

# **Z-Core®**

## **Piping Systems**

### **Competitive Materials Installed Cost Comparison**

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** Fiber Glass Systems**

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## INTRODUCTION

Selecting the right pipe for your corrosive service can result in a system that outlasts lined steel and even stainless steel. The **exceptional corrosion resistance** of **Z-Core** fiberglass reinforced pipe, as shown in the charts on pages 6-8, means a longer service life than pipe made of traditional materials. The longer life means a **reduction in both maintenance and replacement costs**. Plus, compared to metallic piping systems, **Z-Core** pipe can be **installed easier and faster**, and heavy equipment is seldom required. The following installed cost comparison demonstrates that considerable savings on **total installed cost** may be achieved by using **Z-Core** pipe and fittings. Unlike lined steel systems, **Z-Core** pipe is lightweight and easy to handle and field fabricate. **Z-Core** pipe does not require labor-intensive welding operations as stainless steel systems do. Review the following **Installed Cost Comparison** and **Competitive Materials Corrosion Chart** for the facts.

## BASIS FOR INSTALLED COST COMPARISON

1. The five piping systems compared in this analysis include the following:
  - **Z-Core** adhesive-bonded socketed pipe and fittings
  - Polypropylene-lined steel flanged pipe and fittings
  - PVDF-lined steel flanged pipe and fittings
  - PTFE-lined steel flanged pipe and fittings
  - 316 Schedule 40 stainless steel butt weld pipe and fittings

The piping layout and bill of materials used for comparison is shown in Figs. 1 on page 4.

2. Pipe, fittings, and accessories prices are based on the following price sheets and assumptions:
  - **Z-Core** pipe. . . . . October 2008 list prices
  - Polypropylene-lined steel. . . . . September 1, 2008 prices less 50% discount
  - PVDF-lined steel. . . . . September 1, 2008 prices less 50% discount
  - PTFE-lined steel. . . . . September 1, 2008 prices less 65% discount
  - 316 Schedule 40 stainless steel . . . . . October 2008 market buy prices
  - All bolt sets: stainless steel. . . . . Richardson Rapid System
  - Adhesive Kits: 15% extra was added to the adhesive kit totals to account for waste:

Pipe Size	2"	3"	4"	6"
No. of Kits:	8	13	16	22

3. Labor units are based on the following assumptions and were obtained from the following sources:
  - Labor units for lined steel and stainless steel pipe and fittings were obtained from **The Richardson Rapid System Process Plant Construction Estimating Standards**, published by Richardson Engineering Services, Inc., Mesa, Arizona. Comparison units were for "Pipe Installed Inside Battery Limits of a Process Area." Labor units for **Z-Core** pipe and fittings were based on actual field and test lab experience.
4. To determine labor cost, a composite crew rate of **\$45.00** average per man hour was applied.

**Table 1 - Pipe Weights (Lbs. per Foot)**

Pipe Material	2"	3"	4"	6"
<b>Z-Core</b>	1.6	2.4	3.5	7.0
Lined Steel	4.6	9.1	13.0	22.8
316 Sch. 40 Stainless Steel	3.7	7.6	10.8	19.0

**Z-CORE Pipe Features & Benefit**

- Lightweight (See Table 1)
- No external corrosion
- Proprietary Z-Core resin system
- Pure 100 mil corrosion barrier
- Temperatures to 275°F at 150 psig
- Easily field fabricated
- Greatly reduces chance of fugitive emissions with adhesive bonded joints compared to lined-steel flanged joints
- Resistant to virtually all solvents and sulfuric acid to 98%

**Table 2 - Pipe Material (\$ Cost per Foot Based on 20-ft. Length)**

Pipe Material	2"	3"	4"	6"
<b>Z-Core</b>	20.70	25.70	32.90	60.40
Polypropylene-Lined Steel	21.20	36.35	47.70	83.60
PVDF-Lined Steel	40.70	61.15	87.70	146.70
PTFE-Lined Steel	43.61	62.55	91.10	171.17
31 Sch. 40 Stainless Steel	26.28	43.81	61.93	109.34

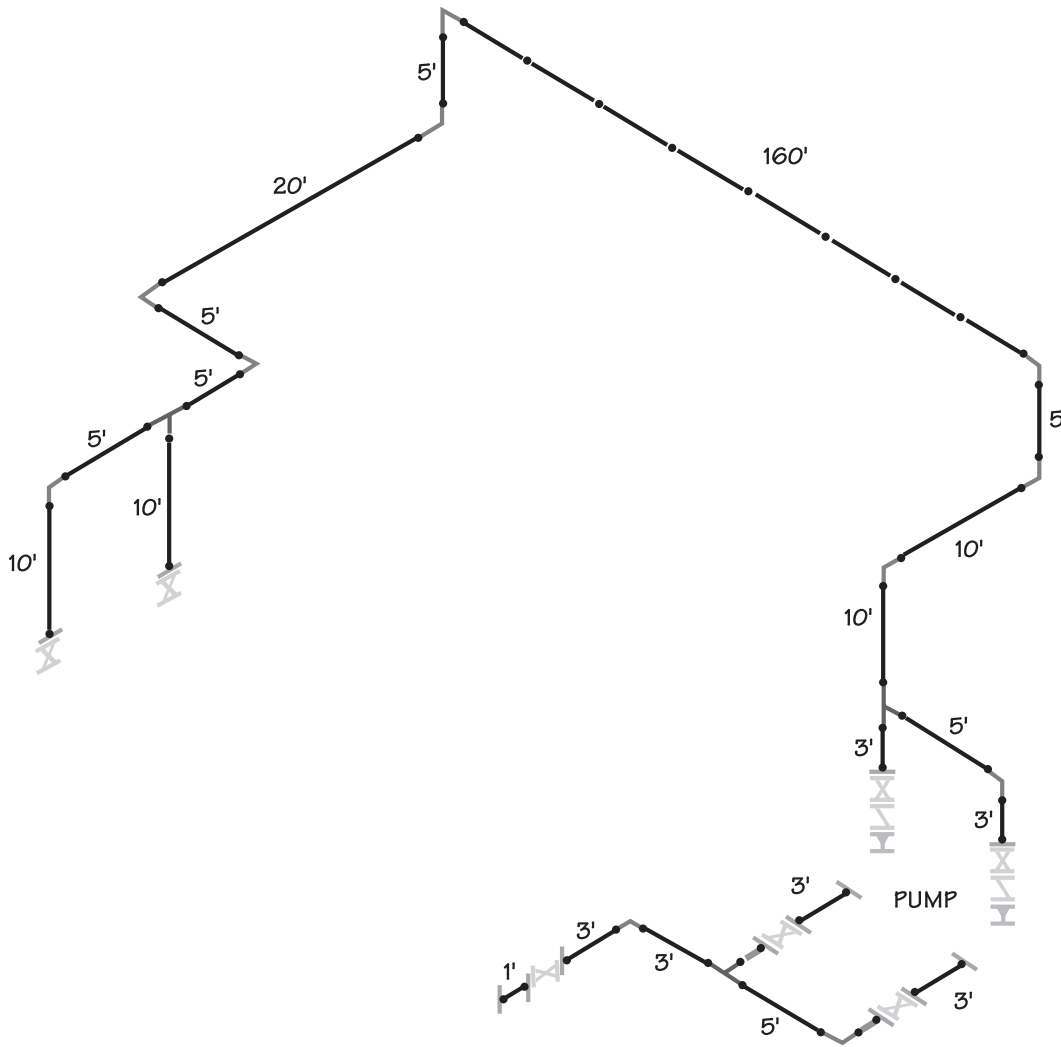
\*Above prices are representative per/foot discounted prices based on a 20-ft. length of pipe. Lined-steel pipe spools are flanged, while **Z-Core** and stainless steel pipe is plain end. Actual pipe material cost in the Installed Cost Comparison is based on the following:

- Calculated to-length, fabricated flanged spool prices (per the bill of materials) for lined-steel pipe
- Calculated full pipe length prices (per the bill of materials) for **Z-Core** and stainless steel pipe

**Table 3 - Labor Units (Hours)**

2" Piping System	Pipe (per foot)	90 Degree Elbow	Tee	Conc. Red.	Coupling	Flange	Bolt Set	Field Cut & Bevel	Erection Butt Weld
<b>Z-Core</b>	0.112	0.520	0.780	0.520	0.520	0.260	0.840	-	-
Lined Steel	0.143	0.350	0.530	0.330	-	-	0.840	-	-
316 Sch. 40 Stainless Steel	0.166	3.400	5.100	3.200	1.700	1.500	0.840	0.460	3.800
<b>3" Piping System</b>									
<b>Z-Core</b>	0.136	0.640	0.960	0.640	0.640	0.320	0.840	-	-
Lined Steel	0.174	0.430	0.650	0.390	-	-	0.840	-	-
316 Sch. 40 Stainless Steel	0.202	4.600	6.900	4.000	2.300	2.100	0.840	0.620	4.700
<b>4" Piping System</b>									
<b>Z-Core</b>	0.160	0.800	1.200	0.800	0.800	0.400	1.700	-	-
Lined Steel	0.194	0.500	0.750	0.470	-	-	1.700	-	-
316 Sch. 40 Stainless Steel	0.250	6.200	9.300	5.400	3.100	2.800	1.700	0.840	6.000
<b>6" Piping System</b>									
<b>Z-Core</b>	0.200	1.340	2.010	1.340	1.340	0.670	2.000	-	-
Lined Steel	0.300	0.650	0.980	0.580	-	-	2.000	-	-
316 Sch. 40 Stainless Steel	0.350	9.000	13.500	7.600	4.500	4.100	2.000	1.220	8.200

Figure 1 - 316 Schedule 40 Stainless Steel Butt Weld System  
or  
**Z-Core** Adhesive-Bonded Socketed System



Bill of Materials		
Item	Qty. S.S.	Qty. <b>Z-Core</b>
Pipe (20-ft lengths	14	14
Total pipe = 280'		
90 degree elbow	11	11
Tee	3	3
Conc. red, FxF	2	2
Flange	13	13
Coupling	2	9
Bolt sets	17	17
Adhesive joints	-	58

Bill of Materials	
Item	Lined Steel Quantity
1-foot pipe spool, FxF	1
3-foot pipe spool, FxF	6
5-foot pipe spool, FxF	7
10-foot pipe spool, FxF	4
20-foot pipe spool, FxF	9
Total pipe = 274'	
90 degree elbow, FxF	11
Tee, FxFxF	3
Concentric reducer, FxF	2
Bolt sets	53

**Table 4 - Installed Cost Comparison**

	Pipe Material \$ Cost	Fittings Material \$ Cost	Bolt Sets & Adhesive \$ Cost	Field Labor \$ Cost (Pipe)	Field Labor \$ Cost (Fittings)	TOTAL INSTALLED \$ COST	% Savings Z-Core Piping
<b>2" Piping System</b>							
<b>Z-Core</b>	5,796.00	2,530.80	1,314.00	1,414.50	1,418.09	12,473.39	
Polypropylene-Lined Steel	7,192.00	2,807.50	3,180.00	1,767.31	2,283.21	17,230.02	28
PVDF-Lined Steel	12,531.00	3,205.50	3,180.00	1,767.31	2,283.21	22,967.02	46
PTFE-Lined Steel	12,749.80	3,623.55	3,180.00	1,767.31	2,283.21	23,603.87	47
316 Sch. 40 Stainless Steel	7,353.40	1,017.35	1,020.00	2,096.48	5,853.73	17,340.96	28
<b>3" Piping System</b>							
<b>Z-Core</b>	7,196.00	3,043.80	1,829.25	1,717.60	1,596.72	15,383.37	
Polypropylene-Lined Steel	11,915.00	3,655.00	4,213.50	2,150.42	2,344.56	24,278.48	37
<b>PVDF-Lined Steel</b>	18,923.00	4,923.00	4,213.50	2,150.42	2,344.56	32,554.48	53
<b>PTFE-Lined Steel</b>	18,319.70	5,248.95	4,213.50	2,150.42	2,344.56	32,277.13	52
316 Sch. 40 Stainless Steel	12,266.00	1,692.25	1,351.50	2,551.15	7,563.21	25,424.11	39
<b>4" Piping System</b>							
<b>Z-Core</b>	9,212.00	3,644.10	2,755.50	2,020.70	2,494.31	20,126.61	
Polypropylene-Lined Steel	15,384.00	4,740.00	6,757.50	2,397.60	4,455.93	33,735.03	40
PVDF-Lined Steel	26,876.00	6,258.00	6,757.50	2,397.60	4,455.93	46,745.03	57
PTFE-Lined Steel	26,573.40	7,674.45	6,757.50	2,397.60	4,455.93	47,858.88	58
316 Sch. 40 Stainless Steel	17,340.40	2,513.25	2,167.50	3,157.35	10,509.47	35,687.97	44
<b>6" Piping System</b>							
<b>Z-Core</b>	16,912.00	6,872.80	4,059.75	2,525.88	3,528.11	33,898.54	
Polypropylene-Lined Steel	25,872.00	8,719.50	10,136.25	3,707.68	5,288.57	53,723.95	37
PVDF-Lined Steel	43,707.00	13,094.00	10,136.25	3,707.68	5,288.57	75,933.45	55
PTFE-Lined Steel	49,045.85	14,231.70	10,136.25	3,707.68	5,288.57	82,410.00	59
316 Sch. 40 Stainless Steel	30,615.20	5,187.00	3,251.25	4,420.29	14,735.80	58,209.54	42

**Table 5\***

Maximum Recommended Operating Temperature, °F

Chemical	Z-Core Pipe Note I	Polypropylene Lined Steel Note II	PVDF Lined Steel Note II	PTFE Lined Steel Note II	316 Stainless Note II
Acetic Acid, 10%	200	200	225	450	420
Acetone	125	125	NR	450	400
Acrylic Acid	100	NR	--	--	120
Acrylonitrile	120	125	75	450	210
Adipic Acid	250	150	150	450	210
Allyl Chloride	150	75	175	450	100
Alum	275	225	275	450	200
Aluminum Chloride, Aqueous	275	225	275	450	NR
Aluminum Hydroxide	200	200	275	450	400
Aluminum Nitrate	250	200	275	450	200
Aluminum Sulfate	275	225	275	450	210(a)
Ammonia Gas <sup>(1)(2)</sup> Anhydrous	275	150	NR	450(e)	90
Ammonium Carbonate	225	225	275	450	400
Ammonium Chloride, Sat'd.	225	225	275	450	NR
Ammonium Fluoride, 25%	100	200	275	450	NR
Ammonium Hydroxide, Sat'd.	175	225	275	450	210
Ammonium Nitrate, Sat'd.	210	150	75	450	300(a)
Ammonium Persulfate, Sat'd.	100	150	275	450	360
Ammonium Phosphate	225	225	275	450	130
Ammonium Sulfate, 10-40%	275	225	125	450	400
Ammonium Sulfide	100	150	125	450	390
Ammonium Sulfite	150	--	--	--	210
Amyl Acetate	150	75	125	450	300
Amyl Alcohol	175	75	275	450	400
Aniline	120	125	125	450	500
Barium Chloride	275	200	275	450	210(b)
Barium Sulfate	275	200	275	450	210
Benzaldehyde	200	75	75	450	400
Benzene	180	NR	150	450(e)	400
Benzoic Acid	200	150	225	450	400
Benzyl Alcohol	150	125	250	450	400
Benzyl Chloride	150	75	275	450	210
Boric Acid	250	225	275	450	400
Butadiene	200	NR	250	450(e)	400
Butyl Acetate	175	NR	75	450	380
Butyl Alcohol	200	--	--	450	400
Calcium Bisulfite	100	200	275	450	350
Calcium Carbonate	225	225	275	450	205
Calcium Chloride	275	225	275	450	210(a)
Calcium Hydroxide, 10%	275	--	275	450	210
Calcium Nitrate	275	200	275	450	350
Calcium Sulfate	275	225	275	450	210

\*Refer to footnotes on last page.

**Table 5\* - cont.**

Maximum Recommended Operating Temperature, °F

Chemical	Z-Core Pipe Note I	Polypropylene Lined Steel Note II	PVDF Lined Steel Note II	PTFE Lined Steel Note II	316 Stainless Note II
Carbon Dioxide, Dry <sup>(1)</sup>	275	225	275	450	570
Carbon Dioxide, Wet <sup>(1)</sup>	250	225	275	450	200
Carbon Disulfide	150	NR	75	450	400
Carbon Tetrachloride	175	NR	275	450(a)	400(a,b)
Carbonic Acid	150	225	275	450	350
Chloroacetic Acid, 10%	150	125	NR	450	NR
Chlorobenzene	200	NR	175	450(e)	260
Chloroform	185	NR	125	450(e)	210(a)
Chromic Acid, 10%	75	--	--	450	400(c)
Citric Acid, 15%	225	225	275	450	200(b)
Copper Carbonate	200	200	275	450	80
Copper Chloride	225	200	275	450	NR
Copper Sulfate	250	200	275	450	400
Cresol	200	NR	150	450	100
Cyclohexane	175	NR	275	450	400
Cyclohexanol	200	75	150	450	80
Dichloroacetic Acid	100	125	125	450	--
Dichloroethane (Ethylene Dichloride)	185	75	175	450(e)	400
Ethylene Glycol	275	125	275	450	340
Ferric Chloride	275	200	275	450	NR
Ferric Nitrate, 10-50%, Sat'd.	275	200	275	450	350
Ferrous Chloride	275	200(a)	275	450	NR
Ferrous Nitrate	275	200	275	450	--
Hydrobromic Acid, 20%-50%	100	175	275	450(a)	NR
Hydrochloric Acid, 20%	200	--	275	450(a)	NR
Hydrochloric Acid, 38%	150	--	275	450(a)	NR
Hydrocyanic Acid, 10%	100	150	275	450	210
Lactic Acid, 80%	275	150	125	450	300(bd)
Magnesium Chloride	275	225	275	450	210(ab)
Manganese Chloride, 30%	250	--	--	--	210
Methyl Chloride	75	NR	275	450(e)	350
Methyl Ethyl Ketone	175	75	NR	450(e)	350
Methylene Chloride	100	NR	125	450(e)	--
Nitric Acid, 5%	150	175	175	450(e)	210(d)
Phenol	100(3)	150	125	450(e)	570
Phosphoric Acid, 50%	125	225	225	450	400(d)
Potassium Bromide, 30%	275	225	275	450	350(b)
Sodium Carbonate, 50%	225	225	275	450	350
Sodium Chloride	275	225	275	450	350(a)
Sodium Hydroxide, 10%	215	200	125	450	350
Sodium Hydroxide, Sat'd.	240	150	NR	450	350
Sodium Sulfide, 15%	250	150	275	450	190

\*Refer to footnotes on last page.

**Table 5\* - cont.**

Maximum Recommended Operating Temperature, °F

Chemical	Z-Core Pipe Note I	Polypropylene Lined Steel Note II	PVDF Lined Steel Note II	PTFE Lined Steel Note II	316 Stainless Note II
Stannic Chloride	225	225	275	450	NR
Sulfuric Acid, 10%	150	225	250	450	NR
Sulfuric Acid, 50%-70%	175	175	250	450	NR
Sulfuric Acid, 90%	120	--	200	450	80(d)
Sulfuric Acid, 98%	120	--	150	450	210(d)
Sulfuric Acid, 100%	100 <sup>(3)</sup>	NR	NR	450	210(d)
Sulfuric Acid, Fuming	100 <sup>(3)</sup>	NR	NR	450(e)	210
Sulfurous Acid, 6%	75	175	200	450	150(d)
Toluene	200	NR	175	450(e)	350
White Liquor	275	--	--	450	100
Zinc Chloride, 50%	250	175	275	450(f)	200

**Notes:**

Chemical test data developed at NOV Fiber Glass Systems, Little Rock, Arkansas

Corrosion Resistant Piping Systems, Philip A. Schweitzer, P.E. ©Marcel Dekker, Inc., NY, NY, 1994. Published with permission.

**Other Notations:**

- a = Subject to stress cracking
- b = Subject to pitting
- c = Subject to crevice attack
- d = Subject to intergranular corrosion
- e = Material will permeate
- f = Material will be absorbed

NR = Pipe material is not compatible.

Blank space indicates pipe material has not been tested in the respective chemical.

NOTE: For applications not listed, consult NOV Fiber Glass Systems.

1. Consult your representative concerning all pressurized gas applications if the pipeline is not buried at least 3 feet deep. Under no circumstances are our piping systems recommended for above ground pressurized gas lines if the operating pressures exceed 25 psig for 2"-6" pipe.

2. Avoid use of the piping systems where contact with liquified gases, such as chlorine or sulfur dioxide, is a possibility. Dry gases under pressure can condense to liquids in cool weather. This situation should be avoided. Liquid chlorine and liquid sulfur dioxide should not be confused with water solutions of these gases.

3. Check with NOV Fiber Glass Systems Applications Engineering for specific recommendations.

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