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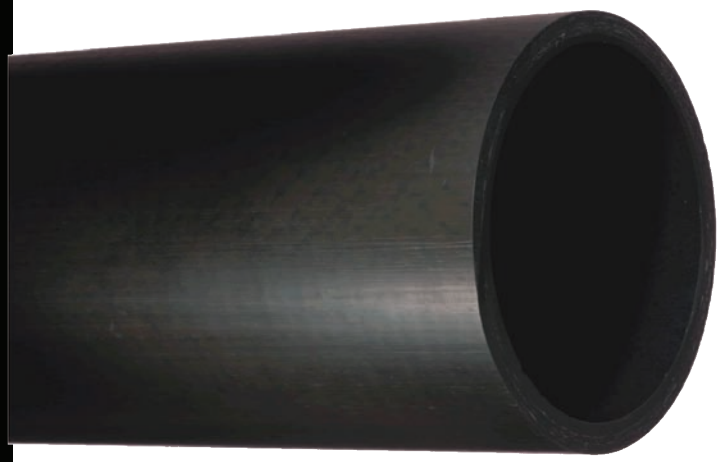
Z-CORE®

Piping System



NOV FiberGlass Systems™

Z-CORE Piping System

PRODUCT

Z-CORE pipe is a centrifugally cast fiberglass pipe with a 100 mil resin-rich liner. Proprietary curing agents coupled with a premium epoxy resin base gives Z-CORE its outstanding corrosion resistance to aggressive solvents and concentrated acids. Currently available in 1" through 8" diameters, Z-CORE pipe is rated for temperatures to 275ºF and for pressures to 150 psig (higher pressures available on special request.)

EXTERNAL BARRIER

Z-CORE has a resin-rick 10-mil reinforced corrosion barrier on the outside surface which provides superior resistance to exterior corrosion. The resin-rich exterior also offers protection against "fiber blooming" caused by ultraviolet radiation. FGS Smith Fibercast warrants Z-CORE pipe and fittings against reduction of physical and corrosion ratings due to ultraviolet exposure for a period of 15 years.

FITTINGS

A complete line of compatible Z-CORE fittings is available with both socket and flanged ends. Fittings are designed to match the temperature, pressure, and corrosion resistance capabilities of the pipe.

Most 1" through 6" diameter fittings are compression molded and other fittings are manufactured using a contact molding and/or filament winding process. *See Bulletin No. A1390 for fitting specifications.*

JOINING METHODS

Z-CORE pipe is joined using the socket joining system. The pipe is supplied with plain ends. Only a thorough sanding of the pipe O.D. and the mating fitting's socket is required prior to applying adhesive. Then, the pipe may be inserted into a coupling or a fitting. Flanged fittings are also available.

An adhesive that has been specially formulated for the operating conditions of the piping system is used to bond the joint. The adhesive, Weldfast® ZC-275, is a two-component system that is recommended for service up to 275ºF. *See Bulletin D4212 for complete adhesive and installation instructions.*

RECOMMENDED SERVICES

Z-CORE pipe has outstanding corrosion resistance to aggressive solvents such as methylene chloride, acetone, dimethyl formamide, and chloroform. It also extends the boundaries for fiberglass piping in sulfuric acid service, up to 98%. It is especially designed for service in severe corrosion applications in the chemical process industry and other industrial plants.

BENEFITS

The exceptional chemical resistance of Z-CORE fiberglass reinforced pipe means a longer service life than pipe made of traditional materials, especially in aggressive solvents and acids. The longer life means a reduction in maintenance and replacement costs.

Compared to metallic piping systems, Z-CORE pipe can be installed easier and faster, and heavy equipment is seldom required. A considerable savings on total installed cost may be achieved because less labor and equipment are needed.

Z-CORE pipe offers the advantage of light weight. For example, 4" Z-CORE pipe weighs 3.5 lbs. per foot compared to 10.8 lbs. per foot for 4" Schedule 40 stainless steel pipe. Therefore, a 20 ft. length of Z-CORE pipe weighs only 70 lbs. while the same length of Schedule 40 weighs 216 lbs. - or three times the weight of Z-CORE pipe.

DISTRIBUTION

FGS Smith Fibercast has a network of stocking distributors across the U.S. as well as representatives and distributors in many other parts of the world. These distributors are supported by a staff of experienced technical personnel at the home office and by highly trained, strategically located field personnel.

PIPE PROPERTIES

General Specifications and Dimensional Data*

Nominal Pipe Size	Nominal I.D.		Nominal O.D.		Nominal Wall Thickness		Reinforcement Thickness		Nominal Weight		Capacity	
In.	In.	mm	In.	mm	In.	mm	In.	mm	Lbs/Ft	kg/m	Gal/Ft.	CuFt/Ft
1	0.92	23.2	1.315	33.4	0.20	5.1	0.09	2.3	0.67	0.99	0.03	0.005
1½	1.40	35.6	1.900	48.3	0.25	6.4	0.14	3.6	1.24	1.84	0.08	0.011
2	1.88	47.6	2.375	60.3	0.25	6.4	0.14	3.6	1.59	2.36	0.14	0.019
3	3.00	76.2	3.500	88.9	0.25	6.4	0.14	3.6	2.43	3.62	0.37	0.049
4	3.94	100.1	4.500	114.3	0.28	7.1	0.17	4.3	3.54	5.26	0.63	0.085
6	5.88	149.2	6.625	168.3	0.38	9.5	0.27	6.7	7.02	10.43	1.41	0.189
8	7.79	197.7	8.625	219.1	0.42	10.7	0.31	7.9	10.32	15.34	2.48	0.331

*All values are nominal. Tolerances or maximum/minimum limits can be obtained from FGS Smith Fibercast.

ASTM D2997 Designation Codes:

1”	RTRP-21CO-3406
1½” - 6”	RTRP-21CO-1446
8”	RTRP-21CO-1445

Pipe Lengths Available

Size	Random Length
In.	Ft.
1-8	20†

†Pipe is offered in random or exact lengths. Random lengths are from 18.5 to 20.4 ft. long

Pressure Ratings(1) (2)

Nominal Pipe Size (In.)	Max. Internal Pressure @ 275ºF (psig)			Maximum External Pressure(6)		
	Socket Pressure Fittings(3)	Flg’d Pressure Fittings(4)	Other Pressure Fittings(5)	@75ºF	@200ºF	@275ºF
1	275	275	NA	2125	1700	1381
1½	275	275	125	2065	1652	1342
2	275	275	125	1170	931	763
3	175	150	100	335	267	219
4	150	150	100	225	179	147
6	150	150	100	62	49	40
8	150	150	100	45	36	29

(1)Static pressure ratings, typically created with use of a gear pump, turbine pump, centrifugal pump, or multiplex pump having 4 or more pistons, or elevation head.
(2)Specially fabricated higher pressure fittings are available on request. Consult the factory for compressible gases. For insulated and heat traced temperatures. Heat cured joints are recommended for all piping systems carrying fluids at temperatures above 120ºF.
(3)Socket elbows, tees reducers, couplings, flanges and nipples joined with WELDFAST ZC-275 adhesive.
(4)Flanged elbows, tees, reducers, couplings and nipples assembled at factory.’
(5)Laterals and crosses.
(6)Ratings shown are 50% of ultimate; 14.7 psi external pressure is equal to full vacuum.
NA = Not available at time of printing.

Average Physical Properties

Property	Nominal Size				Nominal Size				Nominal Size			
	@ 75ºF		@ 24ºC		@ 250ºF		@ 121ºC		@275ºF		@ 135ºC	
	1"		1½"-8"		1"		1½"-8"		1"		1½"-8"	
	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa
Axial Tensile ASTM D2105												
Ultimate Stress	23,000	159	29,000	200	15,000	100	19,000	131	13,500	93	17,500	121
Design Stress	5,750	40	7,250	50	3,750	26	4,750	33	3,375	23	4,375	30
Modulus of Elasticity	-	-	1.9E+06	13,100	-	-	1.6E+06	11,000	-	-	1.5E+06	10,300
Poisson's Ratio	0.15				0.15				0.15			
Axial Compression ASTM D695												
Ultimate Stress	20,000	138	26,000	179	21,000	145	22,000	152	20,000	138	21,000	145
Design Stress	5,000	34	6,500	45	5,250	36	5,500	38	5,000	34	5,250	36
Modulus of Elasticity	4.7E+06	32,400	6.4E+06	44,126	1.4E+06	9,653	1.8E+06	12,411	1.0E+06	6,895	1.1E+06	7.860
Beam Bending ASTM D2925												
Ultimate Stress	50,000	345	42,000	290	32,000	221	27,000	186	29,000	200	25,000	172
Design Stress	6,250	43	5,250	36	4,000	28	3,375	23	3,625	25	3,125	22
Modulus of Elasticity (Long Term)	6.0E+05	4,137	4.0E+06	27,579	1.8E+05	1,241	1.2E+06	8,274	1.2E+05	827	8.0E+05	5,516
Hydrostatic Burst ASTM D1599												
Ultimate Hoop Tensile Stress	28,000	193	11,000	76								
Hoop Tensile/Mod. of Elas.	-	-	2.1E+06	14,686								
Coefficient of Linear Thermal Expansion- ASTM D696	Non-Insulated Pipe: 9.2 E-06 in/in/ºF Insulated Pipe: 1.04 E-05 in/in/ºF				1.7 E-05 mm/mmºC 1.9 E-06 mm/mm/ºC							
Thermal Conductivity	0.09 BTU/(ft)(hr)(ºF)				0.16 W/(m)(ºC)							
Specific Gravity	2.20 (0.079 Lb/in^3)				(2.20 g/cmº3)							
Hazen-Williams Flow Factor	C-150											
Surface Roughness	1.7 x 10^{-5} Feet											
Manning's "n"	0.009											

Properties of Pipe Sections Based on Minimum Reinforced Walls

Size (In)	Reinforcement End Area(In^2)	Reinforcement Moment of Inertia (In^4)	Reinforcement Section Modulus (In^3)	Nominal Wall End Area (In^2)
1	0.35	0.07	0.10	0.70
1^1/$_2$	0.77	0.30	0.32	1.30
2	0.98	0.62	0.52	1.67
3	1.48	2.09	1.19	2.55
4	2.31	5.43	2.41	3.71
6	5.29	26.82	8.10	7.36
8	8.10	70.08	16.25	10.83

Recommended Operating Ratings

Size (In)	Axial Tensile Loads Max. (Lbs)		Axial Compressive Loads Max. (Lbs)[1]		Bending Radius Min. (Ft) Entire Temp. Range	Torque Max. (Ft Lbs) Entire Temp. Range	Parallel Plate Loading[2] @ 2% Deflection ASTM D2412		
	@75ºF	@ Max. Rated Temp.	@75ºF	@ Max. Rated Temp.			Stiffness Factor In^3 Lbs/In^2	Pipe Stiffness (psi)	Hoop Modulus x10^6 (psi)
1	1,990	1,200	1,730	1,700	5	41	170	4,968	2.8
1½	5,610	3,400	5,030	4,100	60	132	869	8,558	3.8
2	7,130	4,300	6,390	5,200	75	216	2,287	10,997	10.0
3	10,710	6,500	9,610	7,800	111	497	2,515	3,560	11.0
4	16,770	10,100	15,030	12,100	143	1,005	4,094	2,708	10.0
6	38,390	23,200	34,420	27,800	210	3,373	10,080	2,104	6.5
8	58,710	35,400	52,640	42,500	274	6,771	10,179	951	4.1

[1]Compressive loads are for short columns only. Buckling loads must be calculated when applicable.

[2]Burial calculations must be based on 2% deflection as shown in table above.

SUPPORTS

The following engineering analysis must be performed to determine the maximum support spacing for the piping system. Proper pipe support spacing depends on the temperature and weight of the fluid carried in the pipe. The support spacing is calculated using continuous beam equations and the pipe bending modulus derived from long-term beam bending tests. The following tables were developed to ensure a design that limits beam mid-span deflection to ½ inch and bending stresses to less than or equal to ⅛ of the ultimate bending stress. Any additional weight on the piping system such as insulation or heat tracing requires further consideration. Restrained (anchored) piping systems operating at elevated temperatures often result in guide spacing requirements that are more stringent than simple unrestrained piping systems. In this case, the maximum guide spacing will dictate the support/guide spacing requirements for the system. Pipe support spans at changes in direction require special attention. Supported and unsupported fittings at changes in direction are considered in the following tables and must be followed to properly design the piping system.

There are seven basic rules to follow when designing piping system supports, anchors, and guides:

1. Do not exceed the recommended support span.
2. Support valves and heavy in-line equipment independently . This applies to both vertical and horizontal piping.
3. Protect pipe from external abrasion.
4. Avoid point contact loads.
5. Avoid excessive bending. This applies to handling, transporting, initial layout, and final installed position.
6. Avoid excessive vertical run loading. Vertical loads should be supported sufficiently to minimize bending stresses at outlets or changes in direction.
7. Provide adequate axial and lateral restraint to ensure line stability during rapid changes in flow.

Maximum Support Spacing for Uninsulated Pipe*

Nominal Pipe Size (In.)	Continuous Spans of Pipe (Ft.) Deflection=1/2" Specific Gravity=1.0		
	75ºF	250F	275F
1	8.2	6.1	5.5
1½	16.3	12.1	10.9
2	17.7	13.1	11.8
3	20.3	15.0	13.6
4	22.9	16.9	15.3
6	28.2	20.9	18.9
8	31.7	23.4	21.2

*Consult factory for insulated pipe support spacing.

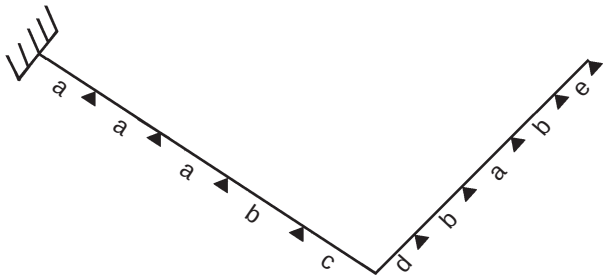
Support Spacing vs. Specific Gravity

Specific Gravity	2.00	1.50	1.25	1.00	0.75
Multiplier	0.80	0.93	0.96	1.00	1.04

Example: 6" pipe @ 250°F with 1.5 specific gravity fluid, maximum support spacing = 20.9 x 0.93 = 19.4 ft.

Adjustment Factors for Various Spans With Unsupported Fitting at Change in Direction

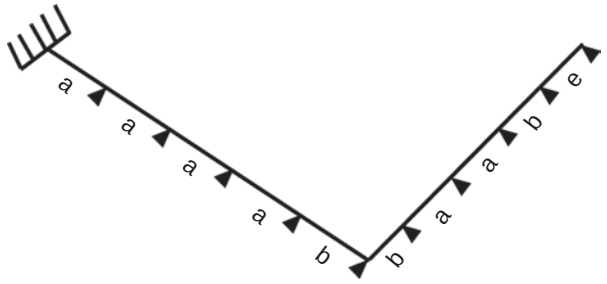
	Span Type	Factor
a	Continuous interior or fixed end spans	1.00
b	Second span from simple supported end or unsupported fitting	0.80
c + d	Sum of unsupported spans at fitting	≤ 0.75*
e	Simple supported end span	0.67



*For example: If continuous support span is 10 ft., c + d must not exceed 7.5 ft. (c = 3 ft. and d = 4.5 ft. would satisfy this condition).

Adjustment Factors for Various SPANS With Supported Fitting at Change in Direction

	Span Type	Factor
a	Continuous interior or fixed end spans	1.00
b	Span at supported fitting or span adjacent to a simple supported end	0.80
e	Simple supported end span	0.67



THERMAL EXPANSION

The effects of thermal gradients on piping systems may be significant and should be considered in every piping system stress analysis. Pipe line movements due to thermal expansion or contraction may cause high stresses or even buckle a pipe line if improperly restrained. Several piping system designs are used to manage thermal expansion and contraction in above ground piping systems. They are listed below according to economic preference:

1. Use of inherent flexibility in directional changes
2. Restraining axial movements and guiding to prevent buckling
3. Use expansion loops to absorb thermal movements
4. Use mechanical expansion joints to absorb thermal movements

To perform a thermal analysis the following information is required:

1. Isometric layout of piping system
2. Physical and material properties of pipe
3. Design temperatures
4. Installation temperature (Final tie in temperature)
5. Terminal equipment load limits
6. Support movements

A comprehensive review of temperature effects on fiberglass pipe may be found in Smith Fibercast's "Engineering and Piping Design Guide", Manual No. E5000, Section 3.

Change in Temperature °F	Pipe Change in Length (In/100 Ft)
25	0.28
50	0.55
75	0.83
100	1.10
125	1.38
150	1.66
175	1.93
200	2.21
225	2.48
250	2.76
275	3.04

Maximum Guide Spacing for Restrained Thermal End Loads (Feet)

Nominal Pipe Size (In)	Temperature Change ºF							
	25	50	75	100	125	150	175	200
1	2.7	1.9	1.5	1.3	1.2	1.1	1.0	0.9
1 1/2	8.5	6.0	4.9	4.3	3.8	3.5	3.2	3.0
2	10.8	7.6	6.2	5.4	4.8	4.4	4.1	3.8
3	16.2	11.5	9.4	8.1	7.3	6.6	6.1	5.7
4	20.9	14.8	12.1	10.5	9.4	8.5	7.9	7.4
6	30.7	21.7	17.7	15.4	13.7	12.5	11.6	10.9
8	40.1	28.4	23.2	20.1	18.0	16.4	15.2	14.2

Based on installation temperature of 75**ºF.**

Expansion Loop Design Minimum Leg Length (Feet)

Size (In)	Change in Length (Inches)										
	1/2	1	2	3	4	5	6	7	8	9	10
1	0.6	0.8	1.2	1.4	1.6	1.8	2.0	2.2	2.3	2.5	2.6
1 1/2	2.6	3.7	5.3	6.5	7.5	8.4	9.2	9.9	10.6	11.2	11.8
2	3.1	4.4	6.2	7.6	8.7	9.8	10.7	11.5	12.3	13.1	13.8
3	3.9	5.5	7.8	9.6	11.1	12.4	13.5	14.6	15.6	16.6	17.5
4	5.4	7.6	10.8	13.2	15.2	17.0	18.7	20.1	21.5	22.8	24.1
6	7.5	10.6	15.0	8.4	21.2	23.8	26.0	28.1	30.0	31.9	33.6
8	9.2	13.1	18.5	22.6	26.1	29.2	32.0	34.6	37.0	39.2	41.3

TESTING

See Smith Fibercast Manual No. F6080, *Pipe Installation Handbook for Hydrostatic Testing and System Startup*.

When possible, FGS Smith Fibercast piping systems should be hydrostatically tested prior to being put into service. Care should be taken when testing, as in actual service, to avoid water hammer. All anchors, guides and supports must be in place prior to testing the line.

Test pressure should not be more than 1 1/2 times the working pressure of the piping system and never exceed 1 1/2 times the rated operating pressure of the lowest rated component in the system.

OTHER CONSIDERATIONS

Steam Cleaning

Z-CORE piping systems can be steam cleaned under the following conditions:

1. The piping must be open-ended to prevent pressure buildup.
2. A maximum steam pressure of 45 psig must not be exceeded. (Temperature not to exceed 275ºF**.)**
3. To prevent pipe sagging at the steam cleaning temperature, support spacing must be adjusted for 275ºF service.

Vacuum Service

All 1”-8” Z-CORE piping systems can be operated under full vacuum at the rated temperature of 275ºF as described in Manual No. E5000.

Water (Fluid) Hammer

A pressure surge will occur when fluid flow in a piping system is abruptly changed during events such as rapid pump startup or a quick closing valve. This surge can be significantly reduced by controlling pump startup and valve closure rates.

The maximum pressure surge in psi caused by water hammer can be calculated by multiplying the fluid velocity in ft/sec times the constant listed in the "Fluid (Water) Hammer Constants" Table. The peak pressure for the system will equal the water hammer surge plus the operating pressure at the time the water hammer occurred.

Pipe Size (In.)	Fluid (Water) Hammer Constants[1]
1	40.7
1 1/2	40.9
2	37.4
3	31.7
4	30.8
6	31.3
8	29.8

CHEMICAL RESISTANCE GUIDE

Chemical	Maximum Recommended Temperature ºF
Acetone	125
Aniline	150
Calcium Chloride	275
Chlorobenzene	200
Chloroform	185
2-Chlorophenol	100
Dichloroethane	185
Dichloromethane (methylene chloride)	100
Dimethyl Formamide	100
Ethyl Acetate	150
Fluorobenzene	180
Potassium Chloride	275
Potassium Sulfate	275
Sodium Hydroxide	240
Sulfuric Acid, 98%	120

This is an abbreviated guide. For a comprehensive listing of chemicals and their maximum recommended temperature for Z-CORE piping, refer to Manual No. E5615.

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FIBER GLASS SYSTEMS

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