Z-CORE® PIPING SYSTEM

One Company | Unlimited Solutions

NOV Fiber Glass Systems

NOV Fiber Glass Systems is the combination of the **Star® Fiberglass** product line and the **Smith Fibercast®** product lines bringing over 60 years of "Time-Tested" composite pipe experience to the Oilfield, Chemical/Industrial, Petroleum Marketing, Marine and Offshore markets.

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 275°F and for pressures to 150 psig (higher pressures available on special request.)

EXTERNAL BARRIER

Z-CORE has a resin-rich 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. NOV Fiber Glass Systems warrants **Z-COR**E 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.

- Fittings Literature:

  A1390-Standard 1"-8"

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. 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 275°F. See **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" 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

NOV Fiber Glass Systems 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.

PRODUCT DATA

Nominal Dimensional Data

Pipe Size (In)	I.D.		O.D.		Wall Thickness		Reinforcement Thickness		Weight		Capacity	
	(In)	(mm)	(In)	(mm)	(In)	(mm)	(In)	(mm)	(Lbs/Ft)	(kg/m)	(Gal/Ft)	(Ft^3/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

Tolerances or maximum/minimum limits can be obtained from NOV Fiber Glass Systems.

ASTM D2997 Designation Codes:

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

Pipe Lengths Available*

Size (In)	Random Length (Ft)
1-8	20

*Pipe is offered in random or exact lengths from 18.0 to 20.4 feet long.

Pressure Ratings[1][2]

Pipe Size (In)	Max Internal Pressure @ 275°F (psig)			Maximum External Pressure (psig)[6]		
	Socket Pressure Fittings [3]	Flg’d Pressure Fittings [4]	Other Pressure Fittings [5]	75°F	200°F	275°F
1	275	275	NA	2,125	1,700	1,381
1½	275	275	125	2,065	1,652	1,342
2	275	275	125	1,170	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 120°F.

[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	75°F/24°C				250°F/121°C				275°F/135°C			
	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	-	-	1.9×10^6	13,100	-	-	1.6×10^6	11,000	-	-	1.5×10^6	10,300
Poisson's Ratio V	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	4.7×10^6	32,400	6.4×10^6	44,126	1.4×10^6	9,653	1.8×10^6	12,411	1.0×10^6	6,895	1.1×10^6	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[(1)]	6,250	43	5,250	36	4,000	28	3,375	23	3,625	25	3,125	22
Modulus of Elasticity (Long Term)	6.0×10^5	4,137	4.0×10^6	27,579	1.8×10^5	1,241	1.2×10^6	8,274	1.2×10^5	827	8.0×10^5	5,516
Hydrostatic Burst - ASTM D1599												
Ultimate Hoop Tensile Stress	28,000	193	11,000	76		NA				NA		
Hoop Tensile Modulus of Elasticity	-	-	2.1×10^6	14,686								

[(1)]Beam bending design stress is one-eighth of ultimate to allow for combined stress

Thermal Expansion Coefficient - ASTM D696	Non-Insulated Pipe: 9.2×10^{-6} in/in/°F Insulated Pipe: 1.04×10^{-5} in/in/°F	1.7×10^{-5} mm/mm°C 1.9×10^{-6} mm/mm/°C
Thermal Conductivity	0.09 BTU / ft-hr-°F	0.16 W/m-°C
Specific Gravity - ASTM D792	2.20	
Hazen-Williams Coefficient	150	
Absolute Surface Roughness	0.00021 in	0.0053 mm
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
1½	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	5.39	27.26	8.23	7.46
8	8.10	70.08	16.25	10.83

Recommended Operating Ratings

Size (In)	Axial Tensile Loads Max. (Lbs) Temperature 75°F	275°F	Axial Compressive Loads Max. (Lbs)[1] Temperature 75°F	275°F	Bending Radius Min. (Ft) Entire Temp. Range	Torque Max. (Ft Lbs) Entire Temp. Range	Parallel Plate Loading ASTM D2412 Stiffness Factor In^3/ Lbs/In^2	Pipe Stiffness (psi)	Hoop Modulus x10^6 (psi)
1	1,990	1,200	1,730	1,700	50	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	39,080	23,580	35,040	28,300	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.

SUPPORTS

Proper pipe support spacing depends on the temperature and weight of the fluid in the pipe. The support spacing table is based on unrestrained continuous beam theory using the pipe bending modulus derived from long-term beam bending tests. The maximum spans lengths were developed to ensure a design that limits mid-span deflection to ½ inch and dead weight bending to 1/8 of the ultimate bending stress. Any additional loads on the piping system such as insulation, wind, seismic, etc. requires further consideration. Restrained (anchored) piping systems operating at elevated temperatures may result in guide spacing requirements that are shorter than unrestrained piping systems. In this case, the maximum guide spacing governs the support span requirements for the system. Pipe spans near elbows require special attention. Both supported and unsupported elbows 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:

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 at supports.
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 fittings.
7. Provide adequate axial and lateral restraint to ensure line stability during rapid changes in flow.

Maximum Support Spacing for Uninsulated Pipe [1]

(In.)	Continuous Spans of Pipe (Ft.) [2] 75°F	250°F	275°F	Gas 75°F
1	8.2	6.1	5.5	9.0
1½	16.3	12.1	10.9	18.2
2	17.7	13.1	11.9	20.4
3	20.3	15.0	13.6	24.9
4	22.9	16.9	15.3	28.8
6	28.4	21.0	19.0	36.2
8	31.7	23.5	21.2	41.8

[1] Consult factory for insulated pipe support spacing.
[2] Maximum mid-span deflection ½" with a specific gravity of 1.0

Support Spacing vs. Specific Gravity

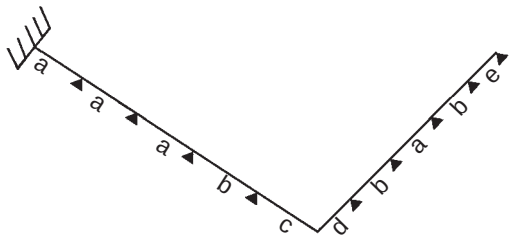
Specific Gravity	2.00	1.50	1.25	1.00	0.75
Multiplier	0.80	0.93	0.96	1.00	1.04

Example: 6" pipe @ 250°F with 1.5 specific gravity fluid, maximum support spacing = 21 x 0.93 = 19.5

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

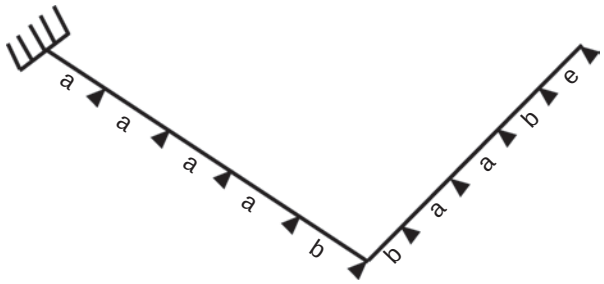
	Span Type	Factor
a	Continuous interior or fixed end spans	1.00
b	Second span from supported end or unsupported fitting	0.80
c+d	Sum of unsupported spans at fitting	≤0.75*
e	Simple supported end span	0.67

*For example: If continuous support 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	Second span from simple supported end or unsupported fitting	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 NOV Fiber Glass Systems' ***"Engineering and Piping Design Guide"***, **Manual No. E5000, Section 3.**

Unrestrained Thermal Expansion Uninsulated Pipe [1]

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

[1] Consult the factory for thermal expansion and compressive end loads of insulated pipe.

Restrained Thermal End Loads and Guide Spacing

Operating Temperature °F (Based on installation temperature of 75°F)										
Size (In)	100		150		200		250		275	
	Guide Spacing (Ft)	Thermal End Load (Lbs)	Guide Spacing (Ft)	Thermal End Load (Lbs)	Guide Spacing (Ft)	Thermal End Load (Lbs)	Guide Spacing (Ft)	Thermal End Load (Lbs)	Guide Spacing (Ft)	Thermal End Load (Lbs)
1	2.7	335	1.5	767	1.2	904	1.0	781	0.9	637
1½	8.5	1,026	4.9	2,388	3.8	2,813	3.2	2,243	3.0	1,567
2	10.8	1,302	6.2	3,032	4.8	3,572	4.1	2,849	3.8	1,990
3	16.2	1,958	9.4	4,558	7.3	5,370	6.1	4,283	5.7	2,991
4	20.9	3,064	12.1	7,133	9.4	8,404	7.9	6,702	7.4	4,681
6	30.7	7,141	17.7	16,626	13.7	19,589	11.6	15,622	10.9	10,910
8	40.1	10,728	23.2	24,976	18.0	29,428	15.2	23,468	14.2	16,390

Allowable Bending Moment 90° Elbow	
Pipe Size (In)	Allowable Moment (Ft /Lbs)
1	100
1½	150
2	225
3	475
4	650
6	1,650
8	2,850

OTHER CONSIDERATIONS

Testing:

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

When possible, NOV Fiber Glass Systems 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 1½ times the working pressure of the piping system and never exceed 1½ times the rated operating pressure of the lowest rated component in the system.

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 275°F.)
3. To prevent pipe sagging at the steam cleaning temperature, support spacing must be adjusted for 275°F service.

Water Hammer:

Care should be taken when designing an FRP piping system to eliminate sudden surges. Soft start pumps and slow actuating valves should be considered.

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