Bulletin No. A1300
December 15, 2008

Fiber Glass Systems GREEN THREAD® Piping Systems

NOV Fiber Glass Systems

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GREEN THREAD PIPE

PRODUCT

GREEN THREAD pipe is filament wound using an amine-cured epoxy resin and fiberglass and has a resin-rich liner reinforced with surfacing veil for superior corrosion resistance. It is recommended for dilute acids and caustics.

Pipe is available in **1" through 16"** diameters with pressure ratings up to 450 psig static at a maximum operating temperature of 225ºF. The pipe diameters of 1" through 6" is available in 20' random lengths and the 8" through 16" diameters are in 19' or 39' random lengths.

GREEN THREAD *Performance Plus™* piping is available in 4" through 24" sizes with a 450 psig static pressure rating. Refer to Bulletin No. A1325.

FITTINGS

Compatible epoxy fittings are manufactured with the same chemical/temperature capabilities as the pipe. Depending on the particular part and size, fittings will be compression molded, contact molded, hand fabricated or filament wound.

Fittings Bulletins:

A1350-Standard 1"-24"

A1355-Performance Plus 8"-24"

JOINING METHODS

GREEN THREAD pipe and fittings are joined using the bell and spigot connection. Pipe is supplied with one end belled (integral bell or factory-bonded coupling) and one end tapered.

Epoxy adhesive is used to secure the joints. When properly installed, the entire system will operate at the maximum pressure rating of the pipe.

FIELD TAPERING & JOINING

Pipe can be cut and easily retapered for installation in the field using Fiber Glass Systems tapering tools. Power or manual tools are available for smaller diameter pipe. Both manual and power operated tools are available for larger diameter pipe. Power-driven tools are recommended for larger pipe sizes and where many tapers are required. See **Manual No. F6000, *Pipe Installation Handbook for Matched Tapered Bell & Spigot Joints,*** for installation instructions and recommendations on the proper tool for your particular application.

RECOMMENDED SERVICES

GREEN THREAD pipe is the appropriate choice for many services requiring the additional chemical resistance provided by a resin-rich corrosion barrier. **Refer to Bulletin E5615 "*Chemical Resistance Guide*" for proper application.**

BENEFITS

GREEN THREAD pipe is light-weight when compared to steel, black iron, copper, and stainless steel. When considering total installed cost, **GREEN THREAD** piping provides significant savings due to its light weight and easy installation features. No heavy handling equipment is required, and the load **GREEN THREAD** pipe adds to a structure is minimal compared to other materials. For example, 4" **GREEN THREAD** pipe weighs only 1.2 lbs. per foot compared to 5.6 lbs. for Schedule 10 stainless.

DISTRIBUTION

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.

PIPE PROPERTIES

General Specifications and Dimensional Data*

Nominal Pipe Size (In)	Nominal I.D.		Nominal O.D.		Nominal Wall Thickness		Nominal Liner Thickness		Nominal Weight		Capacity	
	(In)	(mm)	(In)	(mm)	(In)	(mm)	(In)	(mm)	(Lbs/Ft)	(kg/m)	(Gal/Ft)	(CuFt/Ft)
1	1.193	30	1.370	35	0.090	2.29	0.015	0.38	0.3	0.45	0.06	0.008
1 1/2	1.760	45	1.960	50	0.100	2.54	0.015	0.38	0.5	0.74	0.13	0.017
2	2.152	55	2.390	61	0.119	3.02	0.025	0.64	0.7	1.04	0.19	0.025
3	3.279	83	3.516	89	0.119	3.05	0.025	0.64	1.0	1.49	0.44	0.059
4	4.281	109	4.521	115	0.120	3.05	0.030	0.76	1.3	1.93	0.75	0.100
6	6.351	161	6.645	169	0.147	3.73	0.030	0.76	2.4	3.57	1.65	0.220
8	8.361	212	8.717	221	0.178	4.52	0.030	0.76	3.9	5.80	2.85	0.382
10	10.363	263	10.795	274	0.216	5.49	0.030	0.76	5.9	8.78	4.38	0.586
12	12.286	312	12.758	324	0.236	5.99	0.030	0.76	7.7	11.50	6.16	0.823
14	14.038	357	14.548	370	0.255	6.48	0.030	0.76	9.5	14.10	8.04	1.075
16	16.040	407	16.610	422	0.285	7.24	0.030	0.76	12.2	18.20	10.50	1.403

*All values are nominal. Tolerances or maximum/minimum limits can be obtained from Fiber Glass Systems.

ASTM D2996 Designation Codes:

1”-1 1/2”	RTRP-11FF1-3111
2”-8”	RTRP-11FF1-3112
10”	RTRP-11FF1-3114
12”-16”	RTRP-11FF1-3116

Pipe Lengths Available

Size (In)	Random Length (Ft)
1-6	20
8-16	19 or 39

Pipe is supplied in random lengths.

Pressure Ratings(1)

Size (In)	Maximum Internal Pressure (psig)	Maximum External Pressure (psig)(2)	
	Static @ Max. Temp. 225°F	@ 75°F	@225°F
1	450	360	292
1 1/2	450	187	150
2	450	289	241
3	450	123	69
4	225	77	56
6	225	33	21
8	225	18	15
10	225	18	15
12	225	18	15
14	225	15	10
16	225	15	10

(1)Steady (static) pressure is created when use of a gear pump, turbine pump, centrifugal pump, or multiplex pump having four or more pistons. Pressure ratings to 450 psig are available in 8”-24”.

(1)Vacuum Service: A full vacuum within the pipe is equivalent to 14.7 psig external pressure at sea level. Maximum external pressure ratings are based on test data obtained using ASTM D2924. Contact Fiber Glass Systems if higher external pressure ratings are required.

Average Physical Properties

Property	@ 75ºF psi	@ 24ºC MPa	@ 225ºF psi	@107ºC MPa
Axial Tensile - ASTM D2105				
Ultimate Stress	10,550	71	7,160	49.4
Design Stress	2,637	17.8	1,790	12.3
Modulus of Elasticity	1.75×10^6	12,100	1.03×10^6	7,102
Poisson's Ratio $V_{a/h}$	0.35			
Axial Compression - ASTM D695				
Ultimate Stress	33,300	230	17,800	122.7
Design Stress	8,325	57.4	4,450	30.7
Modulus of Elasticity	1.26×10^6	8,687	0.54×10^6	3,723
Beam Bending - ASTM D2925				
Ultimate Stress	23,000	158.6	16,000	110.0
Design Stress	2,875	19.8	2,000	13.8
Modulus of Elasticity (Long Term)	2.18×10^6	15,031	1.11×10^6	7,653
Hydrostatic Burst - ASTM D1599				
Ultimate Hoop Tensile Stress	46,300	319.2	49,540	342.0
Ring Tensile - ASTM D2290	Sizes			
Minimum Hoop Tensile Stress	1"-1 1/2" 9,018	62.4	-	-
	2"-16" 27,280	188	-	-
Hydrostatic Design - ASTM D2992,				
Procedure A - Hoop Tensile Stress	8,850	61.0	6,400*	44.1*
Cyclic 150 x 10^6 Cycles (* 200ºF data)				
Procedure B - Hoop Tensile Stress LTHS	27,715	191.1	16,945*	116.8*
Static 20 Year Life (* 200ºF data) LCL	22,400	154.4	14,654*	101.0*

Coefficient of Linear Thermal Expansion - ASTM D696	1.26×10^{-5} in/in/ºF	2.27×10^{5} mm/mm/ºC
Thermal Conductivity	0.23 Btu/hr-ft-ºF	0.4 W(m)(ºC)
Specific Gravity - ASTM D792	1.8	
Flow Factor - SF / Hazen-Williams Coefficient	150	
Surface Roughness	1.7×10^{-5} Feet	0.00021 Inch
Manning's "n"	0.009 Inch	

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	0.23	0.06	0.07	0.36
1 1/2	0.37	0.16	0.16	0.58
2	0.57	0.37	0.31	0.85
3	0.85	1.24	0.70	1.27
4	1.06	2.59	1.15	1.66
6	2.20	11.71	3.52	3.00
8	3.66	33.50	7.69	4.78
10	5.70	79.90	14.80	7.18
12	7.46	146.60	22.98	9.28
14	9.30	238.00	32.72	11.45
16	12.04	402.00	48.40	14.62

Recommended Operating Ratings

Size (In)	Axial Tensile Loads Max. (Lbs) @75ºF	Axial Tensile Loads Max. (Lbs) @ 225ºF	Axial Compressive Loads Max. (Lbs)(1) @75ºF	Axial Compressive Loads Max. (Lbs)(1) @ 225ºF	Bending Radius Min. (Ft) Entire Temp. Range	Torque Max. (Ft Lbs) Entire Temp. Range	Parallel Plate Loading(2) @ 5% Deflection ASTM D2412: Stiffness Factor In^3 Lbs/In^2	Parallel Plate Loading(2): Pipe Stiffness (psi)	Parallel Plate Loading(2): Hoop Modulus $x10^6$ (psi)
1	580	410	1,880	1,010	40	25	40	1,170	1.26
1 1/2	960	660	3,090	1,650	60	60	70	640	1.50
2	1,480	1,030	4,770	2,550	80	180	200	910	1.58
3	2,190	1,520	7,090	3,790	110	230	240	330	1.89
4	2,740	1,900	8,840	4,730	140	380	230	140	1.81
6	5,680	3,950	18,350	9,810	210	1,070	540	100	2.13
8	9,430	6,550	30,470	16,290	270	2,490	730	60	2.24
10	14,690	10,200	47,450	25,370	340	4,510	1,620	70	2.95
12	19,210	13,350	62,110	33,200	400	7,000	2,800	80	3.27
14	23,950	16,650	77,420	41,390	460	9,970	3,600	60	2.46
16	31,000	21,550	100,230	53,580	530	14,700	6,500	60	3.20

(1)Compressive loads are for short columns only. Buckling loads must be calculated when applicable.

(2)Burial calculations must be based on 5% 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 1/2 inch and bending stresses to less than or equal to 1/8 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 eight 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.
8. Do not hydrotest until all support, anchors and guides are installed.

Maximum Support Spacing for Uninsulated Pipe*

Nom. Pipe Size (In.)	Continuous Spans of Pipe (Ft.) Deflection=1/2": Specific Gravity=1.0, 75ºF	150F	225F	Gas 75ºF
1	10.9	10.2	9.2	13.9
1 1/2	12.6	11.8	10.7	16.9
2	14.1	13.2	11.9	19.0
3	15.9	14.8	13.4	23.2
4	17.0	15.8	14.3	26.2
6	20.5	19.1	17.3	32.8
8	23.3	21.7	19.7	38.0
10	26.0	24.2	22.0	42.6
12	27.9	26.0	23.5	46.3
14	29.5	27.5	24.9	49.6
16	31.4	29.3	26.6	53.1

*Consult factory for insulated pipe support spacing.

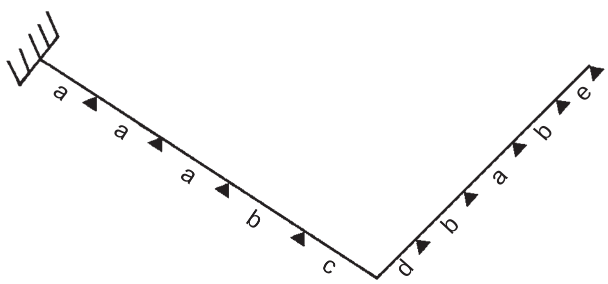
Support Spacing vs. Specific Gravity

Specific Gravity	2.00	1.50	1.25	1.00	0.75
Multiplier	0.86	0.92	0.96	1.00	1.07

Example: 6” pipe @ 150°F with 1.5 specific gravity fluid, maximum support spacing = 19.0 x 0.92 = 17.5 ft.

Piping Span Adjustment Factors With Unsupported Fitting at Change in Direction

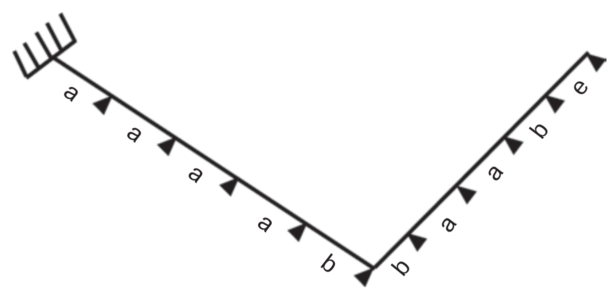
	Span Type	Factor
a	Continuous interior or fixed end spans	1.00
b	Second span from simple supported end or unsupported fitting	0.80
c + d	Sum of unsupported spans at fitting	≤ 0.75*
e	Simple supported end span	0.67



* 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).

Piping Span Adjustment Factors 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 and stiffnesses

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.

Thermal Expansion

Change in Temperature ºF	Pipe Change in Length (In/100 Ft)
25	0.4
50	0.8
75	1.1
100	1.5
125	1.9
150	2.3

Restrained Thermal End Loads and Guide Spacing

Size (In)	Operating Temperature ºF (Based on installation temperature of 75ºF)									
	125		150		175		200		225	
	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 Loads (Lbs)
1	6.3	145	5.2	190	4.6	220	4.2	235	3.9	230
1 1/2	9.2	240	7.6	315	6.6	365	6.1	385	5.7	380
2	11.3	370	9.3	490	8.2	565	7.4	595	7.0	585
3	16.8	550	13.9	720	12.2	835	11.1	885	10.4	870
4	21.8	680	18.0	908	15.8	1,040	14.4	1,100	13.5	1,080
6	32.1	1.420	26.5	1,870	23.3	2,170	21.2	2,190	19.9	2,250
8	42.2	2,350	34.8	3,110	30.6	3,600	27.9	3,800	26.1	3,740
10	52.2	3,660	43.1	4,850	37.9	5,600	34.5	5,930	32.3	5,820
12	61.8	4,790	51.0	6,340	44.8	7,330	40.9	7,750	38.3	7,610
14	70.5	5,980	58.2	7,910	51.2	9,140	46.6	9,670	43.7	9,490
16	80.6	7,740	66.5	10,240	58.4	11,830	53.3	12,520	49.9	12,290

Expansion Loop Design Minimum Leg Length (Feet)

Size (In)	Change in Length (Inches)								
	1/2	1	2	3	4	5	6	8	10
1	2.8	3.7	5.1	6.2	7.0	7.8	8.5	9.8	10.9
1 1/2	3.4	4.5	6.1	7.4	8.4	9.4	10.2	11.7	13.0
2	3.6	4.9	6.7	8.1	9.3	10.3	11.2	12.9	14.3
3	4.5	6.0	8.2	9.9	11.3	12.6	13.7	15.7	17.4
4	5.1	6.8	9.3	11.2	12.8	14.2	15.5	17.8	19.7
6	6.2	8.3	11.3	13.6	15.5	17.2	18.8	21.5	23.9
8	8.6	11.0	14.4	17.0	19.3	21.2	23.0	26.1	28.9
10	9.9	12.6	16.4	19.3	21.8	24.0	25.9	29.4	32.5
12	11.1	14.0	18.2	21.4	24.1	26.4	28.6	32.4	35.7
14	12.3	15.4	19.8	23.2	26.1	28.6	30.9	35.0	38.6
16	13.5	16.8	21.5	25.2	28.2	30.9	33.4	37.7	41.6

Note: Multiply expansion loop minimum leg length by 1.414 for directional change cantilever leg length.

TESTING

See Smith Fibercast Manual No. F6000, Pipe Installation Handbook for Matched Tapered Bell & Spigot Joints.

The normal recommended test procedure for GREEN THREAD pipe is to conduct a cyclic pressure test. A cyclic pressure test subjects the piping system to 10 pressurization cycles at 1$^1/_2$ times the anticipated or design operating pressure. The tenth pressurization is maintained on the line for 1-8 hours while the line is inspected for leaks. Lines that can be subjected to severe temperature cycles, such as steam condensate lines, hot water lines, and cold water lines, should be tested using the cyclic test procedure at 1$^1/_2$ times the system pressure rating, even if the system is to operate at relatively low pressure.

No field test pressure should exceed 1$^1/_2$ times the maximum rated cyclic pressure rating of the lowest rated element in the system. Under no circumstances should a field pressure test exceed 450 psig without consulting Fiber Glass Systems.

OTHER CONSIDERATIONS

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.

Fluid (Water) Hammer Constants[1]

Pipe Size (In.)	Fluid (Water) Hammer Constants[1]
1	35
1$^1/_2$	32
2	30
3	26
4	22
6	21
8	21
10	21
12	20
14	20
16	20

[1]Constants are valid for water at 75ºF.

ISO 9001
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CLASSIFIED UL WATER QUALITY
ANSI/NSF 61
Drinking Water System
Components 35GH
Water Contact Temp: 23C

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