isolated tracing system must be used.

Some material extracted from “Steam vs. Fluid vs. Electric Heat Tracing,” Thermon, 1990.

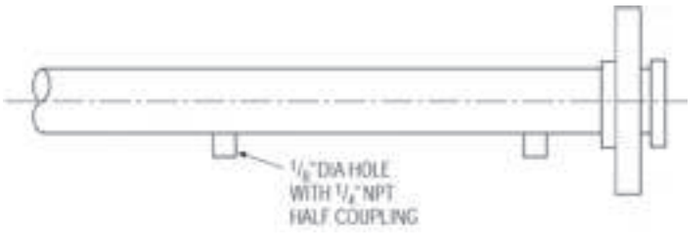
Insulation and Venting

Plastic-lined pipe is often insulated to prevent freezing, save energy or maintain a certain process temperature. Some operating experience has shown that heat tracing and insulating can also reduce permeation rates by lowering the temperature differential across the pipe wall.

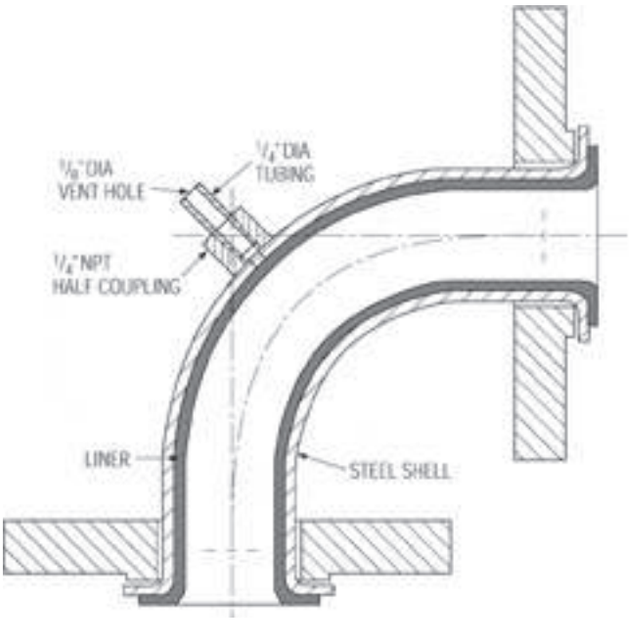
If installed improperly, however, insulation may block the paths for venting permeants on most PTFE-lined components. Under conditions which favor high permeation rates, blockage of the vent path can lead to high exterior steel shell corrosion rates, liner collapse and ultimately to premature failure of the lined components.

All PTFE/PFA-lined pipe and PTFE/PFA-lined fittings are vented via vent holes in the pipe, casting or fabricated steel shell. Welded half couplings and vent extenders can be used to extend the vent path through insulation on pipe or around fittings, as shown in Illustration A & B. Couplings are available as 3000lb. 1/8" or 1/4" sizes.

A. Vent holes and couplings on PTFE-lined pipe



B. Vent extender for fittings



Field Fabrication Procedures

Initial Procedures for Flaring PTFE / PP / PVDF Lined Pipe*

* PFA-lined pipe can be field fabricated using different tooling and procedures - consult factory.

Preparation of Lined Pipe

Note: Heating of the flaring hands can take place while the following preparatory operations are being performed.

WARNING The lining process custom fits each liner to its housing, therefore liners must not be removed from their original housings and indiscriminately used in other housings. If a liner must be removed from its housing, mark both the liner and the housing to assure the right liner goes back into the housing from which it came. Further, put the liner back in as soon as possible, otherwise it could relax slightly and make reinsertion difficult.

1


Driving Plug

Using the driving plug, push the liner along the steel pipe at one end, until it projects out the other end a distance equal to dimension "A" in the table below. (If the liner is difficult to move, use ice, dry ice or some other cooling medium to contract the liner to facilitate its movement.)


Driving plug in lined pipe with liner pushed back

Pipe Size	A	
	Inches	Millimeters
1"	2 5/16	59
1 1/2"	2 7/16	62
2"	2 15/16	75
3"	2 15/16	75
4"	3 3/16	81
6"	3 11/16	94
8"	3 15/16	97

2

Cut the lined steel pipe to length "L" minus dimension "B" (from table below) using an abrasive cut-off wheel, lathe parting tool, or power hacksaw. Cut must be square with as little burr as possible. Do not use a pipe wheel or a tube cutter since these can deform the inside of the steel pipe.


Finished Pipe Spool

Pipe Size	B	
	Inches	Millimeters
1"	13/16	21
1 1/2"		
2"		
3"		
4"	7/8	22
6"	15/16	34
8"	1 3/16	27

Values given in the table are accurate within approximately 1/16" or 2mm.

3

Using the driving plug at the newly cut end, push the liner approximately 2" (50mm) farther along the steel pipe. Then take a reamer or grinder and make a small radius on the inside edge of the steel pipe to eliminate any sharp corners or burrs at the newly cut end.

Note: Each assembly must have at least two vent holes, one at each end approximately 3" to 4" from the end. This distance will allow flanging without obstructing the vent hole. To drill the holes, first push the liner far enough back inside the already-cut-to-length housing to permit drilling the first hole safely. The hole diameter should be 3/23" (2.4mm) for pipe sizes through 4" and 5/32" (4mm) over 4". Be sure to deburr the hole inside the pipe and clean up any chips to prevent damage to the liner when repositioning it in the pipe. Repeat this operation at the opposite end.

Field Fabrication Procedures

④

Thread the end of the pipe with either a straight pipe thread (NPSM) or a tapered pipe thread (NPT). Keep the interior of the lined pipe free of oil. If a straight pipe thread is used, to prevent the flanges from rotating out of position, apply Loctite® thread sealant or equivalent to the pipe threads before putting on the flange. Part # 1XX999, DI threaded flange, can be screwed wrench tight to within 1/16" (1.5mm) of the internal flange shoulder.

Note: No step or offset is permitted on pipe ID where pipe end and flange meet. Grind smooth if necessary. Insure all burrs and chips are removed. Corner radius should be 1/8" in 1"-2", 5/16" in 3", 3/8" in large sizes.

⑤

Using the driving plug at the unflanged end, push the liner back along the pipe until the end of the liner is at least two inches inside the steel housing. Repeat the reaming, threading and flange installation procedures in steps 3 and 4. Make certain flange bolt holes are properly aligned. Flanges may be backed-off as much as 1/4 turn from the fully bottomed position.

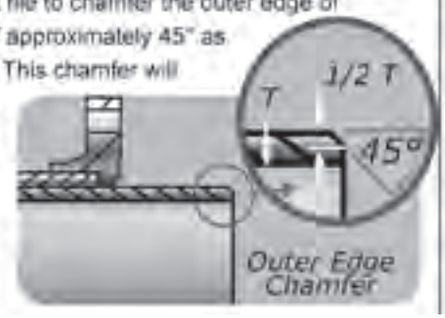
Note: Backing-off of flange must be done before thread sealant has had time to set up.

⑥

Using the driving plug, push the liner along the flanged pipe until it projects an equal amount at each end (Dimension "C" in table below). Make certain that the cut ends of the liner are square and even. Failure to make a clean, square cut could result in a split of the liner during flaring. If necessary, use a sharp knife to trim, any loose edges from the end of the liner, which may have resulted from the sawing or cutting operation.

Pipe Size	C	
	Inches	Millimeters
1"	13/16	21
1 1/2"	7/8	22
2"	1 1/8	29
3"		
4"	1 1/4	32
6"	1 1/2	38
8"	1 5/16	40

Next, use a coarse cut file to chamfer the outer edge of the liner to an angle of approximately 45° as shown in the diagram. This chamfer will smooth out any notch left in the edge of the liner after cutting, thereby preventing splits that could occur during flaring.



⑦

Note: If the liner was cooled to facilitate movement during previous steps, allow it to return to ambient temperature before proceeding with steps 7 and 8.

Remove the driving nut and washer from the expander assembly, then place the special socket wrench over the adjusting nut.

Insert this unit into the pipe so that the index groove on the wrench is even with the end of the liner or a little into the liner. Tighten the expander adjusting nut until the expander assembly is locked tightly in the pipe. Be careful not to misalign the expander or shift the liner.

Note: To insure a proper flare, it is necessary that the expander be centered when locked into the liner. Check this visually by removing the socket wrench and looking from the end of the support rod. If the expander is not centered, loosen it, center and retighten.

To prevent rotation of the rod while the expander adjusting nut is being tightened, hold it by means of the pin punch provided in the kit. The pin punch should be inserted into the small hole at the end of the rod. (There is no hole in the rod of the 1" expander. Instead, the end of the rod has parallel flat surfaces, which can be held with a wrench or pliers.)

Three extension pipes are supplied with the kit. One of the two smaller diameter pipes is supplied for placement over the handle of the pin punch to develop additional leverage, when needed. With PTFE liners, use of the pin punch extension is optional, but with PVDF & PP in 3" and larger sizes, use is desirable. (The second of the two smaller pipes is used in the handle of the socket wrench when flaring pipe liners 1 1/2" - 3" in size. The larger extension pipe is used in the handle of the socket wrench when flaring pipe liners over 3".)

Field Fabrication Procedures

Heating and Flaring

Note: Placing a metal cover over the flaring head opening reduces the heating time.

8

Heat the flaring head to the proper temperature as given in the table on page 17. (To save time, heating of the flaring head can take place while the previous seven steps are being performed.)

WARNING When field forming, use adequate ventilation (indoors, use exhaust fans). Avoid breathing of vapors resulting from overheating and possible degradation of the plastic. Do not consume food or beverages and do not smoke during fabrication process. Please refer to the Material Safety Data Sheet before heating the material. Also, to prevent electrical shock, do not use heat gun near water.

9

WARNING ***HOT Flaring Die***

Wearing the heat resistant gloves, place the heated flaring head onto the support rod. Then place the washer and driving nut onto the rod. (Do not bring the flaring head into contact with the liner extension until the washer and the driving nut are on the rod.) Next, take the special socket wrench and tighten the driving nut. This tightening will bring the hot flaring head into contact with the liner and the flaring process will have begun. A smoother operation and more uniform flare will result by using an extension pipe in the wrench handle as discussed in Step 7 and with a cranking motion, advance the hot flaring head smoothly, steadily and without stopping, until the head bottoms. This is indicated by a sudden noticeable increase in resistance. Then tighten ¼ turn more. ***Speed of flaring will be dictated by following the natural yield of the material as it softens against the flaring head.*** In some instances, after the flaring head has bottomed-out, the outer edge of the flare may not be flat against the flange face. There may be a slight gap. This is a perfectly normal condition and not a cause for rejection.

10

After flaring Heavy Duty PTFE, PVDF, and PP, immediately quench the flare with water. Leave the flaring head and the expander in place until the flare has cooled to 100°F or lower. Then disassemble and remove the flaring head and the expander. A protective cover should be immediately installed on the flared face and should remain on the assembly during handling and storage to prevent damage or excessive springback of the flare.

After the flaring head has been removed, the flared liner may taper away from the flange face at a slight angle, or may have a slightly convex surface. However, when the flaring is bolted into position at installation, the flared liner will be pushed down snugly and provide a tight, leak-proof seal.

Finished Flare

Note: When flaring polypropylene, caution should be taken not to apply excessive torque to the wrench, which could result in forcing the flaring head in too quickly.

Field Fabrication Procedures

11

Spark test the finished face for defects that may not be readily visible. Adjust the sparker to arc about 1" to the flange. Insert probe into the pipe end and circle the inside near the liner. A defect is identified by apparent major arcing through the liner. DO NOT USE pipe with a defective liner.

12

To identify plastic liner, be sure to attach the correct color-coded (p. 5) plastic band to the spool.

13

A 1/2" thick plywood cover should be bolted to the flange to protect the plastic face and to prevent the face from "remembering" its preformed shape and pulling away from the flange.

14

Attach proper label to plywood cover.

Prescribed Temperature, Equipment Settings and Approximate Flaring Head Heating Times

Pipe Liner Material	Nominal Pipe Size (in.)	Prescribed Flaring Head Temp. 1 2 3		Propane Gas Stove (R25750-GS)			Hot Plate W/ Fixed Settings (R25750-HDP)	Hot Plate w/variable settings (R25750-LHP) PVDF & PP		220 Volt Heat Gun (R29050-HG) for Liner Preheat PVDF & PP	
				Approx Heating Time (min.)	Regulator Setting		Approx. Heating Time (min.) Setting H 4	Approx. Heating Time (min.) 4	Approx. Hot Plast Temp. Setting 5	Dial Setting	Approx. Time (min.) to Preheat Liner 6
		°F	°C		psi	kg cm2					
PP	1	290	143	1.5	3	0.2	2	16	290	Maximum Setting	3/4
	1 1/2	290	143	2	3	0.2	2.5	18	290		1
	2	290	143	2	3	0.2	3	19	290		1 1/2
	3	290	143	2.5	3	0.2	4	38	290		2
	4	290	143	3	5	0.4	4.5	45	290		3
	6	290	143	4	15	1.0	13	70	290		4
	8	290	143	5	15	1.0	15	75	290		5
PVDF	1	270	130	2	3	0.2	2	15	270	Maximum Setting	1
	1 1/2	270	130	2	3	0.2	2	17	270		1
	2	270	130	2	3	0.2	2	28	270		1
	3	270	130	2	3	0.2	2	33	270		1
	4	270	130	3	5	0.4	3	38	270		2
	6	270	130	4	15	1.0	7	87	270		3
	8	270	130	4	15	1.0	9	89	270		4
PTFE	1	740	390	6	3	0.2	13	Not recommended Due to Extended Heating Times. Use R25750-GS or R25750-HDP			
	1 1/2	740	390	6	3	0.2	14				
	2	740	390	7	3	0.2	16				
	3	740	390	9	3	0.2	22				
	4	740	390	11	5	0.4	36				
	6	740	390	14	15	1.0	72				
	8	740	390	18	15	1.0	154				

① ALLOWABLE TEMPERATURE VARIATION: In order to achieve the full performance capabilities of the finished field flare piping assembly, it is essential to heat the flaring head to the temperature indicated in the table. A variation of no more than plus or minus 10°F (5°C) from the prescribed temperature is allowable.

② FLARING HEAD TEMPERATURE INDICATION: With smaller size flaring heads, the thermometer reading may lag behind the actual head temperature. Consequently, the thermometer reading may continue to rise even after the head has been removed from the electric hot plate or after the flame of the gas stove has been cut off. To determine whether this has occurred, the thermometer reading should be observed for several seconds. If the temperature continues to rise above the prescribed flaring temperature, the head should be allowed to cool to the prescribed temperature before flaring. (Temperature lag when the head is cooling can be ignored.)

③ THERMOMETER CALIBRATION: Thermometers used to determine flaring head temperature should be checked regularly for accuracy. This can be done by immersing the stem of the thermometer in boiling water to a depth of 1 1/2" (38mm). That is the same depth which the stem is inserted into the flaring head when in use. The dial should read 212°F (100°C). If it doesn't, the adjusting screw on the thermometer should be turned until the dial does read 212°F. If the dial reading cannot be brought into adjustment, the thermometer should be replaced.

④ HEATING TIMES WITH ELECTRIC HOT PLATES: For all liner materials and types, the heating times given in the table are based on the use of an insulating blanket on top of the flaring head and use of a hot plate which has been stabilized at the prescribed temperature for at least one-half hour.

⑤ CALIBRATION OF INFINITELY VARIABLE HOT PLATE: Dial readings on the infinitely variable hot plates are not necessarily accurate. When initially using the hot plate, it should be first preheated with the dial set at 270°F. A flaring head should then be placed on the hot plate with the stem of a thermometer placed into the hole in the head. After the temperature of the head has been allowed to stabilize, the thermometer reading should be observed. If it is not 270°F, the dial setting should be increased or decreased accordingly and the temperature again allowed to stabilize. The temperature reading of the thermometer should again be observed. If it is not 270°F, another adjustment of the dial should be made. This should be continued until the head attains a stabilized temperature of 270°F. A mark should then be made on the temperature dial under the temperature index. Thereafter the temperature index can be set at the mark and the head should stabilize at 270°F. This calibration should be checked periodically to verify its correctness.

⑥ APPROXIMATE PREHEATING TIMES WITH PVDF & PP: The times indicated are offered only as a guide for work scheduling. Actual heating times can vary considerably from those shown. Proper preheating should be determined by periodically pressing the end of the liner being heated until the required degree of "give" has been achieved.

Field Fabrication Tooling

Equipment Type	Item No.	Tooling Description	PSI Part No.	Liner Used to Fabricate		
Pipe Expander		**Pipe expander is used to prevent liner from slipping during forming operation.**				
	1a	1" EXPANDER	R29620-016-1	PP	PVDF	PTFE
	1b	1½" EXPANDER	R29620-024-1	PP	PVDF	PTFE
	1c	2" EXPANDER	R29620-032-1	PP	PVDF	PTFE
	1d	3" EXPANDER	R29620-048-1	PP	PVDF	PTFE
	1e	4" EXPANDER	R29620-064-1	PP	PVDF	PTFE
Cut Off Ring		**Cut off ring is used to measure cut length for pipe liner.**				
	2a	1" CUT-OFF RING	R29650-016-6	PP	PVDF	PTFE
	2b	1½" CUT-OFF RING	R29650-024-6	PP	PVDF	PTFE
	2c	2" CUT-OFF RING	R29650-032-6	PP	PVDF	PTFE
	2d	3" CUT-OFF RING	R29650-048-6	PP	PVDF	PTFE
	2e	4" CUT-OFF RING	R29650-064-6	PP	PVDF	PTFE
Flaring Head		**Flaring Head used to shape the liner face flat to the flange.**				
	3a	1" FLARING HEAD	R29650-016-3	PP	PVDF	PTFE
	3b	1½" FLARING HEAD	R29650-024-3	PP	PVDF	PTFE
	3c	2" FLARING HEAD	R29650-032-3	PP	PVDF	PTFE
	3d	3" FLARING HEAD	R29650-048-3	PP	PVDF	PTFE
	3e	4" FLARING HEAD	R29650-064-3	PP	PVDF	PTFE
Drive Plug		**Drive plug is used to push the liner along the inside of the pipe.**				
	4a	1" DRIVE PLUG	R28650-016-4	PP	PVDF	PTFE
	4b	1½" DRIVE PLUG	R28650-024-4	PP	PVDF	PTFE
	4c	2" DRIVE PLUG	R28650-032-4	PP	PVDF	PTFE
	4d	3" DRIVE PLUG	R28650-048-4	PP	PVDF	PTFE
	4e	4" DRIVE PLUG	R28650-064-4	PP	PVDF	PTFE
T-Wrench		**T-Wrench is used to tighten the expander assembly until it is locked into place.**				
	5a	1" T-WRENCH	R28650-016-2	PP	PVDF	PTFE
	5b	1½"-3" T-WRENCH	R28650-032-2	PP	PVDF	PTFE
	5c	4" T-WRENCH	R28650-064-2	PP	PVDF	PTFE

Field Fabrication Tooling

Equipment Type	Item No.	Tooling Description	PSI Part No.	Liner Used to Fabricate		
	6	Thermometer	R25750-T	PP	PVDF	PTFE
Drive Plug Handle		**Drive Plug Handle**				
	7	Drive Plug Handle	R25750-5	PP	PVDF	PTFE
Pin Punch		**Pin Punch is used to prevent rotation of the rod while expander adjusting nut is being tightened.**				
	8a	PIN PUNCH ¼" (1½-3")	R25750-PP-2	PP	PVDF	PTFE
	8b	PIN PUNCH 3/8" (4" UP)	R25750-PP-3	PP	PVDF	PTFE
Extension Bar		**Placed over handle of pin punch to develop additional leverage.**				
	9a	EXTENSION BAR (1½-3")	R28650-29	PP	PVDF	PTFE
	9b	EXTENSION BAR (1½-3")	R28650-30	PP	PVDF	PTFE
Thread Compound		**Thread compound is used to prevent the flanges from rotating out of position when a straight pipe is used.**				
	10	Thread Compound	R25750-L	PP	PVDF	PTFE
Storage Box		**Storage box is used to store all tooling used to field flare plastic-lined piping.**				
	11a	Storage Box 1"-4"	R25750-B	PP	PVDF	PTFE
	11b	8"	7058480	PP	PVDF	PTFE
High Temperature Gloves		**High Temperature Gloves are used to handling hot flaring head.**				
	12	High Temperature Gloves	R28760-G	PP	PVDF	PTFE

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