

RESISTOFLEX®

Corrosion Control in Chemical Plants: A New Product Solution



Plastic Lined Steel Piping

CRANE®

Crane ChemPharma & Energy

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.



RESISTOFLEX® MANUFACTURING PLANT IN
MARION, USA
320,000 SQ



WAALWIJK
9,000 SQ FT



SUZHOU, CHINA
60,000 SQ FT



SINGAPORE
10,000 SQ FT



AUSTRALIA
108,000 SQ FT

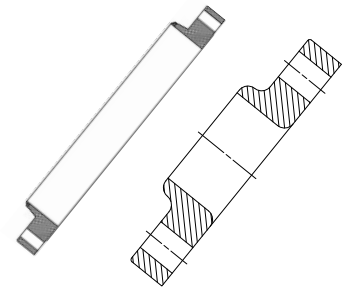
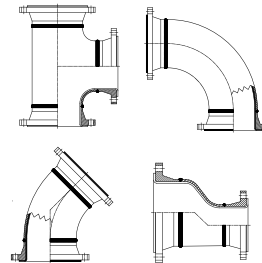
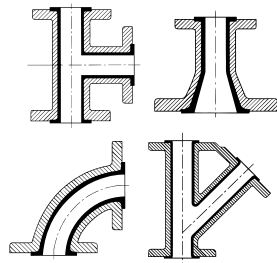
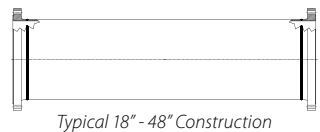
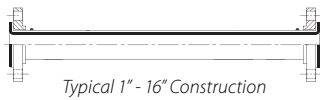
ABOUT RESISTOFLEX

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

- Seawater for Cooling
- Waste Water Collection & Treatment
- Brackish Water
- River or Well Water
- Zebra Mussel Mitigation
- Demin Water
- Brine
- Scrubber Columns
- H₂S Stripper
- Inorganic Acids:
 - Sulfuric
 - Hydrochloric
 - Phosphoric
 - Nitric

Chemical Plant Cooling Water

A large North American chemical plant was experiencing many early failures of their piping which conveyed seawater for cooling. The piping consisted of a mix of cement mortar lined steel piping and epoxy lined steel piping. They found that small flaws in the liner integrity became the starting point for larger scale corrosion and disbondment of the liner, which in turn caused leaks and downstream fouling. The cement mortar lined piping was also susceptible to brittle failure as a result of mechanical impact or water hammer. The chemical company approached Resistoflex® for a solution.

Resistoflex® offered polypropylene lined piping. The thick, seamless liners offered superior corrosion resistance and

mechanical integrity and it was also capable of handling the needed temperatures of up to 220°F. The product line, which was previously available only through 12", has now been expanded to 48", providing a full range replacement for this user. Previously, a more costly PTFE lined steel piping solution had only been available above 12". The PTFE lined alternative had spool length limitations that were also undesirable from an installation and maintenance perspective. Resistoflex® polypropylene lined steel piping is now available in 20' spool lengths throughout its 1"-48" nominal pipe size range. It offers a zero corrosion rate in seawater as well as many common industrial chemical solutions, including HCl, H₂SO₄, HNO₃ and HF.

Key Applications

SO2 Packed Column Replacement

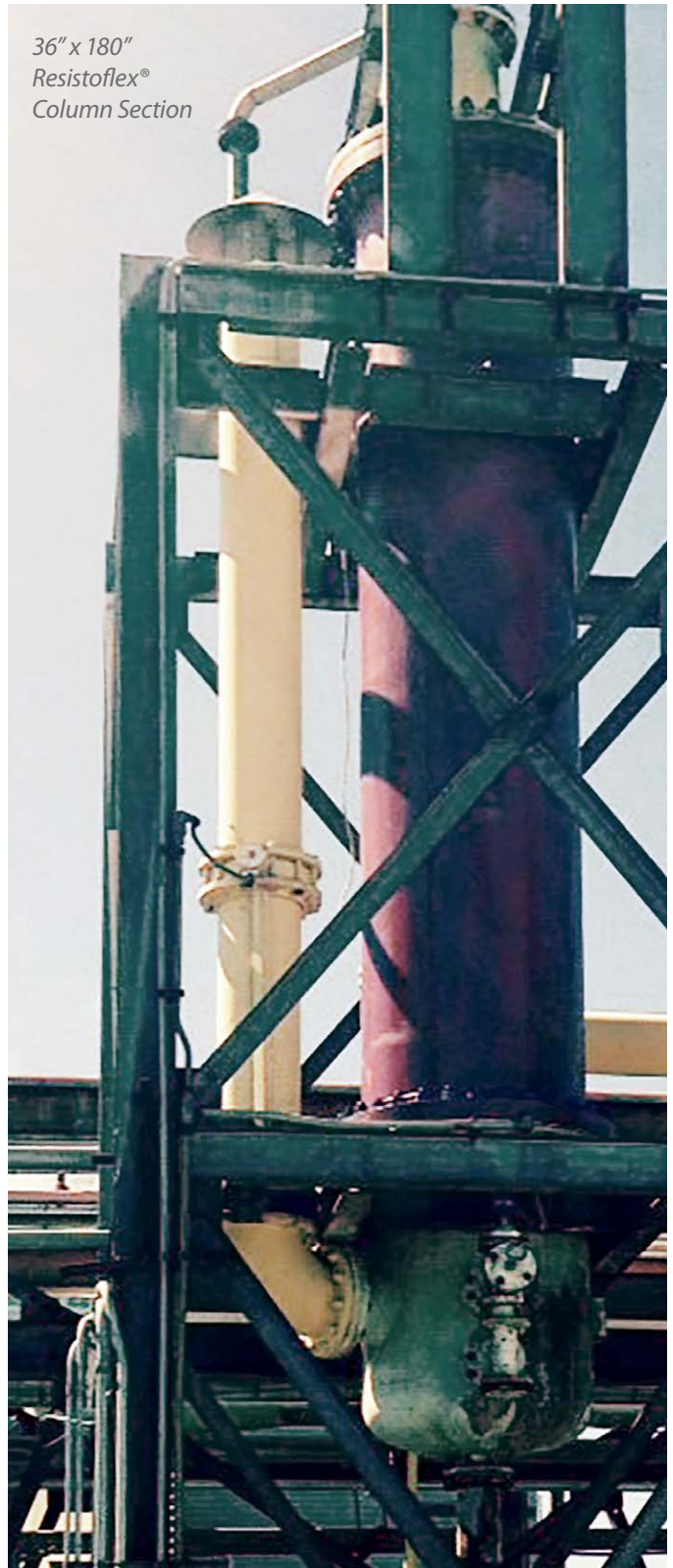
Resistoflex® was approached by a large chemical company that produces chemicals for the refinery market on the west coast. This particular company was looking for an alternative to an installed packed column on their SO2 scrubber system that was showing signs for failure through cracking and pinhole leaking. Their current column was a heavy wall ductile iron piping column and the application was 93% sulfuric acid with a pressure of 5 psi at 150°F. With those parameters in mind, we were able to offer an ETFE-lined 36" x 15' spool to replace their existing column.

As stated, this heavy-wall ductile iron pipe was currently installed in this application as this brand is a common solution in sulfuric acid applications. This brand of heavy wall pipe is marketed with a special metallurgy designed to develop a "film" for sulfuric acids specifically. They continually refer to this chemical resistant "film" that forms on the inside diameter of the pipe overtime that helps to minimize the effects of acid corrosion. What is not prominently mentioned is that their rate of corrosion, far out paces many of other common acid solutions, and that their chemical resistant "film" is very susceptible to temperature variances and other factors that can easily erode this "film." What ultimately remains is a ductile iron pipe with a very thick wall that does more to contain corrosion through thick wall attrition than chemical resistance.

Resistoflex® offered a viable solution with a Rotolined ETFE Column. ETFE is an excellent choice for Sulfuric acids at any concentration up to 300°F. Resistoflex® offered the customer an ETFE lined carbon lined steel pipe painted with a chemical resistant epoxy for their column replacement. Being able to ensure the customer in getting the full corrosion resistance in an economical carbon housing has been a winning formula for Resistoflex® since the mid-1950's, when Resistoflex® invented the first PTFE-lined pipe, hose and expansion joint.

This 36" x 15' column was one of the first rotolined items to be produced in the new large diameter, state-of-the-art product line that Resistoflex® installed to service our customers well beyond our standard product offering. Expanding our size ranges up to 48" in pipe and fittings as well as now having the ability to line Columns, complex shapes, and vessels continues to show our brand's commitment to servicing all of our customer's needs.

36" x 180"
Resistoflex®
Column Section



Key Applications



Fertilizer Phosphoric-Acid Line Replacement

A major fertilizer producer in the US was searching for a solution to a constant maintenance issue of plugged lines in their phosphoric acid lines. The issue was that due to the changing qualities of phosphate rock (a major component of phosphoric-acid), they were having continued problems with their lines clogging and plugging. This would often require shut downs in production to drop and clean these lines, before production could resume.

Current piping solutions included rubber lined, fiberglass reinforced piping and a stainless alloy. All had their separate issues. Traditionally plugged lines in the facilities were cleaned in two different manners; chemical cleaning where they would introduce a chemical wash into the system to help break down the clogs, and a physical removal whereas they would remove the piping and pressure-wash the clogs out. With rubber lined piping, the chemical wash was not an option as the chemicals would break down the rubber compound, and the pressure washing alternative required shutting down to remove the piping. In addition, if the pressure was too high this could cut the rubber lining during clog removal. Fiberglass piping was also not a good alternative as due to the clogging, internal pressures would spike and cause catastrophic blowout failures. The stainless alloy could hold up to the high pressure washing, and the chemical wash techniques, but did not prevent the clogging and came at a high cost.

These facilities were familiar with Resistoflex® as they were using our PTFE-lined piping in different areas of the plant in some of their more severe acid applications. Resistoflex® offered our polypropylene lined pipe as a solution. Typical temperature ranges were below the 225°F max of polypropylene. The liner was able to withstand both the pressure cleaning and chemical wash techniques they used to clear clogging. The real game changer was due to the hardness and slickness of the polypropylene liners, and the clogging lines became a thing of the past. The design and construction of Resistoflex® piping does not give the phosphoric acid an opportunity to attach and build up. The customer was able to move from a monthly maintenance plan of cleaning and clearing clogs to a quarterly spot check of our Resistoflex® polypropylene piping to ensure no clogging or wear exists. The Resistoflex® polypropylene lined piping has been in service over four years without failure.

As a result, this fertilizer company has changed their general piping specification to Resistoflex® polypropylene lined piping. They are also using it in many applications outside of phosphoric acid due to the piping having a corrosion-resistant liner good in applications 225°F and under and a housing with the mechanical strength of steel, eliminating the chances of exterior damage and the need for additional supporting that other piping systems require.

Competitive Solutions

Heavy Wall Ductile Iron Piping System with Special Metallurgy Designed for Sulfuric Acid

Heavy wall ductile iron piping system with special metallurgy designed for sulfuric acid pipe was developed in 1983 as a special pipe solution for handling sulfuric acid at high concentrations (92 to 98%). It is a special alloy of ductile iron containing 0.14% copper and elevated silicon over 3.2% capable to handle this acid to temperatures of up to 300°F.

The standard pipe size range is 3" to 30" with a 3" to 6" pipe length availability of 19 ½ ft and the larger sizes of 8" to 30" available in 17 ½ ft maximum length. The product range includes common piping fittings such as elbows, tees and crosses, and concentric and eccentric reducers. Other common piping fittings such as reducing tees, instrument tees and reducing flanges seem not to be readily available. Instrumentation can be added using special bossed tees and elbows with a small side outlet.

Like Plastic Lined Pipe, the heavy-wall ductile iron pipe is a flanged system. However (unlike plastic lined pipe) the system requires gaskets for a proper seal. For high concentrations of sulfuric acid, the corrosion resistance is achieved through its heavy wall, with expected corrosion rates of .005" per year. For more aggressive lower concentrations, a naturally formed sulfate film provides brief corrosion protection for upset or shutdown conditions. This pipe would not be appropriate where low or varying concentrations of sulfuric acid are the norm. The increased wall thickness naturally raises the weight of the product.

CONS

- Not corrosion resistant to long term low concentration sulfuric acid
- Requirement of gaskets for sealing
- Flow velocity limitations
- Brittle compared to wrought piping solutions and susceptible to shatter under stress

Nickel-Copper Alloys

There are many common nickel alloys used in piping. Nickel-copper alloys and nickel-chrome-molybdenum alloys are the ones commonly used in seawater service. Monel 400 also called alloy 400 has been around for over 100 years being originally developed in 1905. It contains about 30% copper and a minimum of 63% nickel. Manganese, iron and silicon are present in smaller amounts. The alloy has high strength and good corrosion resistance in many aqueous environments. The addition of copper to nickel makes it more inert compared to either pure nickel or copper so that this type of alloy has a lower corrosion rate in reducing conditions than nickel and a lower rate of corrosion than copper under oxidizing conditions. Generally, nickel-alloys are very resistant to SCC (stress corrosion cracking) but can be stress cracked in the presence of chlorides or caustic solutions. SCC resistance is increased by increasing nickel content in alloys, which also increases cost. There are various factors promoting SCC of nickel alloys in aqueous chloride solutions such as elevated temperatures, chloride content, low pH, presence of H₂S, presence of other oxidizing agents and/or high stress. In laboratory and field experiments alloy 400 was highly susceptible to SRB (sulfate-reducing bacteria) in both chlorinated and unchlorinated seawater where oxygen was available. Alloy 400 tubes failed in 3 to 8 months in a refinery heat exchanger using Arabian Gulf seawater as coolant. There have been several other industrial cases of MIC in various nickel alloys reported, too.

CONS

- Cost of material and installation especially for large diameter piping, (and wide swings in cost as market conditions dictate).
- Susceptible to microbiologically influenced corrosion
- Stress corrosion cracking



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

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, H₂SO₄ and HBr.

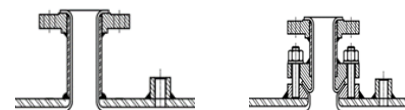
ETFE roto-lined products come with the security of full vacuum resistance throughout the temperature range. Columns made with paste extruded liners or welded sheet liners either have limited vacuum rating or require additional measures such as vacuum plugs or graphite sleeves.

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:

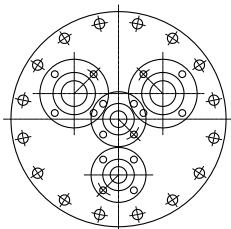
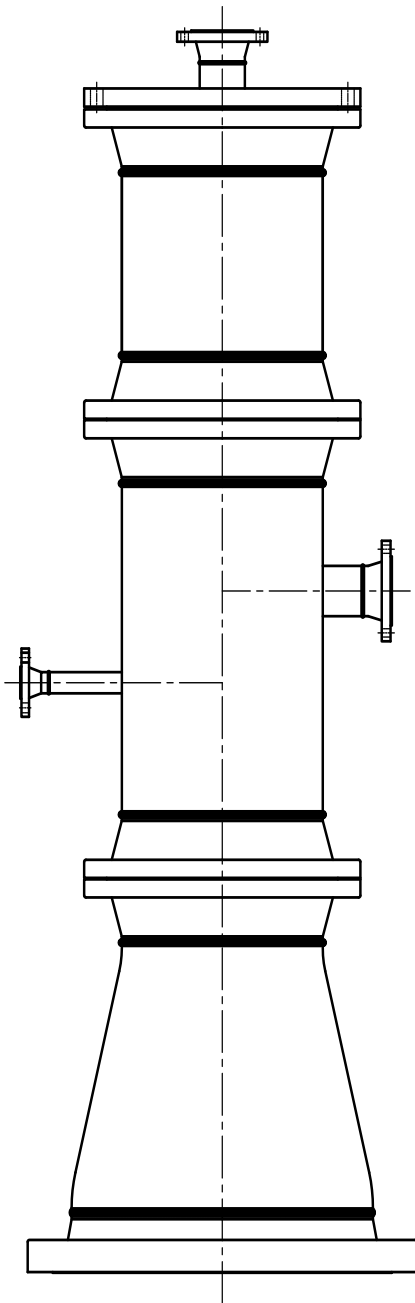
Nozzles are welded on the housing as a single piece vs. multi piece block flange connection



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

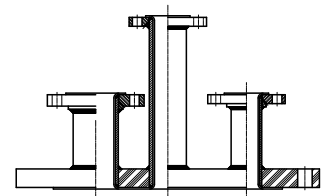
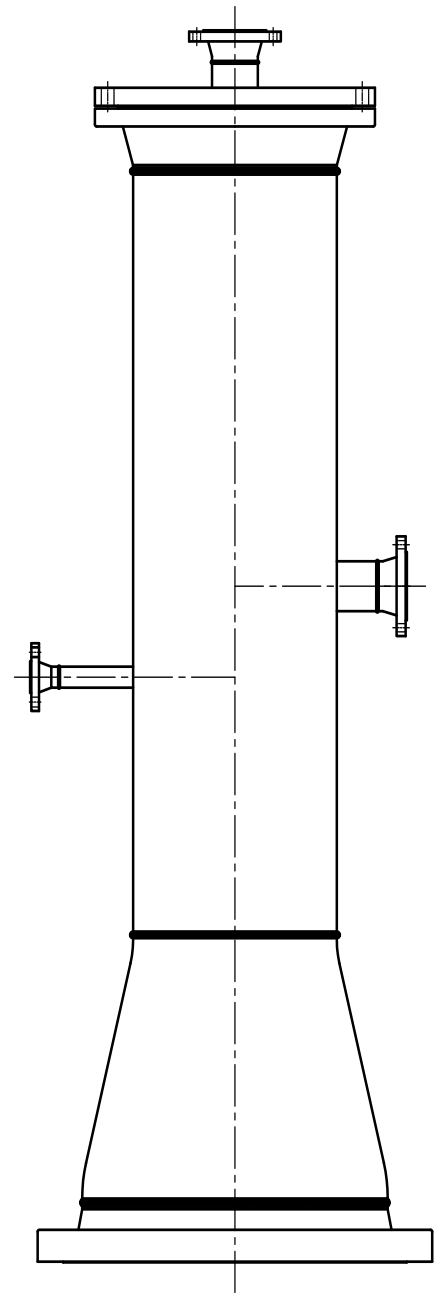
- ASTM A105 and A105N
- ASTM A182

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

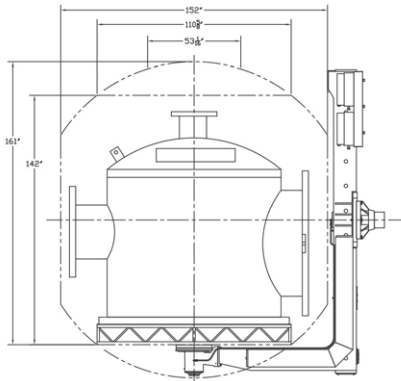
- Trays
- Liquid distributors
- Liquid collectors
- Support grids
- Support Plates
- Bed limiters
- Saddles, rings, and or structured packing



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.

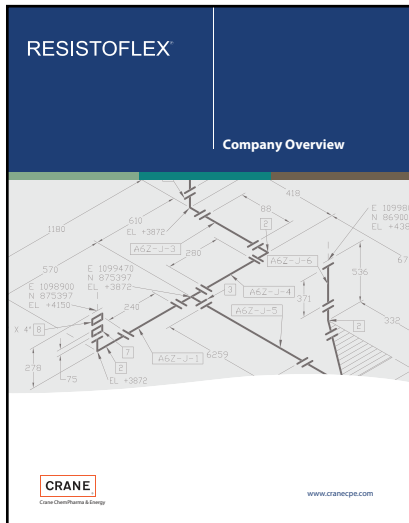
On-Site Training

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.

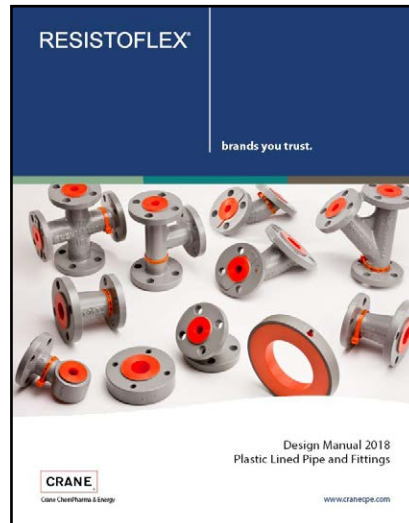
Factory and Field Support After Installation

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 on Resistoflex®.

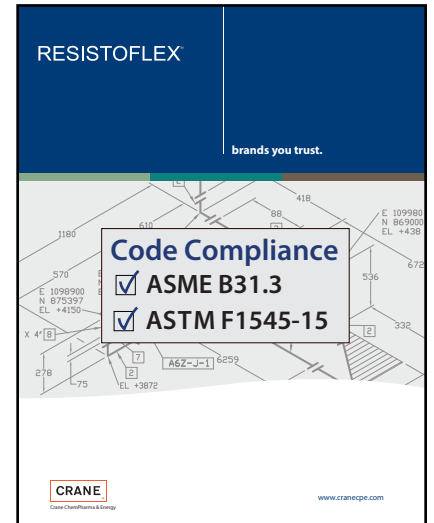
Resistoflex® Literature



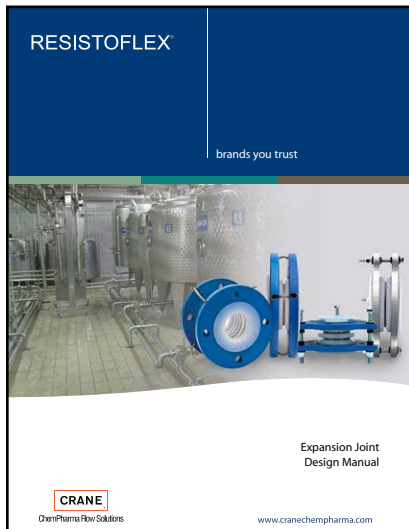
Company Overview



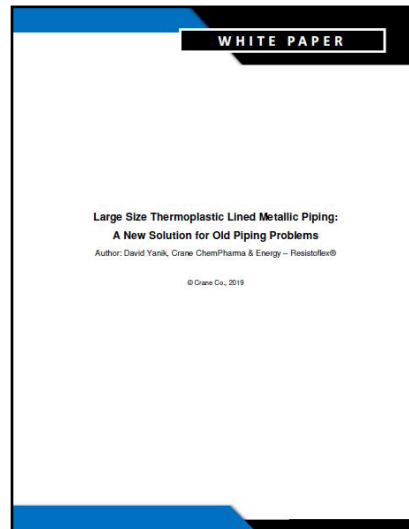
Pipe and Fittings Design Manual



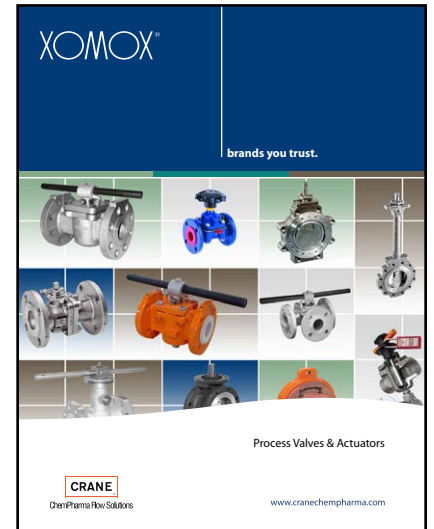
Code Compliance



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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