ETHYLENE™

ChemTite Lined Pipe – Engineering Guide

4855 Broadmoor Avenue S.E. Kentwood, MI. 49512

Tel. (616) 554-0900 • Fax (616) 554-3464 www.ethylene.com

Product Data

Terminology and Industry Standards

INDUSTRY STANDARDS

ANSI	American National Standard Institute
ASTM	American Society for Testing and Materials
ASTM F1545	Standard Specification for Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges
ASTM A53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A105	Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A106	Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A216	Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A234	Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A269	Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A395	Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures
ASTM A513	Standard Specification for Electric-Resistance Welded Carbon and Alloy Steel Mechanical Tubing

Standard Material Specifications

LINING MATERIALS

Abbreviation	*Formal Name*	*Material Standard*
PTFE	Polytetrafluoroethylene	ASTM D4894 / ASTM D4895
PFA	Perfluoroalkoxy	ASTM D3307
PP	Polypropylene	ASTM D4101
PVDF	Polyvinylidene Fluoride	ASTM D5575
FEP	Fluorinated Ethylene-Propylene	ASTM D2116
ETFE	Ethylene Tetrafluoroethylene	ASTM D3159

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Carbon Steel Housing:

PIPE ASTM A53 Gr. B or ASTM A106 Seamless

FITTINGS Fabricated Carbon Steel from pipe as listed, ASTM A513, ASTM A516 or ASTM A234
Cast fittings: ASTM A395 Cast Ductile Iron

FLANGES Rotating Lapped Joint; ASTM A105 Forged Carbon Steel per ASME B16.5
Fixed Slip on; ASTM A105 Forged Carbon Steel per ASME B16.5
Fixed Threaded; ASTM A395 Cast Ductile Iron per ASME B16.42

Stainless Steel Housing:

GRADES Dual Grade 304/304L or 316/316L

PIPE ASTM A312

FITTINGS Fabricated Stainless Steel: ASTM A312, ASTM A240, ASTM A403 or ASTM A269

FLANGES ASTM A182

Liner Material Typical Properties:

Liner Properties	Test Method	PTFE	PFA	PP	PVDF (Copolymer)	FEP	ETFE
Service Temperature (°F)*	-	-20 - 450	-20 – 450	0 – 225	-20 - 275	-20 - 300	-20 - 300
Min. Tensile Strength at Break (psi)	ASTM D638	3,000	3,800	3,000†	4,000	3,000	6,500
Min. Elongation at Break (%)	ASTM D638	250	300	10†	300	250	275
Thermal Conductivity (Btu-in/h-ft^2-°F)	ASTM E1530	1.7	1.35	0.8	1.3	1.3-1.6	1.6
Water Absorption (%)	ASTM D570	<0.01	<0.03	<0.02	0.03 – 0.05	<0.03	<0.03
Specific Gravity	ASTM D792	2.14-2.19	2.15	0.9	1.77 – 1.80	2.15	1.73
Liner Color	-	White	Natural	Orange	Natural or Black	Natural	Natural

* Acceptable maximum temperature depends on process fluid. For more information, see Andronaco Industries Chemical Resistance Guide

† Values listed are taken at yield

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Flange Dimensions

NOMINAL FLANGE DIMENSIONS (in)										
	Class 150					Class 300				
NPS	Flange OD	Min. Flange Thickness	Bolt Circle Dia.	No. Bolt Holes	Bolt Hole Dia.	Flange OD	Min. Flange Thickness	Bolt Circle Dia.	No. Bolt Holes	Bolt Hole Dia.
1	4 1/4	1/2	3 1/8	4	5/8	4 7/8	5/8	3 1/2	4	3/4
1 1/2	5	5/8	3 7/8	4	5/8	6 1/8	3/4	4 1/2	4	7/8
2	6	11/16	4 3/4	4	3/4	6 1/2	13/16	5	8	3/4
3	7 1/2	7/8	6	4	3/4	8 1/4	1 1/8	6 5/8	8	7/8
4	9	7/8	7 1/2	8	3/4	10	1 3/16	7 7/8	8	7/8
6	11	15/16	9 1/2	8	7/8	12 1/2	1 3/8	10 5/8	12	7/8
8	13 1/2	1 1/16	11 3/4	8	7/8	15	1 9/16	13	12	1
10	16	1 1/8	14 1/4	12	1	17 1/2	1 13/16	15 1/4	16	1 1/8
12	19	1 3/16	17	12	1	20 1/2	1 15/16	17 1/4	16	1 1/4
14	21	1 5/16	18 3/4	12	1 1/8	23	2 1/16	20 1/4	20	1 1/4
16	23 1/2	1 7/16	21 1/4	16	1 1/8	25 1/2	2 1/4	22 1/2	20	1 3/8
18	25	1 9/16	22 3/4	16	1 1/4	28	2 3/8	24 3/4	24	1 3/8
20	27 1/2	1 1/16	25	20	1 1/4	30 1/2	2 1/2	27	24	1 3/8
24	32	1 7/8	29 ½	20	1 3/8	36	2 3/4	32	24	1 5/8

* Flange Dimension per ASME B16.5 / ASME B16.42

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Pipe Dimensions

Nominal Pipe Size	Nominal Outside Diameter	Nominal Wall Thickness (in)			
(in)	(in)	SCH 40 (S)	SCH 30	SCH 20	STD WEIGHT
1	1.315	0.133	-	-	Same as SCH 40
1 1/2	1.900	0.145	-	-	
2	2.375	0.154	-	-	
3	3.500	0.216	-	-	
4	4.500	0.237	-	-	
6	6.625	0.280	-	-	
8	8.625	0.322	-	-	
10	10.750	0.365	-	-	
12	12.750	-	-	-	0.375
14	14	-	-	-	0.375
16	16	-	-	-	0.375
18	18	-	-	-	0.375
20	20	-	-	-	0.375
24	24	-	-	-	0.375

* Larger diameter components above 24in are considered custom fabrications, but are available upon request.

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Pressure and Vacuum Ratings

Pressure / temperature rating of ChemTite® lined pipe and fittings are based on the industry standard published ratings for flanges by material grade. In the case of Class 300 ASME B16.5 flanges, the pressure / temperature rating is further limited by the sealing strength of the flared liner so that a leak free flanged joint is ensured. Ratings for these components are less than published within ASME B16.5 since the joint is limited by the sealing capabilities of the flared liner.

In general, ChemTite® lined pipe and fittings are fully vacuum rated up to 450°F for sizes through NPS 12. Consult factory for ratings on larger sizes. Larger sizes above 24in are considered custom fabrications, but are available upon request.

Temperature		Material of Construction and Pressure Class									
		Class 150 ASTM A395 Cast Ductile Iron Flanges		Class 150 ASTM A105 Forged Flanges		Class 150 ASTM A182 Dual Grade F304/F304L		Class 150 ASTM A182 Dual Grade F316/F316L		Class 300 Flanges	
°F	°C	psig	barg	psig	barg	psig	barg	psig	barg	psig	barg
-20	- 28.8	250	17.2	285	19.7	275	19.0	275	19.0	495	34.1
50	10	250	17.2	285	19.7	275	19.0	275	19.0	495	34.1
100	38	250	17.2	285	19.7	275	19.0	275	19.0	495	34.1
150	65	242	16.7	272	18.8	253	17.4	255	17.6	495	34.1
200	93	235	16.2	260	17.9	230	15.9	235	16.2	485	33.4
250	121	225	15.5	245	16.9	218	15.0	225	15.5	470	32.4
300	149	215	14.8	230	15.9	205	14.1	215	14.8	460	31.7
350	177	207	14.3	215	14.8	198	13.7	205	14.1	450	31.0
400	204	200	13.8	200	13.8	190	13.1	195	13.4	440	30.3
450	232	185	12.8	185	12.8	180	12.4	183	12.6	420	28.9

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Installation Recommendations

Handling and Storage

To prevent damage to the flange sealing surfaces, flange protectors should remain in place until installation of ChemTite® pipe and/or fittings. Flange protectors should be reinstalled any time an item is removed from service.

The following considerations should be taken into account when handling ChemTite® lined steel pipe and products.

- Never nest products when transporting as this can damage the liner.
- Never insert forks of a forklift inside pipes or fittings as this can damage the liner.
- Prior to installation inspect all flared sealing surfaces to ensure no unacceptable damage has occurred.
- Immediately install pipe / fittings after removing protective wood covers from flange ends.

Flange Assembly

Bolt Torque Sequence

Prior to applying torque, ensure flanges are aligned appropriately to reduce external loads on the flanged joint and sealing surfaces. Guidance of flange alignment tolerances for axial centerline, parallelism, and rotational conditions per ASME PCC-1, Appendix E should be followed.

Generally, gaskets are not required to be used between ChemTite® lined steel products. However, when a joint is frequently disassembled or has been in service and disassembled, a gasket is recommended during joint reassembly.

When bolting ChemTite® lined steel products to components made of dissimilar materials such as unlined metal, glass lined steel, fiberglass or other materials, gaskets must be used. When bolting together dissimilar liners or materials always use the lowest recommended torque value. Not using the lowest torque value can result in damage of the limiting material in the joint.

Unless using fluoropolymer coated fasteners, lubricate all fastener threads and nut bearing surface that contacts the back side of the flange. Finger tighten all nuts and bolts ensuring the nuts spin freely on the threads. Recommended fastener materials are ASTM A193 B7 studs with ASTM A194 Gr 2H heavy hex nuts. If alternate bolting materials are used the end user is responsible for ensuring the selected material has adequate strength to withstand the stresses required to create a seal on the flange flares and maintain joint tightness at design conditions.

Always use a calibrated torque wrench and tighten bolts in a criss-cross fashion following the recommended bolt torque sequence per Figure 1. Torque should be applied in the criss-cross fashion in 30% increments until attaining the full recommended torque value. When the full recommended torque value has been applied, a final pass at the full recommended torque value shall be applied in a circumferential clockwise fashion.

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Installation Recommendations

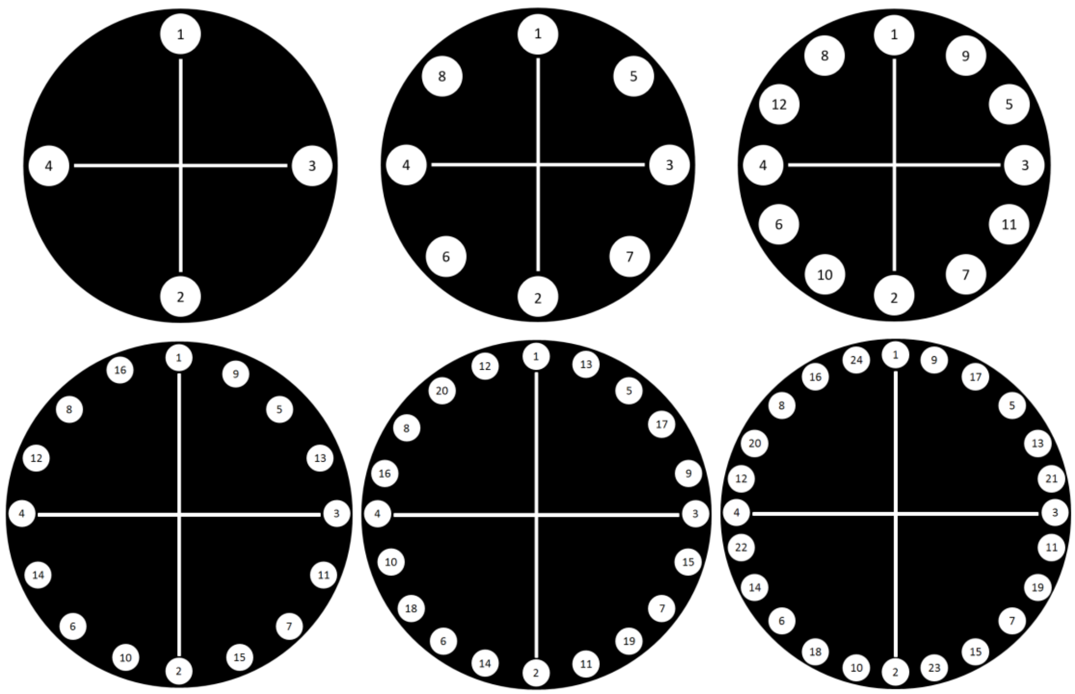

FIGURE 1. RECOMMENDED BOLT TORQUE SEQUENCE

Re-torqueing

A re-torque of all flanged connections is recommended at a minimum of 24 hours after initial assembly of the flange joint or after one thermal cycle. This accommodates relaxation of the flared sealing surfaces and fasteners. Re-torqueing of flanged connections should occur when the piping system has cooled to ambient temperatures with pressure fully relieved from the piping system. Never tighten fasteners on flanged joints at elevated temperatures and/or with the piping system or equipment pressurized. This can result in overstressing the fasteners and/or liners at the sealing surface. Doing so can result in serious injury or harm to personnel and/or equipment.

After the initial re-torque has taken place, a pressure test of the piping system should be conducted and all flanged joints and components inspected. Any leakage issues in the system need to be addressed prior to placing the piping system into service. After this, re-torqueing of flanged connections should not be required unless leakage occurs at flange joints. If a flange leak occurs, the joint should be inspected after being isolated from service. Areas for inspection should focus on the joint itself and piping alignment, ensuring there are not excessive external forces. If the leak cannot be resolved, the joint should be disassembled and flares inspected to ensure there is no damage to the sealing surface such as radial scoring, or thinning / extrusion of the liner at the flare.

Annual re-torqueing flanged joints after being in service can produce misleading results depending on the condition of assembly hardware. Corrosion, paint overspray, loss of fastener lubricant or other factors affecting the fasteners can negatively affect torque values. This can lead to lower than anticipated sealing stresses being applied to the flange joint when re-applying the recommended torques.

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Installation Recommendations

Recommended Bolt Torque

PTFE Lined Systems				
	Bolt Torque (ft-lb)			
	Class 150		Class 300	
Size	Lightly oiled ASTM A193 Gr. B7	PTFE-coated ASTM A193 Gr. B7	Lightly oiled ASTM A193 Gr. B7	PTFE-coated ASTM A193 Gr. B7
1	10 - 15	5 - 10	15 - 20	5 - 10
1-1/2	20 - 30	10 - 20	25 - 50	15 - 30
2	40 - 65	25 - 40	20 - 35	10 - 20
3	60 - 105	40 - 65	35 - 65	20 - 35
4	45 - 75	25 - 40	50 - 80	30 - 50
6	80 - 125	45 - 75	50 - 85	30 - 50
8	100 - 170	60 - 100	75 - 135	50 - 80
10	160 - 200	90 - 125	135 - 180	80 - 110
12	200 - 250	110 - 150	190 - 250	110 - 150
14	150 - 265	95 - 160	110 - 180	65 - 110
16	145 - 240	90 - 150	145 - 240	90 - 145
18	195 – 325	120 - 200	145 - 240	90 - 145
20	170 - 280	100 - 170	160 - 260	95 - 160
24	215 - 365	130 - 220	220 - 360	130 - 220

PFA / FEP Lined Systems				
	Bolt Torque (ft-lb)			
	Class 150		Class 300	
Size	Lightly oiled ASTM A193 Gr. B7	PTFE-coated ASTM A193 Gr. B7	Lightly oiled ASTM A193 Gr. B7	PTFE-coated ASTM A193 Gr. B7
1	10 - 20	8 - 10	15 - 25	10 - 15
1-1/2	30 - 45	15 - 25	40 - 60	25 - 40
2	60 - 90	35 - 55	30 - 45	15 - 25
3	90 - 130	55 – 80	55 - 85	35 - 50
4	60 - 90	35 - 55	70 - 110	45 - 65
6	115 - 165	70 - 100	75 - 115	50 - 70
8	145 - 225	90 - 165	115 - 180	75 - 110
10	240 - 275	135 - 165	180 - 240	120 - 145
12	300 - 335	165 - 200	285 - 335	165 - 200

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Installation Recommendations

Polypropylene Lined Systems				
	Bolt Torque (ft-lb)			
	Class 150		Class 300	
Size	Lightly oiled ASTM A193 Gr. B7	PTFE-coated ASTM A193 Gr. B7	Lightly oiled ASTM A193 Gr. B7	PTFE-coated ASTM A193 Gr. B7
1	15 - 20	8 - 10	15 - 25	10 - 15
1-1/2	30 - 40	20 - 25	50 - 65	25 - 40
2	65 - 85	40 - 50	30 - 45	20 - 25
3	100 - 135	60 - 80	60 - 80	35 - 50
4	65 - 90	40 - 55	80 - 110	50 - 65
6	125 - 160	75 - 100	85 - 110	55 - 70
8	165 - 220	105 - 135	135 -175	80 - 105
10	160 - 205	95 - 125	135 - 175	85 – 110
12	195 - 250	115 - 155	190 – 250	115 - 150

PVDF / ETFE Lined Systems				
	Bolt Torque (ft-lb)			
	Class 150		Class 300	
Size	Lightly oiled ASTM A193 Gr. B7	PTFE-coated ASTM A193 Gr. B7	Lightly oiled ASTM A193 Gr. B7	PTFE-coated ASTM A193 Gr. B7
1	15 - 25	10 - 15	20 - 30	15 - 20
1-1/2	40 - 50	25 - 30	60 - 70	35 - 45
2	85 - 105	50 - 60	40 - 55	25 - 35
3	135 - 165	80 - 100	80 - 105	45 - 60
4	85 - 110	55 - 65	100 - 135	60 - 80
6	165 - 200	105 - 120	110 - 140	65 - 80
8	215 - 270	135 - 170	170 - 215	110 - 125
10	210 - 255	125 - 155	175 - 220	110 - 145
12	255 - 315	155 - 190	245 - 305	150 - 185

Pressure testing

ASME B31.3 requirements for piping system pressure testing can be applied to ChemTite® lined steel products. All anchors, guides and supports must be in place prior to testing the line.

Hydrostatic Leak Test

Typical hydrostatic testing per ASME B31.3 process piping is conducted with water. However, if there is the possibility of damage due to freezing or adverse effects of water with the process fluid alternate test media can be used. Any testing media should be non-toxic and must be compatible with the piping system materials of construction and process fluid. If the piping system to be hydrostatically tested is designed for gas or vapor

Installation Recommendations

service, ensure system supports are adequate to handle the weight of the piping and testing fluid prior to filling the system. Ensure appropriate high point vents and low point drains are installed in the piping system to evacuate trapped air when filling the piping system with test fluid, and to completely drain test fluids after testing.

For hydrostatic testing, test pressures should be at least 1.5 times the system design pressure. Design and test pressures shall be based on the lowest pressure rated component installed. If the piping system design temperature is greater than the testing temperature the calculated test pressure can be determined as:

$P_T = 1.5PS_T/S$
where
P = Design gage pressure / lowest system component rating
P_T = Minimum test gage pressure
S = Allowable stress at maximum design temperature
S_T = Material allowable stress at test temperature

In most case of lined steel piping systems, the above equation typically simplifies to:

$P_T = 1.5P$

Pneumatic Leak Test

Pneumatic leak tests are intended for piping system that cannot tolerate the presence of moisture due to process hazards or incompatibilities, or for those systems that would require significant support rework if explicitly designed for the conveyance of gases and or vapors. Pneumatic testing poses inherent risks due to the storage of large volumes of the compressible test medium. As such, the end user should understand and establish limitations on conducting these tests. The end user should have their own testing procedures and safety measures set in place to safely manage any pneumatic testing.

Other Recommendations

Field Fabrication

Bulk piping can be field fabricated on-site. Fabrication shall only be conducted by trained and certified personnel. When performing liner flares during field fabrication, work should be conducted in a well ventilated area. At temperatures required for flaring, the liner material can create hazardous vapors. Do not breathe vapors as exposure can cause skin, eye and respiratory irritation. It is important to use correct flaring tooling and not to apply heat from an open flame source directly to the liner. Care should be taken to not overheat the liner or flaring tooling during the flaring process.

If sand blasting and painting is conducted by the fabricator, care shall be taken to protect liner flare faces from damage during blasting. Measures shall be taken to prevent any vent holes from being plugged during painting.

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Installation Recommendations

Welding on Plastic Lined Steel Pipe

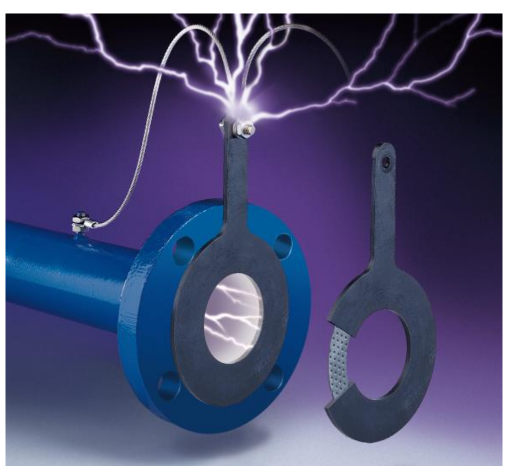
Welding should not be performed on plastic lined pipe or components. The only time it is acceptable to weld on the steel housing is on field fabricated pipe spools, prior to installing and flaring the liner. If welding on the metallic housing is absolutely necessary, the liner shall be removed prior to welding. Failure to remove the liner prior to welding will result in liner damage. Any welding shall be conducted by a qualified and certified welder for the work instructed to be performed i.e. certified to an approved ASME Boiler and Pressure Vessel Code, Section IX Welding Procedure.

Static Charging of Lined Steel Pipe

PTFE is known for the excellent chemical resistant properties, but is also had high electrical insulative properties. PTFE has a dielectric strength of 600 V/mil, this means that there exists a potential for static build-up on the liner of PTFE lined steel pipe. Due to the large, effective capacitance of the PTFE against a steel housing, large surface-charge densities may be formed. These densities give rise to highly energetic, lightning-like sparks in rapid succession known as propagating brush discharges. Such discharges have the potential to ignite most flammable atmospheres and can even ignite some of the more sensitive dusts. Pinholes in the PTFE liner may also be formed by these strong electrostatic charges. If left unchecked, these pinholes will cause premature pipe failure which will lead to chemical leaks and subsequent environmental concerns. Factors that can affect static build-up are:

- Conductivity of the process fluid
- Liquid-full or partially full / two phase flow
- Speed of the process fluid
- Surface area contact or pipe diameter

There are a few methods to control or mitigate static build-up on the PTFE liner. The first method is to slow the process fluid down so that the charge potential does not overcome the dielectric strength of the liner. This however can lead using larger pipe diameters than is necessary which can increase project costs.



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Installation Recommendations

The use of Static Dissipating PTFE TASK-LINE Grounding Paddles is an effective alternative method for addressing static charge build-up. Static dissipating PTFE resin is compression molded around and through a 304 stainless steel, perforated, metal insert. After oven sintering, the porous-free, static-dissipating PTFE resin 100% encapsulates the stainless insert, isolating it from any fluid contact while in service. TASK-LINE grounding paddles have conductivity/static dissipating properties (volume resistivity) of less than or equal to 10^6ohm-cm. The paddle handle extends 2” above the flange and is pre-drilled for grounding hardware and cable (included).

Venting and Insulation

PTFE lined steel pipe and fittings are supplied with weep holes to allow proper ventilation of permeants. The optional ChemTite® PTFE vent tubes aid in channeling these permeants away from the steel housing reducing localized corrosion in the area around the weep hole.

For insulated installations, PTFE lined pipe and fittings can be supplied with half couplings welded around the weep hole. This allows for the installation of threaded nipple vent extensions to direct permeants past the insulation. Improper ventilation past insulation can block or restrict the ventilation path. This can lead to premature failure of PTFE lined pipe or components from corrosion under insulation or buckling of the PTFE liner. If this is a concern, Durcor® Engineered Structural Composite (ESC) pipe is recommended.

Insulation and Heat Tracing

Insulation and heat tracing are not only used to prevent freezing of the process fluid, but can be used to minimize energy losses and reduce viscosity of the process fluid. Common industry methods for heat tracing (steam, fluid and electrical) can be utilized for tracing lined piping systems, but each method has their own design requirements and limitations.

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Installation Recommendations

Temperature set points, temperature cut out limitations and tracing layouts should all be considered in the design of heat tracing systems to avoid localized heating of lined piping systems. The process fluid make-up and operating temperatures play a key role in liner permeation rates. Localized heating of the metallic housing and liner can increase permeation rates leading to reduced service life or can lead to liner collapse. The liner maximum service temperature should never be exceeded. Some chemicals can further reduce the temperature limits of the selected liner. To understand product limitations for specific applications check the Chemical Resistance Guide available at www.ethylene.com.

Steam Tracing: Steam pressure must be controlled so that the temperature does not exceed the liner temperature limits. Since useful steam temperatures can be high (200 ^{o}F -350^{o}F), isolated or insulated steam tracers may be required to prevent localized overheating of the liner.

Fluid: Fluid tracing can work in a wide temperature range with moderate temperature control. Heat transfer cement should be installed for better heat transfer according to cement manufacturers' recommendations.

Electrical: Lined pipe can be successfully traced with electrical cable and sensors to ensure against localized overheating. An appropriate electric heating cable T-Rating must be selected so that the electrical cable cannot exceed the liner maximum service temperature for the specific application.