

The Thermalok® Process

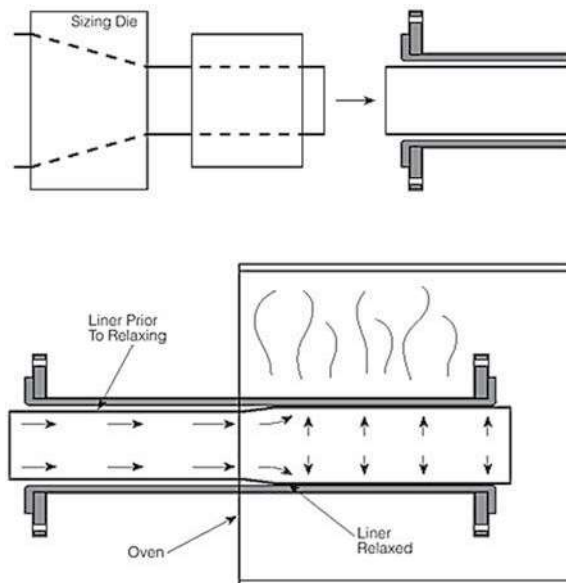
Resistoflex Thermalok steel pipe and liner act as a monolithic unit, even during extreme thermocycling. Combining dissimilar materials with very different coefficients of thermal expansion, our precision Thermalok Process locks the plastic liner into the pipe housing, making it full vacuum rated throughout the liner's temperature range. We developed and patented the Thermalok process for lining steel pipe in the 1950's, and have been the world leader in the manufacture of plastic-lined piping products ever since.

The Thermalok Process:

- Incoming lots of resin are analyzed in our Quality Assurance laboratory for conformance to established raw material specifications as required by ASTM F1545-15.
- The liner is formed 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 outside 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 hot flared. Temperature, time and pressure are carefully monitored.
- The finished pipe is then tested in accordance with ASTM F1545-15 standards.

This unique Thermalok 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



Thermalok Field Flare Pipe

Thermalok Field Flare (FF) pipe is Flange x Plain End or Plain End x Plain End pipe with movable liner for distributor or end-user fabrication¹ with the following features:

- Resistoflex manufactures Field Flare pipe utilizing the the same Thermalok 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 Resistoflex field flare flange, all types of weld flanges, and lap joint flanges.
- Resistoflex Field Flare pipe has the same performance characteristics of the factory-finished pipe, including full vacuum capability.
- Available in PTFE, PP, and PVDF, in the same sizes as factory-finished spools.
- Resistoflex Field Flare pipe has passed all ASTM F1545-15 Qualification Testing
- Housings are available in CS or SS.

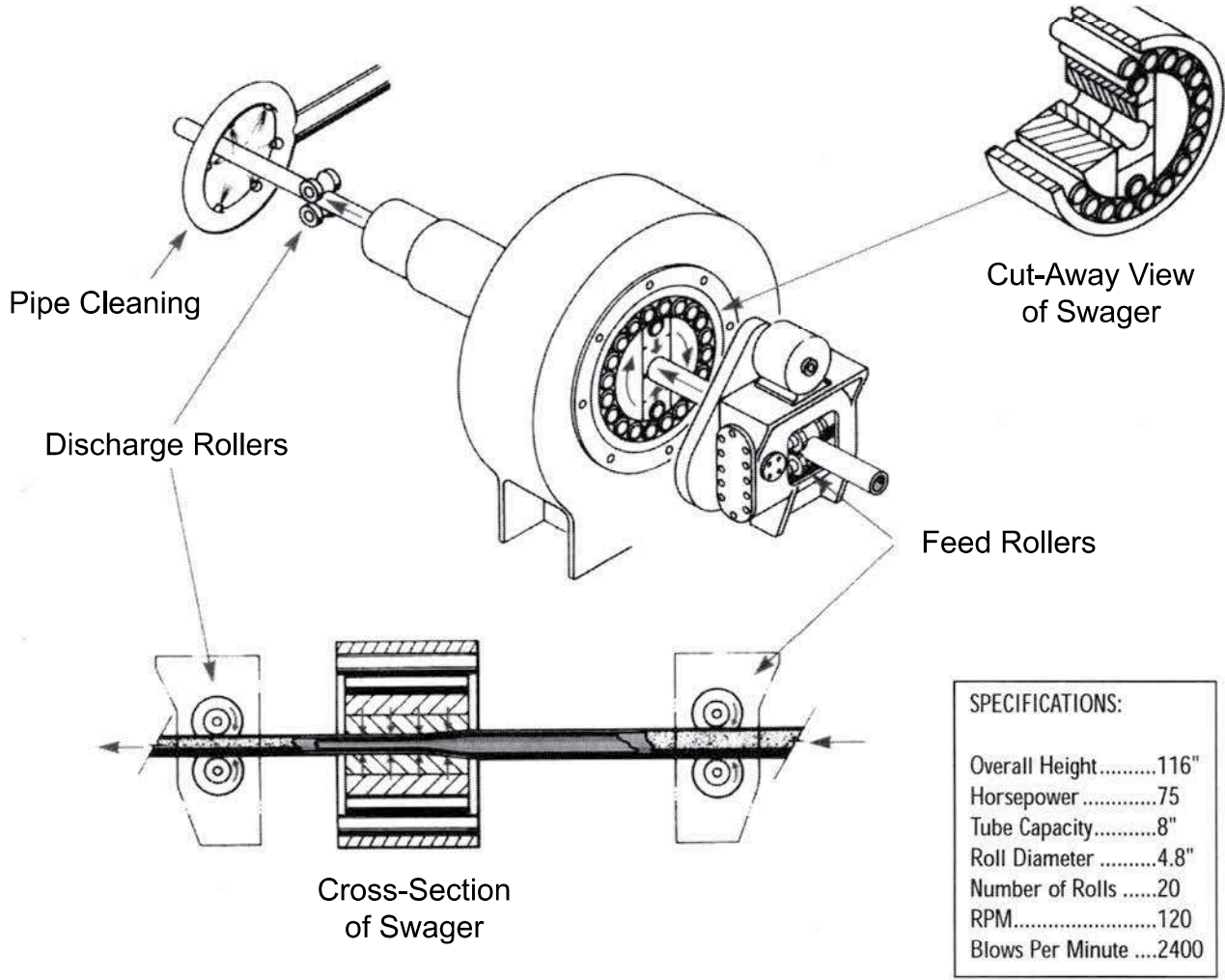
¹ - Special fabrication tooling and training required.

The Swaging Process

The process of swaging, as performed on the Abbey Etna Rotary Swager, consists of hammering metal to reduce its diameter without cutting or grinding.

We start with ASTM A513 tube that has a slightly larger OD than ASME B36.10 pipe, insert the pre-molded liner into the tube, and feed both into the swager. The swager reduces the tube OD to the equivalent of ASME B36.10 pipe, while in the process fully locking the tube down on to the liner.

The result is a lined pipe that acts as a monolithic unit throughout the temperature range, and passes all ASTM F1545-15 qualification tests.



Standard Materials Specifications

Pipe and fittings manufactured by Resistoflex are in full compliance with: ASTM F1545-15a, Standard Specification for Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges as follows

- Resistoflex purchases approved ASTM designations of resin used to manufacture liner
- Resistoflex uses approved ASTM designations of materials of construction of flanged housings
- Resistoflex meets or exceeds minimum dimensional requirements
- Resistoflex meets qualification testing requirements, including steam/cold water, temperature aging, and vacuum testing
- Resistoflex performs proof-testing on 100% of finished goods using approved procedures

Resistoflex products also meet the following specifications/requirements:

Liners:	<p>PTFE — Polytetrafluoroethylene, ASTM D4894 and D4895 PFA — Perfluoroalkoxy, ASTM D3307 PVDF — Polyvinylidene Fluoride, ASTM D3222 and D5575 PP — Polypropylene, ASTM D4101</p>								
Pipe:	<p><u>Thermalok (Carbon Steel):</u> 1" through 4" size, Sch. 40 Carbon Steel per ASTM A53 ERW, Grade B Type E or A587 ERW 6" - 8" size, Sch. 40 Carbon Steel per ASTM A53 ERW, Grade B Type E 10" size, Sch. 30 Carbon Steel per ASTM A53 ERW, Grade B Type E 12" size, Sch. 20 Carbon Steel per ASTM A53 ERW, Grade B Type E 14" - 24" size, Standard Wall Carbon Steel per ASTM A53 ERW, Grade B Type E</p> <p>Note: ASTM A106 Gr. B available on request</p> <p><u>Thermalok (Stainless Steel) 304LSS or 316LSS:</u> 1" through 8" size, Sch. 40 Stainless Steel per ASTM A312 ERW 10" size, Sch. 30 Stainless Steel per ASTM A312 ERW 12" size, Sch. 20 Stainless Steel per ASTM A312 ERW 14" - 24", Standard Wall Stainless Steel per ASTM A312 ERW</p> <p><u>Swaged:</u> 1" through 4" size, Sch. 40 Carbon Steel per ASTM A513 ERW</p>								
Flanges:	<p>Lap-joint, 1" - 12" size, Ductile Iron ASTM A395, dimensions per ASME B16.42 Class 150 Lap-joint, 1" - 24" size, Forged Carbon Steel, ASTM A105, dimensions per ASME B16.5 Class 150 or Class 300 Lap-joint, 1" - 24" size, Forged Stainless Steel, ASTM A182, dimensions per ASME B16.5 Class 150 or Class 300 Threaded (Swaged pipe), 1" - 4" size, Forged Steel ASTM A105, dimensions per ASME B16.5 Class 150 or Class 300</p> <p>Note: Standard flange configuration for Thermalok pipe spools and most PTFE-lined fittings is rotating lap joint. The lap is a "flared lap" conforming to ASME B31.3 Para. 306.4 Flared Laps. Fixed flanges are available.</p>								
Fittings:	<p>Fabricated Carbon Steel: Components per ASTM A587, ASTM A53 and/or ASTM A234 Fabricated Stainless Steel: Components per ASTM A312 and/or ASTM A403 Cast Fittings: Ductile Iron Casting (60-40-18) per ASTM A395 or Cast Steel per ASTM A216 Gr. WCB Fittings Flange Material: Ductile Iron Casting (60-40-18) per ASTM A395, or Cast Steel per ASTM A216 Gr. WCB, or Forged Carbon Steel per ASTM A105, or Forged Stainless Steel per ASTM A182.</p>								
Fabrication:	<p>Pipe and Fittings Tolerances:</p> <table border="0"> <thead> <tr> <th style="text-align: left;"><u>Dimension</u></th> <th style="text-align: left;"><u>Tolerance, in.</u></th> </tr> </thead> <tbody> <tr> <td>Length and Centerline Dimensions</td> <td>± 1/8" (3.2 mm)</td> </tr> <tr> <td>Fixed Flange Bolt Hole Alignment</td> <td>± 1/16" (1.6 mm)</td> </tr> <tr> <td>Flange Perpendicularity (with Pipe Centerline)</td> <td>3/32 in/ft (7.8 mm/m) of nominal pipe diameter</td> </tr> </tbody> </table>	<u>Dimension</u>	<u>Tolerance, in.</u>	Length and Centerline Dimensions	± 1/8" (3.2 mm)	Fixed Flange Bolt Hole Alignment	± 1/16" (1.6 mm)	Flange Perpendicularity (with Pipe Centerline)	3/32 in/ft (7.8 mm/m) of nominal pipe diameter
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Code Compliance

ASTM F1545-15a is the Governing Standard for Plastic-Lined Pipe and Fittings

Full compliance to ASTM F1545-15a requires passing the following qualification tests at design stage:

- **Temperature Aging (Hot)** - (3) 3-hour cycles at rated maximum allowable liner temperature, followed by electrostatic liner inspection
- **Temperature Aging (Cold)** - 48 hours at minimum allowable liner temperature, followed by electrostatic liner inspection.
- **Steam-Cold Water Cycling** - Fill pipe/fitting with steam until metal reaches 350 F (PTFE), drain steam, fill with ambient temperature water until metal temperature cools to 120 F. Repeat 100 cycles.
- **Vacuum Testing** - Full vacuum at desired temperature for 48 hours.

Any changes to manufacturing or design of lined pipe and fittings which affect the fit between the liner and the housing (either pipe or fitting) will require the affected items to be re-tested. Any change in resin formulation also triggers the retest, which applies to lined pipe manufacturers that purchase pre-made liners from multiple vendors.

Resistoflex manufactures 100% of its liners from raw resin. Manufacturers that purchase liners on the open market should not be automatically presumed to meet ASTM F1545-15a. Buyers can and should request manufacturers to submit qualification test reports for review. ASTM F1545-15a requires that manufacturers perform the tests and keep the qualification test reports on file.

Is Compliance with ASME B31.3 Process Piping Code Important to You?

ASTM F1545-15a is a "listed component standard" in ASME B31.3 Table A326.1. A manufacturer that does not fully comply with ASTM F1545-15a, including all qualification test requirements, does not comply with ASME B31.3

Resistoflex meets all requirements of ASTM F1545-15a, including all qualification test requirements. Resistoflex can provide ASTM F1545-15a Qualification Test Reports on request.

Resistoflex Also Performs the Following Tests to Ensure Superior Quality:


Stringent testing of the plastic liners before installation into the housings:

- **Dimensional Checks** - OD and wall thickness must be within tolerance
- **Mechanical Testing** - Tensile strength and elongation must meet the requirements of ASTM F1545-15a Table 4
- **Roll Testing of Liners** - 100% of PTFE liners are "roll tested" to reveal any latent cracks.
- **Light Candeling of Liners** - 100% of PTFE liners are illuminated with high-intensity light to reveal any contamination embedded within the liner wall.
- **Differential Scanning Calorimetry** - Thermal analysis of PTFE liners to ensure proper sintering profile.

Rigorous quality testing of all finished lined products:

- **Dimensional Checks** - Pipe and fitting lengths and plastic flare OD
- **30 kV Electrostatic Test** - Test for liner integrity is Resistoflex default test on most items.
- **450 psig Hydrostatic Test** - Test for liner integrity for 10" and larger PTFE-lined pipe and fittings, and 6" - 12" thermoplastic fittings. 100% hydrostatic test is available on request.

ASTM F1545-15a Test Certification is Available on Request

ASTM F1545-15a Compliance Statement	
This is to certify that Resistoflex piping products are in full compliance with all ASTM F1545-15a requirements. This includes the four design qualification tests specified in Section 6, comprised of the following:	
<ul style="list-style-type: none"> • Elevated Temperature Vacuum Test • Low Temperature Aging Test • High Temperature Cycling Test • Steam/Cold Water Cycling Test 	
Section 6 also requires test documentation be kept on file. Resistoflex test reports are available for customer viewing upon request.	
Respectfully submitted,	
	
David Yanik Resistoflex Engineering Manager	

Contact your Authorized Resistoflex Distributor or the factory to request the Resistoflex Code Compliance brochure, which includes the complete ASTM F1545-15a standard.

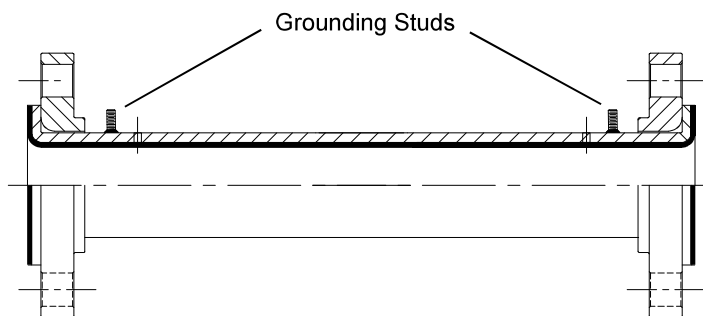
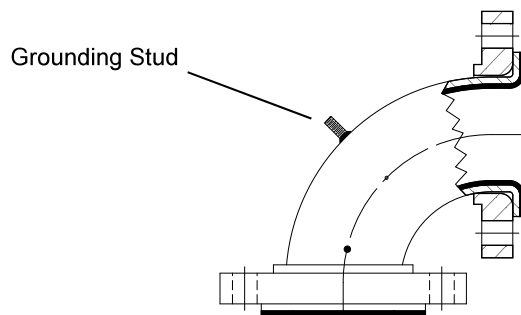
Grounding - External and Internal

External Grounding

Pipe and fittings can be specified with threaded grounding studs, or other connection method, as part of a grounding/continuity strategy for plastic-lined pipe and fittings.

The design and installation of "jumper" cables and connectors to each pipe and fitting and grounding points is the scope of the end user or design engineer.

Pipe and fittings can also be provided with an electrically-conductive paint .



Internal Grounding

Non-conductive fluids can generate a static charge when flowing through a standard PTFE-lined piping system due to the fact that PTFE is electrically insulating. Under certain conditions, conductive and semi-conductive fluids can also generate a static charge. Without dissipative methods, the static charge can build to a level high enough to exceed the dielectric strength of the PTFE liner. This can cause an electrostatic discharge that can arc through the liner, causing liner damage (pinholes) and loss of containment.

Steps can be taken to reduce this condition by limiting fluid velocity in PTFE lined piping as follows:

Liquid Conductivity	Recommended Flow Velocity For PTFE lined piping
1,000 - 10,000 pS/m	less than 9.9 f/s (3 m/s)
50 - 1,000 pS/m	less than 6.6 f/s (2 m/s)
less than 50 pS/m	less than 3.3 f/s (1 m/s)

These values may not be practical, however, due to productivity demands. Where higher flows are necessary, pinholes can be avoided by the prevention of charge accumulation.

The end user can install metal grounding rings or paddles at flange connections to route static charge to grounding points. The paddle material must be compatible with the service fluid. The number and frequency of paddles is determined by the design engineer or a third-party engineer specializing in electrostatic hazard mitigation.

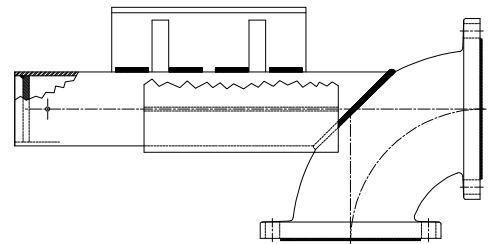
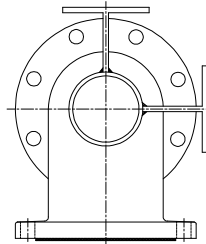
PTFE liner can also be specified as "Anti-Static" or conductive, which is made by adding a small amount of carbon black to the PTFE resin during the liner manufacturing process. The anti-static PTFE has a surface resistivity of 10^4 to 10^8 Ohm. The static charge will dissipate through the liner to the metal housing, rather than accumulating on the surface of the liner.

Welded Supports

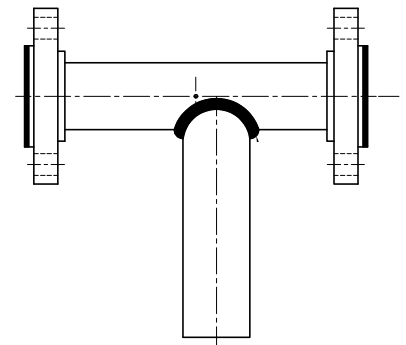
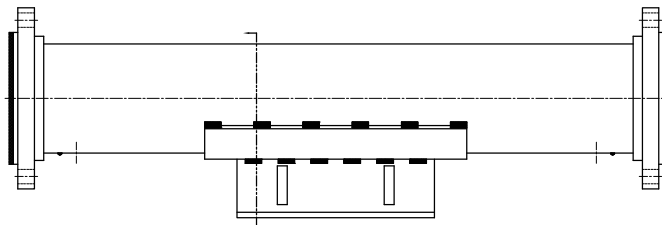
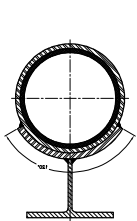
Welded attachments cannot be applied to lined pipe at the site, or liner damage will result. Resistoflex can provide shop-welded supports that are attached to the pipe or fitting prior to lining.

Typical types of welded supports are as shown, with other examples as follows:

- Shoes
- Clips
- Stops
- Trunnions
- Dummy legs
- Reinforcing pads



Piping designers are requested to provide engineering support details to Resistoflex at the time of quotation.



Engineering Support Services

Bill of Material Take-Off for Quotes

Resistoflex can generate a bill of material from customer isometric drawings or orthographic drawings at no charge. Bills of materials from orthographic drawings will be marked as "budgetary". Drawings can be submitted in PDF or *.dwg format.

Resistoflex Isometric Drawing Service

We can develop isometric drawings from customer orthographic drawings, or from hand-sketches of field measurements. This is a fee-based service.

Installation Training Certification

Plastic-lined pipe and fittings are installed like other flanged piping systems, with emphasis placed on using calibrated torque wrenches and following the manufacturer's torque requirements. For installers that are unfamiliar with plastic-lined pipe installation, or would like a refresher course, we offer on-site installation training and certification.

Field Fabrication Training Certification

Resistoflex offers three styles of lined pipe - Thermalok, Swaged, and CONQUEST®, all of which can be field-fabricated at site using tooling and procedures provided by Resistoflex. We strongly recommend that operators be trained and certified before beginning field fabrication.

For more information regarding Engineering Support Services, contact your Resistoflex Distributor or the factory.

Standard and Custom Coatings

Standard Primer

All pipe and fittings are coated with a high-solids polyamide epoxy primer, International Coatings Intergard 345. Color is gray. Surface preparation is SSPC-SP10 Near-White Blast Cleaning.

Optional High Performance Coatings

After collecting input from major end-users, paint manufacturers, and distributors, we have developed four premium paint options with reduced standard pricing. This standardized offering meets 90% of the past special painting requirements. These four options enable improved pricing and shorter lead times by using paints that are designed with high performance and ease of application.

The four High-Performance paints are:

International Coatings Interzinc 52:	Zinc-Rich Epoxy.
International Coatings Intergard 345:	Polyamide Epoxy.
International Coatings Interthane 990:	Acrylic-Polyester Polyurethane.
Carboline Thermaline 450:	High-Temperature, Corrosion-Resistant Glass Flake-Filled Amine-Cured Epoxy Novolac.

These paints are offered in the following 2 & 3 coat combinations.

Paint System Number	Application	Paint System Description	Paint	DFT mils (µm)	Supplier
1	Above Ground, <250 F, Not Insulated	Primer: Organic Zinc-Rich Epoxy per SSPC Paint 20 Topcoat: Polyamide Epoxy	Interzinc 52 Intergard 345	2 - 3 (50 - 75) 4 - 6 (100 - 150)	International Coatings
2	Above Ground, <250 F, Not Insulated UV Resistance	Primer: Organic Zinc-Rich Epoxy per SSPC Paint 20 Topcoat: Acrylic Polyurethane	Interzinc 52 Interthane 990	2 - 3 (50 - 75) 2 - 3 (50 - 75)	International Coatings
3	Above Ground, <250 F, Not Insulated UV Resistance	Primer: Organic Zinc-Rich Epoxy per SSPC Paint 20 Intermediate coat: Polyamide Epoxy Topcoat: Acrylic Polyurethane	Interzinc 52 Intergard 345 Interthane 990	2 - 3 (50 - 75) 4 - 6 (100 - 150) 2 - 3 (50 - 75)	International Coatings
4	Insulated Pipe, Temps to 450 F, corrosive mist or splash	Primer: Glass Flake-Filled Amine-Cured Novolac Epoxy Topcoat: Glass Flake-Filled Amine-Cured Novolac Epoxy	Thermaline 450	4 - 5 (100 - 125) 4 - 5 (100 - 125)	Carboline

Note: Other customer-specified coatings are available on request, including inorganic zinc silicates, epoxy phenolics, siloxanes, and electrically-conductive polyamine-cured epoxies. Upon review of the data sheets of the requested paints, however, Resistoflex reserves the right to decline quoting customer-specified coatings based on VOC content, manufacturing incompatibility, or other factors.

Note: All paint systems have a poor resistance to handling and transit damage. This fact should be considered when evaluating shop painting versus painting at site. If shop painting is selected, touch-up will be required after job-site receipt. Touch-up costs are for Buyer's account.

Flange and Pipe Dimensional Data

ASME B16.5 Flange Dimensions								
Class 150					Class 300			
Size NPS (DN)	Outside Diameter in. (mm)	Thickness in. (mm)	No. and Diameter of Bolt Holes	Bolt Circle Diameter in. (mm)	Outside Diameter in. (mm)	Thickness in. (mm)	No. and Diameter of Bolt Holes	Bolt Circle Diameter in. (mm)
1/2 (15)	3 1/2 (88.9)	7/16 (11.2)	(4) 5/8	2 3/8 (60.3)	3 3/4 (95.3)	9/16 (14.3)	(4) 5/8	2 5/8 (66.7)
3/4 (20)	3 7/8 (98.4)	1/2 (12.7)	(4) 5/8	2 3/4 (69.9)	4 5/8 (117.5)	5/8 (15.9)	(4) 3/4	3 1/4 (82.6)
1 (25)	4 1/4 (107.9)	9/16 (14.3)	(4) 5/8	3 1/8 (79.4)	4 7/8 (123.8)	11/16 (17.5)	(4) 3/4	3 1/2 (88.9)
1 1/2 (40)	5 (127)	11/16 (17.5)	(4) 5/8	3 7/8 (98.4)	6 1/8 (155.6)	13/16 (20.6)	(4) 7/8	4 1/2 (114.3)
2 (50)	6 (152.4)	3/4 (19.1)	(4) 3/4	4 3/4 (120.7)	6 1/2 (165.1)	7/8 (22.2)	(8) 3/4	5 (127)
3 (80)	7 1/2 (190.5)	15/16 (23.9)	(4) 3/4	6 (152.4)	8 1/4 (206.4)	1 1/8 (28.6)	(8) 7/8	6 5/8 (168.3)
4 (100)	9 (228.6)	15/16 (23.9)	(8) 3/4	7 1/2 (190.5)	10 (254)	1 1/4 (31.8)	(8) 7/8	7 7/8 (200)
6 (150)	11 (279.4)	1 (25.4)	(8) 7/8	9 1/2 (241.3)	12 1/2 (317.5)	1 7/16 (36.5)	(12) 7/8	10 5/8 (269.9)
8 (200)	13 1/2 (342.9)	1 1/8 (28.6)	(8) 7/8	11 3/4 (298.5)	15 (381)	1 5/8 (41.3)	(12) 1	13 (330.2)
10 (250)	16 (406.4)	1 3/16 (30.2)	(12) 1	14 1/4 (362)	17 1/2 (444.5)	1 7/8 (47.6)	(16) 1 1/8	15 1/4 (387.4)
12 (300)	19 (482.6)	1 1/4 (31.8)	(12) 1	17 (431.8)	20 1/2 (520.7)	2 (50.8)	(16) 1 1/4	17 3/4 (450.9)
14 (350)	21 (533.4)	1 3/8 (35)	(12) 1 1/8	18 3/4 (476.3)	23 (584.2)	2 1/8 (54)	(20) 1 1/4	20 1/4 (514.4)
16 (400)	23 1/2 (596.9)	1 7/16 (36.6)	(16) 1 1/8	21 1/4 (539.8)	25 1/2 (647.7)	2 1/4 (57.2)	(20) 1 3/8	22 1/4 (571.5)
18 (450)	25 (635)	1 9/16 (39.7)	(16) 1 1/4	22 3/4 (577.9)	28 (711.2)	2 3/8 (60.3)	(24) 1 3/8	24 3/4 (628.7)
20 (500)	27 1/2 (698.5)	1 1/16 (42.9)	(20) 1 1/4	25 (635)	30 1/2 (774.7)	2 1/2 (63.5)	(24) 1 3/8	27 (685.8)
24 (600)	32 (812.8)	1 7/8 (47.7)	(20) 1 3/8	29 1/2 (749.3)	36 (914.4)	2 3/4 (69.9)	(24) 1 5/8	32 (812.8)

ASME B36.10 Pipe Dimensions					
Class 150		Wall Thickness in. (mm)			
Size NPS (DN)	Outside Diameter in. (mm)	Sch. 40	Sch. 30	Sch. 20	Sch. STD
1/2 (15)	0.840 (21.3)	0.109 (2.8)	--	--	--
3/4 (20)	1.050 (26.7)	0.113 (2.9)	--	--	--
1 (25)	1.315 (33.4)	0.133 (3.4)	--	--	--
1 1/2 (40)	1.900 (48.3)	0.145 (3.7)	--	--	--
2 (50)	2.375 (60.3)	0.154 (3.9)	--	--	--
3 (80)	3.500 (88.9)	0.216 (5.5)	--	--	--
4 (100)	4.500 (114.3)	0.237 (6)	--	--	--
6 (150)	6.625 (168.3)	0.280 (7.1)	--	--	--
8 (200)	8.625 (219.1)	0.322 (8.2)	--	--	--
10 (250)	10.750 (273)	--	0.307 (7.8)	--	--
12 (300)	12.750 (323.8)	--	--	0.250 (6.4)	--
14 (350)	14.000 (355.6)	--	--	--	0.375 (9.5)
16 (400)	16.000 (406.4)	--	--	--	0.375 (9.5)
18 (450)	18.000 (457.2)	--	--	--	0.375 (9.5)
20 (500)	20.000 (508)	--	--	--	0.375 (9.5)
24 (600)	24.000 (609.6)	--	--	--	0.375 (9.5)

Pressure Ratings and Liner Data

The pressure/temperature ratings of Resistoflex Plastic-Lined Piping Products conform to ASME B16.5 Class 150 per the appropriate flange metallurgy. See Figure 1. The pressure/temperature ratings for lined piping with ASME B16.5 Class 300 flanges are lower than the true Class 300 ratings due the plastic raised face gasket sealing surface on lined pipe and fittings.

Standard 1" - 12" PTFE-lined pipe and fittings are rated for full vacuum at 450 F (230 C) continuous. There are a few fittings that are not rated for full vacuum to 450 F - the vacuum ratings of all 1" - 12" PTFE-lined fittings are indicated on the product pages in this design manual. PP and PVDF-lined pipe and fittings are rated for full vacuum to 225 F (107 C) and 275 F (135 C), respectively.

14" - 18" PTFE-lined pipe and fittings have limited vacuum resistance. Please consult Resistoflex for specific capabilities. 20" - 24" PTFE-lined pipe and fittings are not rated for vacuum service.

Figure 1: Pressure ratings for Resistoflex 1" - 24" pipe and fittings

Temperature °F (°C)	Pressure Class and Flange Material			
	Class 150 Ductile Iron psig (barg)	Class 150 Carbon Steel psig (barg)	Class 150 Stainless Steel Type 304L/316L psig (barg)	Class 300 Carbon Steel psig (barg)
0 (-18)	250 (17.2)	285 (19.7)	230 (15.9)	485 (33.4)
50 (10)	250 (17.2)	285 (19.7)	230 (15.9)	485 (33.4)
100 (38)	250 (17.2)	285 (19.7)	230 (15.9)	485 (33.4)
150 (65)	242 (16.7)	275 (19.1)	212 (14.6)	485 (33.4)
200 (93)	235 (16.2)	260 (17.9)	195 (13.4)	475 (32.8)
250 (121)	225 (15.5)	245 (16.9)	185 (12.8)	460 (31.7)
300 (149)	215 (14.8)	230 (15.9)	175 (12.1)	450 (31.1)
350 (177)	207 (14.3)	215 (14.8)	167 (11.5)	440 (30.3)
400 (204)	200 (13.8)	200 (13.8)	160 (11.1)	425 (29.3)
450 (232)	185 (12.8)	185 (12.8)	155 (10.7)	405 (27.9)

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 ²	Black ²	Black ³	Natural
Color of Liner Identification Band	White with Black Lettering	Brown w/ White 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 x 10 ⁻⁵	7.8 x 10 ⁻⁵	4.8 x 10 ⁻⁵	6.6 x 10 ⁻⁵	7.8 x 10 ⁻⁵	7.4 x 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 depends on the specific contact chemicals.

² Available unpigmented as a special option.

Thermalok and Swaged Pipe Dimensions

Thermalok Pipe											
Size NPS (DN)	Liner Thickness, in. (mm)						Max. Length ft. (mtr.)	Weight			
	PTFE/ATL*		PP		PVDF			(2) Flanges, lbs.	Per Foot, lbs.	(2) Flanges, kg	Per Meter, kg
	Inch	mm	Inch	mm	Inch	mm					
1/2 (15)	0.054	1.4	N/A				20 (6)	1.2	1	0.5	1.4
3/4 (20)	0.062	1.6	N/A				20 (6)	2	1.4	0.9	2
1 (25)	0.130	3.3	0.135	3.5	0.138	3.5	20 (6)	5.4	1.9	2.5	2.8
1 1/2 (40)	0.150	3.8	0.160	4.1	0.162	4.1	20 (6)	6.4	3.1	2.9	4.6
2 (50)	0.155	3.9	0.175	4.5	0.162	4.1	20 (6)	10.4	4.1	4.7	6.1
3 (80)	0.155	3.9	0.175	4.5	0.162	4.1	20 (6)	16.8	8.3	7.6	12.3
4 (100)	0.160	4.1	0.210	5.4	0.195	5	20 (6)	27	11.8	12.3	17.5
6 (150)	0.255	6.5	0.220	5.6	0.220	5.6	20 (6)	39.8	20.6	18.1	30.6
8 (200)	0.310	7.9	0.220	5.6	0.220	5.6	20 (6)	61	32.1	27.7	47.8
10 (250)	0.350	8.9	0.320	8.2	0.223	5.7	PTFE - 15 (4.5) PP/PVDF - 20 (6)	89	39	40.5	58
12 (300)	0.450	11.4	0.380	9.7	N/A		PTFE - 15 (4.5) PP/PVDF - 20 (6)	130	59	59.1	87.8
14 (350)	0.354	9	0.440	11.2			PTFE - 9.84 (3) PP - 20 (6)	210	61.1	95.5	91.1
16 (400)	0.394	10	0.503	12.8			PTFE - 8.2 (2.5) PP - 20 (6)	280	68.3	127.3	101.9
18 (450)	0.295	7.5	N/A				11.48 (3.5)	320	87.3	145.5	130.2
20 (500)	0.256	6.5					8.2 (2.5)	390	103.8	177.3	154.9
24 (600)	0.177	4.5			3.75 (1.14)	550	136.8	250	204.1		

*ATL is available in 1" - 12", only.

Thermalok pipe housings available in carbon steel, stainless steel and other alloys.

Thermalok standard flange style is rotating both ends. Fixed flange available on request, at additional charge.

1" - 12" PP and 1" - 10" PVDF lined Thermalok are full-vacuum rated to maximum liner operating temperature

PTFE-lined Thermalok is rated to full-vacuum at 450 F (230 C) in 1" - 12" sizes.

Consult factory for vacuum ratings of 14" and larger PP and PTFE-lined Thermalok.

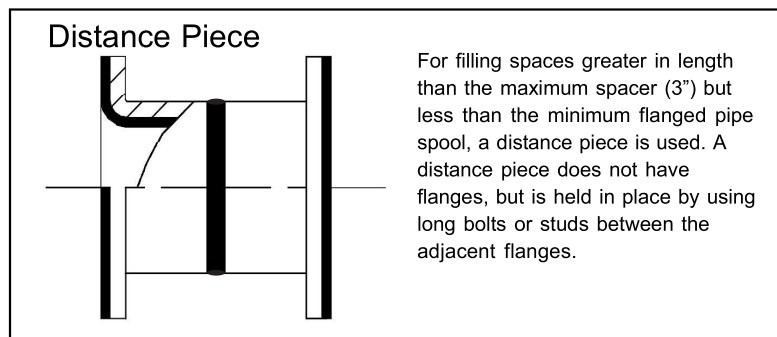
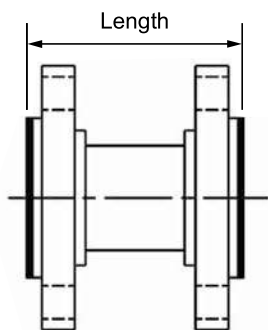
Swaged Pipe									
Size NPS (DN)	Liner Thickness, in. (mm)		Max. Length, ft. (mtr)			Weight			
	PTFE	PP/PVDF	PTFE	PP	PVDF	(2) Flanges, lbs.	Per Foot, lbs.	(2) Flanges, kg	Per Meter, kg
1 (25)	0.130 (3.3)	0.150 (3.9)	20 (6)	20 (6)	20 (6)	5.4	1.9	2.5	3
1 1/2 (40)	0.130 (3.3)	0.160 (4.1)	40 (12.2)	40 (12.2)	40 (12.2)	6.4	3.1	2.9	4.6
2 (50)	0.130 (3.3)	0.172 (4.4)	40 (12.2)	40 (12.2)	40 (12.2)	10.4	4.1	4.7	6.2
3 (80)	0.130 (3.3)	0.175 (4.5)	40 (12.2)	40 (12.2)	40 (12.2)	16.8	8.3	7.6	12.5
4 (100)	0.160 (4.1)	0.207 (5.3)	40 (12.2)	40 (12.2)	40 (12.2)	27.1	11.8	12.2	17.7

Swaged pipe is only available in ASTM A513 ERW carbon steel.

Swaged standard flange is fixed x rotating. Rotating both ends available on request, at additional charge.

Swaged pipe is full-vacuum rated to maximum liner operating temperature

Minimum Flanged Pipe Spool Lengths



Thermalok Minimum Pipe Spool Lengths									
Size NPS (DN)	No Options				With Vent Couplings or Grounding Studs				Class 150 Field Flare *
	Class 150		Class 300		Class 150		Class 300		
	Inch	mm	Inch	mm	inch	mm	inch	mm	
1 (25)	2 5/8	67	3 3/8	86	3 7/8	98	4 5/8	117	5 1/2 (139.7)
1 1/2 (40)	3 1/8	79	3 3/4	95	4 3/8	111	5	127	7 (177.8)
2 (50)	3 3/8	86	4	102	4 5/8	117	5 1/4	133	8 (203.2)
3 (80)	3 3/4	95	4 3/4	121	5	127	6	152	10 5/8 (269.9)
4 (100)	4 1/4	108	5 3/8	137	5 1/2	140	6 5/8	168	11 (279.4)
6 (150)	4 7/8	124	5 7/8	149	6 1/8	156	7 1/4	181	16 1/2 (419.1)
8 (200)	5 1/4	133	6 5/8	168	6 1/2	165	7 7/8	200	16 1/2 (419.1)
10 (250)	5 7/8	149	8 3/8	213	7 1/8	181	9 5/8	244	Consult Factory
12 (300)	6 1/4	156	8 5/8	219	7 3/8	187	9 7/8	251	Consult Factory
14 (350)	9 7/8	251	10 1/4	260	9 3/4	248	11 3/4	298	N/A
16 (400)	10 1/2	267	10 7/8	276	10 1/4	260	12 3/8	314	N/A
18 (450)	11 1/4	286	11 1/2	292	10 7/8	276	13	330	N/A
20 (500)	11 3/4	298	12 1/8	308	11 1/4	286	13 5/8	346	N/A
24 (600)	12 3/8	314	13 1/8	333	12	305	14 5/8	371	N/A

1/2" and 3/4" consult factory

Minimum lengths are with fixed x rotating flanges. Shorter lengths available with fixed x fixed flanges.

* When using a pipe end forming machine such as a Conrac by PHI, a division of Tulip Corporation. Min. length assumes no welding of stubends.

Swaged Minimum Pipe Spool Lengths										
Size NPS (DN)	Standard				Special *				Field **	
	Class 150		Class 300		Class 150		Class 300			
	Inch	mm	Inch	mm	inch	mm	inch	mm	inch	mm
1 (25)	4	102	4	102	2 1/2	64	2 1/2	64	7	178
1 1/2 (40)	4	102	4	102	2 3/4	70	2 3/4	70	7	178
2 (50)	4 1/2	114	4 1/2	114	3 1/8	79	3 1/8	79	7	178
3 (80)	5	127	5	127	3 1/2	89	3 1/2	89	8	203
4 (100)	5 1/2	140	5 1/2	140	3 3/4	95	3 3/4	95	8	203

* Available only as fixed flanged spools

** Capability of field threaders, such as Wheeler Rex, or equal