

# RESISTOFLEX<sup>®</sup>

## Corrosion & Scale Buildup Control in Power Plants: A New Product Solution



Plastic Lined Steel Piping

**CRANE**<sup>®</sup>

Crane ChemPharma & Energy

[www.cranecpe.com](http://www.cranecpe.com)

## CRANE® Co. And Resistoflex®



### ABOUT CRANE CO.

Crane Co. is a diversified manufacturer of highly engineered industrial products with a substantial presence in a number of focused niche markets. With approximately 12,000 employees working together in five business segments across 25 countries, Crane generated 2017 net sales of \$2.8 billion.

#### Financial Strength

Crane has a strong financial position, giving it the capacity to continue strategic acquisitions.

#### Global Reach

Worldwide operations in over 120 locations grow Economic Value Added (EVA) with top people and products, customer focus, and a common Crane Business System throughout the Company.

#### Leadership

Our businesses have leading market shares in focused niche markets and seek to produce high returns and excess cash flow.



### ABOUT RESISTOFLEX

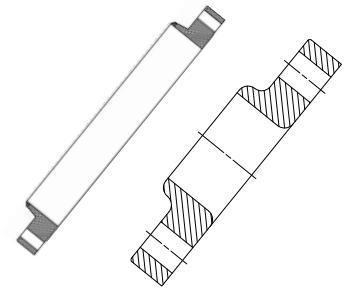
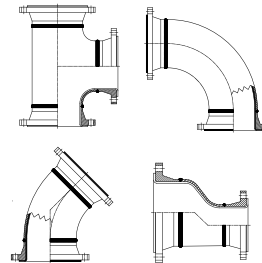
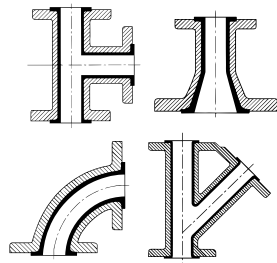
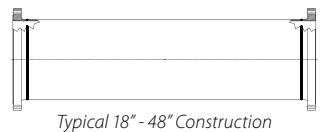
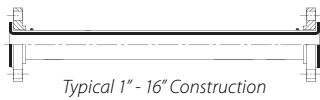
Resistoflex® is the largest plastic-lined piping products supplier in the world, with manufacturing and sales locations in North America, Europe, the Middle East, China, South-East Asia and Australia.

Resistoflex® invented the PTFE lined hose technology in 1953 for the aerospace and chemical industries, and in 1956 introduced the world's first pipe and fittings lined with PTFE. We also offer a full line of pipe and fittings lined with Polypropylene, PVDF, ETFE and now HDPE.

Resistoflex® corrosion-resistant plastic lined pipe, fittings, hoses and expansion joints are used in corrosive fluid services as an economical alternative to expensive alloys.



## Product Overview 1"–48"



### 1" – 48" Pipe Spools:

- ASTM A53B ERW (Standard)
- ASTM A106 Gr. B
- API 5L
- ASTM A312, 304L or 316L
- Other alloys
- 20 foot maximum length

### 1" – 12" Fittings:

- 45 & 90 Degree Elbows
- Equal Tees
- Reducing Tees
- Concentric & Eccentric reducers
- A216 WCB cast steel or A395 ductile iron
- Standard dimensions are ASME B16.5 Class 150
- Other dimensions available
- Complex shapes available

### 14" – 48" Fittings:

- 45 & 90 Degree Elbows
- Equal Tees
- Reducing Tees
- Concentric & Eccentric reducers
- Standard dimensions are achieved with standard B16.9 forgings welded to B16.5 or B16.47 series A flanges
- Other dimensions available
- Complex shapes available

### 1" – 48" Flanges:

- 1"-16" standard pipe flange is class 150 lap joint
- Slip-on & weld neck available
- 18" – 48" standard pipe flange is ASME B16.5 or B16.47
- Slip-on & lap joint available
- Blinds & plate flanges available in all sizes
- ASME, DIN, JIS & other standards

### Paint:

- Polyamide epoxy is standard
- Optional paints:
  - Inorganic zinc silicate
  - Organic zinc epoxy
  - Epoxy mastic
  - Epoxy phenolic
  - Novolac epoxy
  - Polyurethane

- Siloxane
- Electrically conductive epoxy
- Customer Specific Paint System

### Industry Standards:

- ISO 9001
- ASTM F1545-15
- Design Standard: ASME B31.1 and B31.3
- Welding ASME BPVC Section IX
- 1" – 24" flanges: ASME B16.5
- 26" – 48" flanges: ASME B16.47 Series A
- 14" – 48" pipe: ASME 36.10 Sch. STD
- 14" – 48" weld fittings: ASME B16.9 Sch. STD

## Plastic Liner Data



ETFE Flange



Polypropylene Flange



HDPE Flange

As the world's largest supplier of plastic-lined piping products, Resistoflex® offers a 14"-48" product line that includes not only pipe, but a full complement of fittings, flanges, spacers, and specialty items. Liner materials include polypropylene, ETFE, and high-density polyethylene (HDPE). Contact the Resistoflex® Applications Specialist to select the right liner material for your application.

### ETFE

Ethylene tetrafluoroethylene is a partially fluorinated thermoplastic with several characteristics that make it ideal for rotational lining. Typical applications are hydrochloric acid, hydrofluoric acid, sulfuric acid, caustics, bleaches, all at temperatures up to 300°F. ETFE has the highest temperature and chemical resistance of any plastic except PTFE.

### PP

Polypropylene is a thermoplastic that offers good chemical resistance at a price point lower than ETFE. It is widely used in hydrochloric acid to 200°F, and also sees applications in sulfuric acid up to 80% concentration, and HF up to 60%. Where polypropylene has replaced Fusion Bonded Epoxy (FBE) lined piping in cooling water intake from brackish sources, pipe replacement has gone from every two years to ten years and longer.

### HDPE

High density polyethylene provides an economical liner choice that is widely known for its abrasion resistance and general chemical resistance to 180°F. HDPE finds extensive use in oilfield and natural gas production sites in wastewater and multiphase fluid pipelines. HDPE-lined pipe and fittings differ from field-installed HDPE liners by the bonding of the plastic to the metal substrate and the absence of plastic weld seams at the flare faces.

## Liner Data

Property	Polypropylene	ETFE	HDPE
Service Temperature Range, oF	0°F - 225°F	-20°F - 300°F	-20°F - 180°F
Liner Color	Orange	Natural	Black
Color of Identification Band	Orange with Black Lettering	Gray with Black Lettering	Red with White Lettering
Coefficient of Thermal Expansion of Liner. (in/in/ oF)	4.8 x 10-5	7.4 x 10-5	6.7 x 10-5
Thermal Conductivity, (BTU-in)/hr-sq ft-oF)	0.8	1.65	Consult Factory
Tensile Strength of Liner at Yield, (psi, min)	4000	6500	1760
Elongation of Liner at Yield, (%)	10	275	400
Compressive Strength of Liner	5500	2500	2000
Specific Gravity	0.9	1.7	0.94
Durometer Hardness, (Shore "D")	72	72	70

## Features and Benefits

In high volume process flow applications, requiring 14" – 48" piping, designers have limited options for corrosion resistance. Compared to others, the Resistoflex® 14" – 48" range of plastic-lined pipe and fittings is an economical choice in corrosive applications. Resistoflex' thick, chemical resistant liners offer superior performance and durability.

Properly specified, plastic-lined pipe and fittings have a "zero corrosion rate" at temperatures up to 300°F, depending on the plastic resin and the chemical service.

1. Choice of **THREE CHEMICAL RESISTANT LINERS** from our most economical **HDPE** to performance/price balanced **PP**, to **ETFE**, which offers outstanding chemical resistance at a lower price point than most alloys.
2. 100% of lining is performed in our North Carolina facility starting with raw plastic resin. Our liners are **VERY THICK TO ALLOW THERMAL STABILITY, AND TO PROVIDE RESISTANCE AGAINST VACUUM.**
3. Resistoflex® lining processes provide a liner that is **MECHANICALLY LOCKED INTO THE HOUSING.** The result is that metal pipe and plastic liner (with dissimilar rates of thermal contraction and expansion) act as **ONE MONOLITHIC UNIT** even during frequent thermocycling. This is proven by successful steam-cold water thermal cycling testing required by **ASTM F1545-15A** Standard Specification for Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges.
4. Resistoflex® has performed Taber abrasion testing per ASTM D3389-05 using identical test parameters to those published on a leading rubber lined piping manufacturer's website. **THE RESULTS INDICATE THAT RESISTOFLEX® POLYPROPYLENE LINED PIPING WILL OUTPERFORM THE TOP-RATED RUBBER LINED PIPE PRODUCT BY A FACTOR OF FOUR.** Based on this, along with the outstanding mechanical, chemical and thermal properties of polypropylene liners, users should see greatly enhanced service life in fine slurry services.
5. **SMOOTH LINERS PREVENT BUILDUP OF SCALE AND BIOLOGICS**, and the seamless construction prevents failures known to occur with fusion-welded, bonded lap and other joining methods.
6. **LENGTHS UP TO 20 FT** minimize flange connections, installation time, weight, and potential leak points.
7. Resistoflex® plastic-lined pipe and fittings are **FLANGED AND READY TO INSTALL** upon arrival at the job site. All standard dimensions are based on weld neck flanges welded directly to butt-weld fittings. Non-standard or special dimension components are readily available as well.
8. Class 150 flanged pipe and fittings follow the pressure tables in **ASME B16.5 AND ASME B16.47.** Class 300 flanged pipe and fittings maximum pressure is lower than true Class 300 ratings due to the plastic-to-plastic seal between flanges. **THE USE OF RETAINER RINGS ENABLES FULL CLASS 300 AND HIGHER-PRESSURE RATINGS.**
9. Resistoflex® can provide plastic-lined complex shapes, such as manifolds, elbows with process branches, ASME code and non-code pressure vessels and other custom construction, in a wide range of diameters **UP TO 161"**. Maximum diameter depends on the configuration.





## Key Applications

### Key Applications

- Water treatment - ion exchange
- Waste water collection and treatment
- Fly ash slurry pipelines to surface impoundments, settling ponds
- Gypsum slurry
- Condenser water recirculation, allows chemical treatment of scale buildup vs. mechanical removal
- pH buffering / acid injection
- pH buffering / base injection
- Inorganic acids (sulfuric acid, hydrochloric acid, nitric acid)
- Bases / caustics
- Lime / water slurries with average particle size < 60 microns (FGD)
- Brackish water
- Seawater, River or well water
- Zebra mussel mitigation



### Settling Pond Relocation

Resistoflex® was approached by a coal-fired power plant in the US Midwest for an economical piping solution for their drainage improvement project. The customer was looking to relocate their FGD dewatering pond about a ¼ of mile from the plant. The media going through the piping to the ash pond is a mixture of coal ash, limestone, gypsum, and water.

Due to the distance, the pump pressure had to be increased, eliminating reinforced fiber glass pipe as a solution. Therefore, the customer was looking into two other piping solutions—rubber lined or polypropylene Lined.

Rubber lined pipe is well established in coal-fired power plants. It addresses some of the abrasion concerns and is considered a readily available product solution. But it has severe shortcomings in these applications, such as water vapor permeation, limited bond strength and delamination, and poor release properties to solids and biologics. Polypropylene lined piping offers a complete answer to these shortcomings. The thick seamless liners offer corrosion and abrasion resistance, are locked in or mechanically bonded and allow the user to economically treat scaling and biologic build up due to its resistance against a broad spectrum of chemicals. When the quote of the polypropylene lined Piping for the project also turned out to be very competitive against rubber lined piping, the customer chose that solution. The piping has been manufactured, delivered and installed for many years now without any problems.

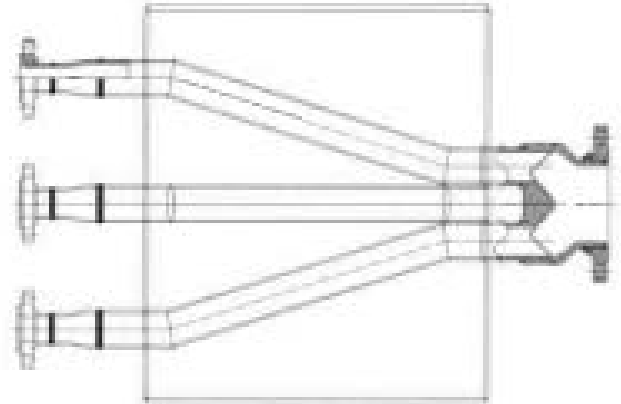
## Key Applications

### Hydrated Lime Run Splitter

A major coal-fired power plant in North America was having issues with one of their production lines. The line divides a single hydrated lime run into four smaller runs for injection into hot flue gas. The lime builds up and hardens on steel piping, requiring periodic drilling to remove.

The purpose of this application is primary SO<sub>3</sub> reduction to 5ppm or less. This flue gas then goes to two other scrubbers known as a selective catalyst deduction (SCR) and a jet bubbling reactor (JBR). In the SCR, the gases are mixed with the catalyst VO<sub>5</sub> (vanadium pentoxide) which converts NO<sub>x</sub> (nitrous oxide) to nitrogen, oxygen and water. The JBR is the final step before release to the atmosphere. In the JBR, the flue gases are bubbled into a slurry of water/limestone slurry for desulfurization.

The customer contacted Resistoflex®, as they are using lined lime injection lances successfully at another plant for many years. In cooperation with the customer, Resistoflex® redesigned the splitter to enable rotational lining. Resistoflex® then constructed and built an ETFE lined splitter to be installed in the service. The splitter with an ETFE lining (characterized by non-stick properties) has been installed for many years with no issue. Several ETFE lined splitter have been ordered and delivered since then.



### Circulation Water

A Resistoflex® distributor worked closely with a major engineering company to determine the right piping solution for a combined cycle power plant application. The service for the piping is circulating water for the condenser units with a temperature range of 140°F and pressures below 150 psig.

The end-user specifically was looking for a solution allowing them to clean the condenser tubes. The previous solution required abrasive balls to be pumped through the tubes. This resulted in damaged as well as clogged tubes.

Resistoflex® offered and supplied polypropylene lined pipes and fittings. Polypropylene was the natural choice as the product offers good chemical resistance at temperatures up to 225°F. By using Resistoflex® polypropylene pipe on the filtered water

side of the process, the customer is now able to use additives to eliminate deposit buildup.

While Resistoflex® has been supplying all small diameter (1"–12") polypropylene lined pipes and fittings to this customer, it was difficult to compete for the large diameter (>14") due to a product limitation. Larger diameter lined pipes and fittings were only available with PTFE lining prior to 2019. PTFE has two disadvantages in these sizes. The cost of the resin is considerably more expensive than polypropylene and the maximum possible pipe length is shorter. With the investment in machinery and the development of large diameter polypropylene lined pipes and fittings in up to 20ft long pipes, Resistoflex® finally has an economical solution for these applications.

## Abrasion Resistance of Polypropylene-Lined Piping

In coal fired power plants, fine slurries such as hydrated lime, calcium sulfate, and fly ash can reduce the service life of conventional piping materials. Polypropylene-lined piping, in addition to its well-known outstanding resistance to chemical attack, has also been shown to stand up to fine particle slurries. In fact, third party abrasion testing confirmed that polypropylene-lined pipe delivered up to 95% better results than rubber formulations, including proprietary formulations specifically marketed as having superior abrasion resistance.

### The results comparison is as follows:

- **Testing Laboratory:** Akron Rubber Development, Inc.
- **Test Standard:** ASTM D3389
- **Test Equipment:** TABER Rotary Platform Abrasion Tester
- **Abrader Type:** H-18 (medium coarse vitrified wheel)
- **Sample Rotation Speed:** 72 ±2 rpm
- **Vertical Force Applied:** 1000 grams
- **Total Revolutions:** 3000

### The Results

Taber Abrasion Comparison of Lining Materials					
	Resistoflex® Polypropylene (Copolymer)	Proprietary Abrasion Resistant Black Natural Rubber	Black Natural Rubber	Polyurethane	Tan Gum
Mass Loss/Revolution (mg)	0.0100	0.0661	0.7918	0.0860	0.9761
Revolutions	3,000	3,000	3,000	3,000	3,000
Total Mass Loss (g)	0.0300	0.1983	2.3754	0.2580	2.9283
Specific Gravity	0.9000	1.1000	1.0990	1.1100	1.0350

The key criteria is Mass Loss/Revolution, and it's clear to see that the polypropylene samples experienced up to 95% lower Mass Loss/Revolution compared to typical rubber formulations. This can translate to increased service life in tough slurry applications.



## Competitive Solutions

### Rubber Lined Piping

Rubber Linings have been used for many years in Power plants where wear is a factor. Natural or synthetic rubbers are used depending on application. Natural rubber linings can be soft or hard. Hard natural rubber linings are more susceptible to mechanical damage and thermal shock than soft linings but have better adhesion, chemical resistance, and resistance to permeation by water and water vapor. Rubber linings are bonded to the steel surface by curing unvulcanized (uncured) rubber in contact with a pretreated steel surface. The chemical bond strength can be higher than the tensile strength of the rubber in the case of natural rubber linings. The steel surface is grit blasted and a bonding agent is applied and allowed to dry. The bonding agents used depends on the rubber formulation. The rubber sheets are laid on the prepared steel equipment and the lining is rolled out to remove air bubbles. Joints between sheets are sealed, often with a cover strap. Upon completion the lining is given a partial cure and is then spark tested. The cure is then completed, and a final spark test is carried out. The temperature limit for most soft rubber compounds is 140°F/60°C for continuous service and about 180°F/82°C for hard rubbers.

#### CONS

- Rubber liner is adhered with adhesive to the steel housing with limited bond strength.
- Multi-piece bonded liner construction can delaminate from the inside wall of the pipe, causing loss of protection and fouling.
- Standard thickness just 4mm (0.157").
- Water vapor readily permeates causing blistering and hastening delamination.
- Poor release properties to solids and biologics can lead to reduced flow and clogging.
- Low hardness reduces abrasion resistance in certain applications.



### Plastic & FRP Piping



Thermoplastic and FRP piping systems are widely used in normal fluid service and category D piping due to its relatively high corrosion resistance. The profile extrusion and winding processes used to produce the piping provides an economical solution where the process permits these materials.

Thermoplastics cannot nearly match the physical strength nor the ruggedness of metallic piping. In addition, special pipe supports are often required, and safety considerations may limit not only allowable temperatures and pressures, but system locations as well. Many chemical, physical and age-related effects can alter the pressure rating of this piping as the polymer structure weakens due to leaching, swelling, UV or other environmental stresses.

FRP systems typically increase the range of allowable temperatures and pressures compared to thermoplastics but still require special supporting procedures, protection from external loading and allowances for expansion and contraction. FRP is very resistant to seawater, but it is subject to joint cracking and leaks after extended service in some operating conditions. Field joining is typically a fusion bonding process, which is a relatively highly skilled trade. Environmental conditions such as wind, rain and dust can create very difficult conditions for the bonder.

#### CONS

- External impact can induce star cracking of the barrier layer, with no apparent damage to the surface of the pipe
- Low resistance to external mechanical damage caused by poor handling and installation practice
- Field joints difficult to make in hot, cold, windy or dirty environments
- Flexible wall makes FRP sensitive to buckling due to vacuum Extra supporting, restraint, or expansion allowances

## Competitive Solutions

### Fusion Bonded Epoxy

FBE is an epoxy-based thermosetting powder coating widely applied to steel pipe, steel reinforcing bars for concrete, tanks, and a wide variety of piping connections (valves and fittings). The "fusion-bonded" designation comes from the chemical cross-linking that occurs during the application process, which differs from the application of standard paints and coatings. FBE is applied by preheating the substrate, typically over 401°F and spraying the coating powder onto the surface. Small parts and fittings can be dipped into FBE powder that has been fluidized by air. Only a small number of types of FBE are suitable for long-term service in water.

Disbondment of the coating is the primary failure mode reported by users of piping with an interior FBE coating. A primary cause of disbondment is cell corrosion starting at minor holidays and scratches, which exist in virtually all systems. Other factors can also cause disbondment, including poor surface preparation, moisture absorption and permeation. The coating is typically about 0.020" (0.5mm) thick. This makes it susceptible to impact and abrasion damage.

#### CONS

- All coatings have minor imperfections (holidays and scratches) leading to the potential for cell corrosion and disbonding
- Thin coating leading to reduced corrosion and abrasion protection
- Thin coating susceptible to damage
- High moisture absorption and permeation
- Requiring internal access



### Cement Mortar Linings



Cement-mortar-lined pipes are centrifugally lined at the factory. This creates a uniform thickness of mortar throughout the entire length of the pipe. Cement linings are also smooth, which results in high flow coefficients. The protective properties of cement linings are due to two properties of cement. The first is the chemical alkaline reaction of the cement and the second is the gradual reduction in the amount of water in contact with the iron.

There is a need for extra care in handling and fitting. If pieces of the lining break off, the area of bare steel exposed is anodic to the steel embedded in the cement. The corrosion rate in such a cell will be determined by the flow of oxygen through the cement and, as the area relationship ratio of embedded to exposed steel is high, the corrosion rate can also be high. Joints at valves and fittings must also be covered with cement to prevent cell corrosion.

Either corrosion or physical damage can cause the lining to spall off and pieces of lining can partially block heat exchanger tubing.

Cement linings are most effective in long, straight runs of large (>1m) diameter. The ability to maintain lining integrity decreases rapidly with diameter, number of fittings, and valves

#### CONS

- Failure of the cement lining by either cracking or spalling due to shock or water hammer in the system
- Bolting induced stresses crack the lining and initiate corrosion
- Difficulties of lining coverage for welded joints (in e.g. nozzles)
- Due to the fragility of the cement lined coating, it is recommended that the pipe is handled as delicately as possible
- Requiring internal access

## Vessels, Columns & Complex Shapes



The resin of choice for Resistoflex® rotationally lined vessels, columns and complex shapes is ETFE, due to its many outstanding features. ETFE is a rugged thermoplastic with an excellent balance of chemical and mechanical properties. ETFE bonds to the metal substrate, with the ability to adhere to virtually any type of metal weldment, casting or forging.

It offers outstanding resistance to attack by a wide range of chemicals and solvents. Additionally, its broad thermal capability (-150°F to 300°F) allows for a multitude of uses. Some of the most common chemical compounds are HCl, HF, H<sub>2</sub>SO<sub>4</sub> and HBr.

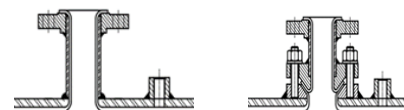
ETFE roto-lined products come with the security of full vacuum resistance throughout the temperature range. Columns made with paste extruded liners or welded sheet liners either have limited vacuum rating or require additional measures such as vacuum plugs or graphite sleeves.

Wall thickness for ETFE vessel and column linings is variable based on customer specification. However, it is desirable to minimize the thickness as the cost of the ETFE resin is a significant part of the total cost of the lined vessel or column. In traditional lined process piping, permeation is a great concern, and

hence, many manufacturers differentiate and promote their products based on a “thicker is better” mindset. In vessels and columns, vapor pressure, a primary driving force for permeation, is typically carefully modulated. This fact, coupled with the very low permeability of ETFE, (5-25% of that of standard PTFE) makes permeation less concerning, and thinner liners become a feasible option.

Nozzles can be fitted at almost any location of the column. Multiple nozzles with different sizes per column section are well within the capabilities of roto-lining. Advantages of this method over housings lined with paste extruded liners are:

Nozzles are welded on the housing as a single piece vs. multi piece block flange connection

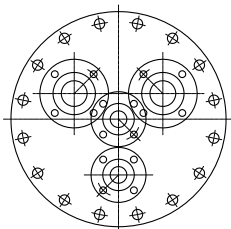
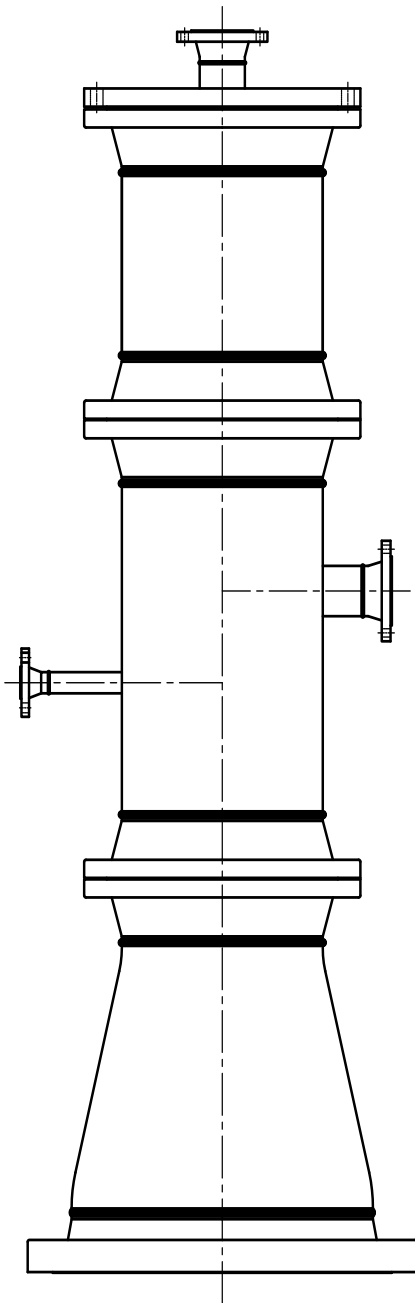


Uniform liner thickness vs. varying thickness because of the blow molding process

Venting is required for each PTFE lined pipe and fitting per ASTM F1545-15a to release any pressure between the liner and the housing. These vent holes are prone to corrode the housing because of permeation. Vent couplings and PTFE vent plugs have been adopted by end users as a solution but do not eliminate the problem completely. ETFE, as a low permeability lining bonded to the metal housing, does not require venting. Hence the risk of a liner collapse due to vent hole blockage is not existing.



# Vessel and Column Design



**Design Standards**

- ASME B31.1 and B31.3
- Available ASME Section VIII Div. 1 "U" stamp
- 161" maximum diameter

**Welding Standards**

- ASME Pressure Vessel and Boiler Code Section IX

**Liner Availability**

- Ethylene tetrafluorethylene (ETFE)
- Polypropylene (PP)
- High Density Polyethylene (HDPE)

**Body Material**

- Carbon Steel
  - ASTM A53 Gr. B
  - ASTM A106 Gr. B
  - API 5L
  - ASTM A234 WPB
- Stainless Steel (304L, 316L, other grades)
  - ASTM A312
  - ASTM A403

**Flange Material**

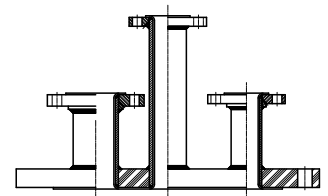
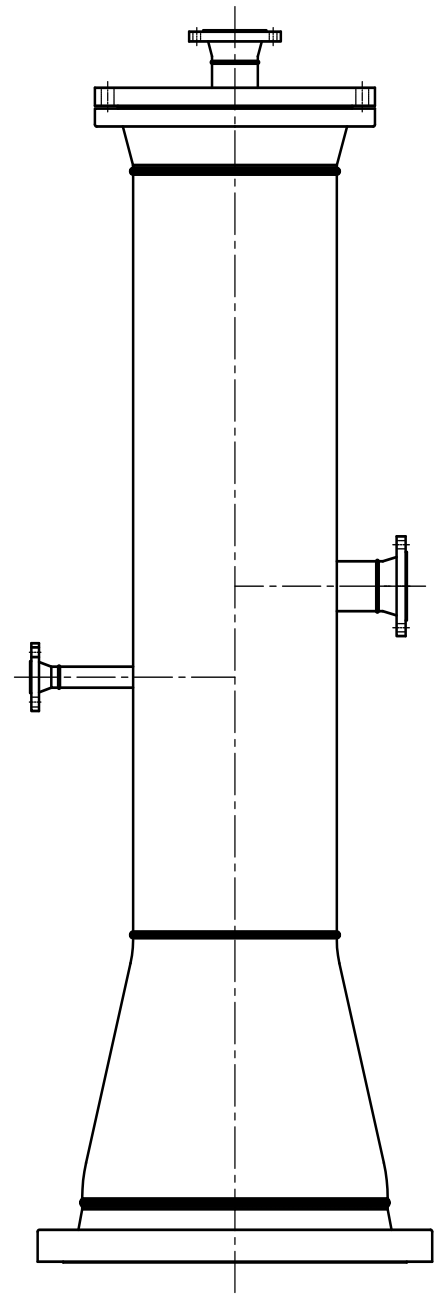
- ASTM A105 and A105N
- ASTM A182

**Paint**

- Polyamide epoxy is standard
- Optional paints:
  - Inorganic zinc silicate
  - Organic zinc epoxy
  - Epoxy mastic
  - Epoxy phenolic
  - Novolac epoxy
  - Polyurethane
  - Siloxane
  - Electrically conductive epoxy

**Optional Internals**

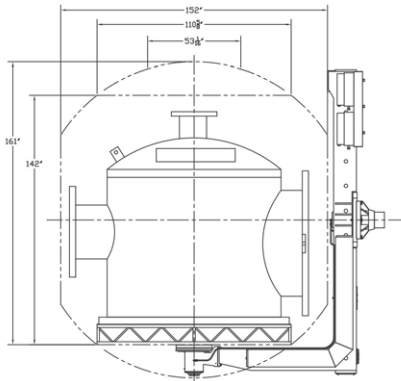
- Trays
- Liquid distributors
- Liquid collectors
- Support grids
- Support Plates
- Bed limiters
- Saddles, rings, and or structured packing



## Rotational Lining Well-Suited to Large Diameter Pipes & Fittings and Custom Configurations

Melt processable resins such as ETFE (ethylene tetrafluoroethylene), PP (polypropylene), and HDPE (high-density polyethylene), in conjunction with rotational lining, have allowed Resistoflex® a new freedom in producing lined steel piping products with custom or complex dimensions—with the same excellent Resistoflex® quality the industry has come to expect, at a price lower than expensive metal alloys and features superior to other lining and coating solutions.

We can supply your corrosion resistant lining requirements for large diameters (up to 161") and custom-dimension fittings, valve bodies, pump casings, flowmeters, and vessels. In fact, our capabilities are limited only by your imagination.



Rotational lining is an ideal method to line the interior surfaces of complex metal fabrications:

1. A pre-weighed amount of granular resin is placed inside the part.
2. With the flanges sealed, the part is heated in a forced-air oven while being rotated on two axes simultaneously.
3. The bi-axial rotation transfers the heat evenly to the fitting, until the resin's melt temperature is reached. As the resin melts, it uniformly coats the interior, regardless of the geometry of the fitting.
4. The heat is turned off, and the part continues to rotate as it cools, allowing the resin to set. The result is a seamless, heavy-duty plastic lining with available thicknesses up to .450" depending on the application.
5. Prior to shipping, all parts must pass an electrostatic test or hydrostatic test as required by ASTM F1545-15a, specification for plastic lined ferrous metal pipe and fittings.

### Why is Rotational Lining Superior to Other Lining Methods for Complex Shapes and Large Diameter Pipe and Fittings?

#### vs Sheet Lining

- Rotational lining provides a seamless liner, no matter the complexity of the part.
- No internal access to the part needed with rotational lining.
- Mechanically bonded liner eliminates the need for adhesives.

#### vs Fiberglass Reinforced Plastic (FRP) / Dual Laminate

- FRP is inherently mechanically weak, with a limited pressure rating compared to plastic-lined steel.
- What FRP gains in weight savings, it gives back in support complexity.
- Plastic-lined composite cannot pass the ASTM F1545 qualification tests required for plastic-lined steel.

#### vs Exotic Alloys

- Plastic-lined steel provides a "zero corrosion rate" at an economical price.
- Alloy pricing fluctuates wildly. Rotationally-lined steel is predictable and stable.
- Many alloys require cost-prohibitive welding processes and non-destructive testing

#### vs Fusion Bonded Epoxy (FBE) Coating

- Thick plastic liner is more durable and reduces permeation better than typically thin (< 0.040") powder coating.
- No internal access to the part needed with rotational lining.
- Thin liner is easily damaged.

#### vs Powder Coating

- Thick plastic liner is more durable and reduces permeation better than typically thin (< 0.040") powder coating.
- No internal access to the part needed with rotational lining.
- Thin liner is easily damaged.

#### vs Glass Lining

- Plastic-lined steel has excellent impact resistance compared to naturally brittle glass.
- Glass lining is extremely expensive compared to plastic lined steel.
- ETFE and polypropylene are fully resistant to hydrofluoric acid and sodium hydroxide, both of which attack glass.

## Flange Reduction by Design

Resistoflex® processing technology and your freedom of design can help reduce emissions as required by the 1990 *Clean Air Act* amendments. Flanged pipe connections are among the most numerous potential emissions points in any chemical process facility. The use of corrosion-resistant plastic-lined complex fittings dramatically reduces the number of flange connections needed in a manifold or short run of piping. In the example below, a customer designed a line using standard pipe and fittings for a total of 11 flange connections. Through weld fabrication and rotational lining, the number of flange connections was reduced to two.



## Professional Support for Every Stage of the Project

Whether you're working on a new project or a retrofit job, you probably have your hands full. Unfortunately, many pipe manufacturers treat lined pipe as a commodity product and offer little technical support.

Resistoflex®, on the other hand, realizes that plastic-lined pipe is used where safety and environmental issues are a major concern. We recognize the need for personal technical support. Resistoflex® backs up its products with the most comprehensive package of service capabilities available. Resistoflex' support services are designed to take some of the burden off you and your people.

Our piping specialists can help you meet tight deadlines and take care of much of the time-consuming paperwork involved in the typical project. We offer the kind of on-site personal attention that's becoming rare in the industry today.

### Bill of Material Take-Off

Submit your isometric drawings to us as CAD or PDF files, and we provide you a bill of materials, by drawing, for each item, including part number, description, tag number, and price. We can add the tag numbers to your drawings as an aid during installation.

### Isometric Drawing Service

We can convert your orthographic drawings into isometric drawings showing all dimensions and tag numbers. Additionally, we can convert a welded metallic-system into isometric drawings of a plastic-lined flanged system.

### On-Site Training

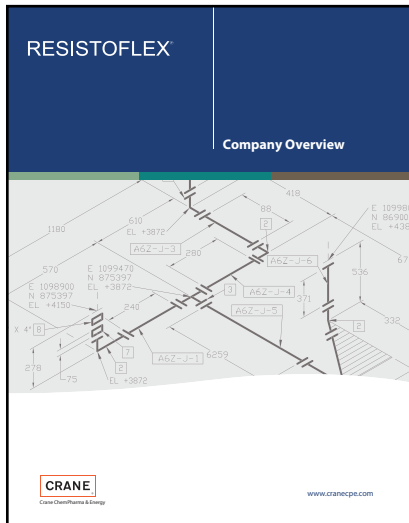
We can send our technician to your site for training on installation and maintenance or field fabrication certification. We will train your operators in the Resistoflex® procedures, and you can be sure that each trainee will have a thorough understanding of the training materials and procedures.

### Factory and Field Support After Installation

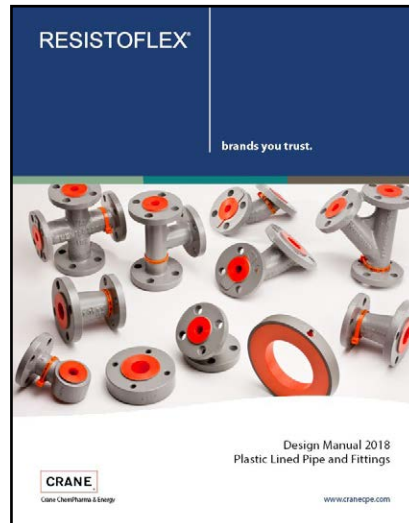
Resistoflex® support doesn't stop after the pipe is installed. Our field technical representatives and trained distributors are always available to help you find piping solutions. Your distributor for Resistoflex® plastic lined piping products maintains a large inventory of piping items for fast delivery when you have field changes or need closure spools. Whenever you need our products or the service that goes with them, you can count of Resistoflex®.



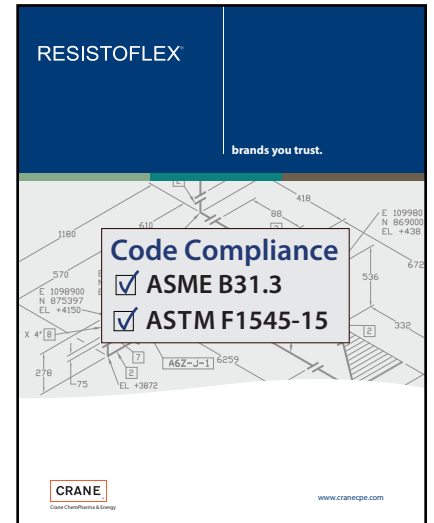
Resistoflex® Literature



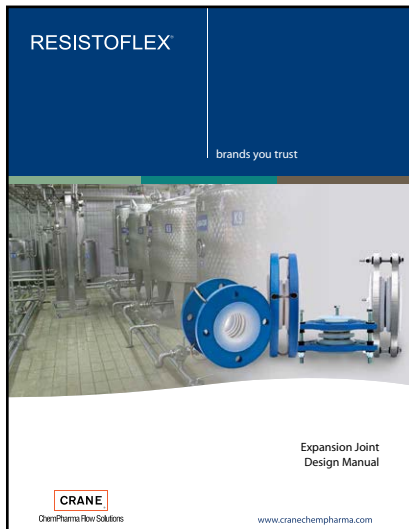
Company Overview



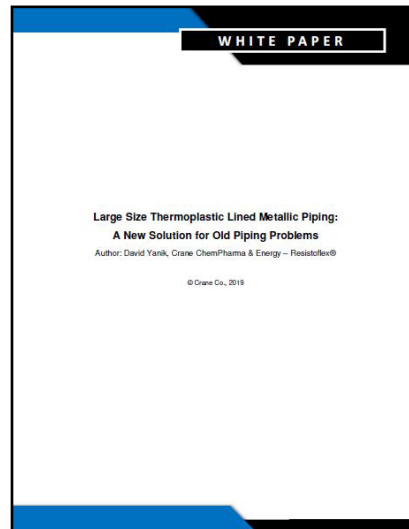
Pipe and Fittings Design Manual



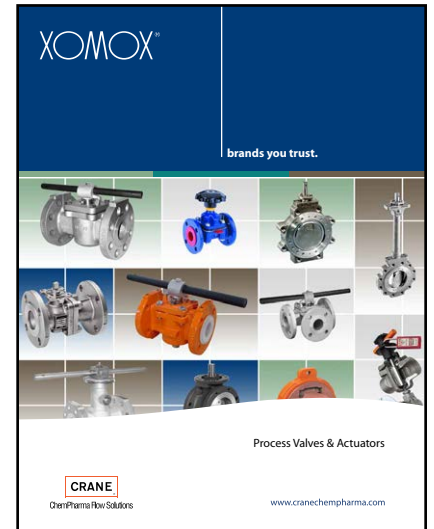
Code Compliance



Expansion Joint Design Manual



Resistoflex® Large Diameter Pipe White Paper



XOMOX® Valves

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Per the Pressure Equipment Directive 97/23/EC Essential Safety Requirements Annex I Checklist, the following Essential Requirements are within the customer scope for all products: Wind, Earthquake, Reaction forces and Moments, Fire, Safety devices, permeation, temperature and pressure spikes. For all products, it is recommended that customer remove representative sample for examination of internal corrosion every 2 years.

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