Bulletin No. A1580
September 15, 2007

Fiber Glass Systems
CENTRICAST Plus® CL-2030 Piping Systems

CENTRICAST PLUS CL-2030 Pipe

PRODUCT

CENTRICAST PLUS CL-2030 pipe is manufactured with high strength glass fabrics and a highly resilient formulation of corrosion resistant vinyl ester resin. A 100 mil integral corrosion barrier of pure resin provides excellent corrosion resistance. It is recommended for most highly chlorinated or acidic mixtures up to 175°F and many other chemicals up to 200°F. CENTRICAST PLUS CL-2030 proprietary resin formulation also provides toughness for many corrosive slurries. Pipe and fittings are available in 1"-14" with static pressure ratings up to 150 psig, with higher pressure ratings in smaller sizes. CENTRICAST PLUS CL-2030 comes in 20' nominal or exact lengths.

EXTERNAL BARRIER

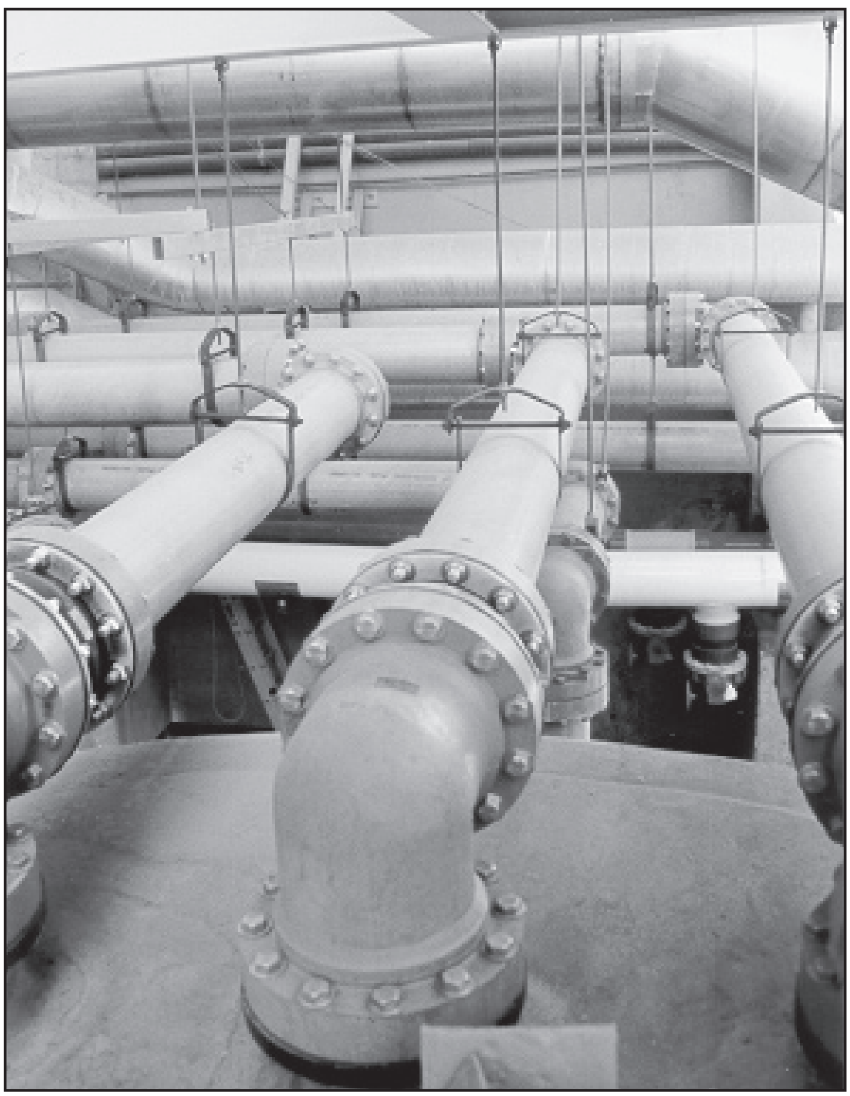
A 10 mil resin-rich reinforced external corrosion barrier provides excellent corrosion resistance and protection from ultraviolent (UV) radiation. CL-2030 pipe also contains a UV inhibitor for protection against "fiber blooming" caused by UV radiation. Fiber Glass Systems warrants CENTRICAST PLUS CL-2030 pipe and fittings against UV degradation of physical properties and chemical resistance for 15 years.

FITTINGS

Compatible vinyl ester fittings are manufactured with the same chemical/temperature capabilities as the pipe. The fabrication process is dependent on the fitting type and size. Fittings are manufactured by compression molding, contact molding or filament winding.

JOINING METHODS

An adhesive bonded socket connection with positive stops in the fittings is standard. The use of positive stops in the fittings is standard. The use of positive stops simplifies close tolerance piping installation. This joining system is easy to install and no special tools are required for field assembly. The joint is prepared for bonding by lightly sanding the pipe O.D. and the mating fitting's socket. A high strength adhesive with the same chemical resistance and temperature capabilities is used to bind the pipe and fittings. See Manual No. F6080 "pipe Installation Handbook" for detailed installation instructions and fabrication techniques.



RECOMMENDED SERVICES

CENTRICAST CL-2030 vinyl ester resin pipe is excellent for many chemical and slurry applications including strong acids, chlorine, salts and oxidizing agents that corrode traditional metal pipe. Refer to Manual No. E5615 "*Chemical Resistance Guide*" for proper application.

BENEFITS

The excellent chemical resistance of the CL-2030 piping system provides longer service life than traditional piping materials. CL-2030 pipe performance conveying chemical mixtures and hot acids is particularly exceptional resulting in a reduction in maintenance and replacement costs.

CL-2030 pipe typically weighs less than 1/4 that of comparable Schedule 40 Stainless Steel. A 20' length of 4" CL-2030 weighs 58 lbs. while the same length of stainless steel weighs 216 lbs.

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 field, strategically located field personnel.

PIPE PROPERTIES

General Specifications and Dimensional Data*

Nominal Pipe Size (In)	Nominal I.D.		Nominal O.D.		Nominal Wall Thickness		Reinforcement Thickness		Nominal Weight		Capacity	
	(In)	(mm)	(In)	(mm)	(In)	(mm)	(In)	(mm)	(Lbs/Ft)	(kg/m)	(Gal/Ft)	(CuFt/Ft)
1	0.94	23.7	1.32	33.4	0.19	4.8	0.095	2.4	0.45	0.68	0.04	0.005
1$^1/_2$	1.42	36.1	1.90	48.3	0.24	6.1	0.140	3.6	0.84	1.26	0.08	0.011
2	1.86	47.1	2.38	60.3	0.26	6.6	0.150	3.8	1.16	1.74	0.14	0.019
3	2.92	74.2	3.50	88.9	0.29	7.4	0.180	4.6	1.97	2.94	0.35	0.047
4	3.84	97.5	4.50	114.3	0.33	8.4	0.220	5.6	2.91	4.35	0.60	0.080
6	5.97	152.0	6.63	168.4	0.33	8.4	0.220	5.6	4.39	6.57	1.45	0.194
8	7.97	202.0	8.63	219.2	0.33	8.4	0.220	5.6	5.78	8.65	2.59	0.348
10	10.10	256.0	10.75	273.1	0.33	8.4	0.220	5.6	7.26	10.90	4.15	0.555
12	12.10	307.0	12.75	323.9	0.33	8.4	0.220	5.6	8.65	13.00	5.96	0.797
14	13.30	339.0	14.00	355.6	0.33	8.4	0.220	5.6	9.52	14.30	7.26	0.971

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

ASTM D2997 Designation Codes*:

1"-1$^1/_2$"	RTRP-22BS-3446
2"-6"	RTRP-22BS-4446
8"	RTRP-22BS-4445
10"-12"	RTRP-22BS-4444
14"	RTRP-22BS-4443

*Mechanical properties cell classifications shown are minimum. Actual classifications may be higher for some sizes.

Pipe Lengths Available

Size (In)	Random Length (Ft)
1"-14"	20*

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

Pressure Ratings for Uninsulated Piping Systems (1) (2)

Nom. Pipe Size (In)	Maximum Internal Pressure @ 175ºF (psig)			Maximum External Pressure(6)		
	Socket Pressure Fittings(3)	Flanged Pressure Fittings(4)	Other Pressure Fittings(5)	75ºF	150ºF	175ºF
1	300	300	-	1,975	1,679	1,383
1$^1/_2$	300	300	-	1,034	878	775
2	275	200	125	1,013	861	759
3	200	150	125	467	397	350
4	150	150	100	425	361	319
6	150	150	100	218	185	163
8	150	150	100	69	59	52
10	150	150	75	34	29	26
12	150	150	75	43	36	32
14	125	150	75	16	14	12

(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. For insulated and/or heat traced piping systems, reduce pressure ratings by 30% for 175ºF to 200ºF operating temperatures. For compressible gases, consult the factory for pressure ratings. CENTRICAST CL-2030 pipe and vinyl ester fittings can be used in insulated drainage and vent systems up to 200ºF operating temperatures. Heat cured adhesive joints are highly recommended for all pipng systems carrying fluids at temperatures above 120ºF.

(3) Socket elbows, tees, reducers, couplings, flanges and nipples joined with WELDFAST CL-200 adhesive.

(4) Flanged elbows, tees, reducers, couplings and nipples assembled at factory.

(5) Laterals, crosses, and saddles.

(6) Ratings shown are 50% of ultimate; 14.7 psi external pressure is equal to full vacuum.

CENTRICAST PLUS CL-2030 Pipe

Average Physical Properties[1]

Property	@ 75ºF		@ 24ºC		@ 150ºF		@ 66ºC		@ 175º		@ 80ºC	
	1" - 1 1/2"		2" - 14"		1" - 1 1/2"		2" - 14"		1" - 1 1/2"		2" - 14"	
	psi	MPa	psi	MPa	psi	MPa	psi	MPA	psi	MPa	psi	MP
Axial Tensile - ASTM D2105 Ultimate Stress Design Stress Modulus of Elasticity	 22,000 5,500 2.1E+06	 150 38 14,500	 22,000 5,500 2.1E+06	 150 38 14,500	 19,000 4,750 1.8E+06	 130 33 12,400	 19,000 4,750 1.8E+06	 130 33 12,400	 18,000 4.500 1.8E+06	 120 31 12,400	 18,000 4,500 1.8E+06	 120 31 12,400
Poisson's Ratio V	0.15				0.15				0.15			
Axial Compression - ASTM D695 Ultimate Stress Design Stress Modulus of Elasticity	26,000 6,500 3.3E+06	 180 45 22,800	 32,000 8,000 2.6E+06	 220 55 17,900	 24,000 6,000 2.9E+06	 170 41 20,000	 30,000 7,500 2.3E+06	 210 52 15,900	 18.000 4,500 2.8E+06	 120 31 19,300	 22,000 5,550 2.2E+06	 150 38 15,100
Beam Bending - ASTM D2925 Ultimate Stress Design Stress[1] Modulus of Elasticity (Long Term)	 22,000 2,750 3.3E+06	 150 19 22,800	 40,000 5,000 3.3E+06	 280 34 22,800	 19,000 2,375 2.9E+06	 130 16 20,000	 35,000 4,375 2.9E+06	 240 30 20,000	 18,000 2,250 2.8E+06	 120 16 19,300	 33,000 4,125 2.8E+06	 230 28 19,300
Hydrostatic Burst - ASTM D1599 Ultimate Hoop Tensile Stress Hoop Tensile Modulus of Elasticity	 25,000 3.0E+06	 170 20,700	 30,000 3.2E+06	 210 22,100	 21,000 2.6E+06	 140 17,900	 26,000 2.8E+06	 180 19,300	 20,000 2.5E+06	 140 17,200	 25,000 2.7E+06	 170 18,600
Hydrostatic Design - ASTM D2992, Procedure B-Hoop Tensile Stress Static 50 Year @ 75ºF	-	-	-	-	-	-	-	-	8,600	60	8,600	60

Coefficient of Linear Thermal Expansion - ASTM D696	Non-Insulated Pipe: 8.9 x 10^{-6} in/in/ºF • 16.1 x 10^{-6} mm/mm/ºC Insulated Pipe: 10.0 x 10^{-6} in/in/ºF • 18.1 x 10^{-6} mm/mm/ºC
Thermal Conductivity	0.07 BTU/(ft)(hr)(ºF) • 0.04 W/(m)(ºC)
Specific Gravity - ASTM D792	1.56 (0.056 Lb/in^3 • (1.56 g/cm^3)
Flow Factor - SF / Hazen-Williams Coefficient	C-150
Surface Roughness	1.7 x 10^{-5} Feet
Manning's "n"	0.009

[1] Stress and modulus values can be interpolated between temperatures shown.

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	0.36	0.07	0.10	0.67
1 1/2	0.77	0.30	0.32	1.25
2	1.05	0.65	0.55	1.73
3	1.88	2.59	1.48	2.92
4	2.96	6.79	3.02	4.32
6	4.43	22.70	6.86	6.53
8	5.81	51.30	11.90	8.60
10	7.28	100.00	18.80	10.80
12	8.66	170.00	26.70	12.90
14	9.52	226.00	32.30	14.20

Recommended Operating Ratings

Size (In)	Axial Tensile Loads Max. (Lbs)		Axial Compressive Loads Max. (Lbs)[(1)(2)]		Bending Radius Min. (Ft) Entire Temp. Range	Torque Max. (Ft Lbs) Entire Temp. Range	Parallel Plate Loading[(2)] 5% Deflection & 75ºF ASTM D2412		
	@ 75ºF	@ 175ºF	@ 75ºF	@175ºF			Stiffness Factor In^3 Lbs/In^2	Pipe Stiffness (psi)	Hoop Modulus $x10^6$ (psi)
1	2,000	1,600	2,400	1,600	66	43	143	4,225	2.0
1$^1/_2$	4,300	3,500	5,000	3,500	95	132	457	4,504	2.0
2	5,800	4,700	8,400	5,800	65	229	563	2,742	2.0
3	10,300	8,400	15,000	10,300	96	618	1,215	1,783	2.5
4	16,300	13,300	23,700	16,300	124	1,260	2,218	1,519	2.5
6	24,300	19,900	35,400	24,300	182	2,860	2,218	453	2.5
8	32,000	26,100	46,500	32,000	237	4,960	2,662	241	3.0
10	40,000	32,800	58,200	40,000	296	7,820	2,662	122	3.0
12	47,600	39,000	69,300	47,600	351	11,100	2,662	73	3.0
14	52,400	42,900	76,200	52,400	385	13,500	2,662	55	3.0

(1) Consult the factory for design recommendations above 175ºF.
(2) Compressive loads are for short columns only. Buckling loads must be calculated when applicable.
(3) 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 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.

Nom. Pipe Size (In.)	Continuous Spans of Pipe (Ft.) Deflection=$^1/_2$" Specific Gravity=1.0		
	75ºF	150ºF	175ºF
1	13.5	13.1	13.0
1$^1/_2$	16.4	15.9	15.8
2	17.9	17.3	17.2
3	21.0	20.4	20.2
4	23.7	22.9	22.7
6	26.7	25.8	25.6
8	28.8	27.9	27.7
10	30.7	29.7	29.4
12	32.2	31.1	30.9
14	33.0	31.9	31.7

*Consult factory for insulated pipe support spacing and oeprating temperatures between 175ºF and 200ºF.

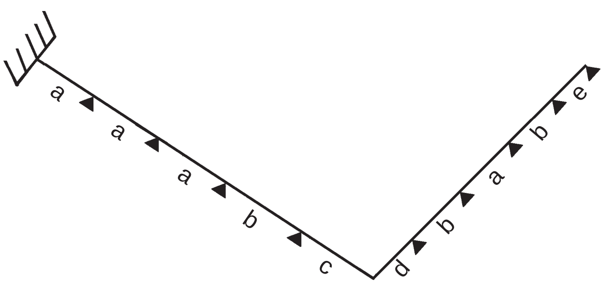
Support Spacing vs. Specific Gravity

Specific Gravity	3.00	2.00	1.50	1.25	1.00	0.75	Gas/Air
Multiplier	0.76	0.84	0.90	0.95	1.00	1.07	1.40

Example: 6" pipe @ 175°F with 1.5 specific gravity fluid,
maximum support spacing = 25.6 x 0.90 = 23 ft.

Piping Span Adjustment Factors With Unsupported Fitting at Change in Direction

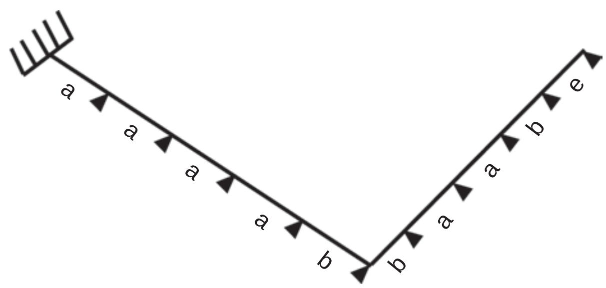
	Span Type	Factor
a	Continuous interior or fixed end spans	1.00
b	Second span from simple supported end or unsupported fitting	0.80
c + d	Sum of unsupported spans at fitting	≤ 0.75*
e	Simple supported end span	0.67



* 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

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

Unrestrained Thermal Expansion Uninsulated Pipe [1]

Change in Temperature ºF	Pipe Change In Length (In/100 Ft)
25	0.27
50	0.53
75	0.80
100	1.07
125	1.34
150	1.60
175	1.87
200	2.14

Restrained Thermal Expansion Pipe Compressive End Loads Uninsulated Pipe [1]

Nominal Pipe Size (In)	End Loads (Lbs/ºF
1	10.69
1 1/2	22.73
2	30.79
3	43.44
4	68.45
6	102.44
8	134.42
10	168.41
12	200.40
14	220.39

Allowable Bending Moment 90º Elbow

Nominal Pipe Size (In)	Allowable Moment (Ft•Lbs)
1	100
1 1/2	150
2	225
3	475
4	650
6	1,650
8	2,850
10	4,500
12	6,500
14	10,000

(1) Consult the factory for thermal expansion and compressive end loads of insulated pipe.

NOTE: The actual moments should never exceed 1/4 of the ultimate moments.

Restrained Thermal End Loads and Guide Spacing

Size (In)	Operating Temperature ºF (Based on installation temperature of 75ºF)									
	100		125		150		175		200	
	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	7.0	267	4.9	535	4.0	802	3.5	1,069	3.1	1,336
1 1/2	10.1	568	7.1	1,137	5.8	1,705	5.0	2,273	4.5	2,841
2	14.4	770	10.2	1,540	8.3	2,309	7.2	3,079	6.4	3,849
3	21.4	1,086	15.1	2,172	12.4	3,258	10.7	4,344	9.6	5,430
4	27.6	1,711	19.5	3,423	15.9	5,134	13.8	6,845	12.3	8,556
6	41.3	2,561	29.2	5,122	23.8	7,683	20.6	10,244	18.5	12,805
8	54.1	3,361	38.3	6,721	31.3	10,082	27.1	13,442	24.2	16,803
10	67.8	4,210	48.0	8,421	39.2	12,631	33.9	16,841	30.3	21,051
12	80.7	5,010	57.1	10,020	46.6	15,030	40.3	20,040	36.1	25,050
14	88.7	5,510	62.8	11,020	51.2	16,529	44.4	22,039	39.7	27,549

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	2.9	4.1	5.8	7.2	8.3	9.2	10.1	10.9	11.7	12.4	13.1
1 1/2	3.5	5.0	7.0	8.6	9.9	11.1	12.2	13.1	14.0	14.9	15.7
2	2.9	4.1	5.8	7.1	8.2	9.2	10.0	10.8	11.6	12.3	13.0
3	4.0	5.6	7.9	9.7	11.2	12.5	13.7	14.8	15.8	16.8	17.7
4	5.5	7.7	10.9	13.4	15.5	17.3	19.0	20.5	21.9	23.2	24.5
6	6.3	8.9	12.6	15.4	17.8	19.9	21.8	23.5	25.1	26.7	28.1
8	7.2	10.2	14.4	17.6	20.3	22.7	24.9	26.9	28.7	30.5	32.1
10	8.0	11.3	16.0	19.6	22.7	25.3	27.8	30.0	32.1	34.0	35.8
12	8.7	12.2	17.3	21.2	24.5	27.4	30.0	32.4	34.6	36.7	38.7
14	8.0	11.4	16.1	19.7	22.8	25.5	27.9	30.1	32.2	34.1	36.0

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

TESTING

See Section 3 of Fiber Glass Systems' Manual No. F6080, Pipe Installation Handbook: Hydrostatic Testing and System Startup.

When possible, Fiber Glass Systems' piping systems should be hydrostatically tested prior to beginning service. Care should be taken when testing, as in actual installation, 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

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	45.1
1$^1/_2$	44.8
2	43.2
3	40.0
4	39.1
6	33.8
8	30.3
10	27.6
12	25.6
14	24.6

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

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FIBER GLASS SYSTEMS • A NATIONAL OILWELL VARCO COMPANY
2700 W. 65th ST., LITTLE ROCK, AR 72209 • 501-568-4010 • FAX 501-568-4465
25 S. MAIN ST., SAND SPRINGS, OK 74063 • 918-245-6651 • FAX 918-245-7566