Chemical & Industrial Piping Systems

NOV Fiber Glass Systems

For over 60 years NOV Fiber Glass Systems has been the industry leader in the Chemical & Industrial market with composite piping systems designed to provide chemical and abrasion resistance. Our extensive line of products has grown to include the leading trade names in this market, creating an unequaled worldwide offering to battle corrosion and erosion.

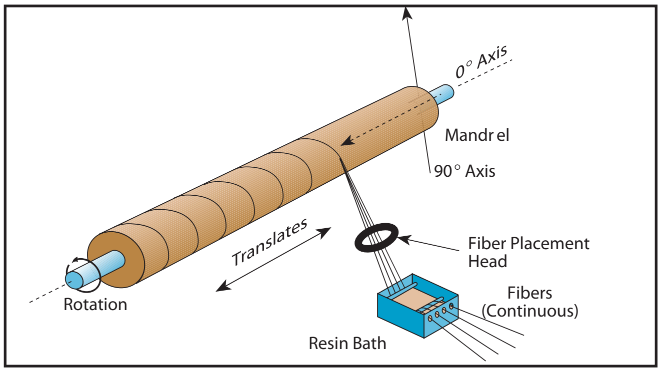
This globally manufactured group of products has become the world's most widely trusted product offering founded upon two essential elements: third party verified ASTM qualifications and decades of experience in tough services. The third party testing provides our customers with confidence that the physical properties we publish are based on test data, not theory. The wide scope of applications within such a diverse market provides our customers confidence that the products' reliability extends beyond rigorous testing into the real world of actual long-term performance in applications where upset conditions and thermal cycling are reality.

Typical applications range from potable water to brine and from harsh chemical feed, waste and vent applications to process lines in nearly every sector of industry imaginable: power generation, metals & minerals, food service, LNG, automotive, aerospace & defense, biotech and pharmaceutical, university and district heating and cooling, general, fine & specialty chemical process industry, petroleum refining, pulp & paper, municipal and industrial waste water treatment.

ASTM Test Methods and Specifications	
D1599	Standard Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings
D2105	Standard Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Tube
D695	Standard Test Method for Compressive Properties of Rigid Plastics
D2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
D2925	Standard Test Method for Beam Deflection of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe Under Full Bore Flow
D4024	Standard Specification for Machine Made "Fiberglass'' (Glass-Fiber-Reinforced Thermosetting Resin) Flanges
D5685	Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe Fittings
D2996	Standard Specification for Filament-Wound "Fiberglass'' (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
D2997	Standard Specification for Centrifugally Cast "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
D2992	Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings

Filament Wound Piping Systems

For more than 40 years, **Green Thread**®, **Red Thread**® and **Bondstrand**® products have been used in potable water, firewater mains, saltwater cooling, saltwater disposal, heating & cooling water systems and wastewater systems across the automotive, power generation, municipal, institutional and aerospace applications.

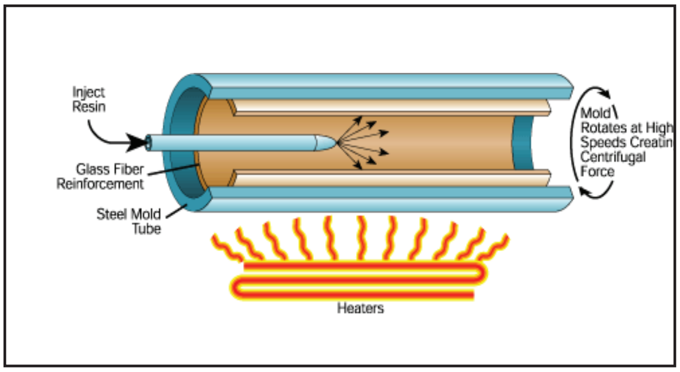


Filament Winding Process

Resin-impregnated glass fibers are wound onto a mandrel in a predetermined pattern under controlled tension. This process results in a pipe that is approximately 75% glass-reinforced for optimum internal pressure capability.

Centrifugally Cast Piping Systems

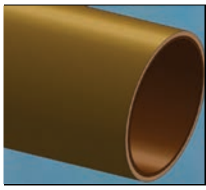
With a 100% resin corrosion barrier, **Centricast**® piping systems provide the most chemically resistant pipe in the market. These products have 60 years of successful history in the steel pickling, chloro-alkali, pharmaceutical, power generation and chemical processing industries.



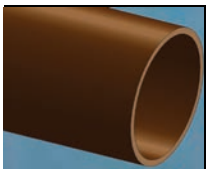
Centrifugal Casting Process

Woven glass fiber (or fabric) in a motor-driven steel tube is saturated with resin while the tube rotates at high speed. Fiber reinforcement in both the hoop and axial directions affords excellent thermal expansion and beam-bending properties.

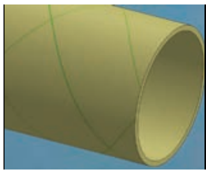
Epoxy Piping Systems



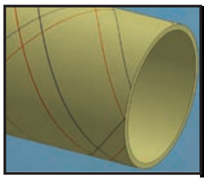
RB-2530 pipe is available in 1”-14” diameters, with pressure ratings from 125-300 psig and temperatures up to 250°F (121°C), and is recommended for most caustics, salts, solvents, many acids and chemical process solutions, including steel pickling. It also handles abrasive slurries.



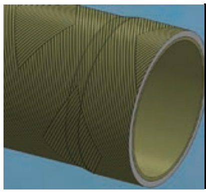
RB-1520 pipe is available in 1½”-14” diameters, with pressure ratings from 125-300 psig and temperatures up to 250°F (121°C), and is recommended for chemical process solutions, solvents, acids, caustics and salt solutions.



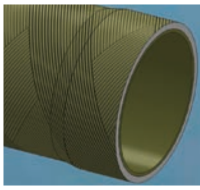
Green Thread HP pipe is available in 1”-42” diameters with pressure ratings up to 725 psig and temperatures up to 230°F (110°C), and is recommended for dilute acids and caustics, produced/hot water, industrial waste and condensate return. (Primary Market-North America)



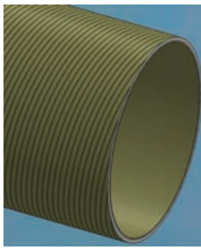
Red Thread HP pipe is available in 2”-42” diameters with pressure ratings up to 362 psig and temperatures up to 210°F (99°C) Pipe sizes 2”-6” have special profile threads for quick and reliable assembly. The product is recommended for general industrial service. (Primary Market-North America)



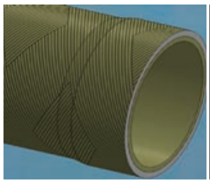
Bondstrand 2000 pipe is available in 1”-16” diameters with pressure ratings up to 450 psig and temperatures up to 250°F (121°C). This product is recommended for dilute acids and caustics, produced/hot water, industrial waste and condensate returns.



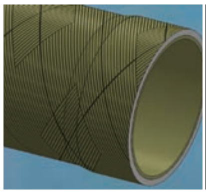
Bondstrand 2400 pipe is available in 2”-40” diameters with pressure ratings up to 725 psig and temperatures up to 250°F (121°C). Recommended for salt waters, brackish water, fire protection, potable/waste water and sewage, oil field reinjection, crude oil transmission and mild chemicals.



Bondstrand 3000, 3200, and 3300 series piping are manufactured using aromatic amine or anhydride epoxy. They are recommended for general industrial service up to 210°F (99°C). The 3000 series pipe is available in 2”-16” diameters with pressure ratings up to 450 psig. The 3200 and 3300 series pipe are available in 8”-16” diameters with pressure ratings of 200 and 300 psig, respectively.



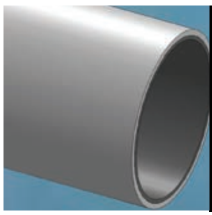
Bondstrand 4000 pipe is available in 1”-16” diameters with pressure ratings from 150 to 300 psi and temperatures up to 250°F (121°C) and is recommended for acid drains, chemical processes, slurries, food processing, non-oxidizing chemicals and acids.



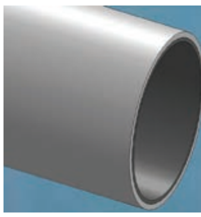
Bondstrand 7000 pipe is available in 2”-16” with a pressure rating of 150 psig and temperatures up to 210°F (99°C). Pipe is recommended for general industrial and jet fuel services where static electrical charge build-up is possible.

Note:
HP pressure classes are 16, 20, 25, 32, 40 and 50 bar.
Bondstrand 2400 pressure classes are 10, 12, 14, 16, 20, 25, 32, 40 and 50 bar.
The above pressure classes are not available in all sizes.

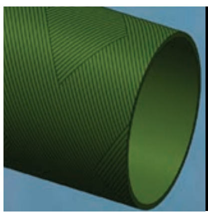
Vinyl Ester Piping Systems



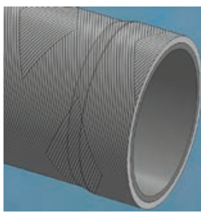
CL2030 pipe is available in 1”-14” diameters with pressure ratings up to 150 psig and is recommended for most chlorinated and acidic mixtures up to 175°F (80°C) and other chemicals up to 200°F (93°C). This pipe is manufactured with a 100 mil liner.



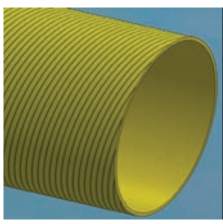
CL1520 pipe is available in 1”-14” diameters with pressure ratings up to 150 psig and is recommended for most chlorinated and acidic mixtures up to 175°F (80°C) and other chemicals up to 200°F (93.3°C). This pipe is manufactured with a 50 mil liner.



F-Chem pipe is a special order product available in 14”-72” with a pressure rating of 50-150 psig. The temperature rating is up to 225°F (121°C).

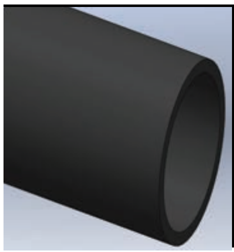


Bondstrand 5000 is available in 1”-16” diameters with temperature range up to 200°F (93°C). This is a custom vinyl ester pipe available in Asia, Europe and South America and is recommended for most chlorinated and acidic mixtures. This pipe is manufactured with a 50 mil liner.

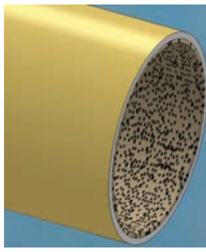


Polyplaster pipe is hand lay up pipe in diameters 1”-8” and is wound on a C.A.M. machine up to 100 inch. A variety of vinyl ester/polyester resin systems and liner thicknesses can be specified. Joint is butt and wrap.

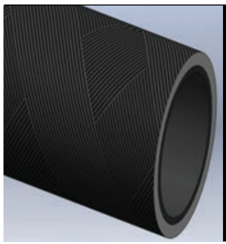
Advanced Performance Specialty Products



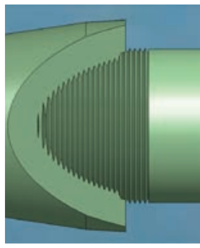
Z-Core products are a propriety thermosetting resin capable of enduring severe environments such as concentrated sulfuric acid, hydrochloric acid, hot caustic and mixtures of acids, solvents and bases. Z-Core is an excellent alternative to fluoropolymer lined pipe and expensive alloys. Temperature ratings up to 275°F and diameters from 1” to 8”.



Ceram Core products are made from high-alumina ceramic with an epoxy exterior making it an ideal material for extreme abrasive and corrosive environments. Applications include bottom ash, ore slurries, mine tailings, salt slurries, dredge lines, wood pulp, concrete slurries and Diatomaceous Earth. Diameters are available from 6” to 16”.

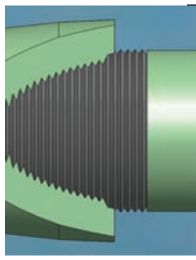


Silver Streak products are made for tough abrasive applications such as Flue Gas Desulfurization. This product is available from 1” through 48” diameters with a pressure rating up to 225 psig and a temperature rating up to 225°F (107°C).

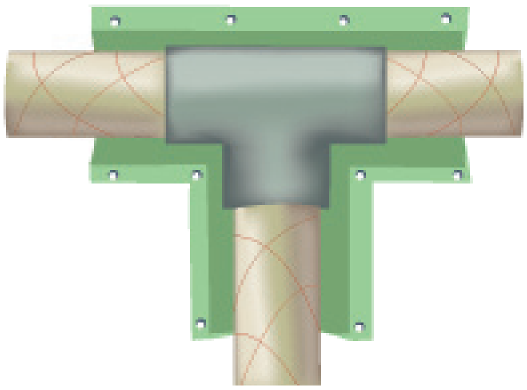


Down Hole Tubing & Casing products are capable of pressures up to 3500 psi and temperatures of 210° F for corrosive applications like CO_2, saltwater/brine and other such services for methane gas, chemical disposal or simply brackish water wells. Diameters are available from 1 ½” through 9” for pressures up to 3500 psi and diameters up to 24” for lower pressure brackish/RO water wells.

Fiberspar LinePipe products are continuous spoolable piping systems with HDPE liners over wrapped with a glass fiber epoxy thermoset matrix for corrosive and abrasive applications up to 2500 psi and up to 180°F. Diameters are available in 2 ½” through 6 ½ “ and continuous lengths up to 2 miles. A down hole version is also available.



High Pressure products are available in sizes ranging from 1½” through 36” for pressures of 150 psi up to 4000 psi at temperatures up to 210°F. Typical applications include water, hydraulic fluid, and other difficult industrial applications in a variety of industries including severe elevation changes.



Secondary Containment

Two-piece secondary containment fittings are available in 3”-16” diameters for primary pipe sizes up to 14”. The systems are designed for maximum field flexibility, ease of installation and the ability to use one size larger containment. When higher pressure, larger diameter or severe temperature changes are required, special fittings can be provided to handle the added requirements.

Other Considerations

In many instances NOV Fiber Glass Systems’ products can be hydroblasted, steam cleaned and heat-traced; please contact FGS for details.

FGS has Factory Mutual Listing for Red Thread FM and Bondstrand 3200/6000 piping.
Bondstrand 3200 has UL and ULC listing for buried fire protection systems.

Factory Mutual System Approved

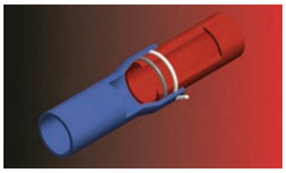
The following FGS pipe systems have UL and NSF 61 Listing for drinking water: Red Thread HP, Green Thread HP, Bondstrand 2000, 2400 series and 7000 pipe.

NSF®

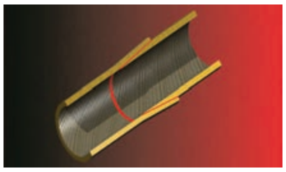
CLASSIFIED UL® WATER QUALITY

ANSI/NSF 61
Drinking Water System
Components 35GH
Water Contact Temp: 23C

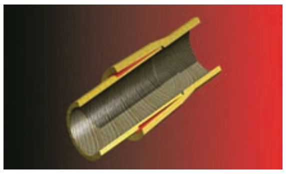
Joining Systems



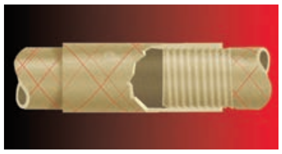
Key Lock® - Self-restrained mechanical joint provides quick assembly by means of locking keys inserted between bell and spigot. Used to install Bondstrand 2400 series pipe in sizes 2" through 40" (50 - 1000 mm).



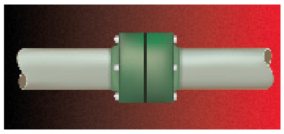
Taper x Taper - Matched taper joint secured with epoxy adhesive. Self-locking feature resists movement, facilitating joining on RT/GT HP 16/20/25 bar piping without awaiting adhesive cure.



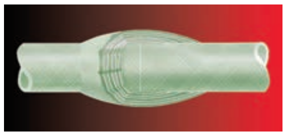
Quick® Lock - Straight spigot/tapered socket adhesive bonded joint for precise make-up to facilitate close tolerance piping. Used for 1"-16" (25-400 mm) Bondstrand 2000/4000/5000/6000/7000 piping.



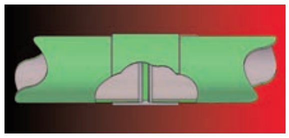
T.A.B.™ - Threaded and bonded joining system. Double-lead threads provide quick and secure adhesive connections. Available for 2" through 6" **Red Thread** pipe sizes.



Flanged - Available for all piping systems and diameters; factory assembled or shipped loose for assembly in the field.

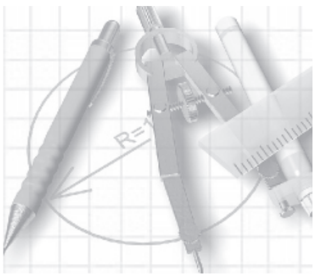


Butt & Wrap - Plain end pipe or pipe and fittings butted together and wrapped with multiple layers of resin-saturated mat or woven roving. Use with all piping systems.



Socket Joint - Adhesive bonded straight socket joint with positive stops. This is the standard for Centricast piping systems.

Engineering Design



The NOV Fiber Glass Systems' "Success by Design" engineering software sets the industry standard for design assistance. From material selection to flow calculations and comparisons; anchor, guide and support calculations; and thermal expansion solutions, this design package assists the engineer and owner in designing a highly successful system. Our applications engineers can assist you in the selection of the proper piping system for your application.

Installation and Fabrication

With eight regional fabrication locations in North America and others around the world, NOV Fiber Glass Systems can rapidly fabricate your project for minimum field installation. All of our shops are staffed with ASME B31.3 certified bonders. Certification of field installation crews to the same ASME standard is available.

SALES OFFICES

United States
San Antonio, Texas
Oilfield Products
Phone: 210 477 7500

Little Rock, Arkansas
C&I/Fuel Handling Products
Phone: 501 568 4010

Burkburnett, Texas
Marine Offshore & Fuel Handling
Phone: 940 569 1471

Mineral Wells, Texas
Centron Products
Phone: 940 325 1341

Houston, Texas
Fiberspar Products
Phone: 713 849 2609

Johnstown, Colorado
Fiberspar Products
Phone: 970 578 2000

Canada
Use U.S.A. Contacts

Mexico, Caribbean, Central America
Use U.S.A. Contacts

South America
Recife, Pernambuco, Brazil
Phone: 55 81 3501 0023

Central Asia / Russia
Aktau, Kazakhstan
Phone: 7 701 5141087

Middle East
Dubai, United Arab Emirates
Phone: 971 4 886 5660

Asia, Pacific Rim
Singapore
Phone: 65 6861 6118

Harbin China
Phone: 86 451 8709 1718

Shanghai, China
Phone: 86 21 5888 1677

Suzhou, China
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Geldermalsen, The Netherlands
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Houston, Texas USA
Betim, Brazil
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Suzhou, China
Malaysia
Singapore
Sohar, Oman

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Downhole Solutions

Drilling Solutions

Engineering and Project Management Solutions

Lifting and Handling Solutions

Production Solutions

Supply Chain Solutions

Tubular and Corrosion Control Solutions

Well Service and Completion Solutions

NATIONAL OILWELL VARCO

One Company . . . Unlimited Solutions

fgspipe@nov.com

www.fgspipe.com

Red Thread™ HP16

(Product Data)

CHEMICAL & INDUSTRIAL

Applications

- Chemical Processing Liquids
- Food Processing Liquids
- Potable Water
- Cooling Water
- Condensate Return
- Industrial Wastewater
- Mildly Corrosive Liquids
- Crude Oil & Gas
- Produced Water
- Saltwater
- CO_2

Materials and Construction

Red Thread HP16 pipe is manufactured by the filament winding process using aromatic amine-cured epoxy thermosetting resin to impregnate strands of continuous glass filaments. The pipe is rated up to 435 psig in accordance with API 15LR, 20 year design life at 200°F (93°C), serviceable up to 210°F (99°C) by applying a derating factor of 0.92 to all component ratings.

ASTM D-2996 Classification: RTRP-11AW1-3110 for static design basis.

Fittings

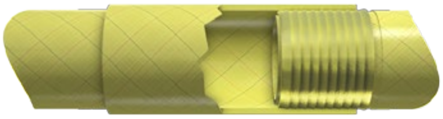
Fittings are manufactured with the same chemical and temperature capabilities as the pipe. Depending on the configurations and size, the fittings construction method will be compression molded, contact molded, fabricated or filament wound. Fittings details are in two documents. Use CI1350 for sizes 2”-16” (50-400 mm) and CI1351 for 18”-42” (450-1050 mm). All fittings may not have the same pressure rating as the pipe. System rating is governed by the lowest rated component used.

Joining System

- **T.A.B.™** - In sizes 2”-6”, pipe and couplings are supplied with a threaded and bonded (T. A. B) joining system. Double-lead threads provide quick secure adhesive connections during installation.
- **Bell & Spigot** - The 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 in sizes 8”-42”. For 8”-42” sizes, the matched tapered joining method is used and the pipe is available in random 12 meter (40 feet) lengths.

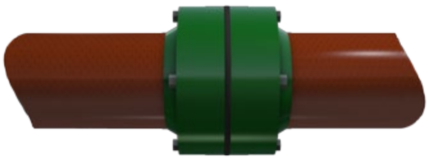
  Epoxy adhesive available from NOV Fiber Glass Systems is used to secure the joint.
- **Flanged** - Flanged connections are available for all components and diameters.

View of Joint Illustrations



T.A.B.

Bell & Spigot



Flanged

Nominal Dimensional Data

Pipe Size		Inside Diameter		Outside Diameter[4]		Reinforced Wall Thickness		Weight		Capacity	
in	mm	in	mm	in	mm	in	mm	lbs/ft	kg/m	gal/ft	l/m
2[1]	50	2.24	57	2.35	60	0.058	1.47	0.4	0.54	0.20	2.5
3[1]	80	3.36	85	3.54	98	0.086	2.18	0.8	1.20	0.46	5.7
4[2]	100	4.36	111	4.53	115	0.083	2.11	1.0	1.52	0.78	9.7
6[2]	150	6.41	163	6.65	169	0.122	3.10	2.2	3.21	1.68	20.9
8	200	8.36	212	8.61	219	0.127	3.23	2.9	4.35	2.85	35.4
10	250	10.36	263	10.67	271	0.156	3.96	4.5	6.62	4.38	54.4
12	300	12.28	312	12.65	321	0.185	4.70	6.3	9.31	6.16	76.4
14	350	14.03	356	14.51	369	0.238	6.05	9.2	13.70	8.03	99.7
16	400	16.03	407	16.57	421	0.272	6.91	12.0	17.90	10.50	130.0
18	450	17.82	453	18.38	467	0.277	7.04	13.6	20.20	13.00	161.0
20	500	19.83	504	20.40	518	0.286	7.26	15.6	23.30	16.00	199.0
24	600	23.83	605	24.50	622	0.334	8.48	21.9	32.60	23.20	288.0
30[3]	750	30.03	763	30.89	785	0.430	10.92	35.6	52.90	36.80	457.0
36[3]	900	36.03	915	37.05	941	0.510	12.95	50.6	75.30	53.00	658.0
42[3]	1050	42.03	1068	43.23	1098	0.600	15.24	69.4	103.00	72.10	895.0

[1] Reinforced wall thickness exceeds the requirement for 232 psig and may be operated up to 435 psig.
[2] Reinforced wall thickness exceeds the requirement for 232 psig and may be operated up to 362 psig.
[3] Qualified for 232 psig, see fittings ratings in CI1351 for exceptions.
[4] Outer diameter is for use in flexibility analysis. Consult factory representative for OD tolerances.

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.

Support Spacing vs. Specific Gravity

Specific Gravity	2.00	1.50	1.25	1.00	0.75
Multiplier	0.85	0.91	0.95	1.00	1.06

Example: 18” pipe @ 75°F (23.9°C) with 1.5 specific gravity fluid, maximum support spacing = 35.2 x 0.91 = 32.0 ft. (9.76 m)

Maximum Support Spacing for Uninsulated Pipe[1]

Size		Continuous Spans of Pipe[2]			
		feet		meters	
in	mm	75°F	200°F	24°C	93°C
2	50	14.0	10.1	4.3	3.1
3	80	17.1	12.4	5.2	3.8
4	100	18.2	13.2	5.6	4.0
6	150	22.1	16.0	6.7	4.9
8	200	24.0	17.4	7.3	5.3
10	250	26.6	19.3	8.1	5.9
12	300	29.0	21.0	8.8	6.4
14	350	31.8	23.1	9.7	7.0
16	400	34.0	24.7	10.4	7.5
18	450	35.2	25.5	10.7	7.8
20	500	36.5	26.5	11.1	8.1
24	600	39.7	28.8	12.1	8.8
30	800	44.8	32.5	13.7	9.9
36	900	49.0	35.5	14.9	10.8
42	1050	53.0	38.4	16.2	11.7

[1] For Sg=1.0, consult manufacturer for heavier insulated pipe support spans. Span recommendations include no provision for weight of (fittings, valves, etc.) or thrusts at branches and turns. Heavy valves and other appurtenances must be supported separately.

[2] Calculated spans are based on ½” mid-span deflections to ensure good appearance and adequate drainage. Total system stresses should always be taken into account by the system design engineer when determining support spans.

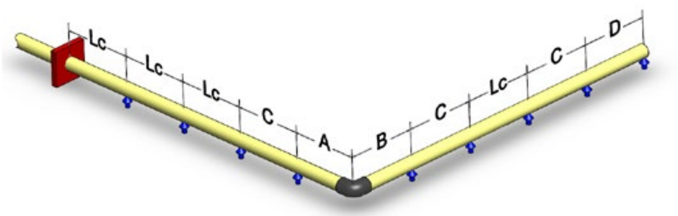
There are seven basic rules to follow when designing piping system supports, anchors, and guides:

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.

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

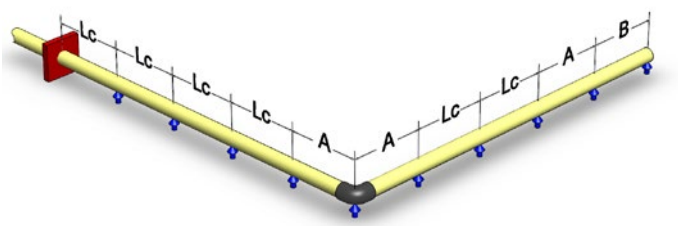
	Span Type	Factor
Lc	Continuous interior or fixed end spans	1.00
C	Second span from supported end or unsupported fitting	0.80
A+B	Sum of unsupported spans at fitting	≤0.75*
D	Simple supported end span	0.67

*For example: If continuous support is 10 ft. (3.04 m), A+B must not exceed 7.5 ft.(2.28 m) (A=3 ft. (0.91 m) and B=4.5 ft. (1.37 m)) would satisfy this condition.



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

	Span Type	Factor
Lc	Continuous interior or fixed end spans	1.00
A	Second span from simple supported end or unsupported fitting	0.80
B	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, Section 3.

Change in Temperature		Pipe Change in Length	
°F	°C	in/100 ft	cm/100 m
25	13.9	0.32	2.67
50	27.8	0.64	5.35
75	41.7	0.96	8.02
100	55.6	1.28	10.7

Testing

Hydrostatic testing is recommended to evaluate the integrity of all new piping installations. For systems operating below the system rating, a test pressure of 1.5 times the system operating pressure is recommended; however, the maximum test pressure must not exceed 1.3 times the lowest pressure rated fiberglass component in the piping system.

The hydro test pressure should be repeated up to ten cycles from 0 psig to the test pressure to provide a high degree of confidence in the piping system. The final pressurization cycle should be allowed to stabilize for 15-30 minutes, then inspected for leaks. Do not attempt to repair leaks while system is pressurized. The hydro test should be repeated after any re-work is performed.

When hydro testing, open high-point vents (if used) to prevent entrapment of air in the lines as the system is slowly filled with water, then close the vents and slowly pressurize to the test pressure. Upon completion of hydro test, relieve the pressure on the system slowly, open vents and any drains to allow for complete drainage of the system.

Water Hammer

Piping systems may be damaged by pressure surges due to water hammer. The use of soft start pumps and slow actuating valves will reduce the magnitude of surge pressures during operation and are highly recommended.

Typical Mechanical Properties

Pipe Property		75°F	24°C	200°F	93°C	Method
		psi	MPa	psi	MPa	
Axial Tensile						
Ultimate Stress		9,530	65.7	6,585	45.4	ASTM D2105
Modulus of Elasticity		1.68 x 10^6	11,584	1.42 x 10^6	9,791	ASTM D2105
Poisson's Ratio, ν_{ah} (ν_{ha})[1]		0.35 (0.61)				
Axial Compression						
Ultimate Stress		12,510	86.3	8,560	59.0	ASTM D695
Modulus of Elasticity		0.677 x 10^6	4,668	0.379 x 10^6	2,613	ASTM D695
Beam Bending						
Modulus of Elasticity (Long Term)		2.6 x 10^6	17,927	0.718 x 10^6	4,951	ASTM D2925
Hydrostatic Burst						
Ultimate Hoop Tensile Stress		40,150	277	36,480	252	ASTM D1599
Hydrostatic Hoop Design Stress						
Static 20 Year Life	LTHS - 95% LCL	-	-	18,203 - 14,689	125.5 - 101.3	ASTM D2992 - Procedure B
Static 50 Year Life	LTHS - 95% LCL	-	-	16,788 - 13,142	115.7 - 90.6	ASTM D2992 - Procedure B
Parallel Plate						
Hoop Modulus of Elasticity		3.02 x 10^6	20,822	-	-	ASTM D2412
Shear Modulus		1.36 x 10^6	9,343	1.15 x 10^6	7,895	-

Typical Physical Properties

Pipe Property	Value	Value	Method
Thermal Conductivity	0.23 BTU/hr•ft•°F	0.4 W/m°C	ASTM D177
Thermal Expansion	10.7 x 10^{-6} in/in/°F	19.3 x 10^{-6} mm/mm/°C	ASTM D696
Absolute Roughness	0.00021 in	0.00053 mm	
Specific Gravity	1.8		ASTM D792

[1] ν_{ha} = The ratio of axial strain to hoop strain resulting from stress in the hoop direction.
ν_{ah} = The ratio of hoop strain to axial strain resulting from stress in the axial direction.

[2] The differential pressure between internal and external pressure which causes collapse.

[3] A 0.67 design factor is recommended for short duration vacuum service. A full vacuum is equal to 14.7 psig (0.101 MPa) differential pressure at sea level.

[4] A 0.33 design factor is recommended for sustained (long-term) differential collapse pressure design and operation.

Ultimate Collapse Pressure

Size		Collapse Pressure[2,3,4]			
		psig		MPa	
In	mm	75°F	200°F	24°C	93°C
2	50	177	133	1.22	0.92
3	80	171	129	1.18	0.89
4	100	69	51	0.48	0.35
6	150	69	51	0.48	0.35
8	200	29	20	0.20	0.14
10	250	27	20	0.19	0.13
12	300	27	20	0.19	0.14
14	350	45	33	0.31	0.23
16	400	45	33	0.31	0.23
18	450	31	23	0.22	0.16
20	550	23	16	0.16	0.11
24	600	20	14	0.14	0.10
30	750	21	15	0.14	0.10
36	900	21	15	0.14	0.10
42	1050	21	15	0.14	0.10

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

CI1200ENG March 2017

Red Thread™ HP16 Piping System

(Specification Guide)

CHEMICAL & INDUSTRIAL

Section 1 - Scope

This section covers the use of fiberglass reinforced plastic (FRP) pipe for mild chemical and water services up to 200°F and 435 psig steady pressure ratings which are diameter dependent. The pipe may be further serviced up to 210°F by applying a pressure derating factor of 0.92 to all component ratings.

The piping shall be furnished and installed complete with all fittings, joining materials, supports, specials, and other necessary appurtenances.

Section 2 - General Conditions

2.01 Coordination - Material furnished and work performed under this section shall be coordinated with related work and equipment specified under other sections.

Valves	Section	_________
Supports	Section	_________
Equipment	Section	_________

2.02 Governing Standards - Except as modified or supplemented herein, all materials and construction methods shall comply with the applicable provisions of the following specifications and be tested using the following standards.

Standard Specifications

ASTM D2996	Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting-Resin) Pipe
ASTM D4024	Standard Specification for Reinforced Thermosetting Resin (RTR) Flanges
ASTM D5685	Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting-Resin) Pressure Pipe Fittings

Standard Test Methods

ASTM D2992	Standard Test Method for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pipe and Fittings
ASTM D2925	Standard Test Method for Measuring Beam Deflection of Reinforced Thermosetting Plastic Pipe Under Full Bore Flow
ASTM D1599	Standard Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings
ASTM D2105	Standard Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pipe and Tube
ASTM D2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading

2.04 Operating Conditions - In addition to the above minimum design requirements, the system shall meet the following minimum operating conditions:

a. Operating Pressure _________

b. Operating Temperature _________

c. Fluid Conveyed _________

d. Test Pressure _________

2.05 Quality Assurance - Pipe manufacturer's quality program shall be in compliance with ISO 9001 and/or API Q1.

2.06 Delivery, Storage and Handling - Pipe and fittings shall be protected from damage due to impact and point loading. Pipe shall be properly supported to avoid damage due to flexural strains. The contractor shall not allow dirt, debris, or other extraneous materials to get into pipe and fittings. All factory machined areas shall be protected from sunlight until installed.

2.07 Acceptable Manufacturers - NOV Fiber Glass Systems, (501) 568-4010, or approved equal.

Section 3 - Materials and Construction

3.01 2"-42" Pipe - The pipe shall be manufactured by the filament winding process using an amine cured epoxy thermosetting resin to impregnate strands of continuous glass filaments, which are wound around a mandrel at a 54 ¾° winding angle under controlled tension. Pipe shall be heat cured and the cure shall be confirmed using a Differential Scanning Calorimeter.

Pipe shall be supplied with a matching tapered bell and a matching tapered spigot.

Pipe shall have a minimum continuous steady pressure rating of 232psig at 200°F in accordance with ASTM D2992 Procedure B.

3.02 Flanges and Fittings - All fittings shall be manufactured using the same type materials as the pipe. Fittings may be manufactured either by compression molding, spray-up/contact molding, or filament winding methods.

Fittings shall be adhesive bonded matched tapered bell and spigot, threaded or grooved adapters, or flanged. Fittings shall be certified to ASTM D5685.

Flanges shall have ANSI B16.5 Class 150 bolt hole patterns.

3.03 Adhesive - Adhesive shall be manufacturer's standard for the piping system specified.

3.04 Gaskets - Gaskets shall be 1/8" thick, 60-70 durometer full-face type suitable for the service shown on the drawings and as recommended in the manufacturer's standard installation procedures.

3.05 Bolts, Nuts and Washers - ASTM A307, Grade B, hex head bolts shall be supplied. SAE washers shall be supplied on all nuts and bolts.

3.06 Acceptable Products - Red Thread HP16 as manufactured by NOV Fiber Glass Systems, or approved equal.

Section 4 - Installation and Testing

4.01 Training and Certification - All joints installed or constructed in the field shall be assembled by employees of the contractor who have been trained and certified to the Bonding Procedure Specification (BPS) provided by the pipe manufacturer. The BPS shall meet or exceed the requirements of ASME B31.3, Section A328.2.1. The pipe manufacturer or their authorized representative shall train the contractor's employees in the proper joining and assembly procedures required for the project, including hands-on participation by the contractor's employees in accordance with the BPS. Each bonder shall fabricate one pipe-to-pipe and one pipe-to-fitting joint for qualification testing. The pipe size and test pressure used in the qualification assembly shall meet or exceed the minimum requirements of ASME B31.3. Only bonders who have successfully completed the qualification pressure test shall bond pipe and fittings.

4.02 Pipe Installation - Pipe shall be installed as specified and indicated on the drawings. The piping system shall be installed in accordance with the manufacturer's current published installation procedures.

Each pressure containing joint shall be clearly marked to identify the bonder in accordance with ASME B31.3, Section A328.5.1.

4.03 Testing - Hydrostatic testing is recommended to evaluate the integrity of all new piping installations. For systems operating below the system rating, a test pressure of 1.5 times the system operating pressure is recommended; however, the maximum test pressure must not exceed 1.3 times the lowest pressure rated fiberglass component in the piping system.

The hydro test pressure should be repeated up to ten cycles from 0 psig to the test pressure to provide a high degree of confidence in the piping system. The final pressurization cycle should be allowed to stabilize for 15-30 minutes, then inspected for leaks. Do not attempt to repair leaks while system is pressurized. The hydro test should be repeated after any re-work is performed.

When hydro testing, open high-point vents (if used) to prevent entrapment of air in the lines as the system is slowly filled with water, then close the vents and slowly pressurize to the test pressure. Upon completion of hydro test, relieve the pressure on the system slowly, open vents and any drains to allow for complete drainage of the system.

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CI1201ENG August 2016

Red Thread™ HP25 Piping System

(Specification Guide)

CHEMICAL & INDUSTRIAL

Section 1 - Scope

This section covers the use of fiberglass reinforced plastic (FRP) pipe for mild chemical and water services up to 200°F and 435 psig steady pressure ratings which are diameter dependent. The pipe may be further serviced up to 210°F by applying a pressure derating factor of 0.92 to all component ratings.

The piping shall be furnished and installed complete with all fittings, joining materials, supports, specials, and other necessary appurtenances.

Section 2 - General Conditions

2.01 Coordination - Material furnished and work performed under this section shall be coordinated with related work and equipment specified under other sections.

Valves	Section	__________
Supports	Section	__________
Equipment	Section	__________

2.02 Governing Standards - Except as modified or supplemented herein, all materials and construction methods shall comply with the applicable provisions of the following specifications and be tested using the following standards.

Standard Specifications

ASTM D2996	Standard Specification for Filament-Wound “Fiberglass” (Glass-Fiber-Reinforced-Thermosetting-Resin) Pipe
ASTM D4024	Standard Specification for Reinforced Thermosetting Resin (RTR) Flanges
ASTM D5685	Standard Specification for “Fiberglass” (Glass-Fiber-Reinforced-Thermosetting-Resin) Pressure Pipe Fittings

Standard Test Methods

ASTM D2992	Standard Test Method for Obtaining Hydrostatic or Pressure Design Basis for “Fiberglass” (Glass-Fiber-Reinforced-Thermosetting Resin) Pipe and Fittings
ASTM D2925	Standard Test Method for Measuring Beam Deflection of Reinforced Thermosetting Plastic Pipe Under Full Bore Flow
ASTM D1599	Standard Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings
ASTM D2105	Standard Test Method for Longitudinal Tensile Properties of “Fiberglass” (Glass-Fiber-Reinforced-Thermosetting Resin) Pipe and Tube
ASTM D2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading

2.04 Operating Conditions - In addition to the above minimum design requirements, the system shall meet the following minimum operating conditions:

a. Operating Pressure __________

b. Operating Temperature __________

c. Fluid Conveyed __________

d. Test Pressure __________

2.05 Quality Assurance - Pipe manufacturer’s quality program shall be in compliance with ISO 9001 and/or API Q1.

2.06 Delivery, Storage and Handling - Pipe and fittings shall be protected from damage due to impact and point loading. Pipe shall be properly supported to avoid damage due to flexural strains. The contractor shall not allow dirt, debris, or other extraneous materials to get into pipe and fittings. All factory machined areas shall be protected from sunlight until installed.

2.07 Acceptable Manufacturers - NOV Fiber Glass Systems, (501) 568-4010, or approved equal.

Section 3 - Materials and Construction

3.01 2"-24" Pipe - The pipe shall be manufactured by the filament winding process using an amine cured epoxy thermosetting resin to impregnate strands of continuous glass filaments, which are wound around a mandrel at a 54 ¾° winding angle under controlled tension. Pipe shall be heat cured and the cure shall be confirmed using a Differential Scanning Calorimeter.

Pipe shall be supplied with a matching tapered bell and a matching tapered spigot.

Pipe shall have a minimum continuous steady pressure rating of 362 psig at 200°F in accordance with ASTM D2992 Procedure B.

3.02 Flanges and Fittings - All fittings shall be manufactured using the same type materials as the pipe. Fittings may be manufactured either by compression molding, spray-up/contact molding, or filament winding methods.

Fittings shall be adhesive bonded matched tapered bell and spigot, threaded or grooved adapters, or flanged. Fittings shall be certified to ASTM D5685.

Flanges shall have ANSI B16.5 Class 300 or 150 bolt hole patterns per specific application requirements.

3.03 Adhesive - Adhesive shall be manufacturer’s standard for the piping system specified.

3.04 Gaskets - Gaskets shall be 1/8" thick, 60-70 durometer full-face type suitable for the service shown on the drawings and as recommended in the manufacturer’s standard installation procedures.

3.05 Bolts, Nuts and Washers - ASTM A307, Grade B, hex head bolts shall be supplied. SAE washers shall be supplied on all nuts and bolts.

3.06 Acceptable Products - Red Thread HP25 as manufactured by NOV Fiber Glass Systems, or approved equal.

Section 4 - Installation and Testing

4.01 Training and Certification - All joints installed or constructed in the field shall be assembled by employees of the contractor who have been trained and certified to the Bonding Procedure Specification (BPS) provided by the pipe manufacturer. The BPS shall meet or exceed the requirements of ASME B31.3, Section A328.2.1. The pipe manufacturer or their authorized representative shall train the contractor's employees in the proper joining and assembly procedures required for the project, including hands-on participation by the contractor's employees in accordance with the BPS. Each bonder shall fabricate one pipe-to-pipe and one pipe-to-fitting joint for qualification testing. The pipe size and test pressure used in the qualification assembly shall meet or exceed the minimum requirements of ASME B31.3. Only bonders who have successfully completed the qualification pressure test shall bond pipe and fittings.

4.02 Pipe Installation - Pipe shall be installed as specified and indicated on the drawings. The piping system shall be installed in accordance with the manufacturer's current published installation procedures.

Each pressure containing joint shall be clearly marked to identify the bonder in accordance with ASME B31.3, Section A328.5.1.

4.03 Testing - Hydrostatic testing is recommended to evaluate the integrity of all new piping installations. For systems operating below the system rating, a test pressure of 1.5 times the system operating pressure is recommended; however, the maximum test pressure must not exceed 1.3 times the lowest pressure rated fiberglass component in the piping system.

The hydro test pressure should be repeated up to ten cycles from 0 psig to the test pressure to provide a high degree of confidence in the piping system. The final pressurization cycle should be allowed to stabilize for 15-30 minutes, then inspected for leaks. Do not attempt to repair leaks while system is pressurized. The hydro test should be repeated after any re-work is performed.

When hydro testing, open high-point vents (if used) to prevent entrapment of air in the lines as the system is slowly filled with water, then close the vents and slowly pressurize to the test pressure. Upon completion of hydro test, relieve the pressure on the system slowly, open vents and any drains to allow for complete drainage of the system.

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CI1266ENG August 2016

Green Thread™ HP16 Piping System

(Specification Guide)

CHEMICAL & INDUSTRIAL

Section 1 - Scope

This section covers the use of fiberglass reinforced plastic (FRP) pipe for dilute acid, caustic, and mild solvent services up to 230°F and 435 psig steady pressure.

The piping shall be furnished and installed complete with all fittings, joining materials, supports, specials, and other necessary appurtenances.

Section 2 - General Conditions

2.01 Coordination - Material furnished and work performed under this section shall be coordinated with related work and equipment specified under other sections.

Valves	Section	_________
Supports	Section	_________
Equipment	Section	_________

2.02 Governing Standards - Except as modified or supplemented herein, all materials and construction methods shall comply with the applicable provisions of the following specifications and be tested using the following standards.

Standard Specifications

ASTM D2996	Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pipe
ASTM D4024	Standard Specification for Reinforced Thermosetting Resin (RTR) Flanges

Standard Test Methods

ASTM D2992	Standard Test Method for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pipe and Fittings
ASTM D1599	Standard Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings
ASTM D2105	Standard Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pipe and Tube
ASTM D2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASTM D2925	Standard Test Method for Beam Deflection of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe Under Bore Flow

2.04 Operating Conditions - In addition to the above minimum design requirements, the system shall meet the following minimum operating conditions:

a. Operating Pressure ________

b. Operating Temperature ________

c. Fluid Conveyed ________

d. Test Pressure ________

2.05 Quality Assurance - Pipe manufacturer's quality program shall be in compliance with ISO 9001 and/or API Q1.

2.06 Delivery, Storage and Handling - Pipe and fittings shall be protected from damage due to impact and point loading. Pipe shall be properly supported to avoid damage due to flexural strains. The contractor shall not allow dirt, debris, or other extraneous materials to get into pipe and fittings. All factory machined areas shall be protected from sunlight until installed.

2.07 Acceptable Manufacturers - NOV Fiber Glass Systems, (501) 568-4010, or approved equal.

Section 3 - Materials and Construction

3.01 2"-42" Pipe - The pipe shall be manufactured by the filament winding process using an amine cured epoxy thermosetting resin to impregnate strands of continuous glass filaments, which are wound around a mandrel at a 54 ¾° winding angle under controlled tension. Pipe shall be heat cured and the cure shall be confirmed using a Differential Scanning Calorimeter.

All pipe shall have a resin-rich corrosion barrier reinforced with surfacing veil. The corrosion barrier shall have a minimum resin content of 80%. The minimum acceptable cured thickness of the corrosion barrier shall be as follows:

1" - 1½"	12 mil minimum
2" - 42"	20 mil minimum

Pipe shall be supplied with a matching tapered bell and a matching tapered spigot.

Pipe shall have a minimum continuous steady pressure rating of 232 psig at 200°F in accordance with ASTM D2992 Procedure B.

3.02 Flanges and Fittings - All fittings shall be manufactured using the same type materials as the pipe. Fittings may be manufactured either by compression molding, spray-up/contact molding, or filament winding methods.

Fittings shall be adhesive bonded matched tapered bell and spigot or flanged.

Flanges shall have ANSI B16.5 Class 150 bolt hole patterns.

3.03 Adhesive - Adhesive shall be manufacturer's standard for the piping system specified.

3.04 Gaskets - Gaskets shall be 1/8" thick, 60-70 durometer full-face type suitable for the service shown on the drawings and as recommended in the manufacturer's standard installation procedures.

3.05 Bolts, Nuts and Washers - ASTM F593, 304 stainless steel hex head bolts shall be supplied. SAE washers shall be supplied on all nuts and bolts.

3.06 Acceptable Products - Green Thread HP16 as manufactured by NOV Fiber Glass Systems, or approved equal.

Section 4 - Installation and Testing

4.01 Training and Certification - All joints installed or constructed in the field shall be assembled by employees of the contractor who have been trained by the pipe manufacturer. The pipe manufacturer or their authorized representative shall train the contractor's employees in the proper joining and assembly procedures required for the project, including hands-on participation by the contractor's employees. Each bonder shall fabricate one pipe-to-pipe and one pipe-to-fitting joint that shall pass the minimum pressure test for the application as stated in section 2.03.d without leaking.

Only bonders who have successfully completed the pressure test shall bond pipe and fittings.

Certification by the manufacturer shall be in compliance with ASME B31.3, Section A328.2 for the type of joint being made.

4.02 Pipe Installation - Pipe shall be installed as specified and indicated on the drawings.

The piping system shall be installed in accordance with the manufacturer's current published installation procedures.

4.03 Testing - Hydrostatic testing is recommended to evaluate the integrity of all new piping installations. For systems operating below the system rating, a test pressure of 1.5 times the system operating pressure is recommended; however, the maximum test pressure must not exceed 1.3 times the lowest pressure rated fiberglass component in the piping system.

The hydro test pressure should be repeated up to ten cycles from 0 psig to the test pressure to provide a high degree of confidence in the piping system. The final pressurization cycle should be allowed to stabilize for 15-30 minutes, then inspected for leaks. Do not attempt to repair leaks while system is pressurized. The hydro test should be repeated after any re-work is performed.

When hydro testing, open high-point vents (if used) to prevent entrapment of air in the lines as the system is slowly filled with water, then close the vents and slowly pressurize to the test pressure. Upon completion of hydro test, relieve the pressure on the system slowly, open vents and any drains to allow for complete drainage of the system.

Fiber Glass Systems
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San Antonio, Texas 78232 USA
Phone: 210 477 7500
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CI1301ENG August 2016

Green Thread™ HP25 Piping System

(Specification Guide)

CHEMICAL & INDUSTRIAL

Section 1 - Scope

This section covers the use of fiberglass reinforced plastic (FRP) pipe for dilute acid, caustic, and mild solvent services up to 362 psig steady pressure at 200°F. Service up to 230°F allowed with reduced pressure.

The piping shall be furnished and installed complete with all fittings, joining materials, supports, specials, and other necessary appurtenances.

Section 2 - General Conditions

2.01 Coordination - Material furnished and work performed under this section shall be coordinated with related work and equipment specified under other sections.

Valves	Section	_________
Supports	Section	_________
Equipment	Section	_________

2.02 Governing Standards - Except as modified or supplemented herein, all materials and construction methods shall comply with the applicable provisions of the following specifications and be tested using the following standards.

Standard Specifications

ASTM D2996	Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pipe RTRP-11FX
ASTM D4024	Standard Specification for Reinforced Thermosetting Resin (RTR) Flanges

Standard Test Methods

ASTM D2992	Standard Test Method for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pipe and Fittings
ASTM D1599	Standard Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings
ASTM D2105	Standard Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pipe and Tube
ASTM D2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASTM D2925	Standard Test Method for Beam Deflection of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe Under Bore Flow

2.04 Operating Conditions - In addition to the above minimum design requirements, the system shall meet the following minimum operating conditions:

a. Operating Pressure ________

b. Operating Temperature ________

c. Fluid Conveyed ________

d. Test Pressure ________

2.05 Quality Assurance - Pipe manufacturer's quality program shall be in compliance with ISO 9001 and/or API Q1.

2.06 Delivery, Storage and Handling - Pipe and fittings shall be protected from damage due to impact and point loading. Pipe shall be properly supported to avoid damage due to flexural strains. The contractor shall not allow dirt, debris, or other extraneous materials to get into pipe and fittings. All factory machined areas shall be protected from sunlight until installed.

2.07 Acceptable Manufacturers - NOV Fiber Glass Systems, (501) 568-4010, or approved equal.

Section 3 - Materials and Construction

3.01 2"-24" Pipe - The pipe shall be manufactured by the filament winding process using an amine cured epoxy thermosetting resin to impregnate strands of continuous glass filaments, which are wound around a mandrel at a 54 ¾° winding angle under controlled tension. Pipe shall be heat cured and the cure shall be confirmed using a Differential Scanning Calorimeter.

All pipe shall have a resin-rich corrosion barrier reinforced with surfacing veil. The corrosion barrier shall have a minimum resin content of 80%. The minimum acceptable cured thickness of the corrosion barrier shall be as follows:

2" - 24"   20 mil minimum

Pipe shall be supplied with a matching tapered bell and a matching tapered spigot.

Pipe shall have a minimum continuous steady pressure rating of 362 psig at 200°F in accordance with ASTM D2992 Procedure B.

3.02 Flanges and Fittings - All fittings shall be manufactured using the same type materials as the pipe. Fittings may be manufactured either by compression molding, spray-up/contact molding, or filament winding methods.

Fittings shall be adhesive bonded matched tapered bell and spigot or flanged.

Flanges shall have ANSI B16.5 Class 300 or Class 150 bolt hole pattern, as ordered.

3.03 Adhesive - Adhesive shall be manufacturer's standard for the piping system specified.

3.04 Gaskets - Gaskets shall be 1/8" thick, 60-70 durometer full-face type suitable for the service shown on the drawings and as recommended in the manufacturer's standard installation procedures.

3.05 Bolts, Nuts and Washers - ASTM F593, 304 stainless steel hex head bolts shall be supplied. SAE washers shall be supplied on all nuts and bolts.

3.06 Acceptable Products - Green Thread HP25 as manufactured by NOV Fiber Glass Systems, or approved equal.

Section 4 - Installation and Testing

4.01 Training and Certification - All joints installed or constructed in the field shall be assembled by employees of the contractor who have been trained by the pipe manufacturer. The pipe manufacturer or their authorized representative shall train the contractor's employees in the proper joining and assembly procedures required for the project, including hands-on participation by the contractor's employees. Each bonder shall fabricate one pipe-to-pipe and one pipe-to-fitting joint that shall pass the minimum pressure test for the application as stated in section 2.03.d without leaking.

Only bonders who have successfully completed the pressure test shall bond pipe and fittings.

Certification by the manufacturer shall be in compliance with ASME B31.3, Section A328.2 for the type of joint being made.

4.02 Pipe Installation - Pipe shall be installed as specified and indicated on the drawings.

The piping system shall be installed in accordance with the manufacturer's current published installation procedures.

4.03 Testing - Hydrostatic testing is recommended to evaluate the integrity of all new piping installations. For systems operating below the system rating, a test pressure of 1.5 times the system operating pressure is recommended; however, the maximum test pressure must not exceed 1.3 times the lowest pressure rated fiberglass component in the piping system.

The hydro test pressure should be repeated up to ten cycles from 0 psig to the test pressure to provide a high degree of confidence in the piping system. The final pressurization cycle should be allowed to stabilize for 15-30 minutes, then inspected for leaks. Do not attempt to repair leaks while system is pressurized. The hydro test should be repeated after any re-work is performed.

When hydro testing, open high-point vents (if used) to prevent entrapment of air in the lines as the system is slowly filled with water, then close the vents and slowly pressurize to the test pressure. Upon completion of hydro test, relieve the pressure on the system slowly, open vents and any drains to allow for complete drainage of the system.

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CI1326ENG January 2017

Red Thread™ HP 25

(Product Data)

CHEMICAL & INDUSTRIAL

Applications

- Chemical Processing Liquids
- Food Processing Liquids
- Potable Water
- Cooling Water
- Condensate Return
- Industrial Wastewater
- Mildly Corrosive Liquids
- Crude Oil & Gas
- Produced Water
- Saltwater
- CO_2

Materials and Construction

All pipe is filament wound with continuous strands of glass filaments saturated with amine-cured epoxy thermosetting resin. The pipe wall includes an internal resin-rich corrosion barrier. The pipe is designed in accordance with API 15LR at 200°F (93°C), serviceable up to 210°F (99°C) by applying a derating factor of 0.92 to all component ratings. The pressure rating is 362 psig (25 Bar) for a hydrostatic design life of 20 years per ASTM D2992 Procedure B. For 2"-6" (50-150 mm) sizes, the matched tapered joining method is used and the pipe is available in random 30 foot (9.14 meter) lengths. For 8"-24" (200-600 mm) sizes, the matched tapered joining method is used and the pipe is available in random 40 foot (12 meter) lengths. Pipe is supplied with one end belled (integral bell or factory-bonded coupling) and one end tapered.

ASTM D-2996 Classification: RTRP-11AW1-3110 for static design basis.

Fittings

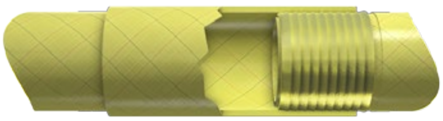
Fittings are manufactured with the same chemical/temperature capabilities as the pipe. Depending on the configurations and size, the fittings construction method will be compression molded, contact molded, fabricated or filament wound.

Joining System

- **T.A.B.™** - In sizes 2"-6", pipe and couplings are supplied with a threaded and bonded (T. A. B) joining system. Double-lead threads provide quick secure adhesive connections during installation.
- **Bell & Spigot** - The 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 in sizes 8"-24". For 8"-24" sizes, the matched tapered joining method is used and the pipe is available in random 12 meter (40 feet) lengths.

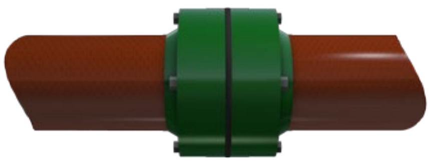
  Epoxy adhesive is used to secure the joint. When properly installed, the system will operate at the maximum pressure rating of the pipe.
- **Flanged** - Flanged connections are available for all components and diameters.

View of Joint Illustrations



T.A.B.

Bell & Spigot



Flanged

Nominal Dimensional Data

Pipe Size		Inside Diameter		Outside Diameter[2]		Reinforced Wall Thickness[1]		Weight		Capacity	
in	mm	in	mm	in	mm	in	mm	lbs/ft	kg/m	gal/ft	l/m
2[1]	50	2.24	57	2.35	60	0.058	1.5	0.4	0.7	0.2	2.5
3[1]	80	3.36	85	3.54	90	0.086	2.2	0.8	1.2	0.5	5.7
4	100	4.36	111	4.53	115	0.083	2.1	1.0	1.5	0.8	9.7
6	150	6.40	163	6.65	169	0.122	3.1	2.2	3.2	1.7	20.9
8	200	8.36	212	8.68	221	0.164	4.2	3.8	5.6	2.9	35.4
10	250	10.36	263	10.76	273	0.203	5.2	5.8	8.7	4.4	54.4
12	300	12.28	312	12.76	324	0.241	6.1	8.2	12.2	6.2	76.4
14	350	14.03	356	14.58	370	0.275	7.0	10.7	15.9	8.0	100.0
16	400	16.03	407	16.66	423	0.314	8.0	13.9	20.7	10.6	130.0
18	450	17.83	453	18.54	471	0.357	9.1	17.6	26.2	13.0	161.0
20	500	19.83	504	20.62	524	0.397	10.1	21.8	32.4	16.0	199.0
24	600	23.83	605	24.78	629	0.477	12.1	31.5	46.9	23.2	288.0

[1] Reinforced wall thickness exceeds the requirement for 362 psig and may be operated up to 435 psig.

[2] Outer diameter is for use in flexibility analysis. Consult factory representative for pipe OD tolerances.

NOTE: System rating is determined by pressure ratings of fittings used in the piping system. See document CI1370 for individual fitting pressure ratings.

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, pressure 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 to ensure good appearance and adequate drainage. 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.

Support Spacing vs. Specific Gravity

Specific Gravity	2.00	1.50	1.25	1.00	0.75
Multiplier	0.85	0.91	0.95	1.00	1.06

Example: 18" (450 mm) pipe @ 75°F (24°C) with 1.5 specific gravity fluid, maximum support spacing = 37.3' x 0.91 = 33.9 ft.

Maximum Support Spacing for Pipe[1]

Size		Continuous Spans of Pipe[2]			
		feet		meters	
in	mm	75°F	200°F	24°C	93°C
2	50	14.0	10.2	4.27	3.10
3	80	17.1	12.4	5.22	3.79
4	100	18.2	13.2	5.56	4.03
6	150	22.1	16.0	6.74	4.89
8	200	25.4	18.4	7.75	5.62
10	250	28.3	20.5	8.63	6.25
12	300	30.8	22.3	9.40	6.81
14	350	32.9	23.9	10.04	7.28
16	400	35.2	25.5	10.74	7.78
18	450	37.3	27.0	11.38	8.25
20	500	39.3	28.5	12.00	8.70
24	600	43.1	31.3	13.15	9.53

[1] For Sg=1.0, consult manufacturer for heavier insulated pipe support spans. Span recommendations include no provision for weight of (fittings, valves, etc.) or thrusts at branches and turns. Heavy valves and other appurtenances must be supported separately.

[2] Calculated spans are based on ½" mid-span deflections to ensure good appearance and adequate drainage. Total system stresses should always be taken into account by the system design engineer when determining support spans.

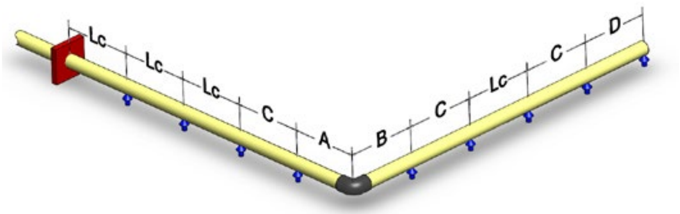
There are seven basic rules to follow when designing piping system supports, anchors, and guides:

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.

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

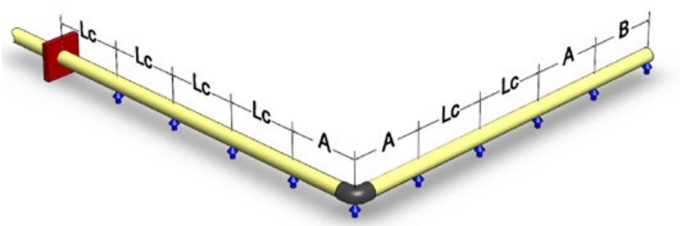
	Span Type	Factor
Lc	Continuous interior or fixed end spans	1.00
C	Second span from supported end or unsupported fitting	0.80
A+B	Sum of unsupported spans at fitting	≤0.75*
D	Simple supported end span	0.67

*For example: If continuous support is 10 ft. (3.04 m), A+B must not exceed 7.5 ft.(2.28 m) (A=3 ft. (0.91 m) and B=4.5 ft. (1.37 m)) would satisfy this condition.



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

	Span Type	Factor
Lc	Continuous interior or fixed end spans	1.00
A	Second span from simple supported end or unsupported fitting	0.80
B	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, Section 3.

Change in Temperature		Pipe Change in Length	
°F	°C	in/100 ft	cm/100 m
25	13.9	0.32	2.67
50	27.8	0.64	5.35
75	41.7	0.96	8.02
100	55.6	1.28	10.7

Testing

Hydrostatic testing is recommended to evaluate the integrity of all new piping installations. For systems operating below the system rating, a test pressure of 1.5 times the system operating pressure is recommended; however, the maximum test pressure must not exceed 1.3 times the lowest pressure rated fiberglass component in the piping system.

The hydro test pressure should be repeated up to ten cycles from 0 psig to the test pressure to provide a high degree of confidence in the piping system. The final pressurization cycle should be allowed to stabilize for 15-30 minutes, then inspected for leaks. Do not attempt to repair leaks while system is pressurized. The hydro test should be repeated after any re-work is performed.

When hydro testing, open high-point vents (if used) to prevent entrapment of air in the lines as the system is slowly filled with water, then close the vents and slowly pressurize to the test pressure. Upon completion of hydro test, relieve the pressure on the system slowly, open vents and any drains to allow for complete drainage of the system.

Water Hammer

Piping systems may be damaged by pressure surges due to water hammer. The use of soft start pumps and slow actuating valves will reduce the magnitude of surge pressures during operation and are highly recommended.

Typical Mechanical Properties

Pipe Property	75°F psi	24°C MPa	200°F psi	93°C MPa	Method
Axial Tensile					
Ultimate Stress	9,530	65.7	6,585	45.4	ASTM D2105
Modulus of Elasticity	1.68 x 10^6	11,584	1.42 x 10^6	9,791	ASTM D2105
Poisson's Ratio, ν_{ah} (ν_{ha})[(1)]	0.35 (0.61)				
Axial Compression					
Ultimate Stress	12,510	86.3	8,560	59.0	ASTM D695
Modulus of Elasticity	0.677 x 10^6	4,668	0.379 x 10^6	2,613	ASTM D695
Beam Bending					
Modulus of Elasticity (Long Term)	2.6 x 10^6	17,927	0.718 x 10^6	4,951	ASTM D2925
Hydrostatic Burst					
Ultimate Hoop Tensile Stress	40,150	277	36,480	252	ASTM D1599
Hydrostatic Hoop Design Stress					
Static 20 Year Life LTHS - 95% LCL	-	-	18,203 - 14,689	125.5 - 101.3	ASTM D2992 - Procedure B
Static 50 Year Life LTHS - 95% LCL	-	-	16,788 - 13,142	115.7 - 90.6	ASTM D2992 - Procedure B
Parallel Plate					
Hoop Modulus of Elasticity	3.02 x 10^6	20,822	-	-	ASTM D2412
Shear Modulus	1.76 x 10^6	12,135	1.63 x 10^6	11,240	-

Typical Physical Properties

Pipe Property	Value	Value	Method
Thermal Conductivity	0.23 BTU/hr•ft•°F	0.4 W/m°C	ASTM D177
Thermal Expansion	10.7 x 10^{-6} in/in/°F	19.3 x 10^{-6} mm/mm/°C	ASTM D696
Absolute Roughness	0.00021 in	0.00053 mm	
Specific Gravity	1.8		ASTM D792

[(1)] ν_{ha} = The ratio of axial strain to hoop strain resulting from stress in the hoop direction.
ν_{ah} = The ratio of hoop strain to axial strain resulting from stress in the axial direction.

[(2)] The differential pressure between internal and external pressure which causes collapse.

[(3)] A 0.67 design factor is recommended for short duration vacuum service. A full vacuum is equal to 14.7 psig (0.101 MPa) differential pressure at sea level.

[(4)] A 0.33 design factor is recommended for sustained (long-term) differential collapse pressure design and operation.

Ultimate Collapse Pressure

Size		Collapse Pressure[(2,3,4)]			
		psig		MPa	
In	mm	75°F	200°F	24°C	93°C
2	50	150	125	1.03	0.86
3	80	150	125	1.03	0.86
4	100	65	50	0.45	0.34
6	150	65	50	0.45	0.34
8	200	65	50	0.45	0.34
10	250	65	50	0.45	0.34
12	300	65	50	0.45	0.34
14	350	65	50	0.45	0.34
16	400	65	50	0.45	0.34
18	450	65	50	0.45	0.34
20	550	65	50	0.45	0.34
24	600	65	50	0.45	0.34

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

CI1265ENG February 2017

Applications

- Chemical Processing Liquids
- Food Processing Liquids
- Potable Water
- Cooling Water
- Condensate Return
- Industrial Wastewater
- Mildly Corrosive Liquids
- Crude Oil & Gas
- Produced Water
- Saltwater
- CO_2

Materials and Construction

Pipe is manufactured by filament winding process using amine-cured epoxy thermosetting resin to impregnate strands of continuous glass filaments. The pipe wall includes an internal resin-rich corrosion barrier.

Green Thread HP 16 products are available in sizes 1”-42” (25-1,050 mm) diameters with a static pressure rating of 232 psig (16 bar). The pipe is designed for continuous operation at 200°F (93°C) serviceable up to 230°F (110°C) by applying a derating factor of 0.76 to all component ratings. Sizes 1”-6” (25-150 mm) are available in 20’ (6 m) lengths and sizes 8”-42” (150-1,050 mm) are available in 19’ or 39’ (6 or 12 m) lengths.

ASTM D-2996 Classification: RTRP-11FX1-3110 for static design basis.

Fittings

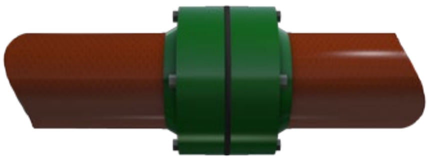
Fittings are manufactured with the same chemical and temperature capabilities as the pipe. Depending on the configurations and size, the fitting construction method will be compression molded, contact molded, fabricated or filament wound. Fitting details are in two documents. Use CI1350 for sizes 1”-16” (25-400 mm)and CI1351 for 18”-42” (450-1050 mm). All fittings may not have the same pressure rating as the pipe. A piping system design pressure rating is governed by the lowest rated component used in the system.

Joining System

- **Bell & Spigot** - Matched-taper joint secured with epoxy adhesive. Self-locking feature resists movement, facilitating joining runs of pipe without waiting for adhesive to cure.
- **Flanged** - Available for all piping systems and diameters; factory assembled or shipped loose for assembly in the field.

View of Joint Illustrations

Bell & Spigot



Flanged

Nominal Dimensional Data

Pipe Size		Inside Diameter		Outside Diameter		Minimum Reinforced Wall Thickness		Liner Thickness		Weight [2]	
in	mm	in	mm	in	mm	in	mm	in	mm	lbs/ft	kg/m
1[1]	25	1.19	30.2	1.34	34.0	0.057	1.45	0.015	0.38	0.2	0.4
1½[1]	40	1.76	44.7	1.91	48.5	0.062	1.57	0.015	0.38	0.4	0.6
2[1]	50	2.15	54.6	2.34	59.4	0.075	1.91	0.020	0.51	0.6	0.8
3[1]	80	3.28	83.3	3.47	88.1	0.075	1.91	0.020	0.51	0.8	1.2
4[1]	100	4.28	108.7	4.47	113.5	0.075	1.91	0.020	0.51	1.1	1.6
6[1]	150	6.35	161.3	6.60	167.6	0.105	2.67	0.020	0.51	2.1	3.2
8	200	8.36	212.3	8.66	220.0	0.127	3.23	0.020	0.51	3.3	4.9
10	250	10.36	263.1	10.72	272.3	0.156	3.96	0.020	0.51	4.9	7.3
12	300	12.29	312.2	12.70	322.6	0.185	4.70	0.020	0.51	7.1	10.6
14	350	14.04	356.6	14.49	368.0	0.204	5.18	0.020	0.51	8.9	13.2
16	400	16.04	407.4	16.55	420.4	0.234	5.94	0.020	0.51	11.6	17.3
18	450	17.82	452.6	18.37	466.6	0.257	6.53	0.020	0.51	14.1	21.0
20	500	19.83	503.7	20.42	518.7	0.273	6.93	0.020	0.51	16.5	24.6
24	600	23.83	605.3	24.53	623.1	0.328	8.33	0.020	0.51	23.7	35.3
30	750	30.03	762.8	30.93	785.6	0.430	10.90	0.020	0.51	38.7	57.6
36	900	36.03	915.2	37.09	942.0	0.510	13.00	0.020	0.51	54.7	81.4
42	1050	42.03	1067.6	43.27	1099.0	0.600	15.20	0.020	0.51	74.8	111.3

[1] Minimum reinforced wall thickness exceeds the requirement for the 232 psi standard rating for HP16. The 1" thru 3" pipe sizes are rated to 435 psig and the 4" and 6" sizes to 300 psig.

[2] Based on the minimum wall.

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 following tables were developed to ensure a design that limits beam mid-span deflection to ½ inch to ensure good appearance and adequate drainage. 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.

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 @ 75°F (23.9°C) with 1.5 specific gravity fluid, maximum support spacing = 21.3 x 0.92 = 19.6 ft.

Maximum Support Spacing for Uninsulated Pipe[1]

Size		Continuous Spans of Pipe[2]			
		feet		meters	
in	mm	75°F	200°F	24°C	93°C
1	25	11.7	8.5	3.6	2.6
1 ½	40	13.3	9.6	4.1	2.9
2	50	14.7	10.6	4.5	3.3
3	80	16.5	12.0	5.0	3.7
4	100	17.7	12.8	5.4	3.9
6	150	21.3	15.4	6.5	4.7
8	200	24.0	17.3	7.3	5.3
10	250	26.6	19.3	8.1	5.9
12	300	29.0	21.0	8.8	6.4
14	350	30.7	22.2	9.4	6.8
16	400	32.8	23.8	10.1	7.3
18	450	34.5	25.0	10.5	7.6
20	500	36.0	26.1	11.0	8.0
24	600	39.5	28.6	12.0	8.7
30	800	44.7	32.4	13.6	9.9
36	900	48.9	35.4	14.9	10.8
42	1050	52.9	38.3	16.1	11.7

[1] For Sg=1.0, consult manufacturer for heavier insulated pipe support spans. Span recommendations include no provision for weight of (fittings, valves, etc.) or thrusts at branches and turns. Heavy valves and other appurtenances must be supported separately.

[2] Calculated spans are based on ½" mid-span deflections to ensure good appearance and adequate drainage. Total system stresses should always be taken into account by the system design engineer when determining support spans.

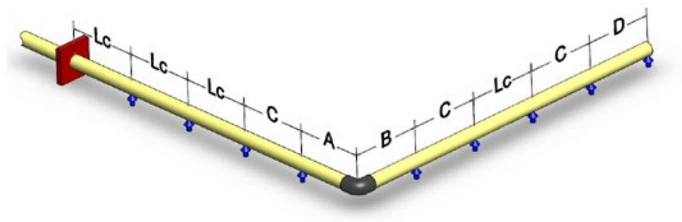
There are seven basic guidelines to follow when designing an above ground piping system:

1. Do not exceed the recommended support span.
2. Support heavy valves and in-line equipment independently.
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 on pipe and fittings.
7. Provide adequate axial and lateral restraint to ensure line stability during rapid changes in flow (water hammer).

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

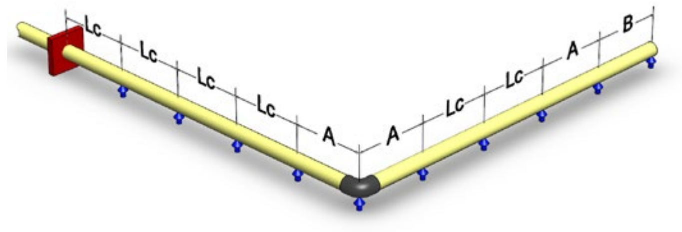
	Span Type	Factor
Lc	Continuous interior or fixed end spans	1.00
C	Second span from supported end or unsupported fitting	0.80
A+B	Sum of unsupported spans at fitting	≤0.75*
D	Simple supported end span	0.67

*For example: If continuous support is 10 ft. (3.04 m), A+B must not exceed 7.5 ft.(2.28 m) (A=3 ft. (0.91 m) and B=4.5 ft. (1.37 m)) would satisfy this condition.



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

	Span Type	Factor
Lc	Continuous interior or fixed end spans	1.00
A	Second span from simple supported end or unsupported fitting	0.80
B	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, Section 3.

Change in Temperature		Pipe Change in Length	
°F	°C	in/100 ft	cm/100 m
25	13.9	0.41	3.45
50	27.8	0.83	6.90
75	41.7	1.24	10.35
100	55.6	1.66	13.80

Testing

Hydrostatic testing is recommended to evaluate the integrity of all new piping installations. For systems operating below the system rating, a test pressure of 1.5 times the system operating pressure is recommended; however, the maximum test pressure must not exceed 1.3 times the lowest pressure rated fiberglass component in the piping system.

The hydro test pressure should be repeated up to ten cycles from 0 psig to the test pressure to provide a high degree of confidence in the piping system. The final pressurization cycle should be allowed to stabilize for 15-30 minutes, then inspected for leaks. Do not attempt to repair leaks while system is pressurized. The hydro test should be repeated after any re-work is performed.

When hydro testing, open high-point vents (if used) to prevent entrapment of air in the lines as the system is slowly filled with water, then close the vents and slowly pressurize to the test pressure. Upon completion of hydro test, relieve the pressure on the system slowly, open vents and any drains to allow for complete drainage of the system.

Water Hammer

Piping systems may be damaged by pressure surges due to water hammer. The use of soft start pumps and slow actuating valves will reduce the magnitude of surge pressures during operation and are highly recommended.

Typical Mechanical Properties

Pipe Property	75°F	24°C	200°F	93°C	Method
	psi	MPa	psi	MPa	
Axial Tensile					
Ultimate Stress	9,530	65.7	6,585	45.4	ASTM D2105
Modulus of Elasticity	1.68 x 10^6	11,584	1.42 x 10^6	9,791	ASTM D2105
Poisson's Ratio, ν_{ah} (ν_{ha})[(1)]	0.35 (0.61)				
Axial Compression					
Ultimate Stress	12,510	86.3	8,560	59.0	ASTM D695
Modulus of Elasticity	0.677 x 10^6	4,668	0.379 x 10^6	2,613	ASTM D695
Beam Bending					
Modulus of Elasticity (Long Term)	2.6 x 10^6	17,927	0.718 x 10^6	4,951	ASTM D2925
Hydrostatic Burst					
Ultimate Hoop Tensile Stress	40,150	277	36,480	252	ASTM D1599
Hydrostatic Hoop Design Stress					
Static 20 Year Life LTHS - 95% LCL	-	-	20,787 - 17,155	143.3 - 118.3	ASTM D2992 - Procedure B
Static 50 Year Life LTHS - 95% LCL	-	-	19,057 - 15,302	131.4 - 105.5	ASTM D2992 - Procedure B
Parallel Plate					
Hoop Modulus of Elasticity	3.02 x 10^6	20,822	-	-	ASTM D2412
Shear Modulus	1.76 x 10^6	12,135	1.63 x 10^6	11,240	

Typical Physical Properties

Pipe Property	Value	Value	Method
Thermal Conductivity	0.23 BTU/hr•ft•°F	0.4 W/m°C	ASTM D177
Thermal Expansion	13.8 x 10^{-6} in/in/°F	24.8 x 10^{-6} mm/mm/°C	ASTM D696
Absolute Roughness	0.00021 in	0.00053 mm	
Specific Gravity	1.8		ASTM D792

[(1)] ν_{ha} = The ratio of axial strain to hoop strain resulting from stress in the hoop direction.
ν_{ah} = The ratio of hoop strain to axial strain resulting from stress in the axial direction.

[(2)] The differential pressure between internal and external pressure which causes collapse.

[(3)] A 0.67 design factor is recommended for short duration vacuum service. A full vacuum is equal to 14.7 psig (0.101 MPa) differential pressure at sea level.

[(4)] A 0.33 design factor is recommended for sustained (long-term) differential collapse pressure design and operation.

Ultimate Collapse Pressure

Size		Collapse Pressure[(2,3,4)]			
		psig		MPa	
in	mm	75°F	200°F	24°C	93°C
1	25	550	430	3.79	2.96
1½	40	340	260	2.34	1.79
2	50	330	250	2.28	1.72
3	80	120	90	0.827	0.621
4	100	49	35	0.338	0.241
6	150	39	28	0.269	0.193
8	200	26	19	0.179	0.131
10	250	26	19	0.179	0.131
12	300	26	19	0.179	0.131
14	350	25	17	0.172	0.117
16	400	23	16	0.159	0.110
18	450	22	15	0.152	0.103
20	550	17	12	0.117	0.083
24	600	17	12	0.117	0.083
30	750	20	14	0.138	0.097
36	900	20	14	0.138	0.097
42	1050	20	14	0.138	0.097

Fiber Glass Systems
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San Antonio, Texas 78232 USA
Phone: 210 477 7500
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CLASSIFIED UL WATER QUALITY
ANSI/NSF 61
Drinking Water System
Components 35GH
Water Contact Temp: 23C

CI1300ENG February 2016

Green Thread™ HP 25 Product Data

Applications

- Dilute Acids
- Caustics
- Industrial Waste
- Hot Water
- Produced Water
- Condensate Return

Materials and Construction

Pipe manufactured by filament winding process using amine-cured epoxy thermosetting resin to impregnate strands of continuous glass filaments. The pipe wall includes an internal resin-rich corrosion barrier.

Pipe is available in 1”-24” (25-600 mm) diameters with pressure ratings up to 360 psig (25 bar). The pipe and fittings are designed for continuous operation at 200°F (93°C) and are serviceable up to 230°F (110°C) by applying a derating factor of 0.76 to all component ratings. Pipe diameters of 1”-6” (25-150 mm) are available in 20’ (6 m) random lengths and the 8”-24” (150 -600 mm) diameters are in 19’ or 39’ (6 or 12 m) random lengths.

ASTM D-2996 Classifiction: RTRP - 11FX1-3110 for static design basis

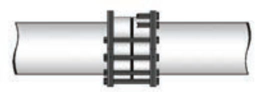
Fittings

Fittings are manufactured with the same chemical and temperature capabilities as the pipe. Depending on the configurations and size, the fitting construction method will be compression molded, contact molded, fabricated or filament wound. Fitting details are in document CI1370.

Joining Systems

Bell & Spigot
Matched-taper joint secured with epoxy adhesive. Self-locking feature resists movement, facilitating joining runs of pipe without waiting for adhesive to cure.

Flanged
Available for all piping systems and diameters; factory assembled are shipped loose for assembly in the field.



Nominal Dimensional Data

Pipe Size		I.D.		O.D.		Minimum Reinforced Wall Thickness		Liner Thickness		Weight	
in	mm	in	mm	in	mm	in	mm	in	mm	lbs/ft	kg/m
1 (1)	25	1.19	30.3	1.35	34.3	0.057	1.45	0.015	0.38	0.26	0.39
1½ (1)	40	1.76	44.7	1.93	49.0	0.062	1.57	0.015	0.38	0.4	0.61
2 (1)	50	2.15	54.7	2.36	59.9	0.075	1.91	0.020	0.51	0.6	0.92
3 (1)	75	3.28	83.3	3.49	88.7	0.075	1.91	0.020	0.51	0.9	1.34
4	100	4.28	109	4.52	115	0.085	2.16	0.020	0.51	1.4	2.08
6	150	6.35	161	6.68	170	0.125	3.18	0.020	0.51	2.8	4.17
8	200	8.36	212	8.78	223	0.164	4.17	0.020	0.51	5.0	7.44
10	250	10.36	263	10.87	276	0.203	5.16	0.020	0.51	7.5	11.16
12	300	12.29	312	12.88	327	0.240	6.10	0.020	0.51	10.4	15.48
14	350	14.04	357	14.71	374	0.274	6.96	0.020	0.51	13.5	20.09
16	400	16.04	407	16.80	427	0.313	7.95	0.020	0.51	17.5	26.04
18	450	17.82	453	18.65	474	0.347	8.81	0.020	0.51	20.4	30.36
20	500	19.83	504	20.75	527	0.386	9.80	0.020	0.51	25.1	37.35
24	600	23.83	605	24.93	633	0.464	11.8	0.020	0.51	36.0	53.57

(1) Minimum reinforced wall thickness exceeds the requirement for the 25 Bar class and may be operated up to 30 Bar (435 psi). Note: System rating is determined by pressure ratings of fittings used in the piping system. See document CI1370 for individual fitting pressure ratings.

Typical Mechanical Properties

Property	75°F psi	24°C MPa	200°F psi	93°C MPa
Axial Tensile - ASTM D2105				
Ultimate Stress	9,530	65.7	6,585	45.4
Modulus of Elasticity	1.68×10^6	11,584	1.42×10^6	9,791
Poisson's Ratio $\nu_{a/h}$ ($\nu_{h/a}$)	0.35 (0.61)			
Axial Compression – ASTM D695				
Ultimate Stress	12,510	86.3	8,560	59.0
Modulus of Elasticity	0.677×10^6	4,668	0.379×10^6	2,613
Beam Bending – ASTM D2925				
Modulus of Elasticity (Long Term)	2.6×10^6	17,927	0.718×10^6	4,951
Hydrostatic Burst – ASTM D1599				
Ultimate Hoop Tensile Stress	40,150	277	36,480	252
Hydrostatic Hoop Design Stress ASTM D2992 - Procedure B				
Static 20 Year Life LTHS - 95% LCL			20,787 - 17,155	143.3 - 118.3
Static 50 Year Life LTHS - 95% LCL			19,057 - 15,302	131.4 - 105.5
Parallel Plate - ASTM D 2412				
Hoop Modulus of Elasticity	3.02×10^6	20,822		

Typical Physical Properties

Thermal Expansion Coefficient - ASTM D696	8.5×10^{-6} in/in/°F	15.3×10^{-6} mm/mm/°C
Thermal Conductivity – ASTM D177	0.23 BTU/hr-ft-°F	0.4 W/m-°C
Specific Gravity – ASTM D792	1.8	
Absolute Surface Roughness	0.00021 in	0.00053 mm

Ultimate Collapse Pressure

Size		Collapse Pressure(1,2,3) psig		MPa	
in	mm	75°F	200°F	24°C	93°C
1	25	576	451	3.97	3.11
1½	40	350	269	2.41	1.86
2	50	447	346	3.08	2.39
3	80	125	93	0.86	0.64
4	100	80	59	0.55	0.41
6	150	75	55	0.52	0.38
8	200	77	57	0.53	0.39
10	250	77	56	0.53	0.39
12	300	76	56	0.52	0.38
14	350	76	56	0.52	0.38
16	400	76	56	0.52	0.38
18	450	75	55	0.52	0.38
20	500	75	55	0.52	0.38
24	600	75	55	0.52	0.38

(1) The differential pressure between internal and external pressure which causes collapse.

(2) A 0.67 design factor is recommended for short duration vacuum service. A full vacuum is equal to 14.7 psig (0.101 MPa) differential pressure at sea level.

(3) A 0.33 design factor is recommended for sustained (long-term) differential collapse pressure design and operation.

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 1/2 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 guidelines to follow when designing an above ground piping system:

1. Do not exceed the recommended support span.
2. Support heavy valves and in-line equipment independently.
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 loading to minimize bending stresses on pipe and fittings.
7. Provide adequate axial and lateral restraint to ensure line stability during rapid changes in flow (water hammer).

Maximum Support Spacing for Pipe[1]

Size		Continuous Spans of Pipe[2]			
		ft		m	
in	mm	75°F	200°F	24°C	93°C
1	25	11.6	8.4	3.54	2.57
1½	40	13.2	9.6	4.03	2.92
2	50	14.6	10.6	4.44	3.22
3	80	16.4	11.9	5.01	3.63
4	100	18.2	13.2	5.54	4.02
6	150	22.1	16.0	6.73	4.88
8	200	25.3	18.3	7.70	5.58
10	250	28.1	20.4	8.58	6.22
12	300	30.6	22.2	9.33	6.76
14	350	32.7	23.7	9.97	7.23
16	400	35.0	25.3	10.65	7.72
18	450	36.9	26.8	11.25	8.16
20	500	38.9	28.2	11.86	8.60
24	600	42.7	30.9	13.01	9.43

[1] Consult manufacturer for heavier insulated pipe support spacing.
[2] Max. mid span deflection ½" (12.7 mm) with specific gravity 1.0.

Support Spacing vs. Specific Gravity

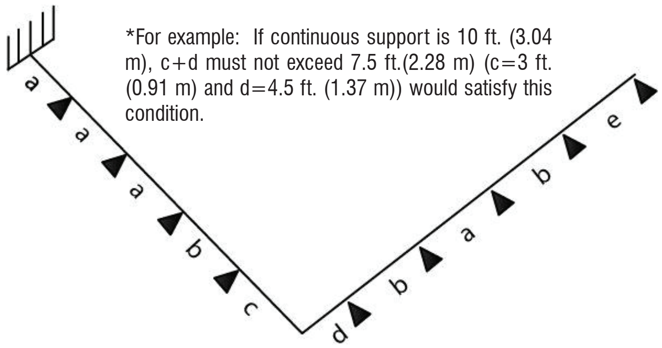
Specific Gravity	2.00	1.50	1.25	1.00	0.75
Multiplier	0.86	0.92	0.96	1.00	1.07

Example: 8" pipe @ 75°F with 1.5 specific gravity fluid, maximum support spacing = 25.3 x 0.92 = 23.3 ft.

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

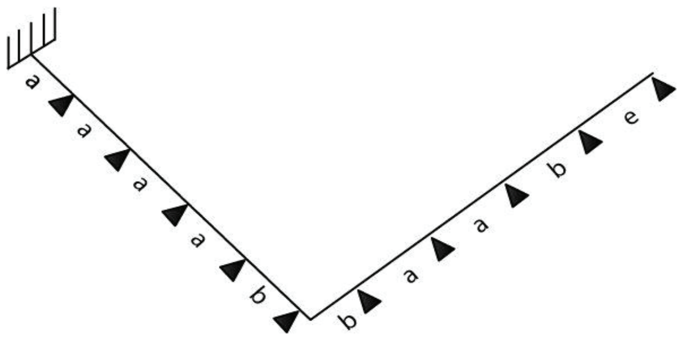
	Span Type	Factor
a	Continuous interior or fixed end spans	1.00
b	Second span from supported end or unsupported fitting	0.80
c+d	Sum of unsupported spans at fitting	≤0.75*
e	Simple supported end span	0.67

*For example: If continuous support is 10 ft. (3.04 m), c+d must not exceed 7.5 ft.(2.28 m) (c=3 ft. (0.91 m) and d=4.5 ft. (1.37 m)) 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' ENG1000 "Engineering and Piping Design Guide", Section 3.

Testing

Hydrostatic testing is recommended to evaluate the integrity of all new piping installations. For systems operating below the system rating, a test pressure of 1.5 times the system operating pressure is recommended; however, the maximum test pressure must not exceed 1.25 times the lowest pressure rated fiberglass component in the piping system.

The hydro test pressure should be repeated up to ten cycles from 0 psig to the test pressure to provide a high degree of confidence in the piping system. The final pressurization cycle should be allowed to stabilize for 15-30 minutes, then inspected for leaks. Do not attempt to repair leaks while system is pressurized. The hydro test should be repeated after any re-work is performed.

When hydro testing, open high-point vents (if used) to prevent entrapment of air in the lines as the system is slowly filled with water, then close the vents and slowly pressurize to the test pressure. Upon completion of hydro test, relieve the pressure on the system slowly, open vents and any drains to allow for complete drainage of the system.

Water Hammer

Piping systems may be damaged by pressure surges due to water hammer. The use of soft start pumps and slow actuating valves will reduce the magnitude of surge pressures during operation and are highly recommended.

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

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NOV Fiber Glass Systems

CI1325 May 2013

Applications

- Chemical Processing Liquids
- Food Processing Liquids
- Potable Water
- Cooling Water
- Condensate Return
- Industrial Wastewater
- Mildly Corrosive Liquids
- Crude Oil & Gas
- Produced Water
- Saltwater
- CO_2

Materials and Construction

Pipe manufactured by filament winding process using amine-cured epoxy thermosetting resin to impregnate strands of continuous glass filaments. The pipe wall includes an internal resin-rich corrosion barrier.

Pipe is available in 1"-24" (25-600 mm) diameters with pressure ratings up to 290 psig (20 bar). The pipe and fittings have an operating temperature of 200°F (93°C) serviceable up to 230°F (110°C) by applying a derating factor of 0.76 to all component ratings. Pipe diameters of 1"-6" (25-150 mm) are available in 20' (6 m) random lengths and the 8"-24" (150 -600 mm) diameters are in 19' or 39' (6 or 12 m) random lengths.

ASTM D-2996 Classification: RTRP - 11FX1-3110 for static design basis.

Fittings

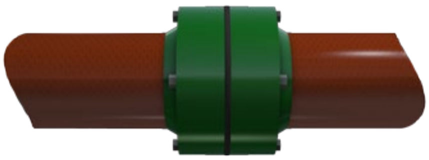
Fittings are manufactured with the same chemical/temperature capabilities as the pipe. Depending on the particular part and size, fittings will be compression molded, contact molded, hand fabricated or filament wound. This piping system is designed to be used with Green Thread HP25 epoxy fittings.

Joining System

- **Bell & Spigot** - Matched-taper joint secured with epoxy adhesive. Self-locking feature resists movement, facilitating joining runs of pipe without waiting for adhesive to cure.
- **Flanged** - Available for all piping systems and diameters; factory assembled or shipped loose for assembly in the field.

View of Joint Illustrations

Bell & Spigot



Flanged

Nominal Dimensional Data

Pipe Size		Inside Diameter		Outside Diameter		Minimum Reinforced Wall Thickness		Liner Thickness		Weight[2]	
in	mm	in	mm	in	mm	in	mm	in	mm	lbs/ft	kg/m
1[1]	25	1.19	30.2	1.34	34.0	0.057	1.45	0.015	0.38	0.2	0.4
1½[1]	40	1.76	44.7	1.91	48.6	0.062	1.57	0.015	0.38	0.4	0.6
2[1]	50	2.15	54.0	2.34	59.5	0.075	1.91	0.020	0.51	0.6	0.8
3[1]	80	3.28	83.0	3.47	88.1	0.075	1.91	0.020	0.51	0.8	1.2
4	100	4.28	109.0	4.47	114.0	0.075	1.91	0.020	0.51	1.1	1.6
6	150	6.35	161.0	6.60	168.0	0.105	2.67	0.020	0.51	2.1	3.2
8	200	8.36	212.0	8.66	220.0	0.131	3.33	0.020	0.51	3.6	5.4
10	250	10.36	263.0	10.73	273.0	0.162	4.11	0.020	0.51	5.3	7.9
12	300	12.29	312.0	12.71	323.0	0.192	4.88	0.020	0.51	7.4	11.0
14	350	14.04	367.0	14.52	369.0	0.219	5.56	0.020	0.51	9.5	14.1
16	400	16.04	407.0	16.58	421.0	0.250	6.35	0.020	0.51	12.3	18.3
18	450	17.82	453.0	18.42	468.0	0.278	7.06	0.020	0.51	15.8	23.5
20	500	19.83	504.0	20.49	520.0	0.309	7.85	0.020	0.51	18.6	27.7
24	600	23.83	605.0	24.61	625.0	0.371	9.42	0.020	0.51	26.7	39.7

(1) Minimum wall exceeds requirement for 20 Bar class, may be rated higher refer to fitting ratings.

(2) Based on the minimum wall.

Supports

Proper pipe support spacing depends on the temperature and weight of the fluid in the pipe. The support spans are based on unrestrained continuous beam theory using 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 to ensure good appearance and adequate drainage. 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.

Support Spacing vs. Specific Gravity

Specific Gravity	2.00	1.50	1.25	1.00	0.75
Multiplier	0.85	0.91	0.95	1.00	1.06

Example: 8” pipe @ 75°F (23.9°C) with 1.5 specific gravity fluid, maximum support spacing = 24.1x 0.91 = 21.93 ft.

Maximum Support Spacing for Pipe[1]

Size		Continuous Spans of Pipe[2]			
		feet		meters	
in	mm	75°F	200°F	24°C	93°C
1	25	11.7	8.4	3.6	2.6
1 ½	40	13.3	9.6	4.1	2.9
2	50	14.7	10.6	4.5	3.2
3	80	16.5	11.9	5.0	3.6
4	100	17.7	12.8	5.4	3.9
6	150	21.3	15.4	6.5	4.7
8	200	24.1	17.5	7.4	5.3
10	250	26.8	19.4	8.2	5.9
12	300	29.2	21.2	8.9	6.5
14	350	31.2	22.6	9.5	6.9
16	400	33.4	24.2	10.2	7.4
18	450	35.1	25.5	10.7	7.8
20	500	37.1	26.9	11.3	8.2
24	600	40.7	29.5	12.4	9.0

(1) For Sg=1.0, consult manufacturer for heavier insulated pipe support spans. Span recommendations include no provision for weight of (fittings, valves, etc.) or thrusts at branches and turns. Heavy valves and other appurtenances must be supported separately.

(2) Calculated spans are based on ½” mid-span deflections to ensure good appearance and adequate drainage. Total system stresses should always be taken into account by the system design engineer when determining support spans.

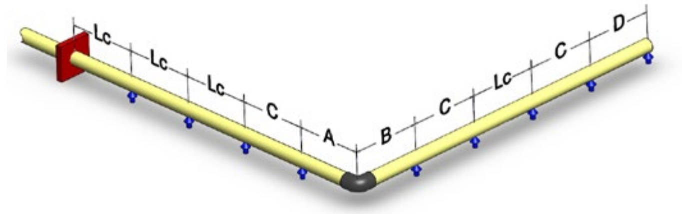
There are seven basic guidelines to follow when designing an above ground piping system:

1. Do not exceed the recommended support span.
2. Support heavy valves and in-line equipment independently.
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 loading to minimize bending stresses on pipe and fittings.
7. Provide adequate axial and lateral restraint to ensure line stability during rapid changes in flow (water hammer).

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

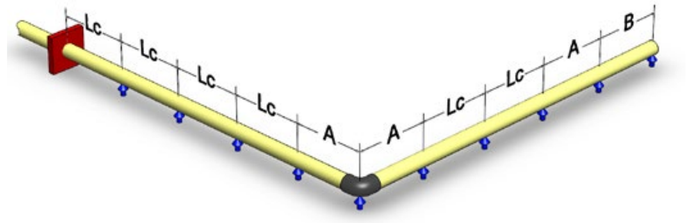
	Span Type	Factor
Lc	Continuous interior or fixed end spans	1.00
C	Second span from supported end or unsupported fitting	0.80
A+B	Sum of unsupported spans at fitting	≤0.75*
D	Simple supported end span	0.67

*For example: If continuous support is 10 ft. (3.04 m), A+B must not exceed 7.5 ft.(2.28 m) (A=3 ft. (0.91 m) and B=4.5 ft. (1.37 m)) would satisfy this condition.



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

	Span Type	Factor
Lc	Continuous interior or fixed end spans	1.00
A	Second span from simple supported end or unsupported fitting	0.80
B	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, Section 3.

Change in Temperature		Pipe Change in Length	
°F	°C	in/100 ft	cm/100 m
25	13.9	0.41	3.45
50	27.8	0.83	6.90
75	41.7	1.24	10.35
100	55.6	1.66	13.80

Testing

Hydrostatic testing is recommended to evaluate the integrity of all new piping installations. For systems operating below the system rating, a test pressure of 1.5 times the system operating pressure is recommended; however, the maximum test pressure must not exceed 1.5 times the lowest pressure rated fiberglass component in the piping system.

The hydro test pressure should be repeated up to ten cycles from 0 psig to the test pressure to provide a high degree of confidence in the piping system. The final pressurization cycle should be allowed to stabilize for 15-30 minutes, then inspected for leaks. Do not attempt to repair leaks while system is pressurized. The hydro test should be repeated after any re-work is performed.

When hydro testing, open high-point vents (if used) to prevent entrapment of air in the lines as the system is slowly filled with water, then close the vents and slowly pressurize to the test pressure. Upon completion of hydro test, relieve the pressure on the system slowly, open vents and any drains to allow for complete drainage of the system.

Water Hammer

Piping systems may be damaged by pressure surges due to water hammer. The use of soft start pumps and slow actuating valves will reduce the magnitude of surge pressures during operation and are highly recommended.

Typical Mechanical Properties

Pipe Property		75°F	24°C	200°F	93°C	Method
		psi	MPa	psi	MPa	
Axial Tensile						
Ultimate Stress		9,530	65.7	6,585	45.4	ASTM D2105
Modulus of Elasticity		1.68 x 10^6	11,584	1.42 x 10^6	9,791	ASTM D2105
Poisson's Ratio, ν_{ah} (ν_{ha})[1]		0.35 (0.61)				
Axial Compression						
Ultimate Stress		12,510	86.3	8,560	59.0	ASTM D695
Modulus of Elasticity		0.677 x 10^6	4,668	0.379 x 10^6	2,613	ASTM D695
Beam Bending						
Modulus of Elasticity (Long Term)		2.6 x 10^6	17,927	0.718 x 10^6	4.951	ASTM D2925
Hydrostatic Burst						
Ultimate Hoop Tensile Stress		40,150	277	36,480	252	ASTM D1599
Hydrostatic Hoop Design Stress						
Static 20 Year Life	LTHS - 95% LCL	-	-	20,787 - 17,155	143.3 - 118.3	ASTM D2992 - Procedure B
Static 50 Year Life	LTHS - 95% LCL	-	-	19,057 - 15,302	131.4 - 105.5	ASTM D2992 - Procedure B
Parallel Plate						
Hoop Modulus of Elasticity		3.02 x 10^6	20,822	-	-	ASTM D2412
Shear Modulus		1.76 x 10^6	12,135	1.63 x 10^6	11,240	

Typical Physical Properties

Pipe Property	Value	Value	Method
Thermal Conductivity	0.23 BTU/hr•ft•°F	0.4 W/m°C	ASTM D177
Thermal Expansion	13.8 x 10^{-6} in/in °F	24.8 x 10^{-6} mm/mm °C	ASTM D696
Absolute Roughness	0.00021 in	0.00053 mm	
Specific Gravity	1.8		ASTM D792

[1] ν_{ha} = The ratio of axial strain to hoop strain resulting from stress in the hoop direction.
ν_{ah} = The ratio of hoop strain to axial strain resulting from stress in the axial direction.

[2] The differential pressure between internal and external pressure which causes collapse.

[3] A 0.67 design factor is recommended for short duration vacuum service. A full vacuum is equal to 14.7 psig (0.101 MPa) differential pressure at sea level.

[4] A 0.33 design factor is recommended for sustained (long-term) differential collapse pressure design and operation.

Ultimate Collapse Pressure

Size		Collapse Pressure[2,3,4]			
		psig		MPa	
in	mm	75°F	200°F	24°C	93°C
1	25	550	430	3.79	2.96
1 ½	40	340	260	2.34	1.79
2	50	330	250	2.28	1.72
3	80	120	90	0.83	0.62
4	100	49	35	0.34	0.24
6	150	40	29	0.28	0.20
8	200	31	23	0.21	0.16
10	250	31	23	0.21	0.16
12	300	31	23	0.21	0.16
14	350	31	23	0.21	0.16
16	400	31	23	0.21	0.16
18	450	31	23	0.21	0.16
20	550	31	23	0.21	0.16
24	600	31	23	0.21	0.16

Fiber Glass Systems
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CI1320ENG February 2017

Applications

- Chemical Processing Liquids
- Food Processing Liquids
- Potable Water
- Cooling Water
- Condensate Return
- Industrial Wastewater
- Mildly Corrosive Liquids
- Crude Oil & Gas
- Produced Water
- Saltwater
- CO_2

Materials and Construction

Pipe manufactured by filament winding process using amine-cured epoxy thermosetting resin to impregnate strands of continuous glass filaments. The pipe wall includes an internal resin-rich corrosion barrier.

Pipe is available in 1”-24” (25-600 mm) diameters with pressure ratings up to 362 psig (25 bar). The pipe and fittings have an operating temperature of 200°F (93°C) serviceable up to 230°F (110°C) by applying a derating factor of 0.76 to all component ratings. Pipe diameters of 1”-6” (25-150 mm) are available in 20’ (6 m) random lengths and the 8”-24” (150 -600 mm) diameters are in 19’ or 39’ (6 or 12 m) random lengths.

ASTM D-2996 Classification: RTRP - 11FX1-3110 for static design basis.

Fittings

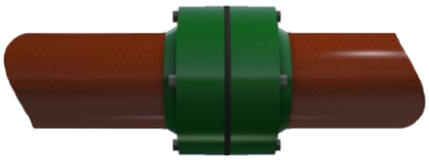
Fittings are manufactured with the same chemical and temperature capabilities as the pipe. Depending on the particular part and size, fittings will be compression molded, contact molded, hand fabricated or filament wound. Fitting details are in document CI1360.

Joining System

- **Bell & Spigot** - Matched-taper joint secured with epoxy adhesive. Self-locking feature resists movement, facilitating joining runs of pipe without waiting for adhesive to cure.
- **Flanged** - Available for all piping systems and diameters; factory assembled or shipped loose for assembly in the field.

View of Joint Illustrations

Bell & Spigot



Flanged

Nominal Dimensional Data

Pipe Size		Inside Diameter		Outside Diameter		Minimum Reinforced Wall Thickness		Liner Thickness		Weight [2]	
in	mm	in	mm	in	mm	in	mm	in	mm	lbs/ft	kg/m
1[1]	25	1.19	30.2	1.34	34.0	0.057	1.45	0.015	0.38	0.3	0.4
1½[1]	40	1.76	44.7	1.91	49.0	0.062	1.57	0.015	0.38	0.4	0.6
2[1]	50	2.15	54.0	2.34	59.5	0.075	1.91	0.020	0.51	0.6	0.8
3[1]	80	3.28	83.0	3.47	88.1	0.075	1.91	0.020	0.51	0.8	1.2
4	100	4.28	109.0	4.49	114.0	0.085	2.16	0.020	0.51	1.2	1.8
6	150	6.35	161.0	6.64	169.0	0.125	3.18	0.020	0.51	2.5	3.7
8	200	8.36	212.0	8.73	222.0	0.164	4.17	0.020	0.51	4.2	6.3
10	250	10.36	263.0	10.81	275.0	0.203	5.16	0.020	0.51	6.3	9.4
12	300	12.29	312.0	12.81	327.0	0.240	6.10	0.020	0.51	8.7	13.0
14	350	14.04	367.0	14.63	372.0	0.274	6.96	0.020	0.51	11.3	16.8
16	400	16.04	407.0	16.71	424.0	0.313	7.95	0.020	0.51	14.6	21.7
18	450	17.82	453.0	18.55	471.0	0.347	8.81	0.020	0.51	17.9	26.6
20	500	19.83	504.0	20.64	524.0	0.386	9.80	0.020	0.51	22.1	32.9
24	600	23.83	605.0	24.80	630.0	0.464	11.80	0.020	0.51	32.0	47.6

[1] Minimum reinforced wall thickness exceeds the requirement for the 25 Bar class and may be operated up to 30 Bar (435 psi).

[2] Based on the minimum wall.

NOTE: System rating is determined by pressure ratings of fittings used in the piping system. See document CI1370 for individual fitting pressure ratings.

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 following tables were developed to ensure a design that limits beam mid-span deflection to ½ inch to ensure good appearance and adequate drainage. 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.

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: 8" pipe @ 75°F (23.9°C) with 1.5 specific gravity fluid, maximum support spacing = 25.4 x 0.92 = 23.4 ft.

Maximum Support Spacing for Pipe[1]

Size		Continuous Spans of Pipe[2]			
		feet		meters	
in	mm	75°F	200°F	24°C	93°C
1	25	11.7	8.5	3.6	2.6
1 ½	40	13.3	9.7	4.1	2.9
2	50	14.7	10.7	4.5	3.3
3	80	16.5	12.0	5.0	3.7
4	100	18.2	13.2	5.5	4.0
6	150	22.2	16.1	6.8	4.9
8	200	25.4	18.4	7.8	5.6
10	250	28.3	20.5	8.6	6.3
12	300	30.8	22.3	9.4	6.8
14	350	32.9	23.8	10.0	7.3
16	400	35.2	25.5	10.7	7.8
18	450	37.1	26.9	11.3	8.2
20	500	39.1	28.3	11.9	8.6
24	600	42.8	31.0	13.1	9.5

[1] For Sg=1.0, consult manufacturer for heavier insulated pipe support spans. Span recommendations include no provision for weight of (fittings, valves, etc.) or thrusts at branches and turns. Heavy valves and other appurtenances must be supported separately.

[2] Calculated spans are based on ½" mid-span deflections to ensure good appearance and adequate drainage. Total system stresses should always be taken into account by the system design engineer when determining support spans.

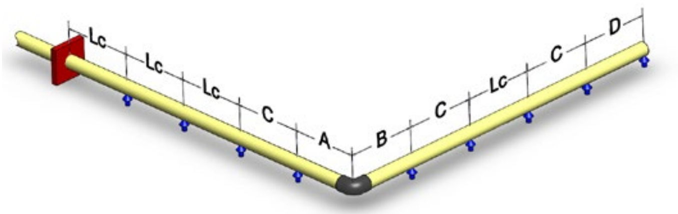
There are seven basic guidelines to follow when designing an above ground piping system:

1. Do not exceed the recommended support span.
2. Support heavy valves and in-line equipment independently.
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 loading to minimize bending stresses on pipe and fittings.
7. Provide adequate axial and lateral restraint to ensure line stability during rapid changes in flow (water hammer).

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

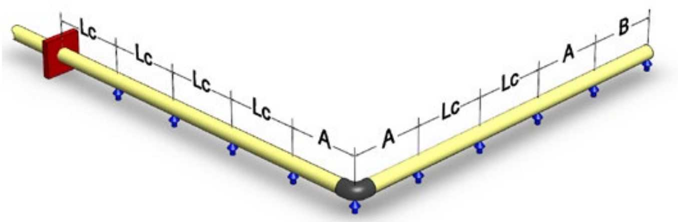
	Span Type	Factor
Lc	Continuous interior or fixed end spans	1.00
C	Second span from supported end or unsupported fitting	0.80
A+B	Sum of unsupported spans at fitting	≤0.75*
D	Simple supported end span	0.67

*For example: If continuous support is 10 ft. (3.04 m), A+B must not exceed 7.5 ft.(2.28 m) (A=3 ft. (0.91 m) and B=4.5 ft. (1.37 m)) would satisfy this condition.



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

	Span Type	Factor
Lc	Continuous interior or fixed end spans	1.00
A	Second span from simple supported end or unsupported fitting	0.80
B	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, Section 3.

Change in Temperature		Pipe Change in Length	
°F	°C	in/100 ft	cm/100 m
25	13.9	0.26	0.65
50	27.8	0.51	1.35
75	41.7	0.77	1.94
100	55.6	1.02	2.59
125	69.4	1.28	3.24

Testing

Hydrostatic testing is recommended to evaluate the integrity of all new piping installations. For systems operating below the system rating, a test pressure of 1.5 times the system operating pressure is recommended; however, the maximum test pressure must not exceed 1.3 times the lowest pressure rated fiberglass component in the piping system.

The hydro test pressure should be repeated up to ten cycles from 0 psig to the test pressure to provide a high degree of confidence in the piping system. The final pressurization cycle should be allowed to stabilize for 15-30 minutes, then inspected for leaks. Do not attempt to repair leaks while system is pressurized. The hydro test should be repeated after any re-work is performed.

When hydro testing, open high-point vents (if used) to prevent entrapment of air in the lines as the system is slowly filled with water, then close the vents and slowly pressurize to the test pressure. Upon completion of hydro test, relieve the pressure on the system slowly, open vents and any drains to allow for complete drainage of the system.

Water Hammer

Piping systems may be damaged by pressure surges due to water hammer. The use of soft start pumps and slow actuating valves will reduce the magnitude of surge pressures during operation and are highly recommended.

Typical Mechanical Properties

Pipe Property	75°F	24°C	200°F	93°C	Method
	psi	MPa	psi	MPa	
Axial Tensile					
Ultimate Stress	9,530	65.7	6,585	45.4	ASTM D2105
Modulus of Elasticity	1.68×10^6	11,584	1.42×10^6	9,791	ASTM D2105
Poisson's Ratio, ν_{ah} (ν_{ha})[1]	0.35 (0.61)				
Axial Compression					
Ultimate Stress	12,510	86.3	8,560	59.0	ASTM D695
Modulus of Elasticity	0.677×10^6	4,668	0.379×10^6	2,613	ASTM D695
Beam Bending					
Modulus of Elasticity (Long Term)	2.6×10^6	17,927	0.718×10^6	4.951	ASTM D2925
Hydrostatic Burst					
Ultimate Hoop Tensile Stress	40,150	277	36,480	252	ASTM D1599
Hydrostatic Hoop Design Stress					
Static 20 Year Life LTHS - 95% LCL	-	-	20,787 - 17,155	143.3 - 118.3	ASTM D2992 - Procedure B
Static 50 Year Life LTHS - 95% LCL	-	-	19,057 - 15,302	131.4 - 105.5	ASTM D2992 - Procedure B
Parallel Plate					
Hoop Modulus of Elasticity	3.02×10^6	20,822	-	-	ASTM D2412
Shear Modulus	1.76×10^6	12,135	1.63×10^6	11,240	-

Typical Physical Properties

Pipe Property	Value	Value	Method
Thermal Conductivity	0.23 BTU/hr•ft•°F	0.4 W/m°C	ASTM D177
Thermal Expansion	8.5×10^{-6} in/in °F	15.3×10^{-6} mm/mm °C	ASTM D696
Absolute Roughness	0.00021 in	0.00053 mm	
Specific Gravity	1.8		ASTM D792

[1] ν_{ha} = The ratio of axial strain to hoop strain resulting from stress in the hoop direction.
ν_{ah} = The ratio of hoop strain to axial strain resulting from stress in the axial direction.

[2] The differential pressure between internal and external pressure which causes collapse.

[3] A 0.67 design factor is recommended for short duration vacuum service. A full vacuum is equal to 14.7 psig (0.101 MPa) differential pressure at sea level.

[4] A 0.33 design factor is recommended for sustained (long-term) differential collapse pressure design and operation.

Ultimate Collapse Pressure

Size		Collapse Pressure[2,3,4]			
		psig		MPa	
in	mm	75°F	200°F	24°C	93°C
1	25	550	430	3.97	3.11
1 ½	40	340	260	2.41	1.86
2	50	330	250	3.08	2.39
3	80	120	90	0.86	0.64
4	100	75	55	0.52	0.38
6	150	75	55	0.52	0.38
8	200	75	55	0.52	0.38
10	250	75	55	0.52	0.38
12	300	75	55	0.52	0.38
14	350	75	55	0.52	0.38
16	400	75	55	0.52	0.38
18	450	75	55	0.52	0.38
20	550	75	55	0.52	0.38
24	600	75	55	0.52	0.38

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

CI1325ENG January 2017

Green Thread™ HP 32
(Product Data)

CHEMICAL & INDUSTRIAL

Applications

- Chemical Processing Liquids
- Food Processing Liquids
- Potable Water
- Cooling Water
- Condensate Return
- Industrial Wastewater
- Mildly Corrosive Liquids
- Crude Oil & Gas
- Produced Water
- Saltwater
- CO_2

Materials and Construction

All pipe manufactured by filament winding process using amine-cured epoxy thermosetting resin to impregnate strands of continuous glass filaments. Pipe wall includes a minimum 0.020” (0.50 mm) resin-rich corrosion barrier (liner).

Pipe is available in 2”-16” (50-400 mm) diameters with static pressure ratings of 464 psig (32 bar). The pipe and fittings are designed for continuous operation at 200°F (93°C) serviceable up to 230°F (110°C) by applying a derating factor of 0.76 to all component ratings. Pipe diameters of 1”-6” (25-150 mm) are available in 20’ (6 m) random lengths and the 8”-16” (200- 400 mm) diameters are in 19’ or 39’ (6 or 12 m) random lengths.

ASTM D-2996 Classification: RTRP - 11FX1-3110 for static design basis.

Fittings

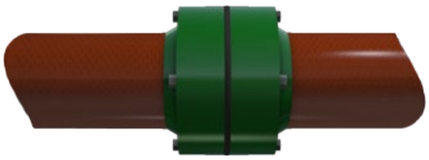
Fittings are filament wound with the same chemical, temperature and pressure capabilities as the pipe. Reference document CI1370 for fitting dimensions. 2”-12” (50-300 mm) fittings use HP 40 dimensions. 14” and 16” (350-400 mm) fittings use HP 32 dimensions.

Joining System

- **Bell & Spigot** - Matched-taper joint secured with epoxy adhesive. Self-locking feature resists movement, facilitating joining runs of pipe without waiting for adhesive to cure.
- **Flanged** - Available for all piping systems and diameters; factory assembled or shipped loose for assembly in the field.

View of Joint Illustrations

Bell & Spigot



Flanged

Nominal Dimensional Data

Pipe Size		Inside Diameter		Outside Diameter		Minimum Reinforced Wall Thickness		Weight[2]	
in	mm	in	mm	in	mm	in	mm	lbs/ft	kg/m
2	50	2.15	55	2.34	59	0.075	1.91	0.60	0.89
3	80	3.28	83	3.49	87	0.084	2.13	0.91	1.35
4	100	4.28	109	4.54	115	0.109	2.77	1.50	2.23
6	150	6.35	161	6.71	170	0.161	4.09	3.10	4.61
8	200	8.36	212	8.83	224	0.212	5.39	5.60	8.33
10	250	10.36	263	10.93	277	0.262	6.66	8.4	12.50
12	300	12.29	312	12.95	329	0.311	7.90	12.3	18.30
14	350	14.04	356	14.79	377	0.355	9.02	15.2	22.62
16	400	16.04	407	16.90	429	0.405	10.29	20.1	29.91

[2] Based on the minimum wall.

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 following tables were developed to ensure a design that limits beam mid-span deflection to ½ inch to ensure good appearance and adequate drainage. 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.

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	1.06

Example: 8" pipe @ 75°F (23.9°C) with 1.5 specific gravity fluid, maximum support spacing = 26.9 x 0.92 = 24.7 ft.

Maximum Support Spacing for Uninsulated Pipe[1]

Size		Continuous Spans of Pipe[2]			
		feet		meters	
in	mm	75°F	200°F	24°C	93°C
2	50	14.7	10.6	4.48	3.23
3	80	16.9	12.2	5.15	3.72
4	100	19.3	14.0	5.88	4.27
6	150	23.5	17.0	7.16	5.18
8	200	26.9	19.5	8.20	5.94
10	250	30.0	21.7	9.14	6.62
12	300	32.5	23.7	9.92	7.19
14	350	34.9	25.3	10.64	7.71
16	400	37.4	27.1	11.40	8.26

[1] For Sg=1.0, consult manufacturer for heavier insulated pipe support spans. Span recommendations include no provision for weight of (fittings, valves, etc.) or thrusts at branches and turns. Heavy valves and other appurtenances must be supported separately.

[2] Calculated spans are based on ½" mid-span deflections to ensure good appearance and adequate drainage. Total system stresses should always be taken into account by the system design engineer when determining support spans.

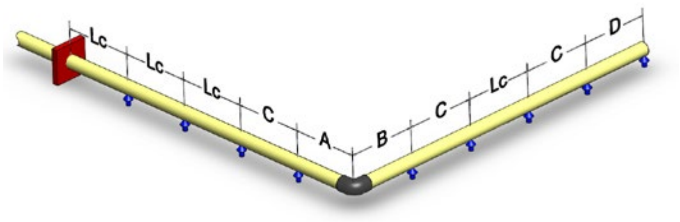
There are seven basic guidelines to follow when designing an above ground piping system:

1. Do not exceed the recommended support span.
2. Support heavy valves and in-line equipment independently.
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 loading to minimize bending stresses on pipe and fittings.
7. Provide adequate axial and lateral restraint to ensure line stability during rapid changes in flow (water hammer).

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

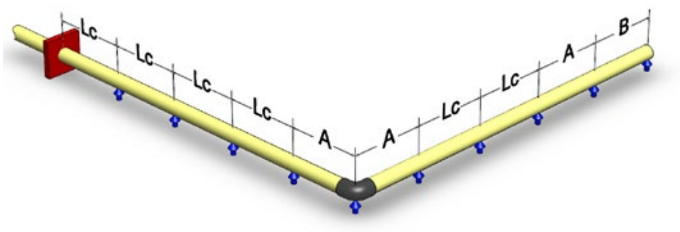
	Span Type	Factor
Lc	Continuous interior or fixed end spans	1.00
C	Second span from supported end or unsupported fitting	0.80
A+B	Sum of unsupported spans at fitting	≤0.75*
D	Simple supported end span	0.67

*For example: If continuous support is 10 ft. (3.04 m), A+B must not exceed 7.5 ft.(2.28 m) (A=3 ft. (0.91 m) and B=4.5 ft. (1.37 m)) would satisfy this condition.



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

	Span Type	Factor
Lc	Continuous interior or fixed end spans	1.00
A	Second span from simple supported end or unsupported fitting	0.80
B	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, Section 3.

Change in Temperature		Pipe Change in Length	
°F	°C	in/100 ft	cm/100 m
25	13.9	0.41	3.45
50	27.8	0.83	6.90
75	41.7	1.24	10.35
100	55.6	1.66	13.80

Testing

Hydrostatic testing is recommended to evaluate the integrity of all new piping installations. For systems operating below the system rating, a test pressure of 1.5 times the system operating pressure is recommended; however, the maximum test pressure must not exceed 1.3 times the lowest pressure rated fiberglass component in the piping system.

The hydro test pressure should be repeated up to ten cycles from 0 psig to the test pressure to provide a high degree of confidence in the piping system. The final pressurization cycle should be allowed to stabilize for 15-30 minutes, then inspected for leaks. Do not attempt to repair leaks while system is pressurized. The hydro test should be repeated after any re-work is performed.

When hydro testing, open high-point vents (if used) to prevent entrapment of air in the lines as the system is slowly filled with water, then close the vents and slowly pressurize to the test pressure. Upon completion of hydro test, relieve the pressure on the system slowly, open vents and any drains to allow for complete drainage of the system.

Water Hammer

Piping systems may be damaged by pressure surges due to water hammer. The use of soft start pumps and slow actuating valves will reduce the magnitude of surge pressures during operation and are highly recommended.

Typical Mechanical Properties

Pipe Property		75°F	24°C	200°F	93°C	Method
		psi	MPa	psi	MPa	
Axial Tensile						
Ultimate Stress		9,530	65.7	6,585	45.4	ASTM D2105
Modulus of Elasticity		1.68 x 10^6	11,584	1.42 x 10^6	9,791	ASTM D2105
Poisson's Ratio, ν_{ah} (ν_{ha})[1]		0.35 (0.61)				
Axial Compression						
Ultimate Stress		12,510	86.3	8,560	59.0	ASTM D695
Modulus of Elasticity		0.677 x 10^6	4,668	0.379 x 10^6	2,613	ASTM D695
Beam Bending						
Modulus of Elasticity (Long Term)		2.6 x 10^6	17,927	0.718 x 10^6	4.951	ASTM D2925
Hydrostatic Burst						
Ultimate Hoop Tensile Stress		40,150	277	36,480	252	ASTM D1599
Hydrostatic Hoop Design Stress						
Static 20 Year Life	LTHS - 95% LCL	-	-	20,787 - 17,155	143.3 - 118.3	ASTM D2992 - Procedure B
Static 50 Year Life	LTHS - 95% LCL	-	-	19,057 - 15,302	131.4 - 105.5	ASTM D2992 - Procedure B
Parallel Plate						
Hoop Modulus of Elasticity		3.02 x 10^6	20,822	-	-	ASTM D2412
Shear Modulus		1.76 x 10^6	12,135	1.63 x 10^6	11,240	-

Typical Physical Properties

Pipe Property	Value	Value	Method
Thermal Conductivity	0.23 BTU/hr•ft•°F	0.4 W/m°C	ASTM D177
Thermal Expansion	13.8 x 10^{-6} in/in °F	24.8 x 10^{-6} mm/mm °C	ASTM D696
Absolute Roughness	0.00021 in	0.00053 mm	
Specific Gravity	1.8		ASTM D792

Ultimate Collapse Pressure

Size		Collapse Pressure[2,3,4]			
		psig		MPa	
in	mm	75°F	200°F	24°C	93°C
2	50	330	250	2.28	1.72
3	80	160	120	1.10	0.83
4	100	160	120	1.10	0.83
6	150	160	120	1.10	0.83
8	200	160	120	1.10	0.83
10	250	160	120	1.10	0.83
12	300	160	120	1.10	0.83
14	350	160	120	1.10	0.83
16	400	160	120	1.10	0.83

(1) ν_{ha} = The ratio of axial strain to hoop strain resulting from stress in the hoop direction.
ν_{ah} = The ratio of hoop strain to axial strain resulting from stress in the axial direction.

(2) The differential pressure between internal and external pressure which causes collapse.

(3) A 0.67 design factor is recommended for short duration vacuum service. A full vacuum is equal to 14.7 psig (0.101 MPa) differential pressure at sea level.

(4) A 0.33 design factor is recommended for sustained (long-term) differential collapse pressure design and operation.

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Fiber Glass Systems
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San Antonio, Texas 78232 USA
Phone: 210 477 7500
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CI1330ENG February 2017

Green Thread™ HP 40

(Product Data)

CHEMICAL & INDUSTRIAL

Applications

- Chemical Processing Liquids
- Food Processing Liquids
- Potable Water
- Cooling Water
- Condensate Return
- Industrial Wastewater
- Mildly Corrosive Liquids
- Crude Oil & Gas
- Produced Water
- Saltwater
- CO_2

Materials and Construction

All pipe manufactured by filament winding process using amine-cured epoxy thermosetting resin to impregnate strands of continuous glass filaments. Pipe wall includes a minimum 0.020” (0.50 mm) resin-rich corrosion barrier (liner).

Pipe is available in 2”-12” (50-300 mm) diameters with static pressure ratings of 580 psig (40 bar). The pipe and fittings are designed for continuous operation at 200°F (93°C) serviceable up to 230°F (110°C) by applying a derating factor of 0.76 to all component ratings. Pipe diameters of 1”-6” (25-150 mm) are available in 20’ (6 m) random lengths and the 8”-12” (200- 300 mm) diameters are in 19’ or 39’ (6 or 12 m) random lengths.

ASTM D-2996 Classification: RTRP - 11FX1-3110 for static design basis.

Fittings

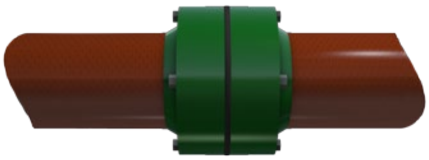
Fittings are filament wound with the same chemical, temperature and pressure capabilities as the pipe. For 2”-12” (50-300 mm) use HP32/40 Bar fittings in document CI1370.

Joining System

- **Bell & Spigot** - Matched-taper joint secured with epoxy adhesive. Self-locking feature resists movement, facilitating joining runs of pipe without waiting for adhesive to cure.
- **Flanged** - Available for all piping systems and diameters; factory assembled or shipped loose for assembly in the field.

View of Joint Illustrations

Bell & Spigot



Flanged

Nominal Dimensional Data

Pipe Size		Inside Diameter		Outside Diameter		Minimum Reinforced Wall Thickness		Liner Thickness		Weight [1]	
in	mm	in	mm	in	mm	in	mm	in	mm	lbs/ft	kg/m
2	50	2.15	55	2.34	60	0.075	1.91	0.02	0.51	0.6	0.93
3	80	3.28	83	3.53	90	0.105	2.67	0.02	0.51	1.1	1.65
4	100	4.28	109	4.60	117	0.137	3.48	0.02	0.51	1.8	2.74
6	150	6.35	161	6.80	173	0.203	5.16	0.02	0.51	3.9	5.80
8	200	8.36	212	8.93	227	0.266	6.76	0.02	0.51	6.6	9.84
10	250	10.36	263	11.06	281	0.330	8.38	0.02	0.51	10.0	14.88
12	300	12.29	312	13.11	333	0.391	9.93	0.02	0.51	14.0	20.83

[1] Based on the minimum wall.

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 following tables were developed to ensure a design that limits beam mid-span deflection to ½ inch to ensure good appearance and adequate drainage. 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 guidelines to follow when designing an above ground piping system:

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5. Avoid excessive bending. This applies to handling, transporting, initial layout, and final installed position.
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7. Provide adequate axial and lateral restraint to ensure line stability during rapid changes in flow (water hammer).

Maximum Support Spacing for Uninsulated Pipe[1]

Size		Continuous Spans of Pipe[2]			
		feet		meters	
in	mm	75°F	200°F	24°C	93°C
2	50	14.7	10.6	4.48	3.23
3	80	17.8	12.9	5.43	3.93
4	100	20.3	14.7	6.19	4.48
6	150	24.7	17.9	7.53	5.46
8	200	28.3	20.6	8.63	6.28
10	250	31.6	22.9	9.63	6.98
12	300	34.3	24.9	10.45	7.59

[1] For Sg=1.0, consult manufacturer for heavier insulated pipe support spans. Span recommendations include no provision for weight of (fittings, valves, etc.) or thrusts at branches and turns. Heavy valves and other appurtenances must be supported separately.

[2] Calculated spans are based on ½" mid-span deflections to ensure good appearance and adequate drainage. Total system stresses should always be taken into account by the system design engineer when determining support spans.

Support Spacing vs. Specific Gravity

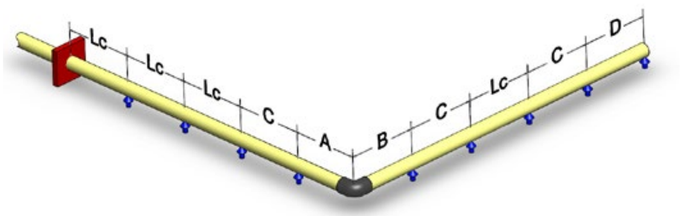
Specific Gravity	2.00	1.50	1.25	1.00	0.75
Multiplier	0.86	0.92	0.96	1.00	1.07

Example: 8" pipe @ 75°F (23.9°C) with 1.5 specific gravity fluid, maximum support spacing = 28.3 x 0.92 = 26.0 ft.

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

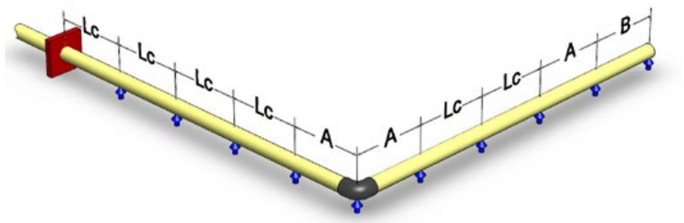
	Span Type	Factor
Lc	Continuous interior or fixed end spans	1.00
C	Second span from supported end or unsupported fitting	0.80
A+B	Sum of unsupported spans at fitting	≤0.75*
D	Simple supported end span	0.67

*For example: If continuous support is 10 ft. (3.04 m), A+B must not exceed 7.5 ft.(2.28 m) (A=3 ft. (0.91 m) and B=4.5 ft. (1.37 m)) would satisfy this condition.



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

	Span Type	Factor
Lc	Continuous interior or fixed end spans	1.00
A	Second span from simple supported end or unsupported fitting	0.80
B	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:

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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, Section 3.

Change in Temperature		Pipe Change in Length	
°F	°C	in/100 ft	cm/100 m
25	13.9	0.41	3.45
50	27.8	0.83	6.90
75	41.7	1.24	10.35
100	55.6	1.66	13.80

Testing

Hydrostatic testing is recommended to evaluate the integrity of all new piping installations. For systems operating below the system rating, a test pressure of 1.5 times the system operating pressure is recommended; however, the maximum test pressure must not exceed 1.3 times the lowest pressure rated fiberglass component in the piping system.

The hydro test pressure should be repeated up to ten cycles from 0 psig to the test pressure to provide a high degree of confidence in the piping system. The final pressurization cycle should be allowed to stabilize for 15-30 minutes, then inspected for leaks. Do not attempt to repair leaks while system is pressurized. The hydro test should be repeated after any re-work is performed.

When hydro testing, open high-point vents (if used) to prevent entrapment of air in the lines as the system is slowly filled with water, then close the vents and slowly pressurize to the test pressure. Upon completion of hydro test, relieve the pressure on the system slowly, open vents and any drains to allow for complete drainage of the system.

Water Hammer

Piping systems may be damaged by pressure surges due to water hammer. The use of soft start pumps and slow actuating valves will reduce the magnitude of surge pressures during operation and are highly recommended.

Typical Mechanical Properties

Pipe Property		75°F	24°C	200°F	93°C	Method
		psi	MPa	psi	MPa	
Axial Tensile						
Ultimate Stress		9,530	65.7	6,585	45.4	ASTM D2105
Modulus of Elasticity		1.68 x 10^6	11,584	1.42 x 10^6	9,791	ASTM D2105
Poisson's Ratio, ν_{ah} (ν_{ha})[1]		0.35 (0.61)				
Axial Compression						
Ultimate Stress		12,510	86.3	8,560	59.0	ASTM D695
Modulus of Elasticity		0.677 x 10^6	4,668	0.379 x 10^6	2,613	ASTM D695
Beam Bending						
Modulus of Elasticity (Long Term)		2.6 x 10^6	17,927	0.718 x 10^6	4.951	ASTM D2925
Hydrostatic Burst						
Ultimate Hoop Tensile Stress		40,150	277	36,480	252	ASTM D1599
Hydrostatic Hoop Design Stress						
Static 20 Year Life	LTHS - 95% LCL	-	-	20,787 - 17,155	143.3 - 118.3	ASTM D2992 - Procedure B
Static 50 Year Life	LTHS - 95% LCL	-	-	19,057 - 15,302	131.4 - 105.5	ASTM D2992 - Procedure B
Parallel Plate						
Hoop Modulus of Elasticity		3.02 x 10^6	20,822	-	-	ASTM D2412
Shear Modulus		1.76 x 10^6	12,135	1.63 x 10^6	11,240	

Typical Physical Properties

Pipe Property	Value	Value	Method
Thermal Conductivity	0.23 BTU/hr•ft•°F	0.4 W/m°C	ASTM D177
Thermal Expansion	13.8 x 10^{-6} in/in °F	24.8 x 10^{-6} mm/mm °C	ASTM D696
Absolute Roughness	0.00021 in	0.00053 mm	
Specific Gravity	1.8		ASTM D792

[1] ν_{ha} = The ratio of axial strain to hoop strain resulting from stress in the hoop direction.
ν_{ah} = The ratio of hoop strain to axial strain resulting from stress in the axial direction.

[2] The differential pressure between internal and external pressure which causes collapse.

[3] A 0.67 design factor is recommended for short duration vacuum service. A full vacuum is equal to 14.7 psig (0.101 MPa) differential pressure at sea level.

[4] A 0.33 design factor is recommended for sustained (long-term) differential collapse pressure design and operation.

Ultimate Collapse Pressure

Size		Collapse Pressure[2,3,4]			
		psig		MPa	
in	mm	75°F	200°F	24°C	93°C
2	50	330	250	2.28	1.72
3	80	280	215	1.93	1.48
4	100	280	215	1.93	1.48
6	150	280	215	1.93	1.48
8	200	280	215	1.93	1.48
10	250	280	215	1.93	1.48
12	300	280	215	1.93	1.48

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Fax: 210 477 7560

CI1340ENG February 2017

Silver Streak® Product Data

Applications

- Flue Gas Desulfurization
- Limestone Slurry
- Ammonium Sulfate
- Gypsum Slurry

Materials and Construction

All pipe manufactured by filament winding process using amine-cured epoxy thermosetting resin to impregnate strands of continuous glass filaments with a resin-rich corrosion barrier. Manufactured with a proprietary blend of abrasion-resistant additives, **Silver Streak** piping is offered with a standard 80 mil nominal liner.

Pipe is available in **2" through 24"** diameters with pressure ratings up to 225 psig static at a maximum operating temperature of 225°F and is ideal for yard piping. **Silver Streak LD** pipe, available in **30" through 54"** diameters, is ideal for recirculating piping and operates at temperatures up to 200°F and pressures up to 150 psig.

The entire 80 mil nominal liner contains 80% resin/abrasion-resistant additives and 20% reinforcement. The pipe is rated for full vacuum service at 175°F and comes spigot x spigot in **2" through 12"** sizes and spigot x spigot or bell x spigot in **14" through 24"** sizes.

Fittings

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.

Joining Systems

Bell & Spigot
Matched-taper joint secured with epoxy adhesive. Self-locking feature resists movement, facilitating joining runs of pipe without awaiting adhesive cure.

Nominal Dimensional Data (Liner Thickness = 0.080"/1.8 mm)

Pipe Size (In)	I.D.		O.D.		Wall Thickness		Weight		Capacity	
	(In)	(mm)	(In)	(mm)	(In)	(mm)	(Lbs/Ft)	(kg/m)	(Gal/Ft)	(Ft³/Ft)
2	2.00	51	2.40	61	0.200	5.1	1.1	1.6	0.16	0.022
3	3.28	83	3.65	93	0.186	4.7	1.6	2.4	0.44	0.059
4	4.28	109	4.66	118	0.190	4.8	2.1	3.1	0.75	0.100
6	6.35	161	6.75	171	0.197	5.0	3.1	4.6	1.65	0.220
8	8.36	212	8.83	224	0.233	5.9	5.0	7.4	2.85	0.381
10	10.36	263	10.87	276	0.251	6.4	6.6	9.8	4.38	0.585
12	12.29	312	12.81	325	0.260	6.6	8.1	12.1	6.16	0.824
14	14.04	357	14.71	374	0.338	8.6	12.3	18.3	8.04	1.075
16	16.04	407	16.68	424	0.320	8.1	13.2	19.6	10.5	1.403
18	17.83	453	18.50	470	0.336	8.5	15.5	23.1	12.97	1.734
20	19.83	504	20.56	522	0.364	9.2	18.7	27.8	16.04	2.145
24	23.83	605	24.66	626	0.414	10.5	25.7	38.3	23.17	3.097

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

Properties of Pipe Sections Based on Minimum Reinforced Wall

Size (In)	Reinforcement End Area (In^2)	Reinforcement Moment of Inertia (In^4)	Reinforcement Section Modulus (In^3)	Nominal Wall End Area (In^2)
2	0.74	0.48	0.40	1.38
3	1.03	1.61	0.88	2.03
4	1.37	3.52	1.51	2.67
6	2.13	11.6	3.45	4.05
8	3.64	34.1	7.72	6.29
10	5.02	71.4	13.1	8.37
12	6.24	124	19.3	10.3
14	10.2	266	36.2	15.3
16	10.8	364	43.7	16.4
18	12.8	531	57.5	19.2
20	15.8	808	78.6	23.0
24	22.3	1,641	133	31.5

Average Physical Properties

Property		75°F psi	24°C MPa	225°F psi	107°C MPa
Axial Tensile - ASTM D2105					
Ultimate Stress		10,550	72.7	7,160	49.4
Modulus of Elasticity		1.75×10^6	12,093	1.03×10^6	7,102
Poisson's Ratio $\nu_{a/h}$ ($\nu_{h/a}$)		0.35 (0.56)			
Axial Compression - ASTM D694					
Ultimate Stress		33,300	229.6	17,800	122.7
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	110.3
Modulus of Elasticity (Long Term)		2.18×10^6	15,030	1.10×10^6	7,653
Hydrostatic Burst - ASTM D1599					
Ultimate Hoop Tensile Stress		46,300	319	49,500	341.3
Ring Tensile - ASTM D2290		27,280	188	-	-
Minimum Hoop Tensile Stress					
Hydrostatic Design - ASTM D2992,					
Procedure B - Hoop Tensile Stress	(LTHS)	27,715	191	16,945*	116.8*
*20 Year Static Life at 200°F/93.3°C	(LCL)	22,400	154	14,654*	101.0*

Thermal Expansion Coefficient - ASTM D696	1.26×10^{-5} in/in/°F	1.58×10^{-5} mm/mm/°C
Thermal Conductivity	0.23 BTU/hr-ft-°F	0.4 W/m-°C
Specific Gravity - ASTM D792	1.8	
Absolute Surface Roughness	0.00021 Inch	0.0053 mm
Manning Roughness Coefficient, n	0.009	

Testing:

Hydrostatic testing should be performed to evaluate the structural integrity of a new piping system installation. Test pressures of 1.5 times the design operating pressure but not exceeding 1.2 times the static pressure rating of the lowest rated fiberglass component in the piping system are recommended. Contact the company if test pressures exceed 450 psig before testing. The hydro test pressure should be repeated up to ten cycles from 0 psig to the test pressure to provide a high degree of confidence in the piping system. The final pressurization cycle should be allowed to stabilize for 15-30 minutes, then inspected for leaks. Do not attempt to repair leaks while system is pressurized. The hydro test should be repeated after any re-work is performed.

When hydro testing, open vents to prevent entrapment of air in the lines as the system is slowly filled with water. Then close the vents and slowly pressurize to the test pressure. Upon completion of hydrotest, relieve the pressure on the system slowly, open vents and any drains to allow for complete drainage of the system.

Piping systems with design temperatures above 150°F should be tested at 1.2 times the static pressure rating of the lowest rated fiberglass component in the system.

Recommended Operating Ratings

Size (In)	Axial Tensile Loads Max. (Lbs) Temperature 75°F	Axial Tensile Loads Max. (Lbs) Temperature 225°F	Axial Compressive Loads Max. (Lbs)(1) Temperature 75°F	Axial Compressive Loads Max. (Lbs)(1) Temperature 225°F	Bending Radius Min. (Ft) Entire Temp. Range	Torque Max. (Ft Lbs) Entire Temp. Range	Parallel Plate Loading ASTM D2412 @ 5% Defection: Stiffness Factor ($In^3/Lbs/In^2$)	Pipe Stiffness (psi)	Hoop Modulus $x10^6$ (psi)
2	1,900	1,300	6,600	3,000	75	130	n/a	n/a	n/a
3	2,700	1,800	8,500	4,000	110	280	n/a	n/a	n/a
4	3,600	2,400	11,000	6,000	140	480	n/a	n/a	n/a
6	5,600	3,800	17,000	9,000	210	1,100	n/a	n/a	n/a
8	9,500	6,500	30,000	16,000	270	2,480	n/a	n/a	n/a
10	13,000	8,900	41,000	22,000	340	4,200	n/a	n/a	n/a
12	16,000	11,000	51,000	27,000	400	6,200	n/a	n/a	n/a
14	26,000	18,000	85,000	45,000	460	11,000	n/a	n/a	n/a
16	28,000	19,000	90,000	48,000	520	14,000	n/a	n/a	n/a
18	33,000	22,000	100,000	56,000	580	18,000	n/a	n/a	n/a
20	41,000	28,000	130,000	70,000	640	25,000	n/a	n/a	n/a
24	58,000	39,000	180,000	99,000	770	42,000	n/a	n/a	n/a

(1)Compressive loads are for short columns only.

Pressure Ratings

Size (In)	Maximum Internal Static Pressure (psig) 225°F	Maximum External Static Pressure (psig) 175°F
2-24	225	Full Vacuum

ASTM D2996 Designation Codes:

2”-24”	RTRP-11FY1-3110

Pipe Lengths Available

Size (In)	Random Length (Ft)
2-6	20
8-24	40

Water Hammer:

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

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 1/2 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 heavy valves and in-line equipment independently.
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 loading to minimize bending stresses on pipe and fittings.
7. Provide adequate axial and lateral restraint to ensure line stability during rapid changes in flow.

Maximum Support Spacing for Uninsulated Pipe[(1)]

Pipe Size (In.)	Continuous Spans of Pipe (Ft.)[(2)]		
	75°F	150°F	225°F
2	14.7	13.7	12.4
3	16.5	15.4	13.9
4	17.9	16.7	15.1
6	20.2	18.9	17.1
8	23.2	21.6	19.6
10	25.2	23.5	21.3
12	26.7	24.9	22.5
14	30.0	28.0	25.4
16	30.6	28.6	25.9
18	32.0	29.8	27.0
20	33.7	31.4	28.4
24	36.7	34.3	31.0

[(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

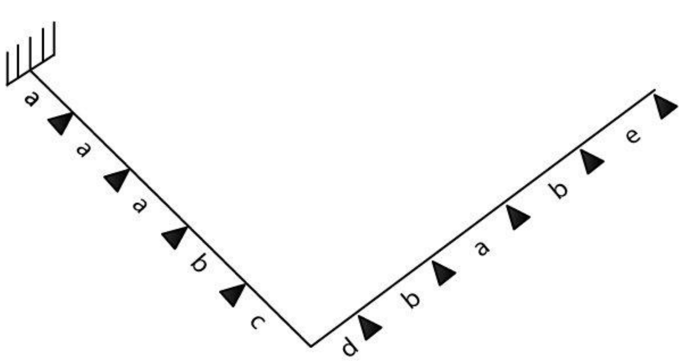
Specific Gravity	2.00	1.50	1.25	1.00	0.75
Multiplier	0.87	0.92	0.96	1.00	1.05

Example: 6" pipe @ 150°F with 1.5 specific gravity fluid, maximum support spacing = 18.9 x 0.92 = 17.4 ft.

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

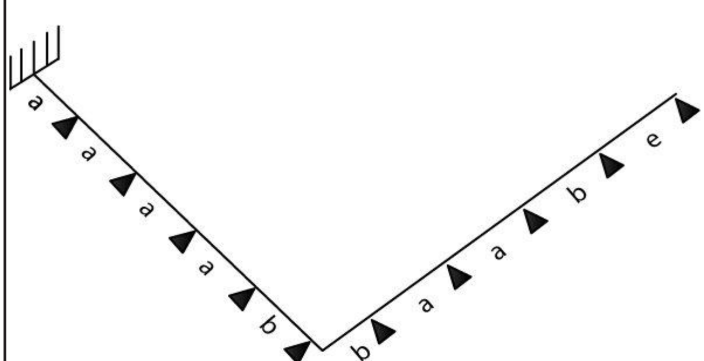
	Span Type	Factor
a	Continuous interior or fixed end spans	1.00
b	Second span from supported end or unsupported fitting	0.80
c+d	Sum of unsupported spans at fitting	≤0.75*
e	Simple supported end span	0.67

*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 flexibility 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. Using directional changes inherent flexibility
2. Restrain pipe axially and guide supports to control deflections and 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. An isometric layout of piping system
2. Physical geometry and material properties of pipe
3. Design temperatures
4. Installation temperature (Final tie in temperature)
5. Terminal equipment load limits
6. Support movements

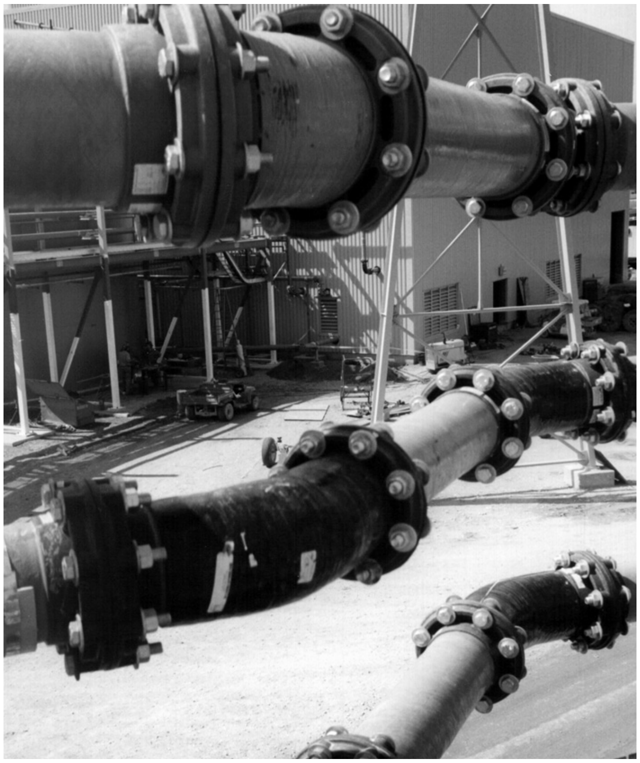
A comprehensive review of temperature effects on fiberglass pipe may be found in NOV Fiber Glass Systems' **Engineering and Piping Design Guide.**

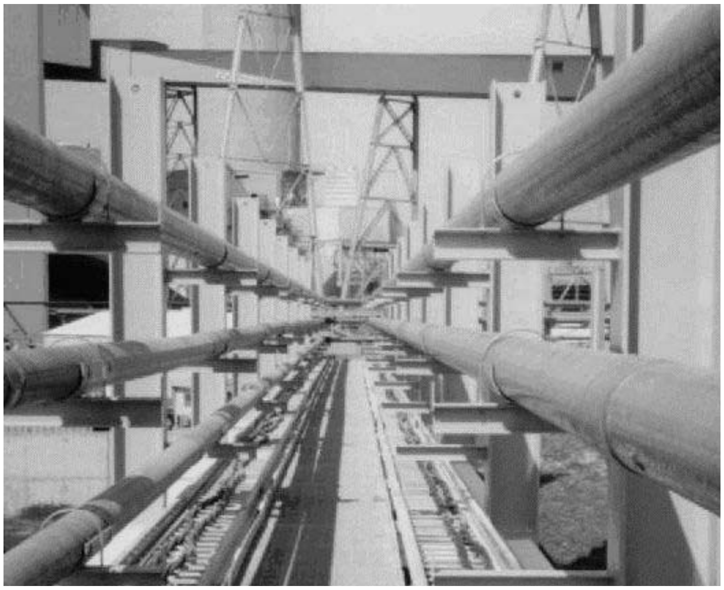
Change in Temperature °F	Pipe Change in Length (In/100 Ft)
25	0.38
50	0.76
75	1.13
100	1.51

Restrained Thermal End Loads and Guide Spacing

Size (In)	Operating Temperature °F (Based on installation temperature of 75°F)							
	125°F		150°F		175°F		200°F	
	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)
2	11.1	481	9.2	637	8.1	736	7.4	778
3	17.4	661	14.4	875	12.7	1,011	11.5	1,069
4	22.4	877	18.5	1,161	16.2	1,342	14.8	1,419
6	32.7	1,366	27.0	1,809	23.7	2,090	21.6	2,211
8	42.7	2,339	35.3	3,095	31.0	3,577	28.2	3,783
10	52.7	3,225	43.5	4,269	38.2	4,933	34.8	5,218
12	62.2	4,009	51.4	5,307	45.1	6,132	41.1	6,486
14	71.2	6,573	58.8	8,700	51.7	10,054	47.1	10,364
16	81.0	6,959	66.9	9,210	58.8	10,643	53.5	11,257
18	90.0	8,225	74.3	10,886	65.3	12,579	59.5	13,305
20	99.8	10,153	82.5	13,437	72.4	15,528	66.0	16,424
24	119.8	14,329	98.9	18,966	86.9	21,916	79.1	23,180

Note: If guide spacing exceeds support span length, then guide at each support.





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NOV Fiber Glass Systems

CI1400 - February 2011

SECTION 1 – Scope

This section covers the use of fiberglass reinforced plastic (FRP) pipe for medium duty slurry service such as limestone slurry to 225°F and 225 psig pressure.

The piping system shall be furnished and installed complete with all fittings, joining materials, supports, specials, and other necessary appurtenances.

SECTION 2 – General Conditions

2.01 Coordination - Material furnished and work performed under this section shall be coordinated with related work and equipment specified under other sections.

Valves	Section__________
Supports	Section__________
Equipment	Section__________

2.02 Governing Standards - Except as modified or supplemented herein, all materials and construction methods shall comply with the applicable provisions of the following specifications and be tested using the following standards:

Standard Specifications

ASTM D2996	Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin Pipe
ASTM 4024	Standard Specification for Reinforced Thermosettting Resin (RTR) Flanges
ASTM D5685	Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pressure Pipe Fittings

Standard Test Methods

ASTM D1599	Standard Test method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings
ASTM D2105	Standard Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Tube
ASTM D2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASTM D2925	Standard Test Method for Beam Deflection of Fiberglass Pipe Under Full Bore Flow
ASTM D2992	Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe

2.03 Operating Conditions - In addition to the above listed minimum design requirements, the system shall meet the following minimum operating conditions:

a. Operating Pressure __________
b. Operating Temperature __________
c. Fluid Conveyed __________
d. Test Pressure __________

2.04 Quality Assurance - Pipe manufacturer's quality program shall be in compliance with ISO 9001.

2.05 Delivery, Storage, and Handling - Pipe and fittings shall be protected from damage due to impact and point loading. Pipe shall be properly supported to avoid damage due to flexural strains. The contractor shall not allow dirt, debris, or other extraneous materials to get into pipe and fittings. All factory machined areas shall be protected from sunlight until installed.

2.06 Acceptable Manufacturers - NOV Fiber Glass Systems, 501-568-4010, or approved equal.

SECTION 3 – Materials and Construction

3.01 2"-24" Pipe - The pipe shall be manufactured by the filament winding process using an amine cured epoxy thermosetting resin to impregnate strands of continuous glass filaments, which are wound around a mandrel at a 54¾° winding angle under controlled tension. Pipe shall be heat cured and the cure shall be confirmed using a Differential Scanning Calorimeter.

All pipe shall have a resin-rich corrosion/abrasion resistant barrier reinforced with synthetic surfacing veil. The corrosion/abrasion barrier shall contain a minimum resin/abrasion additive content of 80 percent and a reinforcement content of 20 percent. The minimum acceptable cured thickness of the corrosion/abrasion barrier shall be 80 mils nominal.

3.02 Flanges and Fittings - All fittings shall be manufactured using the same type materials as the pipe. Fittings may be manufactured either by spray-up/contact molding, contact molding/filament winding, or compression molding methods.

All fittings, except compression molded, shall have a minimum corrosion/abrasion barrier of 100 mils.

All elbows shall have a minimum radius of 1½ "D".

Fittings shall be adhesive bonded matched tapered bell and spigot or flanged.

Flanges shall have ANSI B16.5 Class 150 bolt hole patterns.

3.03 Adhesive - Adhesive shall be manufacturer's standard for the piping system specified.

3.04 Gaskets - Gaskets shall be 1/8" thick, 60-70 durometer full-face type suitable for the service shown on the drawings and as recommended in the manufacturer's standard installation procedures.

3.05 Bolts, Nuts, and Washers - ASTM A307, Grade B, hex head bolts shall be supplied. SAE washers shall be supplied on all nuts and bolts.

3.06 Acceptable Products - Silver Streak as manufactured by Fiber Glass Systems, or approved equal.

SECTION 4 – Installation and Testing

4.01 Training and Certification. All joints installed or constructed in the field shall be assembled by employees of the contractor who have been trained by the pipe manufacturer. The pipe manufacturer or their authorized representative shall train the contractor's employees in the proper joining and assembly procedures required for the project, including hands-on training by the contractor's employees. Each bonder shall fabricate one pipe-to-pipe and one pipe-to-fitting joint that shall pass the minimum pressure test for the application without leaking.

Only bonders who have successfully completed the pressure test shall bond pipe and fittings.

Certification by the manufacturer shall be in compliance with ASME B31.3, Section A328.2 for the type of joint being made.

4.02 Pipe Installation. Pipe shall be installed as specified and indicated on the drawings.

The piping system shall be installed in accordance with the manufacturer's current published installation procedures.

4.03 Testing. Hydrostatic testing should be performed to evaluate the structural integrity of a new piping system installation. Test pressures of 1.5 times the design pressure but not exceeding 1.5 times the static pressure rating of the lowest rated fiberglass component in the piping system is recommended. The hydrotest pressure should be repeated up to ten times to provide a high degree of confidence in the piping system. The final pressurization should be allowed to stabilize for 15-30 minutes, then, inspected for leaks. Do not attempt to repair leaks while system is pressurized. The hydro test should be repeated after any re-work is performed.

When hydro testing open vents to prevent entrapment of air in the lines as the system is slowly filled with water. Then close the vents and slowly pressurize to the test pressure. Upon completion of hydro test, relieve the pressure on the system slowly, open vents and any drains to allow for complete drainage of the system.

Piping systems with design temperatures above 150°F should be tested at 1.5 times the static pressure rating of the lowest rated fiberglass component in the system.

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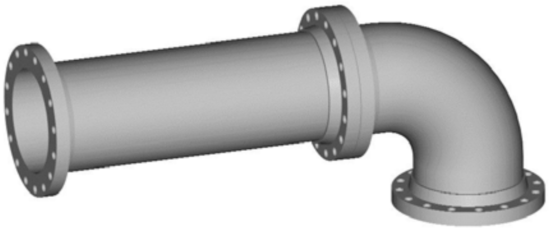
NOV Fiber Glass Systems

CI1401 - July 2013

SILVER STREAK® LD Abrasion Resistant Pipe



PRODUCT

SILVER STREAK LD piping is specifically designed for flue gas desulfurization, FGD, recirculation piping applications. The pipe is a filament wound product using vinyl ester resins and continuous glass filaments. The standard 100 mil liner is manufactured using a proprietary blend of abrasion-resistant additives formulated specifically for limestone, gypsum and ammonium sulfate slurries. Custom liner thicknesses are available on special order.

Pipe and fittings are available in 30" through 48" diameter sizes with static pressure ratings up to 150 psig operating up to 200°F and full vacuum ratings. A recommended specification guide is available in Bulletin No. 2021.

FITTINGS

Compatible vinyl ester fittings are manufactured with the same chemical resistance and temperature/pressure capabilities as the pipe. The fittings are mitered fabrications available in long radius when required.

SHOP & FIELD JOINING

Pipe can be cut and easily prepared for joining in the shop or field. Piping joints may be joined using flanges or Butt & Wrap joints. See **Socket Joint Installation Handbook**, for installation procedures for your application.

FEATURES & BENEFITS

- Standard sizes include with 30"-48" diameters
- Operating temperatures up to 200°F
- Operating pressures up to 150 psig
- Full vacuum service
- Custom-fabricated assemblies are available.

DIMENSIONAL DATA

Nominal Pipe Size	Nominal I.D.		Nominal Wall Thickness		Nominal Liner		Nominal Weight		Max. Support Spacing(1) @175°F	
in.	in.	mm	in.	mm	in.	mm	lbs./ft.	kg/m	ft.	m
30	30.19	767	0.65	16.5	0.100	2.54	50.3	75.3	33.5	10.2
36	36.19	919	0.73	18.5	0.100	2.54	68.1	101.3	36.1	11.0
42	42.19	1072	0.86	21.8	0.100	2.54	93.1	138.5	39.5	12.0
48	48.06	1221	0.94	23.9	0.100	2.54	116	172.6	48.4	14.7

(1) Based on ½" deflection at mid-span.

TYPICAL PHYSICAL PROPERTIES

Property	75°F psi	175°F psi	24°C MPa	79°C MPa
Axial Tensile - ASTM D2105				
Ultimate Stress	9,300	5,500	64.1	37.9
Modulus of Elasticity	1.50×10^6	-	10,342	-
Poisson's Ratio	0.35			
Axial Compression - ASTM D695				
Ultimate Stress	17,900	14,700	123	101
Modulus of Elasticity	1.40×10^6	9.00×10^5	9,653	6,205
Beam Bending - ASTM D2925				
Ultimate Stress	14,500	8,000	100	55.2
Modulus of Elasticity (Long Term)	1.99×10^6	1.14×10^6	13,721	7,860
Hydrostatic Burst - ASTM D1599				
Ultimate Hoop Tensile Stress	40,000	40,000	276	276
Hydrostatic Design - ASTM D2992, Procedure B - Hoop Tensile Stress Static 50 Year Life	12,000	-	82.7	-

Coefficient of Linear Thermal Expansion - ASTM D696	9.2×10^{-6} in/in/°F	16.6×10^{-6} mm/mm/°C
Thermal Conductivity	0.11 BTU/hr-ft-°F	0.19 W(m)(°C)
Specific Gravity - ASTM D792	1.86 (0.067 lb/in^3)	
Flow Factor - SF / Hazen-Williams Coefficient	C-150	
Surface Roughness	1.7×10^{-6} Feet	
Manning's "n"	0.009 Inch	

ASTM D2996 Designation Codes

30" -48"	RTRP-12ET1-3110

Vacuum Ratings

Nominal Pipe Size	75°F	150°F	175°F
Inches	psi	psi	psi
30	18.3	15.0	13.0
36	16.3	13.3	11.3
42	17.8	14.5	12.6

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NOV Fiber Glass Systems

CI1420 February 2009

Silver Streak™ LD Piping System

Specification Guide

SECTION 1 - Scope

This section covers the use of fiberglass reinforced plastic (FRP) pipe for medium duty slurry service such as limestone slurry up to 200°F and up to 150 psig pressure.

The piping shall be furnished and installed complete with all fittings, joining materials, supports, specials, and other necessary appurtenances.

SECTION 2 - General Conditions

2.01 Coordination - Material furnished and work performed under this section shall be coordinated with related work and equipment specified under other sections.

Valves	Section ________
Supports	Section ________
Equipment	Section ________

2.02 Governing Standards - Except as modified or supplemented herein, all materials and construction methods shall comply with the applicable provisions of the following standards:

Standard Test Methods

ASTM D1599	Standard Test method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings
ASTM D2105	Standard Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Tube
ASTM D2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASTM D2925	Standard Test Method for Beam Deflection of Fiberglass Pipe Under Full Bore Flow

2.03 Quality Assurance - Pipe manufacturer's quality program shall be in compliance with ISO 9001.

2.04 Delivery, Storage and Handling - Pipe and fittings shall be protected from damage due to impact and point loading. Pipe shall be properly supported to avoid damage due to flexural strains. The contractor shall not allow dirt, debris, or other extraneous materials to get into pipe and fittings. All factory machined areas shall be protected from sunlight until installed.

2.05 Acceptable Manufacturers - NOV Fiber Glass Systems (501) 568-4010 or approved equal.

SECTION 3 - Materials and Construction

3.01 30"- 48" Pipe - The pipe shall be manufactured by the filament winding process using a vinyl ester or epoxy thermosetting resin to impregnate strands of continuous glass filaments, which are would around a mandrel at a 54¾° winding angle under controlled tension. Pipe shall be heat cured and the cure shall be confirmed using a Differential Scanning Calorimeter.

All pipe shall have a resin-rich corrosion/abrasion resistant barrier. The minimum acceptable cured thickness of the corrosion/abrasion barrier shell be 100 mils nominal.

Pipe 30"- 48" shall be supplied plain end.

3.02 Flanges and Fittings - All fittings shall be manufactured using the same type materials as the pipe. Fittings may be manufactured either by spray-up/contact molding, contact molding/filament winding, or compression molding methods.

All fittings, except compression molded, shall have a minimum corrosion/abrasion barrier of 100 mils.

All elbows shall have a minimum radius of 1½ Diameter

Fittings shall be adhesive bonded matched tapered bell and spigot, flanged or butt and wrap.

Flanges shall have ANSI B16.5, Class 150 bolt hole patterns.

3.03 Adhesive - Adhesive shall be manufacturer's standard for the piping system specified.

3.04 Gaskets - Gaskets shall be ¼" thick, 60-70 durometer full-fact type suitable for the service shown on the drawings and as recommended in the manufacturer's standard installation procedures.

3.05 Bolts, Nuts and Washers - ASTM A307, Grade B, hex head bolts shall be supplied. Washers shall be supplied on all nuts and bolts.

3.06 Acceptable Products - Silver Streak LD as manufactured by NOV Fiber Glass Systems or approved equal.

SECTION 4 - Installation and Testing

4.01 Training and Certification - All joints installed or constructed in the field shall be assembled by employees of the contractor who have been trained by the pipe manufacturer. The pipe manufacturer or their authorized representative shall train the contractor's employees in the proper joining and assembly procedures required for the project, including hands-on training by the contractor's employees. Each bonder shall fabricate one pipe-to-pipe and one pipe-to-fitting joint that shall pass the minimum pressure test for the application without leaking.

Only bonders who have successfully completed the pressure test shall bond pipe and fittings.

Certification by the manufacturer shall be in compliance with ASME B31.3, Section A328.2 for the type of joint being made.

4.02 Pipe Installation - Pipe shall be installed as specified and indicated on the drawings.

The piping system shall be installed in accordance with the manufacturer's current published installation procedures.

4.03 Testing - When testing 30" and larger pipe, a steady pressure test shall be conducted on the completed piping system. The pipe shall be subjected to a steady pressure test at 1½ times the design operating pressure as shown on the drawings.

Test pressure shall not exceed 1½ times the maximum rated pressure of the lowest rated element in the system.

The system shall be filled with water at the lowest point and air bled off from the highest point. Systems shall be brought up to test pressure slowly to prevent water hammer or overpressurization.

All pipe joints shall be water tight. All joints that are found to leak by observation or during testing shall be repaired by the contractor and retested.

QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
ISO 9001:2008
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NOV Fiber Glass Systems

CI1421 - February 2009

Applications

- Bottom Ash
- Wet Fly Ash
- Vanadium Ore Slurries
- Potash Tailings
- Zinc Tailings
- Taconite Tailings
- Heavy Salt Slurries
- Uranium Ore Slurries
- Dredge Lines
- Smelter Slags
- Wet Process Slurries
- Wood Pulp Slurries
- Copper Tailings
- Iron Ore Tailings
- Diatomaceous Earth
- Concrete Slurries

Materials and Construction

Ceram Core is a fiberglass reinforced epoxy resin pipe with a special abrasion resistant liner composed of small spherical beads of high alumina ceramic, held in an epoxy matrix. Because of its unique combination of ceramic beads and epoxy resin, Ceram Core pipe also exhibits excellent corrosion resistance.

Ceram Core piping is specifically designed for the severe abrasion conditions caused by sharp angular particles in high flow streams. Most noticeable is its successful service in handling bottom ash (see Field Tests). The pipe outlasts and outperforms steel, special alloys, and other lined pipe at competitive costs and is available in 6”-16” diameters in standard 25 foot (7.6 meters lengths ±⅛”), for slurry abrasion service up to 200°F (93°C). The system includes 45° and 90° elbows with a 3-diameter sweep radius. Special angle fittings, including laterals, are available on request.

Fittings

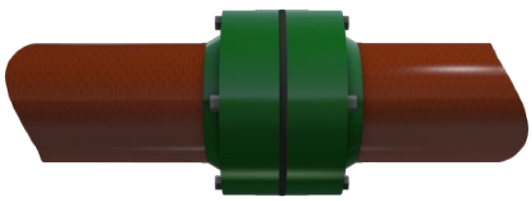
Fittings are manufactured with the same chemical/temperature capabilities as the pipe. Depending on the particular part and size, fittings will be compression molded, contact molded, hand fabricated or filament wound.

Joining System

Flanged

Flanged connections are available for all components and diameters.

View of Joint Illustrations



Flanged

Nominal Dimensional Data

Pipe Size		Outside Diameter		Inside Diameter		Total Wall Thickness		Liner Thickness		Max. Operating Pressure		Max. Operating Temperature* Hydraulic Service		Nominal Weight	
in	mm	in	mm	in	mm	in	mm	in	mm	psig	MPa	°F	°C	lbs/ft	kg/m
6	150	6.70	170.18	6.125	155.58	0.288	7.32	0.13	3.3	225	1.55	200	93	5.6	8.33
8	200	8.71	221.23	8.095	205.61	0.308	7.82	0.13	3.3	225	1.55	200	93	7.8	11.60
10	250	10.78	273.81	10.16	258.06	0.310	7.87	0.13	3.3	225	1.55	200	93	9.8	14.60
12	300	12.98	329.69	12.30	312.42	0.340	8.64	0.13	3.3	225	1.55	200	93	12.8	19.00
14	350	14.75	374.52	14.02	356.11	0.363	9.22	0.13	3.3	100	0.69	200	93	15.4	22.90
16	400	16.80	426.72	16.02	406.91	0.390	9.91	0.13	3.3	100	0.69	200	93	18.8	28.00

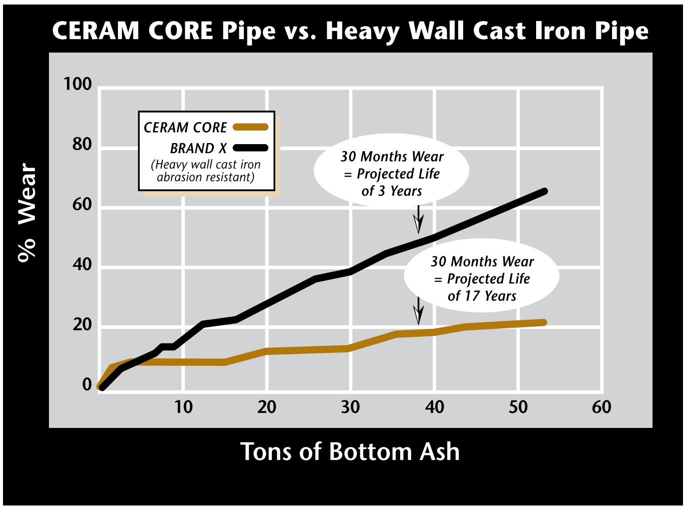
(*) Consult NOV Fiber Glass Systems concerning all pneumatic applications with Ceram Core pipe.

Significant Field Test

An Idaho mine installed a Ceram Core test spool in a zinc slurry to compare it to Schedule 80 steel. Normal life for the steel was one month. After 21 months, the Ceram Core spool was still in service.

A Ceram Core test spool was installed in a Wisconsin taconite operation. Carbon steel in this application lasted from 6 to 12 months without rotation. After 19 months without rotation, the Ceram Core spool showed little wear.

A 10-inch diameter, 18-foot Ceram Core test spool was installed in bottom ash service at a major power station in Georgia. Similar test spools of other types of pipe including heavy wall abrasion resistant cast iron were also installed. After 30 months handling 53,000 tons of ash, the Ceram Core test spool showed a projected continuing wear life of over 17 years versus 3 years for the metallic pipe (see graph). This utility since expanded Ceram Core pipe use, in 8”-12” diameters, to more than 6 miles at five separate plants.



Abrasion Resistant Piping Systems Comparison

Property	Ceram Core Pipe			Basalt Pipe			High Chromium Cast Iron Pipe		
	8”	10”	12”	8”	10”	12”	8”	10”	12”
I.D. Hardness	Brinell - Exceeds 615 MOH - 9 Rockwell - R45N - 79			- MOH - 7.8 -			Brinell - 300-500 - Rockwell - C-34-57		
Flow Factor (Hazen-Williams Coefficient)	130			100			100		
(1) **Weight per foot (lbs)**	7.2	9.8	12.8	58	70	83	55	60-70	75-93
Standard Length (ft)	25			18			18		
Weight per length of 10” pipe (lbs)	245(1)			1,260			1,170		
Typical fitting weight 90° elbow (lbs)	75	125	190	326	398	462	465	760	1,130

(1) Weight per 25-foot length of Ceram Core pipe includes two flanges.

Labor Estimate Example (Inside Building)

Pipe	Estimated man hours/ft of pipe installed	Estimated man hours to install 6,000 ft of pipe	
10" Ceram Core	0.302	1,814	
10" Cast Iron	0.810	4,860	
10" Basalt	1.140	6,840	
Fittings	**90°**	**45°**	**Laterals**
10" Ceram Core	3.39	3.26	5.89
10" Cast Iron	7.87	7.37	10.80
10" Basalt	10.23	9.58	14.04

Testing

Hydrostatic testing is recommended to evaluate the integrity of all new piping installations. CERAM CORE piping systems may be hydro tested to 1.5 times the maximum operating pressure rating. Note: The lateral fittings pressure ratings are lower than the pipe and standard fittings requiring special consideration. All other fittings match the pipe pressure ratings.

When hydro testing, open high-point vents (if used) to prevent entrapment of air in the lines as the system is slowly filled with water, then close the vents and slowly pressurize to the test pressure. Upon completion of hydro test, relieve the pressure on the system slowly, open vents and any drains to allow for complete drainage of the system.

Water Hammer

Piping systems may be damaged by pressure surges due to water hammer. The use of soft start pumps and slow actuating valves will reduce the magnitude of surge pressures during operation and are highly recommended.

Ceram Core Joining Methods

Proper joining procedures are extremely important to obtain the maximum service life from Ceram Core pipe.

Ceram Core pipe flanges have been designed to align and seal properly when installed as directed. Particular attention must be given to accurately align pipe I.D.'s at all joints. Proper installation prevents undercutting of the lining and protects the piping system from premature wear.

Ceram Core pipe can be installed in a new or existing systems. Since dimensions vary with the application, NOV Fiber Glass Systems will design transition fittings as needed for each installation upon receipt of necessary dimensional information.

More detailed information on proper handling and installation is available in Ceram Core Installation Manual.

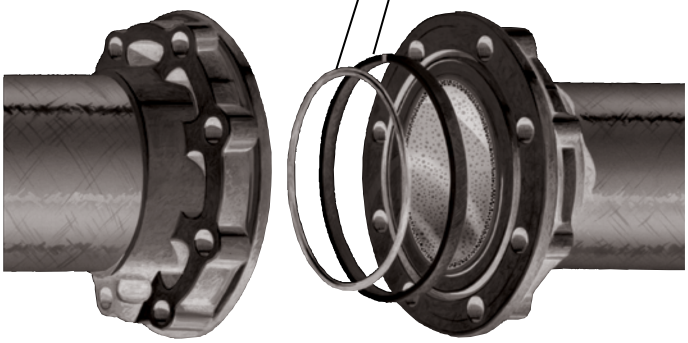
Self-aligning flanges are used on Ceram Core pipe and fittings to assure the inside diameters of the liners are properly aligned.

One filament wound epoxy resin aligning ring and one Buna™ N O-ring, supplied by NOV Fiber Glass Systems, is used on each joint. See Ceram Core pipe installation instructions.

Buna™ is a trademark of DuPont.

Self-Aligning Flanges

Specially designed Ceram Core flanges make it easy to properly align pipe and fittings when installing to new or existing systems.



Maximum Support Spacing for Uninsulated Pipe[1]

Nominal Pipe Size		Continuous Span [2]	
in	**mm**	**ft**	**m**
6	150	22.1	6.75
8	200	24.6	7.50
10	250	26.2	7.99
12	300	28.7	8.75
14	350	30.5	9.30
16	400	32.4	9.88

[1] For Sg=1.0, consult manufacturer for heavier insulated pipe support spans. Span recommendations include no provision for weight of (fittings, valves, etc.) or thrusts at branches and turns. Heavy valves and other appurtenances must be supported separately.

[2] Calculated spans are based on ½" mid-span deflections to ensure good appearance and adequate drainage. Total system stresses should always be taken into account by the system design engineer when determining support spans.

Support Span vs. Specific Gravity

Specific Gravity	1.25	1.5	2.0
Adjustment Factor	0.92	0.85	0.75

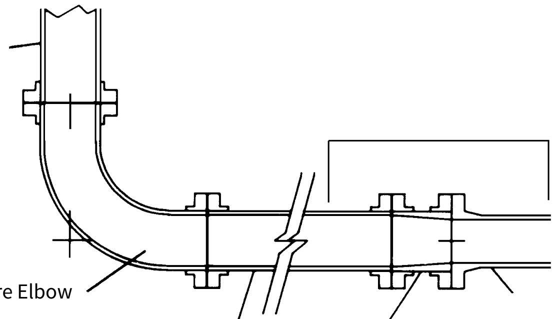
Transition Fittings

Transition fittings are necessary to join Ceram Core pipe to systems with different inside diameters. It is essential that inside diameters of pipe-to-pipe and pipe-to-fittings be exactly matched. Mismatched I.D.'s can cause liners to be undercut and scooped away, causing premature failure.

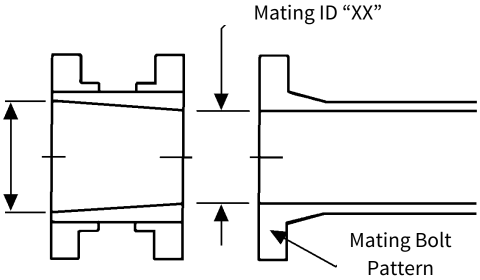
Two flanged transition fittings generally will be required for each application. A typical concentric reducer transition fitting is shown that will join another type of flanged system having an inside diameter "XX" to a Ceram Core system having an inside diameter "CC."

Connection to Other Piping

Ceram Core piping



Other Piping (flanged) - Detail A



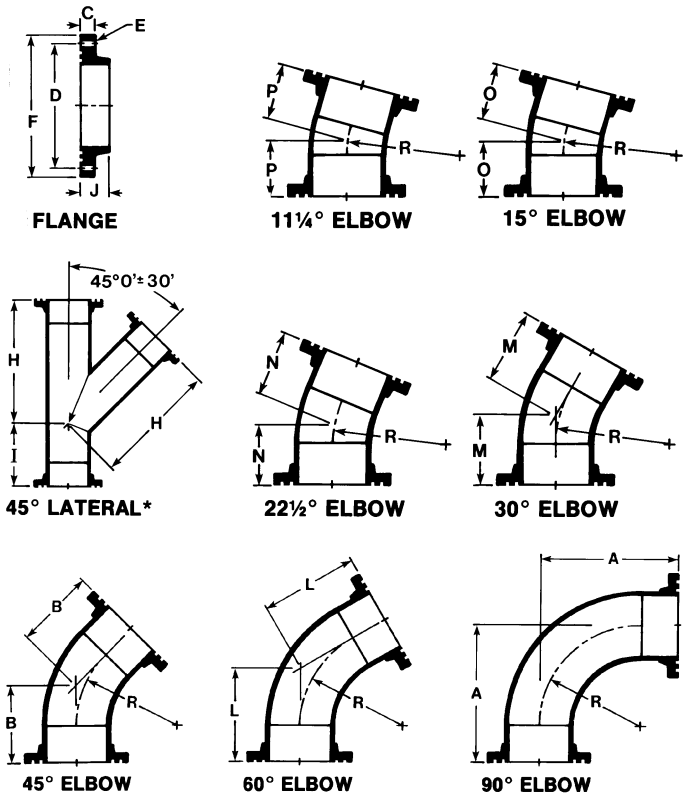
Fittings Information

Ceram Core abrasion resistant fittings 6" through 16" diameters are available in a variety of configurations - 45° elbows and 90° elbows[1], 45° laterals, flanges and 11 ¼°, 15°, 22 ½°, 30°, and 60° elbows, are standard parts. Other odd degree elbows are available on request.

All fittings have liners composed of tiles similar in composition to the alumina ceramic beads used in the liner of Ceram Core pipe. Fittings are designed to resist high turbulence and high impact.

Ceram Core fittings have thermosetting resin and fiberglass reinforcement for physical strength. Self-aligning flanges are utilized on all fittings.[2]

Ceram Core sweep elbows have a center line radius of three times the nominal diameter (see dimension R in table).



(1) 14" and 16" sweep elbows available in 45° or less only

(2) See NOV Fiber Glass Systems **Ceram Core Installation Manual** for bolt torque recommendations.

NOTE: Elbows and flanges pressure ratings match pipe ratings. 6"-12" laterals pressure rating are 100 psig; 14" and 16" are 80 psig. Do not pressurize over 1½ times the maximum operating pressure during hydrotest or due to surge pressure.

General Fittings Dimensions

Pipe Size			A	B	C	D	E	F	H	I	J	L	M	N	O	P	R
6	150	in	23 ½	12 ⅞	1 ½	9 ½	⅞ D-8 Holes	11	18	9	3	15 ⅞	10 ¼	9	7 ⅞	7 ¼	18
		mm	597	329	38	241	22 D - 8 Holes	279	457	229	76	404	262	230	200	184	457
8	200	in	30 ½	16 ⅜	1 ¾	11 ½	⅞ D-8 Holes	13 ½	22	11	4	20 ⅜	12 ⅞	11 ¼	9 ⅝	8 ⅞	24
		mm	775	418	44	298	22 D - 8 Holes	349	559	279	102	517	328	287	246	225	610
10	250	in	37 ¾	20 ⅛	2	14 ¼	1 D - 12 Holes	16	28	14	4 ¾	25	15	13	11 ⅝	10 ⅝	30
		mm	959	513	51	362	25 D - 12 Holes	406	711	356	121	637	402	349	297	271	762
12	300	in	44 ⅝	23 ½	2 ¼	17	1 D - 12 Holes	19	30	16	5	29 ⅜	18 ¼	15	13	12 ⅛	36
		mm	1113	598	57	432	25 D - 12 Holes	483	813	406	127	747	465	402	340	310	914
14	350	in	-	22 ⅞	2½	18 ¾	1 ⅛ D - 12 Holes	20 ¾	36	18	3 ⅛	-	16	13 ⅞	11	9 ⅝	42
		mm	-	581	64	476	29 D - 12 Holes	527	914	457	79	-	425	352	279	244	1067
16	400	in	-	27 ⅛	2 ½	21 ¼	1 ⅛ D - 16 Holes	23 ¼	42	21	3 ⅛	-	20 ⅛	16	13	12	48
		mm	-	689	64	540	29 D - 16 Holes	591	1067	533	79	-	511	427	345	305	1219

NOTE:
Consult NOV Fiber Glass Systems concerning all pneumatic applications with Ceram Core pipe.
Tolerances or maximum/minimum limits can be obtained from NOV Fiber Glass Systems.
For corrosion resistance data in liquid systems, refer to NOV Fiber Glass Systems **Chemical Resistance Guide** and use data for Green Thread™ Product.

Typical Mechanical Properties

Pipe Property	75°F	24°C	200°F	93°C	Method
	psi	MPa	psi	MPa	
Axial Tensile					
Ultimate Stress	9,530	65.7	6,585	45.4	ASTM D2105
Modulus of Elasticity	1.68×10^6	11,583	1.42×10^6	9,791	ASTM D2105
Poisson's Ratio, ν_{ah} (ν_{ha})(1)	0.35 (0.61)				
Axial Compression					
Ultimate Stress	12,510	86.3	8,560	59.0	ASTM D695
Modulus of Elasticity	0.677×10^6	4,668	0.379×10^6	2,620	ASTM D695
Beam Bending					
Ultimate Stress	20,200	139.3	15,400	106.2	ASTM D2925
Modulus of Elasticity (Long Term)	2.60×10^6	17,927	0.72×10^6	4,964	ASTM D2925
Hydrostatic Burst					
Ultimate Hoop Tensile Stress	40,150	276.8	36,480	251.5	ASTM D1599
Hydrostatic Design - Hoop Tensile Stress					
Static 20 Year Life LTHS - 95% LCL	-	-	18,203 - 14,689	125.5 - 101.3	ASTM D2992 - Procedure B
Static 50 Year Life LTHS - 95% LCL	-	-	16,788 - 13,142	115.7 - 90.6	ASTM D2992 - Procedure B
Parallel Plate					
Hoop Modulus of Elasticity	3.02×10^6	20,820	-	-	ASTM D2412
Shear Modulus	1.36×10^6	9,343	1.15×10^6	7,895	-

Typical Physical Properties

Pipe Property	Value	Value	Method
Thermal Conductivity	0.23 BTU/hr•ft•°F	0.4 W/m°C	ASTM D177
Thermal Expansion	8.5×10^{-6} in/in °F	15.3×10^{-6} mm/mm °C	ASTM D696
Absolute Roughness	0.00021 in	0.00053 mm	-
Specific Gravity	1.8		ASTM D792
Hazen-Williams Coefficient	150		-
Manning's Roughness Coefficient	0.009		-

(1) ν_{ah}= The ratio of hoop strain to axial strain resulting from stress in the axial direction.
ν_{ha}= The ratio of axial strain to hoop strain resulting from stress in the hoop direction.

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CI1500ENG February 2016

CERAM CORE® Piping System

Specification Guide

SECTION 1 – Scope

This section covers the use of fiberglass reinforced plastic (FRP) pipe for severe abrasion conditions caused by sharp angular particles in high flow streams services up to 210˚F and 225 psig steady pressure.

The piping system shall be furnished and installed complete with all fittings, joining materials, supports, specials, and other necessary appurtenances.

SECTION 2 – General Conditions

2.01 Coordination - Material furnished and work performed under this section shall be coordinated with related work and equipment specified under other sections.

Valves	Section	________
Supports	Section	________
Equipment	Section	________

2.02 Governing Standards - Except as modified or supplemented herein, all materials and construction methods shall comply with the applicable provisions of the following specifications and be tested using the following standards:

Standard Specifications

ASTM D2996	Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pipe
ASTM D4024	Standard Specification for Reinforced Thermosetting Resin (RTR) Flanges

Standard Test Methods

ASTM D2992	Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pipe and Fittings
ASTM D2925	Standard Practice for Measuring Beam Deflection of Reinforced Thermosetting Plastic Pipe Under Full Bore Flow
ASTM D1599	Standard Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings
ASTM D2105	Standard Test method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pipe and Tube
ASTM D2412	Standard Test Method for Determination of External Loading Characteristics of Plastic PIpe by Parallel-Plate Loading

2.03 Operating Conditions - In addition to the above listed minimum design requirements, the system shall meet the following minimum operating conditions:

a. Operating Pressure ________
b. Operating Temperature ________
c. Fluid Conveyed ________
d. Test Pressure ________

2.04 Quality Assurance – Pipe manufacturer's quality program shall be in compliance with ISO 9001.

2.05 Delivery, Storage, and Handling - Pipe and fittings shall be protected from damage due to impact and point loading. Pipe shall be properly supported to avoid damage due to flexural strains. The contractor shall not allow dirt, debris, or other extraneous materials to get into pipe and fittings. All factory machined areas shall be protected from sunlight until installed.

2.06 Acceptable Manufacturers - NOV Fiber Glass Systems, 501-568-4010, or approved equal.

SECTION 3 – Materials and Construction

3.01 6"-16" Pipe - The pipe shall be manufactured by the filament winding process using an amine cured epoxy thermosetting resin to impregnate strands of continuous glass filaments, which are wound around a mandrel at a $54^{1}/_{4}$˚ winding angle under controlled tension. Pipe shall be heat cured and the cure shall be confirmed using a Differential Scanning Calorimeter.

All pipe shall have a liner consisting of ceramic beads suspended in an epoxy matrix. The minimum liner thickness shall be 130 mil nominal.

Pipe shall be supplied with self-aligning flanges to assure the inside diameters of the liners are properly aligned.

Pipe shall have a continuous steady pressure rating at 200˚F as follows 6"-12" at 225 psig and 14"-16" at 100 psig in accordance with ASTM D2992 Procedure B.

All pipe shall be 100% hydrotested at the factory before shipment at a minimum pressure of 100 psig.

3.02 Flanges and Fittings – Abrasion resistant elbows shall be three diameter sweep radius and have self-aligning flanged ends. They shall be glass reinforced thermosetting resin with abrasion resistant ceramic tile liner.

Flanges shall have ANSI B16.5 Class 150 bolt hole patterns. It is recommended that a protective coating be used on the bolts to facilitate removal for rotation.

3.04 O-Ring Seals - O-Rings shall be 60-70 durometer Shore A hardness elastomeric material. O-rings for the self-aligning flanged joints will be supplied by manufacturer.

3.05 Bolts, Nuts, and Washers - ASTM A307, Grade B, hex head bolts shall be supplied. SAE washers shall be supplied on all nuts and bolts.

3.06 Acceptable Products - Ceram Core as manufactured by NOV Fiber Glass Systems, or approved equal.

SECTION 4 – Installation and Testing

4.01 Training and Certification - All joints installed or constructed in the field shall be assembled by employees of the contractor who have been trained by the pipe manufacturer. The pipe manufacturer or their authorized representative shall train the contractor's employees in the proper joining and assembly procedures required for the project, including hands-on participation by the contractor's employees.

4.02 Pipe Installation - Pipe shall be installed as specified and indicated on the drawings.

The piping system shall be installed in accordance with the manufacturer's current published installation procedures.

4.03 Testing - A hydrostatic pressure test shall be conducted on the completed piping system. The piping system should be pressurized to 1½ times the operating design pressure, and inspected. Then the pressurization should be maintained for 1-8 hours and the line inspected for leaks.

Field test pressures are limited to 1½ times the maximum cyclic rating of the lowest rated component in the system. The maximum test pressure should not exceed 338 psig. The system shall be filled with water at the lowest point and air bled off from the highest point. Systems shall be brought up to test pressure slowly to prevent water hammer or over-pressurization.

All pipe joints shall be water tight. All joints that are found to leak by observation or during testing shall be repaired by the contractor and retested.

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ISO 9001:2008
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NOV Fiber Glass Systems

CI1501 February 2009

Centricast RB-1520™ Product Data

Applications

- Dilute Acids
- Caustics
- Salts
- Solvents
- Chemical Process Solutions

Materials and Construction

All pipe is manufactured with high strength glass fabrics and a highly resilient formulation of aromatic amine cured epoxy resin. A 50-mil integral corrosion barrier of pure resin provides excellent corrosion resistance. The pipe's proprietary resin formulation provides the toughness for many corrosive slurries. A 10-mil resin-rich reinforced external corrosion barrier provides excellent corrosion resistance and protection from ultraviolet (UV) radiation. Fiber Glass Systems warrants CENTRICAST RB-1520 pipe and fittings against UV degradation of physical properties and chemical resistance for 15 years.

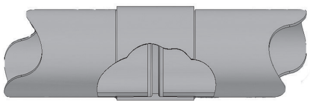
Pipe is available in **1½" through 14"** diameters with pressure ratings up to 150 psig at a maximum operating temperature of 225°F. **Centricast RB-1520** comes in 20' nominal or exact lengths from 18.0-20.4 feet long.

Fittings

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.

Joining Systems

Socket Joint
Adhesive bonded straight socket joint with positive stops. This is the standard for Centricast piping systems.



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)	(CuFt/Ft)
1½	1.55	39.4	1.90	48.3	0.18	4.4	0.12	2.9	0.58	0.86	0.10	0.013
2	2.06	52.2	2.38	60.3	0.16	4.1	0.10	2.5	0.68	1.01	0.17	0.023
3	3.18	80.8	3.50	88.9	0.16	4.1	0.10	2.5	1.03	1.53	0.41	0.055
4	4.18	106.2	4.50	114.0	0.16	4.1	0.10	2.5	1.34	1.99	0.71	0.095
6	6.27	159.0	6.63	168.0	0.18	4.6	0.12	3.0	2.23	3.32	1.60	0.214
8	8.23	209.0	8.63	219.0	0.20	5.1	0.14	3.6	3.24	4.82	2.76	0.369
10	10.30	262.0	10.75	273.0	0.22	5.6	0.16	4.1	4.45	6.63	4.34	0.580
12	12.30	312.0	12.75	324.0	0.24	6.1	0.18	4.6	5.77	8.59	6.14	0.821
14	13.50	343.0	14.00	356.0	0.24	6.1	0.18	4.6	6.35	9.45	7.46	0.997

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

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)
1½	0.67	0.27	0.28	0.97
2	0.71	0.46	0.39	1.11
3	1.07	1.54	0.88	1.68
4	1.38	3.35	1.49	2.18
6	2.45	13.00	3.92	3.64
8	3.73	33.60	7.79	5.29
10	5.32	74.60	13.90	7.28
12	7.11	140.00	22.00	9.43
14	7.82	187.00	26.70	10.40

Average Physical Properties

Property	75°F psi	24°C MPa	200°F psi	99°C MPa	225°F psi	107°C MPa
Axial Tensile - ASTM D2105						
Ultimate Stress	30,000	210	26,000	180	25,000	170
Design Stress	7,500	52	6,500	45	6,250	43
Modulus of Elasticity	$2.5x10^6$	17,200	$2.2x10^6$	15,200	$2.1x10^6$	14,500
Poisson's Ratio ν	0.15		0.15		0.15	
Axial Compression - ASTM D695						
Ultimate Stress	35,000	240	28,000	190	17,000	110
Design Stress	8,750	60	7,000	48	4,250	29
Modulus of Elasticity	$3.2x10^6$	22,000	$2.8x10^6$	19,300	$2.7x10^6$	18,600
Beam Bending - ASTM D2925						
Ultimate Stress	40,000	280	35,000	240	33,000	230
Design Stress(1)	5,000	34	4,375	30	4,125	28
Modulus of Elasticity (Long Term)	$3.7x10^6$	26,000	$3.2x10^6$	22,000	$3.1x10^6$	21,000
Hydrostatic Burst - ASTM D1599						
Ultimate Hoop Tensile Stress	30,000	210	26,000	180	25,000	170
Hoop Tensile Modulus of Elasticity	$2.4x10^6$	17,000	$2.1x10^6$	14,500	$2.0x10^6$	13,800
Hydrostatic Design - ASTM D2992, Procedure B - Hoop Tensile Stress Static 50 Year @ 75°F	19,270	130	-	-	-	-

(1) Stress and modulus values can be interpolated between temperatures shown.

Coefficient of Linear Thermal Expansion - ASTM D696	Non-Insulated Pipe: $9.6 x 10^{-6}$ in/in/°F • $17.4 x 10^{-6}$ mm/mm/°C Insulated Pipe: $13.0 x 10^{-6}$ in/in/°F • $23.5 x 10^{-6}$ mm/mm/°C
Thermal Conductivity	0.07 BTU/-hr-ft-°F • 0.04 W/-m-°C
Specific Gravity - ASTM D792	1.41
Flow Factor - SF / Hazen-Williams Coefficient	150
Absolute Surface Roughness	0.00021 Inch • 0.0053 mm
Manning's Roughness Coefficient, n	0.009

Testing:

See NOV FIber Glass Systems' **Socket Joint Installation Handbook.**

When possible, the piping system should be hydrostatically tested prior to beginning service. Care should be taken when testing 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.

Water Hammer:

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

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

Pipe Size (In)	Maximum Internal Pressure @ 225°F (psig)			Maximum External Pressure(6)		
	Socket Pressure Fittings(3)	Flanged Pressure Fittings(4)	Other Pressure Fittings(5)	75°F	150°F	225°F
1 1/2	300	150	NA	920	753	649
2	300	150	125	290	231	199
3	275	150	125	103	104	90
4	150	150	100	47	37	32
6	150	150	100	22	18	16
8	150	150	100	19	12	11
10	150	150	75	12	10	8
12	150	150	75	7	6	5
14	125	150	-	7	6	5

ASTM D2997 Designation Codes	
1½"- 4"	RTRP-21CW-4556
6"	RTRP-21CW-4555
8"	RTRP-21CW-4554
10"-12"	RTRP-21CW-4553
14"	RTRP-21CW-4552

(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) For insulated and/or heat traced piping systems, use 100% of the uninsulated piping recommendations up to 200°F and reduce these ratings 50% for 200°F to 225°F operating temperatures. **Centricast RB-1520** pipe and epoxy fittings can be used in drainage and vent systems up to 250°F operating temperatures. For compressible gasses consult the factory for pressure ratings. Heat cured adhesive joints are highly recommended for all piping systems carrying fluids at temperatures above 120°F.

(3) Socket elbows, tees, reducers, couplings, flanges and nipples joined with **WELDFAST ZC275** 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.

Recommended Operating Ratings

Size (In)	Axial Tensile Loads Max. (Lbs) Temperature		Axial Compressive Loads Max. (Lbs)(1) Temperature		Bending Radius Min. (Ft) Entire Temp. Range	Torque Max. (Ft Lbs) Entire Temp. Range	Parallel Plate Loading ASTM D2412		
	@ 75°F	@ 225°F	@ 75°F	@ 225°F			Stiffness Factor In^3 Lbs/In^2	Pipe Stiffness (psi)	Hoop Modulus $x10^6$ (psi)
1 1/2	5,000	4,100	5,800	2,800	59	113	279	2,632	2.2
2	5,400	4,500	6.300	3,000	73	163	317	1,444	3.8
3	8,000	6,700	9,300	4,500	108	368	317	433	3.8
4	10,400	8,600	12,100	5,900	139	620	317	200	3.8
6	18,400	15,300	21,500	10,400	204	1,632	547	107	3.8
8	28,000	23,300	32,700	15,900	266	3,246	709	62	3.1
10	39,900	33,300	46,600	22,600	331	5,786	1,195	54	3.5
12	53,300	44,400	62,200	30,200	393	9,178	1,701	46	3.5
14	58,600	48,800	68,400	33,200	432	11,108	1,701	35	3.5

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

Support

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 heavy valves and in-line equipment independently.
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 loading to minimize bending stress on pipe and fittings.
7. Provide adequate axial and lateral restraint to ensure line stability during rapid changes in flow.

Maximum Support Spacing for Uninsulated Pipe[1]

Pipe Size (In.)	Continuous Spans of Pipe (Ft.)[2]		
	75°F	150°F	225°F
1½	16.6	16.0	15.9
2	17.3	16.7	16.6
3	19.4	18.7	18.6
4	20.9	20.1	20.0
6	24.2	23.3	23.2
8	26.9	26.0	25.8
10	29.5	28.4	28.2
12	31.7	30.6	30.4
14	32.5	31.4	31.4

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

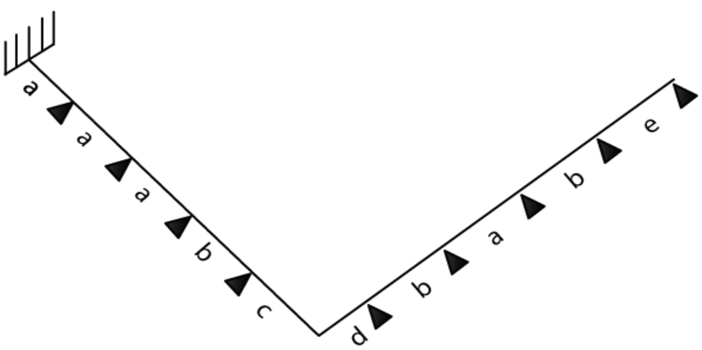
Support Spacing vs. Specific Gravity

Specific Gravity	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 @ 150°F with 1.5 specific gravity fluid,maximum support spacing = 23.9 x 0.90 = 21.5 ft.

Piping Span Adjustment Factors With Unsupported Fitting at Change in Direction

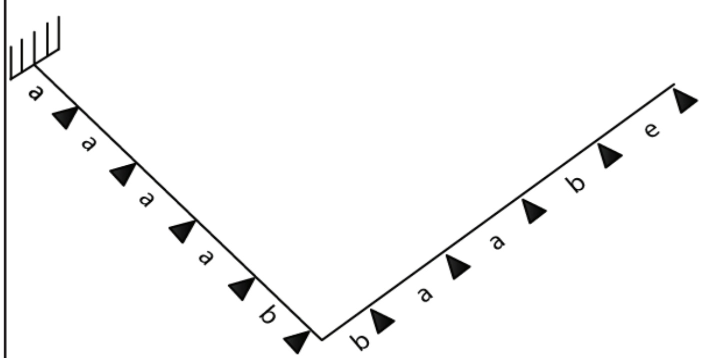
	Span Type	Factor
a	Continuous interior or fixed end spans	1.00
b	Second span from simple supported end or unsupported fitting	0.80
c + d	Sum of unsupported spans at fitting	≤ 0.75*
e	Simple supported end span	0.67



** 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

A comprehensive review of temperature effects on fiberglass pipe may be found in Fiber Glass Systems' **Engineering and Piping Design Guide.**

Change in Temperature °F	Pipe Change In Length (In/100 Ft)
25	0.29
50	0.58
75	0.86
100	1.15
125	1.44
150	1.73
175	2.02
200	2.30

Restrained Thermal End Loads and Guide Spacing

Size (In)	Operating Temperature °F (Based on Installation Temperature of 75°F)									
	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)
1½	8.2	982	6.6	1,440	5.6	1,862	4.9	2,255	4.4	2,609
2	10.5	1,046	8.4	1,533	7.1	1,983	6.2	2,401	5.6	2,779
3	15.6	1,564	12.6	2,292	10.6	2,963	9.3	3,589	8.4	4,153
4	20.2	2,024	16.3	2,966	13.8	3,835	12.0	4,645	10.8	5,374
6	29.9	3,590	24.0	5,262	20.4	6,804	17.8	8,240	16.0	9,535
8	39.0	5,463	31.4	8,007	26.6	10,354	23.2	12,539	20.9	14,510
10	48.6	7,793	39.1	11,421	33.2	14,768	29.0	17,886	26.0	20,696
12	57.7	10,406	46.5	15,251	39.4	19,721	34.4	23,883	30.9	27,637
14	63.4	11,441	51.1	16,768	43.3	21,682	37.8	26,528	34.0	30,385

Elbow Strength

Allowable Bending Moment 90° Elbow			
Nominal Pipe Size (In)	Allowable Moment (Ft•Lbs)	Nominal Pipe Size (In)	Allowable Moment (Ft•Lbs)
1½	150	8	2,850
2	225	10	4,500
3	475	12	6,500
4	650	14	10,000
6	1,650		

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NOV Fiber Glass Systems

CI1610 -June 2010

CENTRICAST™ RB-1520 Piping System

General Specifications

SECTION 1 - Scope

This section covers the use of fiberglass reinforced plastic (FRP) pipe for chemical process and chemical handling applications up to 250°F and up to 150 psig pressure.

The piping shall be furnished and installed complete with all fittings, joining materials, supports, specials, and other necessary appurtenances.

SECTION 2 - General Conditions

2.01 Coordination - Material furnished and work performed under this section shall be coordinated with related work and equipment specified under other sections.

Valves	Section ________
Supports	Section ________
Equipment	Section ________

2.02 Governing Standards - Except as modified or supplemented herein, all materials and construction methods shall comply with the applicable provisions of the following specifications and be tested using the following standards:

Standard Specifications

ASTM D2997	Standard Specification for Centrifugal Cast "Fiberglass" (Glass-Fiber-Reinforced Thermosetting) Resin Pipe
AWWA 45	Fiberglass Pipe Design
ASTM D5685	Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pressure Pipe Fittings
ASTM D4024	Standard Specification for Reinforced Thermo-setting Resin (RTR) Flanges

Standard Test Methods

ASTM D2992	Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe
ASTM D1599	Standard Test method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings
ASTM D2105	Standard Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Tube
ASTM D2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASME B31.3	Process Piping

2.03 ASTM D2997 Designation Codes

1½"-4"	RTRP-21CW-4556
6"	RTRP-21CW-4555
8"	RTRP-21CW-4554
10"-12"	RTRP-21CW-4553
14"	RTRP-21CW-4552

Mechanical properties cell classifications shown are minimums.

2.04 Operating Conditions- In addition to the above minimum design requirements, the system shall meet the following minimum operating conditions:

a. Operating Pressure _______
b. Operating Temperature _______
c. Fluid Conveyed _______
d. Test Pressure _______

2.05 Quality Assurance - Pipe manufacturer's quality program shall be in compliance with ISO 9001.

2.06 Delivery, Storage and Handling - Pipe and fittings shall be protected from damage due to impact and point loading. Pipe shall be properly supported to avoid damage due to flexural strains. The contractor shall not allow dirt, debris, or other extraneous materials to get into pipe and fittings. All factory machined areas shall be protected from sunlight until installed.

2.07 Acceptable Manufacturers - NOV Fiber Glass Systems - 918-245-6651 or approved equal.

SECTION 3 - Materials and Construction

3.01 1½"-14" Pipe The pipe shall be manufactured by the centrifugal casting process using premium grade amine cured epoxy thermosetting resin to impregnate woven glass filaments. Pipe shall be heat cured and the degree of cure shall be confirmed using a Differential Scanning Calorimeter. All pipe shall have a 100% resin corrosion barrier and the cured thickness shall be 50 mils nominal.

All pipe shall have a resin-rich reinforced 10 mil nominal exterior layer.

The pipe shall have a minimum design pressure rating of 150 psig at 225°F following ASTM D2992, Procedure B.

Minimum Reinforced Wall Thickness

1½"	0.120 inches
2"-4"	0.100 inches
6"	0.120 inches
8"	0.140 inches
10"	0.160 inches
12"-14"	0.180 inches

3.02 Flanges and Fittings - All fittings shall be manufactured either by compression molding or contact molding. Fitting joints shall be either adhesive bonded socket or flanged. Flanges shall have ANSI B16.5 Class 150 bolt hold patterns.

3.03 Adhesive - Adhesive shall be manufacturer's standard for the piping system specified. All adhesive bonded joints shall be cured according to the manufacturer's instructions for maximum strength and corrosion resistance.

3.04 Gaskets - Gaskets shall be 3/16" thick, 60-70 durometer full-face type suitable for the service shown on the drawings and as recommended in the manufacturer's standard installation procedures.

3.05 Bolts, Nuts and Washers - ASTM F593, 304 stainless steel hex head bolts shall be supplied. Two each SAE size washers shall be supplied on all nuts and bolts.

3.06 Acceptable Products Centricast RB-1520 as manufactured by NOV Fiber Glass Systems or approved equal.

SECTION 4 - Installation and Testing

4.01 Training and Certification - All joints installed or constructed in the field shall be assembled by employees of the contractor who have been trained by the pipe manufacturer. The pipe manufacturer or their authorized representative shall train the contractor's employees in the proper joining and assembly procedures required for the project, including hands-on participation by the contractor's employees. Each bonder shall fabricate one pipe-to-pipe and one pipe-to-fitting joint that shall pass the minimum pressure test for the application as stated in Section 2.04.d without leaking.

Only bonders who have successfully completed the pressure test shall bond pipe and fittings.

Certification by the manufacturer shall be in compliance with ASME B31.3, Section A328.2.

4.02 Pipe Installation Pipe shall be installed as specified and indicated on the drawings and in accordance with the manufacturer's current published installation procedures.

4.03 Testing - A hydrostatic pressure test shall be conducted on the completed piping system. **The piping shall be subjected to a steady pressure at 1½ times the design operating pressure as stated in Section 2.04d.** The pressure shall be held on the system for a minimum of one hour and the line inspected for leaks.

The test pressure should not exceed 1½ times the maximum rated operating pressure for the lowest rated element in the system.

The system shall be filled with water at the lowest point and air bled off from all the highest points. Systems shall be brought up to test pressure slowly to prevent water hammer or over pressurization.

All pipe joints shall be water tight. All joints that are found to leak by observation or during testing shall be repaired by the contractor and retested.

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NOV Fiber Glass Systems

CI1611 February 2009

Centricast® RB-2530 Product Data

Applications

- Acids
- Caustics
- Salts
- Solvents
- Chemical Process Solutions

Materials and Construction

All pipe is manufactured with glass fabrics and a highly resilient formulation of aromatic amine cured epoxy resin. A 100 mil integral corrosion barrier of pure resin provides excellent corrosion resistance. The pipe's proprietary resin formulation provides the toughness for many corrosive slurries. A 10 mil resin-rich reinforced external corrosion barrier proves excellent corrosion resistance and protection from ultraviolet (UV) radiation. Fiber Glass Systems warrants CENTRICAST RB-2530 pipe and fittings against UV degradation of physical properties and chemical resistance for 15 years.

Pipe is available in **1" through 14"** diameters with pressure ratings up to 150 psig, with higher pressure ratings in smaller sizes. **Centricast RB-2530** comes in 20' nominal or exact lengths from 18.0-20.4 feet long.

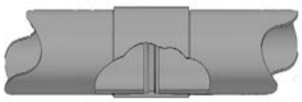
Fittings

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.

Joining Systems

Socket Joint

Adhesive bonded straight socket joint with positive stops. This is the standard for Centricast piping systems.



Nominal Dimensional Data

Pipe Size	I.D.		O.D.		Wall Thickness		Reinforcement Thickness		Weight		Capacity	
(In)	(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	0.45	0.66	0.03	0.005
1½	1.40	35.6	1.900	48.3	0.25	6.4	0.14	3.6	0.82	1.23	0.08	0.011
2	1.88	47.6	2.375	60.3	0.25	6.4	0.14	3.6	1.06	1.58	0.14	0.019
3	3.00	76.2	3.500	88.9	0.25	6.4	0.14	3.6	1.62	2.42	0.37	0.049
4	3.94	100.1	4.500	114.0	0.28	7.1	0.17	4.3	2.36	3.51	0.63	0.085
6	6.07	154.0	6.625	168.0	0.28	7.1	0.17	4.3	3.55	5.28	1.50	0.201
8	8.03	204.0	8.625	219.0	0.30	7.6	0.19	4.8	4.99	7.43	2.63	0.351
10	10.10	256.0	10.750	273.0	0.33	8.4	0.22	5.6	6.87	10.2	4.15	0.555
12	12.10	307.0	12.750	324.0	0.33	8.4	0.22	5.6	8.19	12.2	5.96	0.797
14	13.30	339.0	14.000	356.0	0.33	8.4	0.22	5.6	9.01	13.4	7.26	0.971

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

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	3.45	18.00	5.42	5.58
8	5.03	44.80	10.40	7.85
10	7.28	101.00	18.80	10.80
12	8.66	170.00	26.70	12.90
14	9.52	226.00	32.30	14.20

Average Physical Properties

Property	75°F/ 24°C 1”		75°F/24°C 1½”-14”		225°F/107°C 1”		225°F/107°C 1½”-14”		250°F/121°C 1”		250°F/121°C 1½”-14”	
	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa
Axial Tensile - ASTM D2105												
Ultimate Stress	18,000	120	22,000	150	15,000	100	18,000	120	14,000	100	17,000	110
Design Stress	4,500	31	5,500	38	3,750	26	4,500	31	3.500	24	4,250	29
Modulus of Elasticity	-	-	2.5×10^6	17,000	-	-	2.1×10^6	14,000	-	-	1.9×10^6	13,000
Poisson's Ratio ν	0.15				0.15				0.15			
Axial Compression - ASTM D695												
Ultimate Stress	19,600	140	35,000	240	10,000	70	19,000	130	7.000	50	13,000	90
Design Stress	4,900	34	8,750	60	2,500	17	4,750	33	1,750	12	3,250	22
Modulus of Elasticity	1.3×10^6	9,000	2.5×10^6	17,000	1.1×10^6	8,000	2.1×10^6	14,000	1.0×0^6	7,000	1.9×10^6	13,000
Beam Bending - ASTM D2925												
Ultimate Stress	28,000	190	42,000	290	23,000	160	35,000	240	21,000	140	32,000	220
Design Stress(1)	3,500	24	5,250	36	2,875	20	4,375	30	2,625	18	4,000	28
Modulus of Elasticity (Long Term)	5.6×10^6	4,000	3.7×10^6	26,000	4.7×10^6	3,200	3.1×10^6	21,000	4.4×10^6	3,000	2.9×10^6	20,000
Hydrostatic Burst - ASTM D1599												
Ultimate Hoop Tensile Stress	30,000	210	30,000	210	25,000	170	25,000	170	23,000	160	23,000	160
Hoop Tensile Modulus of Elasticity	-	-	2.8×10^6	19,000	-	-	2.3×10^6	16,000	-	-	2.2×10^6	15,000
Hydrostatic Design - ASTM D2992, Procedure B-Hoop Tensile Stress Static 50 Year @ 75°F	16,090	110	16,090	110	-	-	-	-	-	-	-	-

(1)Stress and modulus values can be interpolated between temperatures shown.

Thermal Expansion Coefficient - ASTM D696	Non-Insulated Pipe: 11.0×10^{-6} In/In/°F • 19.9×10^{-6} mm/mm/°C Insulated Pipe: 12.0×10^{-6} In/In/°F • 21.7×10^{-6} mm/mm/°C	
Thermal Conductivity	0.07 BTU/hr-ft-°F	0.4 W/m-°C
Specific Gravity - ASTM D792	1.47	
Hazen-Williams Coefficient	150	
Absolute Surface Roughness	0.00021 Inch	0.0053 mm
Manning's Roughness Coefficient, n	0.009	

Testing:

See NOV Fiber Glass Systems' **Socket Joint Installation Handbook.**

When possible, the piping system should be hydrostatically tested prior to beginning service. Care should be taken when testing 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.

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

Nominal Pipe Size (In)	Maximum Internal Pressure @ 225°F (psig)			Maximum External Pressure (psig)(6)		
	Socket Pressure Fittings(3)	Flanged Pressure Fittings(4)	Other Pressure(5)	75°F	150°F	250°F
1	300	300	-	2,125	1,849	1,381
1½	300	300	-	2,065	1,797	1,342
2	300	150	125	1,170	1,014	763
3	275	150	125	335	290	219
4	150	150	100	225	195	147
6	150	150	100	62	54	40
8	150	150	100	45	39	29
10	150	150	75	35	30	23
12	150	150	75	23	20	15
14	125	150	-	16	14	10

ASTM D2997 Designation Codes:	
1”	RTRP-21CW-4356
1½”-4”	RTRP-21CW-4456
6”-8”	RTRP-21CW-4455
10”-12”	RTRP-21CW-4454
14”	RTRP-21CW-4553

(1)Static pressure ratings, typically created with use of a gear turbine, centrifugal, 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/or heat traced piping systems, use 100% of the uninsulated piping recommendations up to 200°F and reduce these ratings 50% for 200°F to 250°F operating temperatures. For uninsulated piping systems, reduce these ratings 30% for 225°F to 250°F operating temperatures. Heat cured adhesive joints are highly 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, crosses, and saddles.
(6)Ratings shown are 50% of ultimate; 14.7 psi external pressure is equal to full vacuum.

Recommended Operating Ratings

Size (In)	Axial Tensile Loads Max. (Lbs) Temperature 75°F	Axial Tensile Loads Max. (Lbs) Temperature 250°F	Axial Compressive Loads Max. (Lbs)(1) Temperature 75°F	Axial Compressive Loads Max. (Lbs)(1) Temperature 250°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	1,560	1,200	1,700	600	50	41	164	4,791	2.7
1½	4,260	3,300	6,770	2,500	56	132	617	6,080	2.7
2	5,410	4,200	8,600	3,200	70	216	617	2,969	2.7
3	8,130	6,300	12,930	4,800	103	497	617	874	2.7
4	12,720	9,800	20,230	7,500	132	1,000	1,105	731	2.7
6	18,960	14,700	30,160	11,200	195	2,260	1,228	245	3.0
8	27,690	21,400	44,060	16,400	253	4,330	1,715	153	3.0
10	40,030	30,900	63,680	23,700	316	7,820	3,106	143	3.5
12	47,630	36,800	75,780	28,100	374	11,100	3,106	85	3.5
14	52,380	40,500	83,340	31,000	411	13,500	3,106	64	3.5

(1)Compressive loads are for short columns only.

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.

Support

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 heavy valves and in-line equipment independently.
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 loading to minimize bending stresses on pipe and fittings.
7. Provide adequate axial and lateral restraint to ensure line stability during rapid changes in flow.

Maximum Support Spacing for Uninsulated Pipe[1]

Pipe Size (In.)	Continuous Spans of Pipe (Ft.)[2]		
	75°F	150°F	250°F
1	8.4	8.3	7.9
1½	16.6	16.4	15.6
2	18.3	18.0	17.2
3	20.7	20.4	19.5
4	23.3	22.9	21.9
6	26.0	25.7	24.5
8	28.8	28.4	27.1
10	31.6	31.1	29.8
12	33.2	32.7	31.2
14	34.1	33.6	32.0

[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

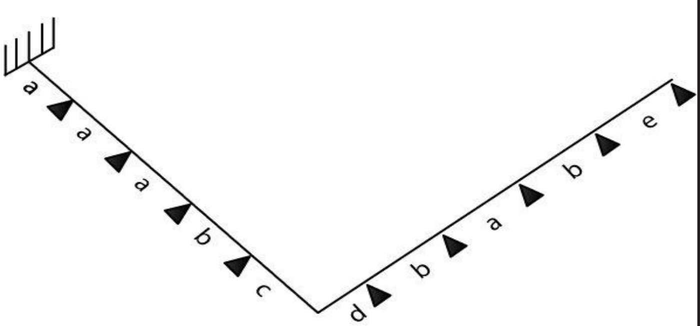
Specific Gravity	3.00	2.00	1.50	1.25	1.00	0.75	Gas/Air
Multiplier	0.76	0.84	0.90	0.95	1.00	1.07	1.40

Example: 6" pipe @ 150°F with 1.5 specific gravity fluid, maximum support spacing = 25.7 x 0.90 = 23.1 ft.

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

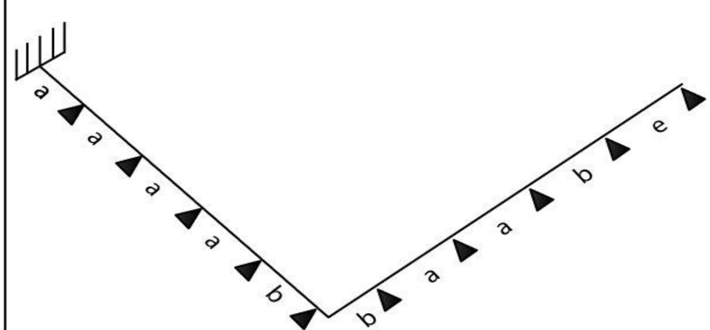
	Span Type	Factor
a	Continuous interior or fixed end spans	1.00
b	Second span from supported end or unsupported fitting	0.80
c+d	Sum of unsupported spans at fitting	≤0.75*
e	Simple supported end span	0.67

*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.**

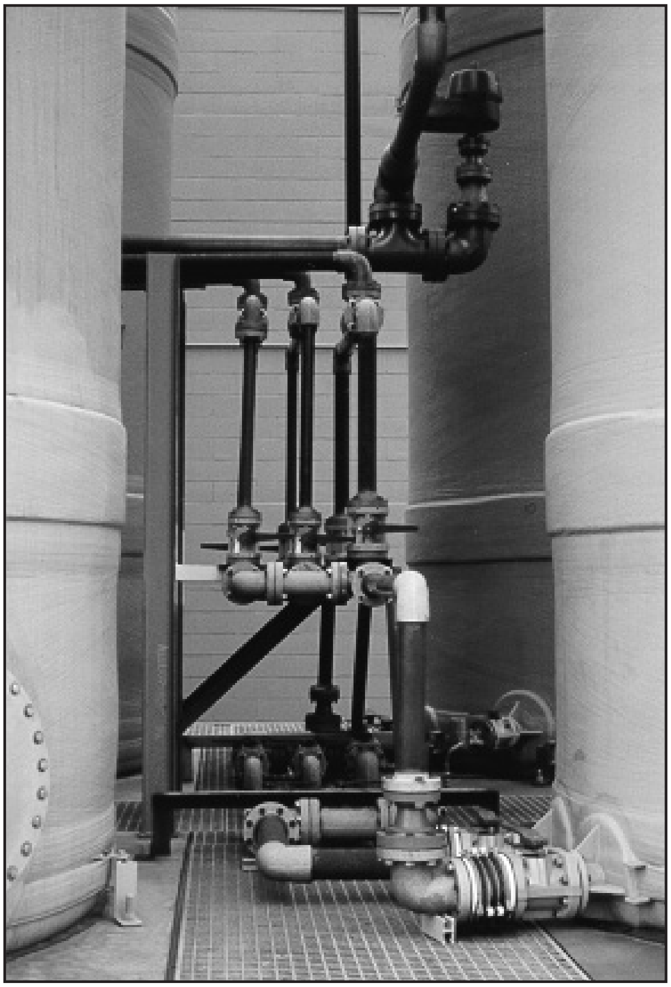
Change in Temperature °F	Pipe Change in Length (In/100 Ft)
25	0.3
50	0.7
75	1.0
100	1.3
125	1.7
150	2.0
175	2.3
200	2.6

Restrained Thermal End Loads and Guide Spacing

Size (In)	Operating Temperature °F (Based on Installation Temperature of 75°F)									
	100°F		150°F		175°F		200°F		225°F	
	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	3.9	128	2.3	383	2.0	510	1.8	638	1.6	765
1½	10.4	553	6.0	1,658	5.2	2,210	4.7	2,763	4.3	3,315
2	13.2	700	7.6	2,100	6.6	2,800	5.9	3,500	5.4	4,200
3	19.9	1,053	11.5	3,158	9.9	4,210	8.9	5,263	8.1	6,315
4	25.6	1,648	14.8	4,943	12.8	6,590	11.4	8,238	10.4	9,885
6	38.1	2,458	22.0	7,373	19.1	9,830	17.1	12,288	15.6	14,745
8	49.8	3,588	28.8	10,763	24.9	14,350	22.3	17,938	20.3	21,525
10	62.2	5,185	35.9	15,555	31.1	20,740	27.8	25,925	25.4	31,110
12	74.0	6,170	42.7	18,510	37.0	24,680	33.1	30,850	30.2	37,020
14	81.4	6,785	47.0	20,355	40.7	27,140	36.4	33,925	33.2	40,710

Elbow Strength

Allowable Bending Moment - 90° Elbow			
Nominal Pipe Size (In)	Allowable Moment (Ft•Lbs)	Nominal Pipe Size (In)	Allowable Moment (Ft•Lbs)
1	100	6	1,650
1½	150	8	2,850
2	225	10	4,500
3	475	12	6,500
4	650	14	10,000



QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
ISO 9001:2008
LITTLE ROCK, AR
SAND SPRINGS, OK
SUZHOU, CHINA
FIBER GLASS SYSTEMS

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

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NOV Fiber Glass Systems

CI1600 - September 2012

Centricast™ RB-2530 Piping System

(Specification Guide)

CHEMICAL & INDUSTRIAL

Section 1 - Scope

This section covers the use of fiberglass reinforced plastic (FRP) pipe for chemical process and chemical handling up to 250°F and up to 150 psig pressure.

The piping shall be furnished and installed complete with all fittings, joining materials, supports, specials, and other necessary appurtenances.

Section 2 - General Conditions

2.01 Coordination - Material furnished and work performed under this section shall be coordinated with related work and equipment specified under other sections.

Valves	Section	_________
Supports	Section	_________
Equipment	Section	_________

2.02 Governing Standards - Except as modified or supplemented herein, all materials and construction methods shall comply with the applicable provisions of the following specifications and be tested using the following standards.

Standard Specifications

ASTM D2997	Standard Specification for Centrifugal Cast "Fiberglass" (Glass-Fiber-Reinforced Thermosetting) Resin Pipe
AWWA 45	Fiberglass Pipe Design
ASTM D5685	Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pressure PIpe Fittings
ASTM D4024	Standard Specification for Reinforced Thermosetting Resin (RTR) Flanges

Standard Test Methods

ASTM D2997	Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe
ASTM D1599	Standard Test method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings
ASTM D2105	Standard Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Tube
ASTM D2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASTM B31.3	Process Piping

2.03 ASTM D2997 Designation Codes

1" - 1½"	RTRP-21CW-4326
2" - 4"	RTRP-21CW-4456
6" - 8"	RTRP-21CW-4455
10" - 12"	RTRP-21CW-4454
14"	RTRP-21CW-4553

Mechanical properties cell classifications shown are minimums.

2.04 Operating Conditions - In addition to the above minimum design requirements, the system shall meet the following minimum operating conditions:

a. Operating Pressure ________

b. Operating Temperature ________

c. Fluid Conveyed ________

d. Test Pressure ________

2.05 Quality Assurance - Pipe manufacturer's quality program shall be in compliance with ISO 9001.

2.06 Delivery, Storage and Handling - Pipe and fittings shall be protected from damage due to impact and point loading. Pipe shall be properly supported to avoid damage due to flexural strains. The contractor shall not allow dirt, debris, or other extraneous materials to get into pipe and fittings. All factory machined areas shall be protected from sunlight until installed.

2.07 Acceptable Manufacturers - NOV Fiber Glass Systems (918) 245-6651 or approved equal.

Section 3 - Materials and Construction

3.01 1"-14" Pipe - The pipe shall be manufactured by the centrifugal casting process using premium grade amine cured epoxy thermosetting resin to impregnate woven glass filaments. Pipe shall be heat cured and the degree of cure shall be confirmed using a Differential Scanning Calorimeter. All pipe shall have a 100% resin corrosion barrier and the cured thickness shall be 100 mils nominal.

All pipe shall have a resin-rich reinforced 10 mil nominal exterior layer.

The pipe shall have a minimum design pressure rating of 150 psig at 150°F following ASTM D2992 Procedure B.

Nominal Reinforced Wall Thickness

1"	0.090 inches
1½" - 3"	0.140 inches
4" - 6"	0.170 inches
8"	0.190 inches
10" - 14"	0.220 inches

3.02 Flanges and Fittings - All fittings shall be manufactured either by compression molding or contact molding. Fitting joints shall be either adhesive bonded socket or flanged. Flanges shall have ANSI B16.5 Class 150 bolt hole patterns.

3.03 Adhesive - Adhesive shall be manufacturer's standard for the piping system specified. All adhesive bonded joints shall be cured according to the manufacturer's instructions for maximum strength and corrosion resistance.

3.04 Gaskets - Gaskets shall be 3/16" thick, 60-70 durometer full-fact type suitable for the service shown on the drawings and as recommended in the manufacturer's standard installation procedures.

3.05 Bolts, Nuts and Washers - ASTM F593, 304 stainless steel hex head bolts shall be supplied. Two each SAE size washers shall be supplied on all nuts and bolts.

3.06 Acceptable Products - Centricast RB-2530 as manufactured by NOV Fiber Glass Systems or approved equal.

Section 4 - Installation and Testing

4.01 Training and Certification - All joints installed or constructed in the field shall be assembled by employees of the contractor who have been trained by the pipe manufacturer. The pipe manufacturer or their authorized representative shall train the contractor's employees in the proper joining and assembly procedures required for the project, including hands-on participation by the contractor's employees. Each bonder shall fabricate one pipe-to-pipe and one pipe-to-fitting joint that shall pass the minimum pressure test for the application as stated in Section 2.04.d without leaking.

Only bonders who have successfully completed the pressure test shall bond pipe and fittings.

Certification by the manufacturer shall be in compliance with ASME B31.3, Section A328.2.

4.02 Pipe Installation - Pipe shall be installed as specified and indicated on the drawings and in accordance with the manufacturer's current published installation procedures.

4.03 Testing A hydrostatic pressure test shall be conducted on the completed piping system. The pipe shall be subjected to a steady pressure at 1½ times the design operating pressure as stated in Section 2.04d. The pressure shall be held on the system for a minimum of one hour and the line inspected for leaks.

The test pressure should not exceed 1½ times the maximum rated operating pressure for the lowest rated element in the system.

The system shall be filled with water at the lowest point and air bled off from all the highest points. Systems shall be brought up to test pressure slowly to prevent water hammer or over pressurization.

All pipe joints shall be water tight. All joints that are found to leak by observation or during testing shall be repaired by the contractor and retested.

Fiber Glass Systems
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Fax: 210 477 7560

CI1601ENG July 2016

Centricast CL-1520® Product Data

Applications

- Acids
- Salts
- Oxidizing Agents
- Chlorine Water

Materials and Construction

All pipe is manufactured with glass fabrics and a highly resilient formulation of vinyl ester resin. A 50-mil integral corrosion barrier of pure resin provides excellent corrosion resistance. It is recommended for most chlorinated and/or acidic mixtures up to 175°F and other chemicals up to 200°F. A 10-mil resin-rich reinforced external corrosion barrier provides excellent corrosion resistance and protection from ultraviolet (UV) radiation. Fiber Glass Systems warrants Centricast CL-1520 pipe and fittings against UV degradation of physical properties and chemical resistance for 15 years.

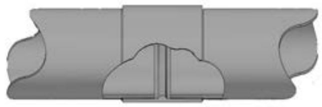
Pipe is available in **1½" through 14"** diameters and is recommended for highly chlorinated or acidic mixtures up to 175°F and many other chemicals up to 200°F. **Centricast CL-1520** comes in 20' nominal or exact lengths from 18.0-20.4 feet long.

Fittings

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.

Joining Systems

Socket Joint
An adhesive bonded socket connection with positive stops in the fittings is standard and simplifies close tolerance piping installation. This joining system is easy to install and no special tools are required for field assembly.



Nominal Dimensional Data

Pipe Size	I.D.		O.D.		Wall Thickness		Reinforcement Thickness		Weight		Capacity	
in	in	mm	in	mm	in	mm	in	mm	lbs/ft	kg/m	gal/ft	ft³/ft
1½	1.52	38.6	1.90	48.3	0.19	4.8	0.13	3.3	0.67	1.00	0.09	0.013
2	2.00	50.8	2.38	60.5	0.19	4.8	0.13	3.3	0.86	1.28	0.16	0.022
3	3.12	79.2	3.50	88.9	0.19	4.8	0.13	3.3	1.30	1.94	0.40	0.053
4	4.12	104.6	4.50	114.3	0.19	4.8	0.13	3.3	1.70	2.53	0.69	0.093
6	6.21	157.7	6.63	168.4	0.21	5.3	0.15	3.8	2.79	4.16	1.57	0.210
8	8.15	207.0	8.63	219.2	0.24	6.1	0.18	4.6	4.17	6.21	2.71	0.362
10	10.30	261.6	10.75	273.1	0.24	6.1	0.18	4.6	5.23	7.78	4.30	0.575
12	12.30	312.4	12.75	323.9	0.24	6.1	0.18	4.6	6.23	9.26	6.14	0.821
14	13.50	342.9	14.00	355.6	0.24	6.1	0.18	4.6	6.85	10.19	7.46	0.997

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

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
1½	0.72	0.29	0.30	1.02
2	0.92	0.58	0.49	1.30
3	1.38	1.96	1.12	1.98
4	1.79	4.26	1.90	2.57
6	3.05	16.00	4.83	4.23
8	4.78	42.60	9.88	6.32
10	5.98	83.50	15.50	7.92
12	7.11	140.00	22.00	9.43
14	7.82	187.00	26.70	10.40

Average Physical Properties

Property	75°F psi	24°C MPa	150°F psi	66°C MPa	175°F psi	180°C MPa
Axial Tensile - ASTM D2105						
Ultimate Stress	30,000	210	26,000	180	25,000	170
Design Stress	7,500	52	6,500	45	6,200	43
Modulus of Elasticity	2.6×10^6	17,900	2.3×10^6	15,900	2.2×10^6	15,200
Poisson's Ratio ν			0.15			
Axial Compression - ASTM D695						
Ultimate Stress	32,000	220	30,000	200	22,000	150
Design Stress	8,000	55	7,500	52	5,550	38
Modulus of Elasticity	3.1×10^6	21,400	2.7×10^6	18,600	2.6×10^6	17,900
Beam Bending - ASTM D2925						
Ultimate Stress	40,000	280	35,000	240	33,000	230
Design Stress(1)	5,000	34	4,375	30	4,125	28
Modulus of Elasticity (Long Term)	3.3×10^6	22,800	2.9×10^6	20,000	2.8×10^6	19,300
Hydrostatic Burst - ASTM D1599						
Ultimate Hoop Tensile Stress	30,000	200	26,000	180	25,000	170
Hoop Tensile Modulus of Elasticity	2.4×10^6	17,000	2.1×10^6	14,500	2.0×10^6	13,800
Hydrostatic Design - ASTM D2992						
Procedure B-Hoop Tensile Stress						
Static 50 Year @ 175°F	-	-	-	-	11,690	81

(1)Stress and modulus values can be interpolated between temperatures shown.

Thermal Expansion Coefficient - ASTM D696	Non-Insulated Pipe: 8.4×10^6 In/In/°F • 15.2×10^6 mm/mm/°C Insulated Pipe: 9.2×10^6 In/In/°F • 16.6×10^6 mm/mm/°C	
Thermal Conductivity	0.07 BTU/hr-ft-°F	0.04 W/m-°C
Specific Gravity - ASTM D792	1.52	
Hazen-Williams Coefficient	150	
Absolute Surface Roughness	0.00021 in	0.0053 mm
Manning's Roughness Coefficient, n	0.009	

Testing:

See Fiber Glass Systems' **Socket Joint Installation Handbook.**

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

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

Nominal Pipe Size in	Maximum Internal Pressure @ 175°F psig			Maximum External Pressure psig(6)		
	Socket Pressure Fittings(3)	Flanged Pressure Fittings(4)	Other Pressure(5)	75°F	150°F	175°F
1½	300	300	-	650	579	491
2	275	200	125	380	268	227
3	200	150	125	130	74	63
4	150	150	100	50	33	28
6	150	150	100	30	21	17
8	150	150	100	25	17	14
10	150	150	75	16	13	11
12	150	150	75	10	8	7
14	125	150	-	7	5	4

ASTM D2997 Designation Codes:

1½"-4"	RTRP-22BT-4556
6"	RTRP-22BT-4555
8"	RTRP-22BT-4554
10"-12"	RTRP-22BT-4553
14"	RTRP-22BT-4552

(1)Static pressure ratings, typically created with use of a gear turbine, centrifugal, or multiplex pump having 4 or more pistons or elevation head.
(2)Reduce pressure ratings by 30% for 175°F to 200°F operating temperatures. For compressible gases, insulated and/or heat traced piping systems, consult the factory for pressure ratings. **Centricast CL-1520** pipe and vinyl ester fittings can be used in drainage and vent systems up to 200°F. Heat cured adhesive joints are highly recommended for all piping systems carrying fluids at temperatures above 120°F.
(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.

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 ASTM D2412		
	Temperature 75°F	Temperature 175°F	Temperature 75°F	Temperature 175°F			Stiffness Factor In^3 Lbs/In^2	Pipe Stiffness psi	Hoop Modulus $x10^6$ psi
1½	5,400	4,500	5,800	4,000	52	125	366	3,545	2.0
2	6,900	5,700	7,300	5,000	65	203	366	1,738	2.0
3	10,300	8,600	11,000	7,600	96	466	458	642	2.5
4	13,400	11,200	14,300	9,800	124	790	458	294	2.5
6	22,900	19,100	24,400	16,800	182	2,013	788	156	2.8
8	35,800	29,800	38,200	26,300	237	4,115	1,264	113	2.6
10	44,800	37,400	47,800	32,900	296	6,473	1,458	66	3.0
12	53,300	44,400	56,900	39,100	351	9,178	1,652	45	3.4
14	58,600	48,800	62,500	43,000	385	11,108	1,652	34	3.4

(1)Compressive loads are for short columns only.

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

Pipe Lengths Available*

Size in	Random Length ft
1½-14	20

*Pipe comes in random or exact lengths from 18.0 - 20.4 feet long.

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 heavy valves and in-line equipment independently.
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 loading to minimize bending stresses on pipe and fittings.
7. Provide adequate axial and lateral restraint to ensure line stability during rapid changes in flow.

Maximum Support Spacing for Uninsulated Pipe(1)

Pipe Size in	Continuous Spans of Pipe (Ft.)(2)		
	75°F	150°F	175°F
1½	16.4	15.8	15.7
2	17.6	17.0	16.9
3	19.9	19.2	19.1
4	21.4	20.7	20.5
6	24.7	23.9	23.7
8	27.7	26.8	26.5
10	29.4	28.5	28.2
12	30.8	29.8	29.5
14	31.6	30.6	30.3

(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

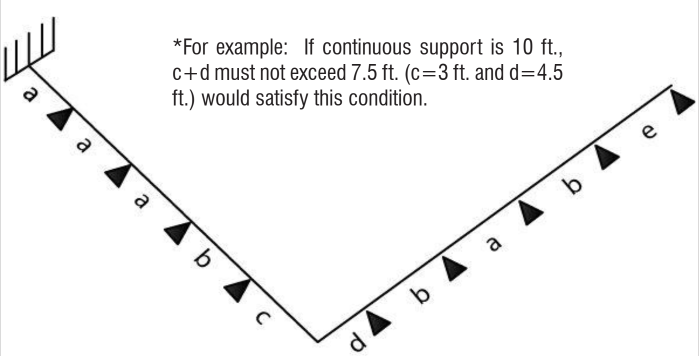
Specific Gravity	3.00	2.00	1.50	1.25	1.00	0.75	Gas/Air
Multiplier	0.76	0.84	0.90	0.95	1.00	1.07	1.40

Example: 6" pipe @ 150°F with 1.5 specific gravity fluid, maximum support spacing = 23.9 x 0.90 = 21.5 ft.

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

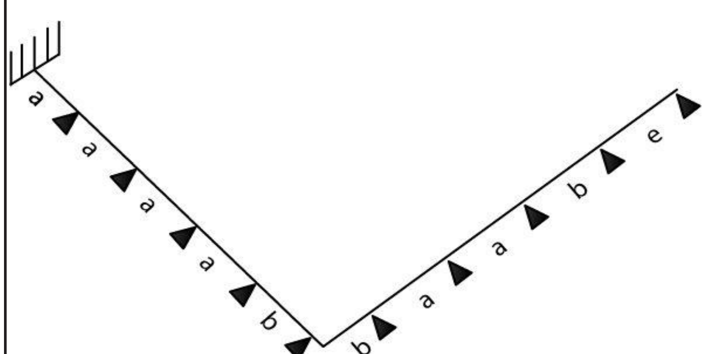
	Span Type	Factor
a	Continuous interior or fixed end spans	1.00
b	Second span from supported end or unsupported fitting	0.80
c+d	Sum of unsupported spans at fitting	≤0.75*
e	Simple supported end span	0.67

*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.**

Change in Temperature °F	Pipe Change In Length in/100 Ft
25	0.25
50	0.50
75	0.76
100	1.01
125	1.26
150	1.51
175	1.76
200	2.02

Restrained Thermal End Loads and Guide Spacing

Size in	Operating Temperature °F (Based on Installation Temperature of 75°F)									
	100°F		125°F		150°F		175°F		200°F	
	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
1½	11.2	492	7.9	938	6.5	1,347	5.6	1,729	5.0	1,663
2	14.2	624	10.0	1,189	8.2	1,708	7.1	2,193	6.3	2,109
3	21.2	937	15.0	1,785	12.3	2,564	10.6	3,292	9.5	3,166
4	27.5	1,215	19.5	2,315	15.9	3,325	13.8	4,269	12.3	4,105
6	40.8	2,077	28.8	3,958	23.5	5,685	20.4	7,299	18.2	7,018
8	53.2	3,251	37.6	6,195	30.7	8,897	26.6	11,423	23.8	10,984
10	66.6	4,069	47.1	7,754	38.4	11,136	33.3	14,297	29.8	13,748
12	79.2	4,839	56.0	9,221	45.7	13,243	39.6	17,003	35.4	16,349
14	87.0	5,320	61.5	10,138	50.2	14,559	43.5	18,694	38.9	17,975

Elbow Strength

Allowable Bending Moment - 90° Elbow			
Nominal Pipe Size in	Allowable Moment ft/lbs	Nominal Pipe Size in	Allowable Moment ft/lbs
1½	150	8	2,850
2	225	10	4,500
3	475	12	6,500
4	650	14	10,000
6	1,650		

QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
ISO 9001:2008
LITTLE ROCK, AR
SAND SPRINGS, OK
SUZHOU, CHINA
FIBER GLASS SYSTEMS

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NOV Fiber Glass Systems

CL1700 - September 2012

CENTRICAST™ CL-1520 Piping System

Specification Guide

SECTION 1 – Scope

This section covers the use of fiberglass reinforced plastic (FRP) pipe for chemical process and chemical handling applications up to 200°F and 150 psig steady pressure.

The piping system shall be furnished and installed complete with all fittings, joining materials, supports, specials, and other necessary appurtenances.

SECTION 2 – General Conditions

2.01 Coordination - Material furnished and work performed under this section shall be coordinated with related work and equipment specified under other sections.

Valves	Section	________
Supports	Section	________
Equipment	Section	________

2.02 Governing Standards - Except as modified or supplemented herein, all materials and construction methods shall comply with the applicable provisions of the following specifications and be tested using the following standards:

Standard Specifications

ASTM D2997	Standard Specification for Centrifugal Cast "Fiberglass" (Glass-Fiber-Reinforced Thermosetting) Resin Pipe
AWWA M45	Fiberglass Pipe Design
ASTM D5685	Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pressure PIpe Fittings
ASTM D4024	Standard Specification for Reinforced Thermosetting Resin (RTR) Flanges

Standard Test Methods

ASTM D2992	Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe
ASTM D1599	Standard Test method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings
ASTM D2105	Standard Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Tube
ASTM D2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASME B31.3	Process Piping

2.03 ASTM D2997 Designation Codes:

1½" - 4"	RTRP-22BT-4556
6"	RTRP-22BT-4555
8"	RTRP-22BT-4554
10" - 12"	RTRP-22BT-4553
14"	RTRP-22BT-4552

Mechanical properties cell classifications shown are minimums.

2.04 Operating Conditions - In addition to the above listed minimum design requirements, the system shall meet the following minimum operating conditions:

a. Operating Pressure ________
b. Operating Temperature ________
c. Fluid Conveyed ________
d. Test Pressure ________

2.05 Quality Assurance – Pipe manufacturer's quality program shall be in compliance with ISO 9001.

2.06 Delivery, Storage, and Handling - Pipe and fittings shall be protected from damage due to impact and point loading. Pipe shall be properly supported to avoid damage due to flexural strains. The contractor shall not allow dirt, debris, or other extraneous materials to get into pipe and fittings. All factory machined areas shall be protected from sunlight until installed.

2.07 Acceptable Manufacturers - NOV Fiber Glass Systems, (918) 245-6651, or approved equal.

SECTION 3 – Materials and Construction

3.01 1½"-14" Pipe - The pipe shall be manufactured by the centrifugal casting process using premium grade vinyl ester thermosetting resin to impregnate woven glass filaments. Pipe shall be heat cured and the cure shall be confirmed using a Differential Scanning Calorimeter. All pipe shall have a 100% resin corrosion barrier and the cured thickness shall be 50 mils nominal. All pipe shall have a resin rich reinforced 10 mil nominal exterior layer with UV (ultraviolet) inhibitor.

The pipe shall have a minimum design pressure rating of 150 psig @ 175°F following ASTM D2992, Procedure B.

Minimum Reinforced Wall Thickness

1½" - 4"	0.130 inches
6"	0.150 inches
8" - 14"	0.180 inches

3.02 Flanges and Fittings - All fittings shall be manufactured either by compression molding or contact molding. Fitting joints shall be either adhesive bonded socket or flanged. Flanges shall have ANSI B16.5 Class 150 bolt hole patterns.

3.03 Adhesive - Adhesive shall be manufacturer's standard for the piping system specified. All adhesive bonded joints shall be cured according to the manufacturer's instructions for maximum strength and corrosion resistance.

3.04 Gaskets - Gaskets shall be 3/16" thick, 60-70 durometer full-face type suitable for the service shown on the drawings and as recommended in the manufacturer's standard installation procedures.

3.05 Bolts, Nuts and Washers - ASTM F593, 304 stainless steel hex head bolts shall be supplied. Two each SAE size washers shall be supplied on all nuts and bolts.

3.06 Acceptable Products - Centricast CL-1520 as manufactured by NOV Fiber Glass Systems or approved equal.

SECTION 4 - Installation and Testing

4.01 Training and Certification - All joints installed or constructed in the field shall be assembled by employees of the contractor who have been trained by the pipe manufacturer. The pipe manufacturer or their authorized representative shall train the contractor's employees in the proper joining and assembly procedures required for the project, including hands-on participation by the contractor's employees. Each bonder shall fabricate one pipe-to-pipe and one pipe-to-fitting joint that shall pass the minimum pressure test for the application as stated in Section 2.04.d without leaking.

Only bonders who have successfully completed the pressure test shall bond pipe and fittings.

Certification by the manufacturer shall be in compliance with ASME B31.3 Section A328.2.

4.02 Pipe Installation - Pipe shall be installed as specified and indicated on the drawings and in accordance with the manufacturer's current published installation procedures.

4.03 Testing - A hydrostatic pressure test shall be conducted on the completed piping system. **The pipe shall be subjected to a steady pressure at 1½ times the design operating pressure as stated in Section 2.04a.** The pressure shall be held on the system for a minimum of 1 hour and the line inspected for leaks.

The test pressure should not exceed 1½ times the maximum rated operating pressure for the lowest rated element in the system.

The system shall be filled with water at the lowest point and air bled off from all the highest points. Systems shall be brought up to test pressure slowly to prevent water hammer or over pressurization.

All pipe joints shall be water tight. All joints that are found to leak by observation or during testing shall be repaired by the contractor and retested.

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NOV Fiber Glass Systems

CI1701 February 2009

Centricast CL-2030® Product Data

Applications

- Acids
- Salts
- Chlorine Water
- Oxidizing Agents
- Chemical Process Solutions

Materials and Construction

All pipe manufactured is manufactured with glass fibers and a highly resilient formulation of vinyl ester resin. A 100-mil integral corrosion barrier of pure resin provides excellent corrosion resistance. It is recommended for most chlorinated and/or acidic mixtures up to 175°F and other chemicals up to 200°F. A 10-mil resin-rich reinforced external corrosion barrier provides corrosion resistance and protection from ultraviolet (UV) radiation. Fiber Glass Systems warrants Centricast CL-2030 pipe and fittings against UV degradation of physical properties and chemical resistance for 15 years.

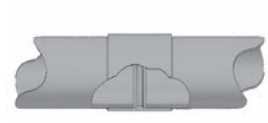
Pipe is available in **1" through 14"** diameters with static pressure ratings up to 150 psig, with higher pressure ratings in smaller sizes. **Centricast CL-2030** comes in 20' nominal or exact lengths from 18.0-20.4 feet long.

Fittings

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.

Joining Systems

Socket Joint
Adhesive bonded straight socket joint with positive stops. This is the standard for Centricast piping systems.



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	cuft/ft
1	0.94	23.7	1.32	33.4	0.19	4.8	0.080	2.0	0.45	0.68	0.04	0.005
1½	1.42	36.1	1.90	48.3	0.24	6.1	0.130	3.8	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

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

Pressure Ratings[(1)(2)]

Nominal Pipe Size in	Maximum Internal Pressure @ 175°F psig			Maximum External Pressure psig[(6)]		
	Socket Pressure Fittings [(3)]	Flg'd Pressure Fittings [(4)]	Other Pressure Fittings [(5)]	75ºF	150ºF	175°F
1	300	300	N/A	1,975	1,679	1,383
1½	300	300	N/A	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 temperatures, reduce pressure ratings by 30% for 175°F to 200°F 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 200°F operating temperatures. Heat cured joints are highly recommended for all piping systems carrying fluids at temperatures above 120°F.

(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 and crosses.

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

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 ASTM D2412		
	Temperature 75°F	Temperature 175°F	Temperature 75°F	Temperature 175°F			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
1½	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 175°F.

Testing:

See Fiber Glass Systems' **Socket Joint Installation Handbook.** When possible, NOV Fiber Glass Systems' piping systems should be hydrostatically tested prior to beginning service. Care should be taken when testing 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. Do not hydrotest until all support, anchors, and guides are properly installed.

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.

Average Physical Properties

Property	75°F/24°C				150°F/66°C				175°F/80°C			
	1” - 1½”		2” - 14”		1” - 1½”		2” - 14”		1” - 1½”		2” - 14”	
	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa
Axial Tensile - ASTM D2105												
Ultimate Stress	22,000	150	22,000	150	19,000	130	19,900	130	18,000	120	18,000	120
Design Stress	5,500	38	5,500	38	4,750	33	4,750	33	4,500	31	4,500	31
Modulus of Elasticity	2.1×10^6	14,500	2.1×10^6	14,500	1.8×10^6	12,400	1.8×10^6	12,400	1.8×10^6	12,400	1.8×10^6	12,400
Poisson’s Ratio ν	0.15				0.15				0.15			
Axial Compression - ASTM D695												
Ultimate Stress	26,000	180	32,000	220	24,000	170	30,000	210	18,000	120	22,000	150
Design Stress	6,500	45	8,000	55	6,000	41	7,500	52	4,500	31	5,550	38
Modulus of Elasticity	3.3×10^6	22,800	2.6×10^6	17,900	2.9×10^6	20,000	2.3×10^6	15,900	2.8×10^6	19,300	2.2×10^6	15,100
Beam Bending - ASTM D2925												
Ultimate Stress	22,000	150	40,000	280	19,000	130	35,000	240	18,000	120	33,000	230
Design Stress[1]	2.750	19	5,000	34	2.375	16	4.375	30	2.250	16	4,125	28
Modulus of Elasticity (Long Term)	3.3×10^6	22,800	3.3×10^6	22,800	2.9×10^6	20,000	2.9×10^6	20,000	2.8×10^6	19,300	2.8×10^6	19,300
Hydrostatic Burst - ASTM D1599												
Ultimate Hoop Tensile Stress	25.000	170	30,000	210	21,000	140	26,000	180	20,000	140	25,000	170
Hoop Tensile Modulus of Elasticity	3.0×10^6	20,700	3.2×10^6	22,100	2.6×10^6	17,900	2.8×10^6	19,300	2.5×10^6	17,200	2.7×10^6	18,600
Hydrostatic Design - ASTM D2992, Procedure B-Hoop Tensile Stress Static 50 Year @ 175°F	-	-	-	-	-	-	-	-	8,600	60	8,600	60

(1)Beam bending design stress is one-eighth of ultimate to allow for combined stress. Stress and modulus values can be interpolated between temperatures shown.

Coefficient of Linear Thermal Expansion - ASTM D696	Non-Insulated Pipe: 8.9×10^{-6} in/in/°F Insulated Pipe: 10.0×10^{-6} in/in/°F	16.1×10^{-6} mm/mm°C 18.1×10^{-6} mm/mm/°C
Thermal Conductivity	0.07 BTU/hr-ft-°F	0.04 W/m-°C
Specific Gravity - ASTM D792	1.56	
Flow Factor - SF / Hazen-Williams Coefficient	150	
Absolute Surface Roughness	0.00021 in	0.0053 mm
Manning’s Roughness Coefficient, n	0.009	

Properties of Pipe Sections Based on Minimum Reinforced Walls

Size in	Reinforcement End Area in²	Reinforcement Moment of Inertia in⁴	Reinforcement Section Modulus in³	Nominal Wall End Area in²
1	0.31	0.06	0.09	0.67
1½	0.72	0.28	0.30	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

ASTM D2997 Designation Codes

1” - 1½”	RTRP-22BS-3446
2” - 6”	RTRP-22BS-4446
8”	RTRP-22BS-4445
10” - 12”	RTRP-22BS-4444
14”	RTRP-22BS-4443

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 movement

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***.

Unrestrained Thermal Expansion Uninsulated Pipe

Change in Temperature °F	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	2.21

Elbow Strength

Allowable Bending Moment - 90° Elbow			
Nominal Pipe Size in	Allowable Moment ft/lbs	Nominal Pipe Size in	Allowable Moment ft/lbs
1	100	6	1,650
1½	150	8	2,850
2	225	10	4,500
3	475	12	6,500
4	650	14	10.000

Restrained Thermal End Loads and Guide Spacing

	Operating Temperature °F (Based on Installation Temperature of 75°F)									
	100		125		150		175		200	
Size in	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	7.2	248	5.1	473	4.2	675	3.6	869	3.2	776
1½	10.4	578	7.3	1,102	6.0	1,572	5.2	2,024	4.6	1,807
2	14.7	655	10.4	1,258	8.5	1,809	7.4	2,307	6.6	2,621
3	21.9	1,173	15.5	2,253	12.7	3,239	11.0	4,130	9.8	4,694
4	28.3	1,849	20.0	3,550	16.3	5,103	14.1	6,508	12.6	7,395
6	42.3	2,767	29.9	5,312	24.4	7,636	21.1	9,739	18.9	11,067
8	55.5	3,631	39.2	6,971	32.0	10,021	27.7	12,780	24.8	14,523
10	69.5	4,549	49.1	8,733	40.1	12,554	34.7	16,011	31.1	18,195
12	82.6	5,413	58.4	10,392	47.7	14,939	41.3	19,052	37.0	21,650
14	90.9	5,953	64.3	11,429	52.5	16,429	45.4	20,953	40.6	23,810

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)]

Pipe Size in	Continuous Spans of Pipe ft.[(2)]		
	75°F	150°F	175°F
1	13.5	13.1	13.0
1½	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

(1) Consult factory for insulated pipe support spacing and operating temperatures between 175°F and 200°F.
(2 Maximum mid-span deflection ½" with a specific gravity of 1.0

Support Spacing vs. Specific Gravity

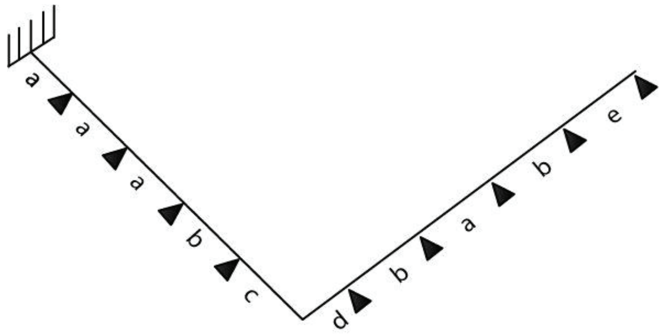
Specific Gravity	3.00	2.00	1.50	1.25	1.00	0.75	Gas/Air
Multiplier	0.76	0.84	0.90	0.95	1.00	1.07	1.40

Example: 6" pipe @ 150°F with 1.5 specific gravity fluid, maximum support spacing = 25.8 x 0.90 = 23.2

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

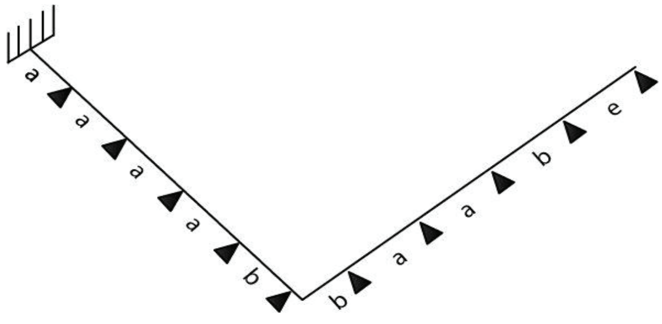
	Span Type	Factor
a	Continuous interior or fixed end spans	1.00
b	Second span from supported end or unsupported fitting	0.80
c+d	Sum of unsupported spans at fitting	≤0.75*
e	Simple supported end span	0.67

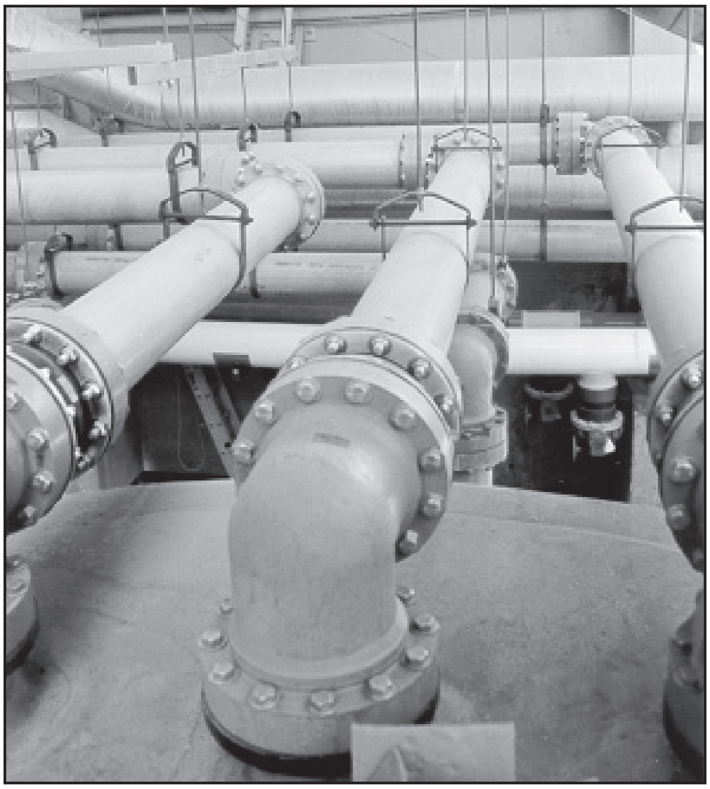
*For example: If continuous support is 10 ft., c+d must not exceed 7.5 ft. (c=3 ft. and d=4.5 ft.) would satisfy this condition.



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





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NOV Fiber Glass Systems

CI1710 - June 2010

CENTRICAST™ CL-2030 Piping System

Specification Guide

SECTION 1 - Scope

This section covers the use of fiberglass reinforced plastic (FRP) pipe for chemical process and chemical handling up to 200°F and up to 150 psig pressure.

The piping shall be furnished and installed complete with all fittings, joining materials, supports, specials, and other necessary appurtenances.

SECTION 2 - General Conditions

2.01 Coordination - Material furnished and work performed under this section shall be coordinated with related work and equipment specified under other sections.

Valves	Section ________
Supports	Section ________
Equipment	Section ________

2.02 Governing Standards - Except as modified or supplemented herein, all materials and construction methods shall comply with the applicable provisions of the following specifications and be tested using the following standards:

Standard Specifications

ASTM D2997	Standard Specification for Centrifugal Cast "Fiberglass" (Glass-Fiber-Reinforced Thermosetting) Resin Pipe
AWWA M45	Fiberglass Pipe Design
ASTM D5685	Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pressure Pipe Fittings
ASTM D4024	Standard Specification for Reinforced Thermosetting Resin (RTR) Flanges

Standard Test Methods

ASTM D2992	Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings
ASTM D1599	Standard Test method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings
ASTM D2105	Standard Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Tube
ASTM D2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASME B31.3	Process Piping

2.03 ASTM D2997 Designation Codes

1"-1½"	RTRP-22BS-3446
2"-6"	RTRP-22BS-4446
10"-12"	RTRP-22BS-4444
14"	RTRP-22BS-4443

Mechanical properties cell classifications shown are minimums.

2.04 Operating Conditions - In addition to the above minimum design requirements, the system shall meet the following minimum operating conditions:

a. Operating Pressure _______
b. Operating Temperature _______
c. Fluid Conveyed _______
d. Test Pressure _______

2.05 Quality Assurance - Pipe manufacturer's quality program shall be in compliance with ISO 9001.

2.06 Delivery, Storage and Handling - Pipe and fittings shall be protected from damage due to impact and point loading. Pipe shall be properly supported to avoid damage due to flexural strains. The contractor shall not allow dirt, debris, or other extraneous materials to get into pipe and fittings. All factory machined areas shall be protected from sunlight until installed.

2.07 Acceptable Manufacturers - NOV Fiber Glass Systems (918) 245-6651 or approved equal.

SECTION 3 - Materials and Construction

3.01 1"-14" Pipe - The pipe shall be manufactured by the centrifugal casting process using premium grade vinyl ester thermosetting resin to impregnate woven glass filaments. Pipe shall be heat cured and the degree of cure shall be confirmed using a Differential Scanning Calorimeter. All pipe shall have a 100% resin corrosion barrier and the cured thickness shall be 100 mils nominal.

All pipe shall have a resin-rich reinforced 10 mil nominal exterior layer with UV (ultraviolet) inhibitor.

The pipe shall have a minimum design pressure rating of 150 psig at 175°F following ASTM D2992 Procedure B.

Minimum Reinforced Wall Thickness

1"	0.095 inches
1½"	0.120 inches
2"	0.150 inches
3"	0.180 inches
4"-14"	0.220 inches

3.02 Flanges and Fittings - All fittings shall be manufactured either by compression molding or contact molding. Fitting joints shall be either adhesive bonded socket or flanged. Flanges shall have ANSI B16.5 Class 150 bolt hole patterns.

3.03 Adhesive - Adhesive shall be manufacturer's standard for the piping system specified. All adhesive bonded joints shall be cured according to the manufacturer's instructions for maximum strength and corrosion resistance.

3.04 Gaskets - Gaskets shall be 3/16" thick, 60-70 durometer full-face type suitable for the service shown on the drawings and as recommended in the manufacturer's standard installation procedures.

3.05 Bolts, Nuts and Washers - ASTM F593, 304 stainless steel hex head bolts shall be supplied. Two each SAE size washers shall be supplied on all nuts and bolts.

3.06 Acceptable Products - Centricast CL-2030 as manufactured by NOV Fiber Glass Systems or approved equal.

SECTION 4 - Installation and Testing

4.01 Training and Certification - All joints installed or constructed in the field shall be assembled by employees of the contractor who have been trained by the pipe manufacturer. The pipe manufacturer or their authorized representative shall train the contractor's employees in the proper joining and assembly procedures required for the project, including hands-on participation by the contractor's employees. Each bonder shall fabricate one pipe-to-pipe and one pipe-to-fitting joint that shall pass the minimum pressure test for the application as stated in Section 2.04.d without leaking.

Only bonders who have successfully completed the pressure test shall bond pipe and fittings.

Certification by the manufacturer shall be in compliance with ASME B31.3 Section A328.2.

4.02 Pipe Installation - Pipe shall be installed as specified and indicated on the drawings and in accordance with the manufacturer's current published installation procedures.

4.03 Testing - A hydrostatic pressure test shall be conducted on the completed piping system. **The pipe shall be subjected to a steady pressure at 1½ times the design operating pressure as stated in Section 2.04a.** The pressure shall be held on the system for a minimum of 1 hour and the line inspected for leaks.

The test pressure should not exceed 1½ times the maximum rated operating pressure for the lowest rated element in the system.

The system shall be filled with water at the lowest point and air bled off from all the highest points. Systems shall be brought up to test pressure slowly to prevent water hammer or over pressurization.

All pipe joints shall be water tight. All joints that are found to leak by observation or during testing shall be repaired by the contractor and retested.

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NOV Fiber Glass Systems

CI1711 June 2013

Z-Core® Product Data

Applications

- Sulfuric Acid
- Hydrochloric Acid
- Solvents
- Caustics
- Process Drains

Materials and Construction

Z-Core pipe is a centrifugally cast fiberglass pipe with a 100 mil resin-rich liner and is available in 1" through 8" diameters. The pipe is rated for temperatures to 275°F and for pressures to 150 psig (higher pressures available on request).

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. Pipe and fittings are warranted against reduction of physical and corrosion ratings due to ultraviolet exposure for a period of 15 years.

Fittings

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.

Joining Systems

Socket Joint
Adhesive bonded straight socket joint with positive stops.
This is the standard for Centricast piping systems.

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.

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

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
Modulus of Elasticity	-	-	1.9×10^6	13,100	-	-	1.6×10^6	11,000	-	-	1.5×10^6	10,300
Poisson's Ratio ν	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
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
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								

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^{-5} 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 Roughness Coefficient, n	0.009	

Testing:

See ***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 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.

Pressure Ratings[1]

Pipe Size In	Max Internal Pressure @ 275°F (psig)			Maximum External Pressure (psig)[5]		
	Socket Pressure Fittings [2]	Flg'd Pressure Fittings [3]	Other Pressure Fittings [4]	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) Specially fabricated higher pressure fittings are available on request. Consult the factory for compressible gases. Heat cured joints are recommended for all piping systems carrying fluids at temperatures above 120°F.

(2) Socket elbows, tees reducers, couplings, flanges and nipples joined with **WELDFAST ZC-275** adhesive.

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

(4) Laterals and crosses.

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

NA = Not available at time of printing.

ASTM D2997 Designation Codes:

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

Recommended Operating Ratings

Size In	Axial Tensile Loads Max. (Lbs) Temperature 75°F	Axial Tensile Loads Max. (Lbs) Temperature 275°F	Axial Compressive Loads Max. (Lbs)[1] Temperature 75°F	Axial Compressive Loads Max. (Lbs)[1] Temperature 275°F	Bending Radius Min. (Ft) Entire Temp. Range	Torque Max. (Ft Lbs) Entire Temp. Range	Parallel Plate Loading ASTM D2412 Stiffness Factor In³/ Lbs/In²	Parallel Plate Loading ASTM D2412 Pipe Stiffness (psi)	Parallel Plate Loading ASTM D2412 Hoop Modulus x10⁶ (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.

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.

Pipe Lengths Available*

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

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

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 $^1/_2$ 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 heavy valves and in-line equipment independently.
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 loading to minimize bending stresses on pipe and fittings.
7. Provide adequate axial and lateral restraint to ensure line stability during rapid changes in flow.

Maximum Support Spacing for Uninsulated Pipe (1)

	Continuous Spans of Pipe (Ft.) (2)			
(In.)	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

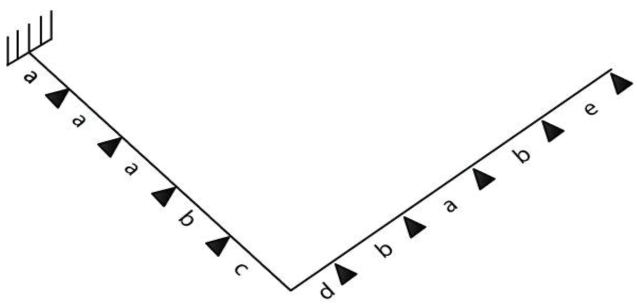
Specific Gravity	2.00	1.50	1.25	1.00	0.75
Multiplier	0.80	0.93	0.96	1.00	1.04

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

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

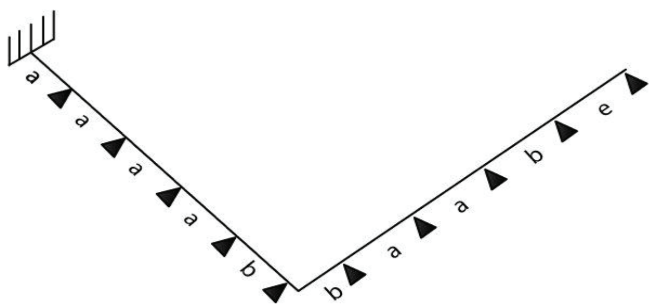
	Span Type	Factor
a	Continuous interior or fixed end spans	1.00
b	Second span from supported end or unsupported fitting	0.80
c+d	Sum of unsupported spans at fitting	≤0.75*
e	Simple supported end span	0.67

*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.**

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

Size (In)	Operating Temperature °F (Based on installation temperature of 75°F)									
	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

QUALITY MANAGEMENT SYSTEM
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ISO 9001:2008
LITTLE ROCK, AR
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FIBER GLASS SYSTEMS

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NOV Fiber Glass Systems

CI1800 March 2010

Z-Core™ Piping System

Specification Guide

SECTION 1 – Scope

This section covers the use of fiberglass reinforced plastic (FRP) pipe for severe chemical process and chemical handling applications up to 275ºF and 150 psig steady pressure.

The piping system shall be furnished and installed complete with all fittings, joining materials, supports, specials, and other necessary appurtenances.

SECTION 2 – General Conditions

2.01 Coordination - Material furnished and work performed under this section shall be coordinated with related work and equipment specified under other sections.

Valves	Section ______
Supports	Section ______
Equipment	Section ______

2.02 Governing Standards - Except as modified or supplemented herein, all materials and construction methods shall comply with the applicable provisions of the following specifications and be tested using the following standards:

Standard Specifications

ASTM D2997	Standard Specification for Centrifugal Cast Pipe
ASTM D5685	Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pressure Pipe Fittings
ASTM D4024	Standard Specification for Reinforced Thermosetting Resin (RTR) Flanges

Standard Test Methods

ASTM D2992	Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings
ASTM D1599	Standard Test method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings
ASTM D2105	Standard Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Tube
ASTM D2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASME B31.3	Process Piping

2.03 ASTM D2310 Designation Code

1"-8" RTRP-21CO

Mechanical properties cell classification shown are minimum.

2.04 Operating Conditions - In addition to the above listed minimum design requirements, the system shall meet the following minimum operating conditions:

a. Operating Pressure _______
b. Operating Temperature _______
c. Fluids Conveyed _______
d. Test Pressure _______

2.05 Quality Assurance - Pipe manufacturer's quality program shall be in compliance with ISO 9001.

2.06 Delivery, Storage, and Handling - Pipe and fittings shall be protected from damage due to impact and point loading. Pipe shall be properly supported to avoid damage due to flexural strains. The contractor shall not allow dirt, debris, or other extraneous materials to get into pipe and fittings. All factory-machined areas shall be protected from sunlight until installed.

2.07 Acceptable Manufacturers - NOV Fiber Glass Systems (918) 245-6651, or approved equal.

SECTION 3 – Materials and Construction

3.01 1"-8" Pipe - The pipe shall be manufactured by the centrifugal casting process utilizing amine cured, premium grade epoxy thermosetting resin to impregnate woven continuous glass filaments. Pipe shall be shall be heat cured and the degree of cure shall be confirmed by determining the glass transition temperature.

All pipe shall have an integral corrosion barrier of pure resin with a nominal cured thickness of 100 mils.

All pipe shall have a resin rich, reinforced 10 mil nominal exterior layer with a UV (ultraviolet) inhibitor.

The pipe shall have a minimum design pressure of 150 psig @ 275ºF following ASTM D2992 Procedure B.

Minimum Reinforced Wall Thickness:

1"	0.09"
1½"-3"	0.14"
4"	0.17"
6"	0.27"
8"	0.31"

3.02 Flanges and Fittings - All fittings shall be manufactured using the same type materials as the pipe. Fittings may be manufactured either by compression molding or contact molding methods.

Fittings shall be adhesive bonded socket joint or flanged.

Flanges shall have ANSI B16.5, Class 150 bolt hole patterns.

3.03 Adhesive - Adhesive shall be manufacturer's standard for the piping system specified. All adhesive bonded joints shall be cured according to the manufacturer's instructions for maximum structural strength and corrosion resistance.

3.04 Gaskets - Gaskets shall be 3/16" thick, 60-70 durometer full-face type suitable for the service shown on the drawings and as recommended in the manufacturer's standard installation procedures.

3.05 Bolts, Nuts, and Washers - ASTM F593, 304, stainless steel hex head bolts shall be supplied. Two each SAE size washers shall be supplied on all nut and bolts.

3.06 Acceptable Products - Z-CORE as manufactured by NOV Fiber Glass Systems or approved equal.

SECTION 4 – Installation and Testing

4.01 Training and Certification - All joints installed or constructed in the field shall be assembled by employees of the contractor who have been trained by the pipe manufacturer. The pipe manufacturer or their authorized representative shall train the contractor's employees in the proper joining and assembly procedures required for the project, including hands-on training by the contractor's employees. Each bonder shall fabricate one pipe-to-pipe or one pipe-to-fitting joint that shall pass the minimum pressure test for the application as stated in Section 2.04.d without leaking.

Only bonders who have successfully completed the pressure test and are certified shall bond pipe and fittings.

Certification by the manufacturer shall be in compliance with ANSI B31.3 Section A328.2.

4.02 Pipe Installation - Pipe shall be installed as specified and indicated on the drawings.

The piping system shall be installed in accordance with the manufacturer's current published installation procedures.

4.03 Testing - A hydrostatic pressure test shall be conducted on the completed piping system. **The pipe shall be subjected to a steady pressure at 1½ times the design operating pressure as stated in Section 2.04.d.** The pressure shall be held on the system for a minimum of one hour and the line inspected for leaks.

Test pressure shall not exceed 1½ times the maximum rated pressure of the lowest rated element in the system.

The system shall be filled with water at the lowest point and air bled off from all the highest points. Systems shall be brought up to test pressure slowly to prevent water hammer or over-pressurization.

All pipe joints shall be watertight. All joints that are found to leak by observation or during testing shall be repaired by the contractor and retested.

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NOV Fiber Glass Systems

CI1801 February 2009

F-Chem® Product Data

Applications

- Potable Water
- pH 2-13 Solutions
- Wastewater
- Brine Solutions
- Food Processing
- Cooling Water
- Chemical Processing
- Saltwater Handling
- Produced Water
- Crude Oil & Gas
- CO_2
- Effluent Drains

Materials and Construction

All pipe manufactured by filament winding process using vinyl ester thermosetting resin. **F-Chem** pipe can be provided with custom tailored vinyl ester resin systems, reinforced corrosion and abrasion resistant barriers, reinforced structural walls and joining techniques to meet specific project requirements. The pipe is available in 14"-72" diameters.

Fittings

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

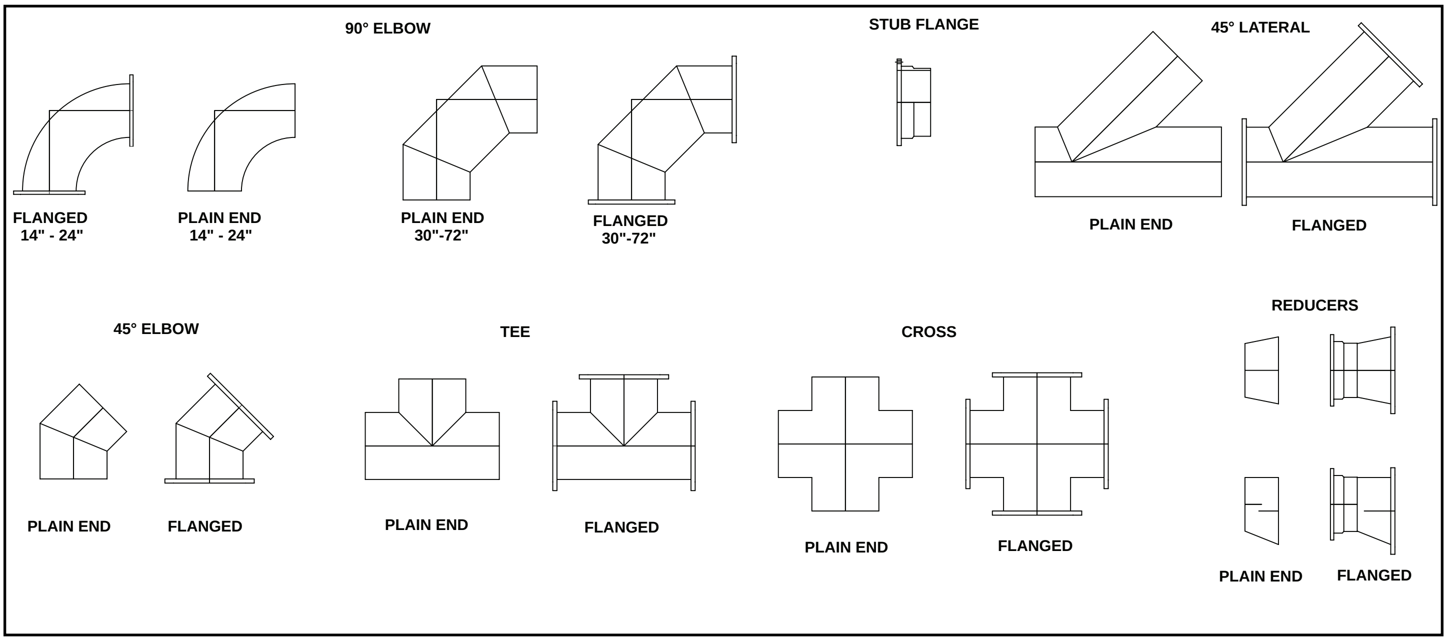
Joining Systems

Bell & Spigot
Matched-taper joint secured with epoxy adhesive. Self-locking feature resists movement, facilitating joining runs of pipe without awaiting adhesive cure.

Butt & Wrap
Plain end pipes or pipe and fittings butted together and wrapped with multiple layers of resin-saturated mat or woven roving.

Flanged
Available for all piping systems and diameters; factory assembled or shipped loose for assembly in the field.

F-CHEM LARGE DIAMETER FITTINGS



F-Chem® Product Data

Average Physical Properties

Property	75°F psi	24°C MPa	175°F psi	79°C MPa
Axial Tensile - ASTM D2105				
Ultimate Stress	9,300	64.1	5,500	37.9
Modulus of Elasticity[(1)]	1.50×10^6	10,342	1.04 x 6	7,171
Poisson's Ratio $\nu_{a/h}$ ($\nu_{h/a}$)		0.33 (0.73)		
Axial Compression - ASTM D695				
Ultimate Stress	17,900	123.0	14,700	101
Modulus of Elasticity	1.40×10^6	9,653	9.00×10^5	6,205
Beam Bending - ASTM D2925				
Ultimate Stress	14,500	100.0	8,000	55.2
Modulus of Elasticity (Long Term)	1.99×10^6	13,721	1.14×10^6	7,860
Hydrostatic Burst - ASTM D1599				
Ultimate Hoop Tensile Stress	40,000	276	40,000	276
Hydrostatic Design - ASTM D2992, Procedure B - Hoop Tensile Stress				
Static 50 Year Life	14,000	96.5	-	-

[(1)]Consult the factory for Modulus of Elasticity values between 75°F and 175°F.

Thermal Expansion Coefficient - ASTM D696 (Insulated Pipe)	10.5×10^{-6} in/in/°F	18.9×10^{-6} mm/mm/°C
Thermal Conductivity	0.11 BTU/hr-ft-°F	0.06 W/m-°C
Specific Gravity - ASTM D792	1.8	
Hazen-Williams Coefficient	150	
Absolute Surface Roughness	0.00021 Inch	0.0053 mm
Manning's Roughness Coefficient, n	0.009	

ASTM D2996 Designation Codes:	
14"-24""	RTRP-12EU-3111
The scope of ASTM D2996 is limited to 24" and smaller	
ASTM D2310 Designation Codes	
30"-72"	RTRP-12EU
Mechanical properties cell classifications shown are minimum. Actual classifications may be higher for some sizes.	

National Specification Compliance:

Pipe is manufactured in compliance with ASTM D2996, ASTM D2310 and ASTM D2992.

The following national specifications are met or exceeded when specified:
Designed in accordance with AWWA M45
Can be manufactured with ANSI/NSF Std. No. 61 approved resin system for potable water usage.
ASTM D6041 fittings
ASME/ANSI B31.3 compliant installation and training.

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NOV Fiber Glass Systems

CI1900 February 2012

F-Chem® Piping System

GENERAL SPECIFICATIONS

SECTION 1 – Scope

This section covers the use of fiberglass reinforced plastic (FRP) pipe for chemical and water services.

The piping system shall be furnished and installed complete with all fittings, joining materials, supports, specials, and other necessary appurtenances.

SECTION 2 – General Conditions

2.01 Coordination - Material furnished and work performed under this section shall be coordinated with related work and equipment specified under other sections.

Valves	Section ______
Supports	Section ______
Equipment	Section ______

2.02 Governing Standards - Except as modified or supplemented herein, all materials and construction methods shall comply with the applicable provisions of the following specifications and be tested using the following standards:

Standard Specifications

ASTM D2310	Standard Classification for Machine-Made "Fiberglass" (Glass-Fiber-Reinforced Thermosetting) Resin Pipe
AWWA M45	Fiberglass Pipe Design

Standard Test Methods

ASTM D2992	Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe
ASTM D2996	Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting Resin) Pipe
ASTM 2925	Standard Practice for Measuring Beam Deflection of Reinforced Thermosetting Plastic Pipe Under Full Bore Flow
ASTM D1599	Standard Test method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings
ASTM D2105	Standard Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Tube
ASTM D2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASME B31.3	Process Piping

2.03 ASTM D2310 Designation Code - All pipe shall be labeled with a four (4) character cell classification based on the design conditions in Section 2.04.

2.04 Design Conditions - The specified product shall meet the following design/operating conditions:

a. Operating Pressure _______
b. Operating Temperature _______
c. Fluids Conveyed _______
d. Minimum Liner Thickness _______
e. Resin Type _______

2.05 Quality Assurance - Pipe manufacturer's quality program shall be in compliance with ISO 9001.

2.06 Delivery, Storage, and Handling - Pipe and fittings shall be protected from damage due to impact and point loading. Pipe shall be properly supported to avoid damage due to flexural strains. The contractor shall not allow dirt, debris, or other extraneous materials to get into pipe and fittings. All factory-machined areas shall be protected from sunlight until installed.

2.07 Acceptable Manufacturers - NOV Fiber Glass Systems (918) 245-6651, or approved equal.

SECTION 3 – Materials and Construction

3.01 14"- 72" Pipe - The pipe shall be manufactured by the filament winding process utilizing the thermosetting resin listed in Section 2.04.e to impregnate strands of continuous glass filaments, which are wound around a mandrel at a 54¾° winding angle under controlled tension. Pipe cure shall be confirmed using a Differential Scanning Calorimeter (DSC) or Thermal Mechanical Analysis (TMA)

The Pipe corrosion barrier shall consist of a 10-mil layer of synthetic surfacing veil, a 10 mil glass veil, and additional layers of 1½ ounce chopped strand mat to reach the liner thickness listed in Section 2.04.d. The nominal resin content in the veil layers shall be 80%. The minimum resin content in the 1½ ounce chopped strand mat layers shall be 60%.

3.02 Flanges and Fittings - All fittings shall be manufactured using the same type materials and liner construction as the pipe. Fittings may be manufactured either by spray-up/contact molding or mitered/spray-up methods. Compression molded fittings manufactured with the same resin as the pipe are acceptable.

Flanges shall have ANSI B16.1 Class 125 bolt hole patterns.

3.03 Joints - All joints shall be butt and wrap, tapered bell & spigot, or flanged as specified on the project drawings. The joints shall be the manufacturer’s standard thickness and shall utilize the same resin system as the piping system specified. All joints shall have a pressure rating equal to the pipe rating.

3.04 Gaskets - Gaskets shall be 1/4” thick, 60-70 durometer full-face type suitable for the service shown on the drawings and as recommended in the manufacturer’s standard installation procedures.

3.05 Bolts, Nuts, and Washers - ASTM A307, Grade B, hex head bolts shall be supplied. Two each SAE size washers shall be supplied on all nut and bolt sets.

3.06 Buried Pipe - All buried pipe shall have a minimum ASTM D2412 pipe stiffness of 9 psi at 5% deflection and must be buried in accordance with the manufacturer’s standard installation instructions.

3.07 Acceptable Products - F-CHEM as manufactured by NOV Fiber Glass Systems or approved equal.

SECTION 4 – Installation and Testing

4.01 Training and Certification - All joints installed or constructed in the field shall be assembled by employees of the contractor who have been trained by the pipe manufacturer. The pipe manufacturer or their authorized representative shall train the contractor’s employees in the proper joining and assembly procedures required for the project, including hands-on training by the contractor’s employees. Each bonder shall fabricate one pipe-to-pipe or one pipe-to-fitting joint that shall pass the minimum pressure test for the application without leaking.

Only bonders who have successfully completed the pressure test and are certified shall bond pipe and fittings.

Certification by the manufacturer shall be in compliance with ASME B31.3, Section A328.2 for the type of joint being made.

4.02 Pipe Installation - Pipe shall be installed as specified and indicated on the drawings.

The piping system shall be installed in accordance with the manufacturer’s current published installation procedures.

4.03 Testing - A hydrostatic pressure test shall be conducted on the completed piping system. **The pipe shall be subjected to a steady pressure at 1½ times the design operating pressure as stated in Section 2.04a.** The pressure shall be held on the system for a minimum of 1 hour and the line inspected for leaks.

Test pressure shall not exceed 1½ times the maximum rated pressure of the lowest rated element in the system.

The system shall be filled with water at the lowest point and air bled off from all the highest points. Systems shall be brought up to test pressure slowly to prevent water hammer or over-pressurization.

All pipe joints shall be water tight. All joints that are found to leak by observation or during testing shall be repaired by the contractor and retested.

All the system high points shall be open when draining the system to prevent vacuum collapse of the pipe.

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NOV Fiber Glass Systems

CI1901 February 2009

Bondstrand™ 2000 Product Data

(For General Industrial Service, Maintenance and Repair

Uses and Applications

- Chemical process piping
- Cooling water piping
- Deionized water systems
- Drainage systems
- Food processing plant piping
- Jet engine air start systems
- Jet fuel[1] and liquid petroleum piping
- Piping systems for alkalis and non-oxidizing chemicals
- Potable water lines
- Waste water and sewage systems
- General industrial service for moderately corrosive liquids

(1) This is not suitable for primary pipe conveying jet fuel that is secondarily contained.

Listings

Mil-P-29206A for jet fuel and petroleum liquids

U.S. Federal Regulations 21CFR175.105 and 21CFR177.2280 for conveying foodstuffs when joined with Bondstrand RP6B epoxy adhesive.

Performance

Pipe designs to 450 psi (3.1 MPa) using an 8000 psi (41.2 MPa) hydrostatic design stress in accordance with ASTM D2992 (B).

Continuous operating temperatures to 250°F (121°C).

Excellent corrosion resistance over a wide temperature range. See most recent release of Bondstrand Corrosion Guide for specific applications.

Weighs 1/6th as much as Sch. 40 steel.

Does not require thrust blocks at ambient temperatures when properly installed in most soils.

Smooth inner liner (Hazen-Williams C = 150) produces extremely low frictional loss for greater discharge and reduced pumping costs.

Low thermal conductivity (1/100th of steel) minimizes heat losses.

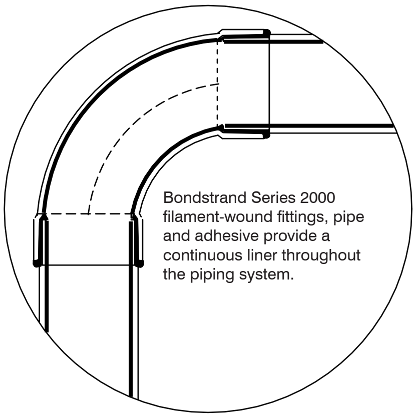
Individual system components may not have the same ratings as the pipe. Refer to the detailed product information for the specific components to determine the pressure rating for the system as a whole.

Joining Systems

Quick-Lock straight/taper adhesive-bonded joint. 2”-6” pipe outside diameter is within tolerance for reliable bonding without shaving. Integral pipe stop in socket featured for predictable, precise laying lengths.

Flanges and flanged fittings.

Composition



Pipe
Filament-wound fiberglass-reinforced epoxy resin pipe with integral resin-rich reinforced liner of 20 mil (0.5 mm) nominal thickness.

Filament-wound fittings
Furnished with 50 mil (1.3 mm) reinforced liner using same materials as the pipe.

Tees	Flanges*
90° and 45° elbows	Nipples and coupling
Crosses	Tapered body reducers
45° laterals	Saddles*

*No liner.

Molded fittings(1)
Tees
90° and 45° elbows
Reducing flanges
Plugs and end-caps
Reducer bushings
Blind flanges

(1) Available parts vary by diameter.

Flanged fittings
2-12 inch filament-wound flanged fittings match ANSI B16.1 and ANSI B16.5 bolt hole pattern and face-to-face dimensions for 150 lb flanges.

1-16 inch flanges match ANSI B16.1 and ANSI B16.5 bolt hole pattern for 150 lb flanges.

Other flange drilling patterns such as DIN, ISO, JIS, ANSI B16.5 300 lb. etc., available on special request.

Thermosetting adhesives
PSX™•34 two-part epoxy adhesive for general industrial service and for service in compliance with U.S. Federal Regulations 21CFR175.105 and 21CFR177.2280.

Pipe Lengths

Nominal Pipe Size		Random Lengths	
in	mm	ft	m
1-1 $^1/_2$	25 - 40	10	3
2-6	50 - 150	20 - 30	6 - 9
8	200	20 - 30	6 - 9
10 - 16	250 - 400	40	12

1) Other lengths and exact lengths available on special request.

Typical Pipe Dimensions and Weights

Nominal Pipe Size		Pipe I.D.		Nominal Wall Thickness*		Average Sectional Area**		Pipe Weight	
in	mm	in	mm	in	mm	in^2	mm^2	lb/ft	kg/m
1	25	1.07	27	.140	3.6	0.50	323	0.4	0.6
1 1/2	40	1.67	42	.140	3.6	0.80	516	0.7	1.0
2	50	2.10	53	.123	3.7	0.73	730	0.7	1.3
3	80	3.21	82	.126	3.7	1.07	1100	1.1	1.8
4	100	4.14	105	.151	3.8	1.78	1760	1.7	3.0
6	150	6.19	159	.181	4.6	3.22	2620	2.6	4.5
8	200	8.22	209	.226	5.7	5.83	3720	4.3	6.4
10	250	10.35	263	.226	5.7	7.31	4720	5.4	8.0
12	300	12.35	314	.226	5.7	8.69	5610	6.4	9.5
14	350	13.56	344	.250	6.4	10.32	6660	7.4	11.0
16	400	15.50	394	.269	6.8	13.33	8600	9.5	14.1

* Minimum wall thickness shall not be less than 87.5% of nominal wall thickness in accordance with ASTM D2996.
** Use these values for calculating longitudinal thrust.

Typical Pipe Performance

Nominal Pipe Size		Internal Pressure Rating*		Collapse Pressure Rating**		Designation
in	mm	psig	MPa	psig	MPa	per ASTM D2996
1	25	450	3.10	945	6.52	RTRP-11FE-1112
1 1/2	40	450	3.10	280	1.93	RTRP-11FE-1114
2	50	450	3.10	260	1.80	11FW-2232
3	80	450	3.10	80	0.55	11FW-2232
4	100	450	3.10	70	0.48	11FW-2232
6	150	375	2.59	50	0.34	11FW-2232
8	200	250	1.72	30	0.21	RTRP-11FE-1114
10	250	200	1.38	14	0.097	RTRP-11FE-1114
12	300	170	1.17	8	0.055	RTRP-11FE-1114
14	350	165	1.14	8	0.055	RTRP-11FE-1115
16	400	165	1.14	8	0.055	RTRP-11FE-1116

* At 200°F (94°C) using Bondstrand type PSX™•34 adhesive. For sustained service above 200°F, reduce ratings linearly to 50% from 200°F to 250°F (121°C).
** At 70°F (21°C). Reduce linearly to 90% at 150°F (66°C), 80% at 200°F (94°C), and 65% at 230°F (110°C).

Fittings Pressure Ratings

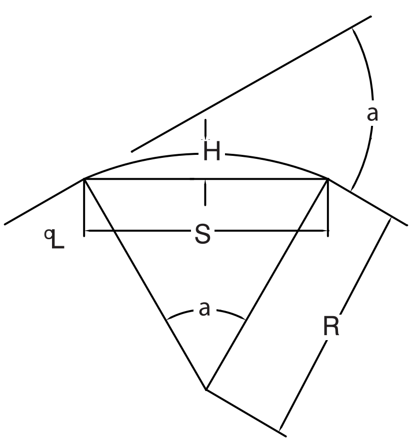
Nominal Pipe Size		Elbows & Tees Filament Wound		Elbows & Tees Molded		Tapered Body Reducers & Flanges		Blind Flanges & Bushed Saddles**	
in	mm	psig	MPa	psig	MPa	psig	MPa	psig	MPa
1	25	300	2.07	-	-	600	4.14	150	1.03
1 1/2	40	300	2.07	-	-	550	3.79	150	1.03
2	50	375	2.59	300	2.07	450	3.10	150	1.03
3	80	325	2.24	225	1.55	350	2.41	150	1.03
4	100	300	2.07	175	1.21	350	2.41	150	1.03
6	150	225	1.55	150	1.03	250	1.72	150	1.03
8	200	225	1.55	-	-	225	1.55	150	1.03
10	250	200	1.38	-	-	175	1.21	150	1.03
12	300	175	1.21	-	-	150	1.03	150	1.03
14	350	150	1.03	-	-	150	1.03	-	-
16	400	150	1.03	-	-	150	1.03	-	-

1) Refer to for fittings dimensions.
** With 316 stainless steel outlet. Other outlet materials available on special order.

Nominal Pipe Size		Laterals		Crosses		Reducers Bushings	
in	mm	psig	MPa	psig	MPa	psig	MPa
1	25	-	-	-	-	50	.35
1 1/2	40	-	-	-	-	50	.35
2	50	275	1.90	150	1.03	50	.35
3	80	250	1.72	150	1.03	50	.35
4	100	200	1.38	150	1.03	50	.35
6	150	150	1.03	100	0.69	50	.35
8	200	150	1.03	100	0.69	50	.35
10	250	150	1.03	100	0.69	50	.35
12	300	150	1.03	100	0.69	50	.35
14	350	150	1.03	100	0.69	50	.35
16	400	150	1.03	100	0.69	50	.35

1) Reducer bushings bonded into flanges will have the same rating as the flange. Otherwise, rated as shown.

Bending Radius



Nominal Pipe Size		Bending Radius* (R)		Maximum Allowable Deflection** (H)		Turning Angle
in	mm	ft	m	ft	m	(a)
1	25	45.2	13.8	24.9	7.6	127
1 1/2	40	66.4	20.2	17.9	5.5	86
2	50	75	22.9	15.9	4.8	76
3	80	100	30.5	12.1	3.7	57
4	100	200	70.0	6.4	2.0	29
6	150	250	76.2	5.0	1.5	23
8	200	304	93	4.1	1.2	19
10	250	379	116	3.3	1.0	15
12	300	450	137	2.8	0.85	13
14	350	494	151	2.5	0.76	12
16	400	564	172	2.2	0.67	10

* Do not bend pipe until adhesive has cured. At rated pressure sharper bends may create excessive stress concentrations.
** For 100-ft (30m) Bending length (S)

Typical Mechanical Properties

Pipe Property / Nominal Pipe Size	Units	70°F 21°C: 1", 1 1/2" 8"-16"	70°F 21°C: 2"-6"	200°F 93°C: 1", 1 1/2" 8"-16"	200°F 93°C: 2"-6"	ASTM Method
Circumferential						
Tensile stress at weeping	10^3 psi MPa	24.00 165.00	32.00 22.00	- -	- -	D1599
Tensile modulus	10^6 psi GPa	3.65 25.20	4.20 29.00	3.20 22.10	3.70 25.50	
Poisson's ratio		0.56	0.26	0.70	0.32	D2105
Longitudinal						
Tensile strength	10^3 psi MPa	8.50 58.60	16.00 110.00	6.90 47.60	13.00 90.00	D2105
Tensile modulus	10^6 psi GPa	1.60 11.00	3.00 20.70	1.24 8.50	2.40 16.50	D2105
Poisson's ratio		0.37	0.16	0.41	0.20	D2105
Beam apparent						
Elastic modulus	10^6 psi GPa	1.70 11.70	2.40 16.60	1.00 6.90	1.77 12.20	D2925
Hydrostatic design						
basis (cyclic)	10^3 psi MPa	6.00 41.40[1]	16.00[1,2] 110.00	- -	- -	D2992
Thermal conductivity						
Pipe wall	Btu•in/(hr•ft²•°F) W/m•°C	2.00 0.29	1.70 10.25	- -	- -	C177
Thermal expansion						
Linear	10^{-6}in/in/°F 10^{-6} mm/mm°C	10.00 18.00	8.50 15.30	- -	- -	D696
Flow coefficient	Hazens-Wiliams	150.00	150.00	-	-	-
Absolute roughness	10^{-6} ft 10^{-6} m	17.40 5.30	17.40 3.30	- -	- -	-
Specific gravity	-	1.80	1.80	-	-	D792
Density	lb/in³ g/cm³	0.07 1.80	0.07 1.80	- -	- -	-

1) At 150°F (66°C)
2) Static

Nominal Pipe Size		Stiffness Factor*		Pipe Stiffness		Beam Moment of Inertia**	
in	mm	lb/ft	N/m	psi	MPa	in⁴	10⁶ mm⁴
1	25	770	87	26400	182	0.09	0.037
1 1/2	40	1610	182	17200	119	0.36	0.150
2	50	265	30	1350	9.3	0.46	0.191
3	80	285	32	550	3.80	1.57	0.653
4	100	500	56	335	2.30	4.13	1.72
6	150	925	104	200	1.40	16.5	6.87
8	200	1890	214	170	1.17	45.1	18.8
10	250	1890	214	86	0.59	88.6	36.9
12	300	1890	214	51	0.35	149.0	62.0
14	350	2230	252	46	0.32	208.0	86.6
16	400	3250	367	45	0.31	353.0	147.0

* Per ASTM D2412.
** Use these values to calculate permissible spans.

Buried Installations

Thrust blocks
Most installations at ambient operating temperatures do not require thrust blocks. Consult FGS for information regarding blocking of buried pipelines for your specific application.

Live loads
Bondstrand 2000 will carry H20 wheel loadings of at least 16,000 lb (7250 kg) per axle when properly bedded in compacted sand in stable soils and provided with at least 3 ft (1 m) of cover.

Earth loads on buried pipe

Nominal Pipe Size		Maximum Earth Cover[1]					
		100 psi	0.69 MPa	125 psi	0.86 MPa	150 psi	1.03 MPa
in	mm	ft	m	ft	m	ft	m
1	25	30	9	30	9	30	9
1 1/2	40	30	9	30	9	30	9
2	50	30	9	30	9	30	9
3	80	30	9	30	9	30	9
4	100	30	9	30	9	30	9
6	150	30	9	24	7	23	7
8	200	23	7	22	6	21	6
10	250	23	7	21	6	19	5
12	300	23	7	21	6	18	5
14	350	23	7	21	6	17	5
16	400	23	7	20	6	16	5

1) Based on a 120 lb/ft3 (1925 kg/m3) soil density and 1000 psi (6.9 MPa) modulus of soil reaction.

Span Lengths

Recommended maximum support spacings for Bondstrand Series 2000 pipe at various operating temperatures. Values based on 0.5-inch (12 mm) deflection at midspan for fluid specific gravity = 1.0.

Nominal Pipe Size		Continuous Spans ft				Simple Spans ft			
in	mm	100°F	150°F	200°F	250°F	100°F	150°F	200°F	250°F
1	25	11.7	11.1	10.3	9.3	7.3	7.4	6.7	6.2
1 1/2	40	13.8	13.0	12.1	11.0	9.2	8.7	8.1	7.3
2	50	14.3	13.5	12.6	11.4	9.5	9.0	8.4	7.6
3	80	16.2	15.4	14.3	12.9	10.8	10.2	9.5	8.6
4	100	18.5	17.5	16.3	14.7	12.3	11.7	10.9	9.8
6	150	20.7	19.6	18.2	16.5	13.8	13.1	12.1	11.0
8	200	22.9	21.7	20.2	18.2	15.3	14.5	13.5	12.2
10	250	24.3	23.0	21.4	19.3	16.2	15.3	14.3	12.9
12	300	25.5	24.1	22.4	20.3	17.0	16.1	15.0	13.5
14	350	26.5	25.0	23.3	21.1	17.6	16.7	15.5	14.0
16	400	28.2	26.7	24.9	22.5	18.9	17.8	16.6	15.0

1) Span recommendations include no provision for weights (fittings, valves, flanges, etc.) or thrusts (branches, turns, etc.). Fittings, valves, flanges and other appurtenances must be supported separately.
2) Span recommendations are calculated for a maximum long-term deflection of 1/2 inch to ensure good appearance and adequate drainage.
3) Continuous spans are defined as interior (not end) spans that are uniform in length and free from structural rotation at the supports. Simple spans are supported only at the ends and are hinged or free to rotate at the supports.

Field Testing

Bondstrand 2000 piping systems are designed for hydrostatic field testing at 150% of rated operating pressure. Pneumatic testing is not recommended.

Pipe Construction

The structural wall of fiberglass pipe shall have continuous glass fibers in a matrix of aromatic amine cured epoxy resin.

The integral, reinforced resin-rich liner shall consist of C-glass and a resin/hardener system identical to that of the structural wall, and shall have a 20 mil nominal thickness.

Pipe in 1 through 16-inch sizes shall be rated for a minimum of 165 psig at 250°F. In 1 through 6-inch sizes the pipe shall have full vacuum capability at 70°F, when installed above ground with a safety factor of 3:1.

Pipe shall be manufactured according to ASTM D2996 specification for filament- wound Reinforced Thermosetting Resin Pipe (RTRP). When classified under ASTM D2310, the pipe shall meet Type 1, Grade 1 and Class F (RTRP-11FE or W) cell limits in 1 through 16-inch nominal pipe sizes.

Filament-wound epoxy fiberglass pipe shall be translucent to allow for inspection of damage.

Pipe in 2 through 8-inch sizes shall be furnished in 30 or 40-ft. length to minimize the number of field-bonded joints for rapid installation.

Standard Fittings Construction

Fittings in 1 through 16-inch sizes shall be filament wound with a reinforced resin-rich liner of 50 mil minimum thickness and of the same glass and resin type as the pipe. Pipe, filament-wound fittings and adhesive shall, as an assembly, provide a continuous liner throughout the system.

Compression-molded fittings in 2, 3, 4 and 6-inch nominal sizes may also be allowed upon agreement between purchaser and manufacturer.

Contact-molded, spray-up or hand-layup fittings shall not be allowed. Pipe and fittings shall be joined using a straight spigot by socket with a 0.5° taper angle and a pipe stop inside the socket to allow precise makeup.

Workmanship

The pipe and fittings shall be free from all defects, including delaminations, indentations, pinholes, foreign inclusions, bubbles and resin-starved areas which, due to their nature, degree or extent, detrimentally affect the strength and serviceability of the pipe or fittings. The pipe and fittings shall be as uniform as commercially practicable in color, density and other physical properties.

Testing

Samples of pipe and couplings shall be tested at random, based on standard quality control practices to determine conformance of the materials to American Society for Testing and Materials guidelines for testing fiberglass pipe products: ASTM D1599, D2105, D2925, D2992A or D2992B.

Test samples may be hydrostatically tested by the manufacturer to 1.5 times the pressure rating for signs of leakage.

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NOV Fiber Glass Systems

CI2000ENG - May 2014

Bondstrand™ 2000 Guide Specification

Scope

This specification defines the reinforced thermosetting resin (RTR) piping system to be used in those sections of Plant Piping–General Services calling for fiberglass piping systems.

References, Quality Assurance

References are made to other standards and tests which are a part of this section as modified Where conflict exists between the requirements of this specification and listed references, the specification shall prevail.

Physical and Mechanical Properties

Pipe Property	Units	70°F 21°C		200°F 93°C		ASTM Method
Nominal Pipe Size		1”, 1 1/2” 8”-16”	2”-6”	1”, 1 1/2” 8”-16”	2”-6”	
Circumferential						
Tensile stress at weeping	10^3 psi MPa	24.00 165.00	32.00 22.00	- -	- -	D1599
Tensile modulus	10^6 psi GPa	3.65 25.20	4.20 29.00	3.20 22.10	3.70 25.50	
Poisson’s ratio		0.56	0.26	0.70	0.32	D2105
Longitudinal						
Tensile strength	10^3 psi MPa	8.50 58.60	16.00 110.00	6.90 47.60	13.00 90.00	D2105
Tensile modulus	10^6 psi GPa	1.60 11.00	3.00 20.70	1.24 8.50	2.40 16.50	D2105
Poisson’s ratio		0.37	0.16	0.41	0.20	D2105
Beam apparent						
Elastic modulus	10^6 psi GPa	1.70 11.70	2.40 16.60	1.00 6.90	1.77 12.20	D2925
Hydrostatic design						
basis (cyclic)	10^3 psi MPa	6.00 41.40[1]	16.00[1,2] 110.00	- -	- -	D2992
Thermal conductivity						
Pipe wall	Btu•in/(hr•ft²•°F) W/m•°C	2.00 0.29	1.70 10.25	- -	- -	C177
Thermal expansion						
Linear	10^{-6}in/in/°F 10^{-6} mm/mm°C	10.00 18.00	8.50 15.30	- -	- -	D696
Flow coefficient	Hazens-Wiliams	150.00	150.00	-	-	-
Absolute roughness	10^{-6} ft 10^{-6} m	17.40 5.30	17.40 3.30	- -	- -	-
Specific gravity	-	1.80	1.80	-	-	D792
Density	lb/in³ g/cm³	0.07 1.80	0.07 1.80	- -	- -	-

1) At 150°F (66°C)
2) Static

Performance Requirements

The pipe in sizes 1” through 16” must comply with U.S. Federal Regulations 21CFR 175.105 and 21CFR 177.2280 for conveying foodstuffs when joined with RP6B epoxy adhesive. Pipe shall be listed under NSF Standard 61-Drinking Water System Components. Piping must meet or exceed the requirements of MIL-P-29206A and ASTM D5677-95 when used in aviation fuel service. Fittings will be manufactured according to ASTM D5685. Piping will be manufactured according to ASTM D2996 for RTRP. When classified under ASTM D2310, the pipe shall meet Type I, Grade I and Class F (RTRP-11FE) cell limits in 1” through 16” nominal pipe sizes.

Materials

Pipe Construction
Filament-wound fiberglass reinforced epoxy resin pipe shall be Bondstrand 2000 as manufactured by FGS, or approved equal. The integral reinforced corrosion barrier shall have a nominal 20 mil thickness, and be constructed with the same epoxy resin as the pipe structural wall. Non-reinforced liners, or corrosion barriers, shall not be allowed due to potential for fracturing during lower temperatures, transportation and installation.

Structural wall
The pipe shall have the following nominal wall thickness:

Pipe Diameter	Nominal Wall Thickness	
in	in	mm
1	.140	3.5
1 1/2	.140	3.5
2	.123	3.1
3	.126	3.2
4	.151	3.8
6	.181	4.6
8	.226	5.7
10	.226	5.7
12	.226	5.7
14	.250	6.4
16	.269	6.8

Pipe end preparation options
The piping manufacturer will provide 20' or 40' RL joints if the contractor requests them in sizes 2" through 6" to reduce field labor time in those sections of the system where longer lengths may be employed. Additionally, the pipe manufacturer will provide pipe joints with the spigot ends already prepared to reduce field labor time on all pipe sizes (2" -16").

Pressure rating
Aromatic amine cured epoxy resin piping shall be rated for a minimum of 165 psi at 200°F in sizes through 16". Pressure ratings reduce linearly to 50% at 250°F.

Fittings

It is important to maintain compatibility of fittings, piping and adhesives to ensure that the system performs as specified. Pipe, fittings and adhesive shall be supplied by the same manufacturer.

Filament-wound fittings
Fittings in 1" through 16" sizes shall be filament-wound with a reinforced resin-rich liner of equal or greater thickness than the pipe liner and shall be manufactured with the same resin type as the pipe.

Compression-molded fittings
Compression molded fittings in sizes 2" through 6" may be used in services at or below 200°F. Where fast closure of valves may produce surges (water hammer), filament-wound fittings will be used.

Contact molded, spray up or hand lay-up fittings shall not be allowed.

Testing

Inspection and testing
Inspection and testing of the piping will be performed in accordance with the requirements of ASME B31.1. Hydrostatic testing of all installed piping shall be performed with water at 1 1/2 times the design pressure of the lowest rated piping system component.

Test and repair procedures
The RTRP manufacturer will provide test and repair procedures in the event field repairs are required.

Installation

Installation procedures and techniques as well as system design criteria including burial, anchoring, guiding and supporting shall be in accordance with manufacturer's recommendations.

Piping system installers and fitters will be trained by a direct factory employee of the piping system manufacturer and certified by the trainer prior to system assembly in the field.

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CI2001 - May 2013

Bondstrand™ 2400 Series Product Data

Glassfiber Reinforced Epoxy (GRE) pipe systems

Applications

- Potable Water
- Cooling Water
- Produced Water
- Fire Water (FM Approved)
- Waste Water
- Salt Water
- Crude Oil & Gas
- Brine Solutions
- Drainage
- Sewage
- CO_2
- General Service for Mildly Corrosive Liquids

Materials and Characteristics

Filament wound Glassfiber Reinforced epoxy (GRE) pipe with an integral Taper female x shaved spigot adhesive bonded joint or Key-Lock integral female x male mechanical joint.

- Laminate meets requirements of API Specification 15LR and ISO 14692
- Pipe wall design based on hydrostatic design basis (Procedure B) with a 0.5 service factor
- Maximum operating temperature: 200°F (93°C). Temperatures up to 250°F (121°C) are possible. Please consult NOV Fiber Glass Systems
- Pipe sizes: 2 - 40 inch (50 - 1000 mm)
- Standard pressure rating up to 725 psi (50 bar). Higher pressure ratings are possible. Please consult NOV Fiber Glass Systems.
- ASTM D-2310 classification: RTRP-11AW for conductive pipe and RTRP-11FW for non-conductive pipe.
- Non-conductive pipe has a standard liner thickness of 0.5 mm. Conductive pipe has no liner.

Joining Systems

Fittings

Filament wound Glassfiber Reinforced epoxy (GRE) fittings with integral taper female bell ends. A wide range of fittings is available.

Flanges

Filament wound GRE heavy duty and stub end flanges with integral taper female bell end are available. Standard flange drilling pattern per ASME B16.5 and B16.47A, Class 150 are available. Other drilling patterns, such as Class 300, DIN and JIS are available.

For dimensional data and standard configurations for fittings, refer to the respective fitting guides. Optionally, the system can be suppled conductive (Bondstrand 2400C) or with fireproofing (Bondstrand 2400FP).

Pipe Lengths

From 2 - 6 inch (50 - 150 mm)	9 m random length
From 8 - 40 inch (200 - 1000 mm)	11.89 m random length

Note: Overall pipe length depends on size, end configuration and production location.

Total Wall Thickness

Pipe Size		Pressure Class (bar)								
inch	mm	2410	2412	2414	2416	2420	2425	2432	2440	2450
2	50	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.8	3.3
3	80	2.3	2.3	2.3	2.3	2.3	2.7	3.1	3.9	4.7
4	100	2.3	2.3	2.3	2.5	2.7	3.3	3.9	4.9	5.9
6	150	2.5	2.7	3.0	3.4	3.8	4.6	5.6	7.0	8.7
8	200	3.1	3.2	3.7	4.2	4.8	5.8	7.2	9.1	11.2
10	250	3.5	3.9	4.5	5.1	5.8	7.2	8.8	11.2	13.8
12	300	3.9	4.5	5.3	6.0	6.8	8.4	10.4	13.4	16.6
14	350	4.1	4.8	5.7	6.6	7.4	9.2	11.4	14.5	18.2
16	400	4.5	5.5	6.4	7.4	8.4	10.5	12.9	15.6	
18	450	4.9	6.0	7.0	8.1	9.2	11.5	14.2	18.2	
20	500	5.4	6.6	7.7	8.9	10.1	12.7	15.7	20.1	
24	600	6.3	7.7	9.3	10.6	12.1	15.1	18.8	24.0	
28	700	7.4	9.1	10.8	12.6	14.3	17.9	22.3		
30	750	7.9	9.7	11.6	13.5	15.3	19.1	23.9		
32	800	8.4	10.3	12.3	14.3	16.3	20.4	25.5		
36	900	9.3	11.5	13.7	16.1	18.2	22.8	28.5		
40	1000	10.3	12.8	15.3	17.8	20.3	24.8			

Note: (1) Pipe wall thickness measured according to NOV Fiber Glass Systems' procedure.
(2) Total pipe wall thickness includes 0.5 mm liner for non-conductive pipe.

External Pressure (Ultimate Collapse Pressure at 21°C / 70°F)

Pipe Size		Pressure Class (bar)								
inch	mm	2410	2412	2414	2416	2420	2425	2432	2440	2450
2	50	18.6	18.6	18.6	18.6	18.6	18.6	18.6	37.7	66.3
3	80	5.3	5.3	5.3	5.3	5.3	9.5	15.5	33.7	61.7
4	100	2.5	2.5	2.5	3.4	4.6	9.2	16.3	34.3	61.7
6	150	1.0	1.3	2.0	3.0	4.5	8.4	15.9	32.1	62.5
8	200	1.0	1.1	1.8	2.8	4.4	8.0	15.9	32.8	61.4
10	250	0.8	1.1	1.8	2.7	4.1	8.1	15.2	31.7	61.8
12	300	0.7	1.1	1.8	2.7	4.0	7.9	15.2	32.7	61.7
14	350	0.6	1.0	1.7	2.8	4.0	7.9	15.3	32.2	61.9
16	400	0.5	1.0	1.7	2.7	4.0	8.1	15.1	26.7	
18	450	0.5	1.0	1.7	2.7	4.0	8.0	15.2	31.9	
20	500	0.5	1.0	1.7	2.7	3.9	8.0	15.1	31.6	
24	600	0.5	1.0	1.8	2.7	4.0	7.9	15.3		
28	700	0.5	0.9	1.6	2.6	3.8	7.6	14.6		
30	750	0.5	0.9	1.6	2.6	3.8	7.5	14.7		
32	800	0.5	0.9	1.6	2.6	3.9	7.6	14.7		
36	900	0.5	0.9	1.6	2.6	3.8	7.5	14.6		
40	1000	0.5	1.0	1.6	2.6	3.9	7.5			

Typical Mechanical Properties

Pipe Property	Units	Value 21°C	Value 93°C	Method
Hydrostatic Design Basis	N/mm²	161 (1)	121	ASTM D2992, Proc. B (20 years)
Ultimate Hoop Stress at Weeping	N/mm²	280	334	ASTM D1599
Circumferential				
Hoop Tensile Strength	N/mm²	380	-	ASTM D2290
Hoop Tensile Modulus	N/mm²	26700	16300	ASTM D2290
Poisson's Ratio ν_{ha} (2)	-	0.61	0.80	NOV FGS
Longitudinal				
Axial Tensile Strength	N/mm²	80	65	ASTM D2105
Axial Strength Modulus	N/mm²	15500	8550	ASTM D2105
Poisson's Ratio ν_{ah} (3)	-	0.35	0.42	ASTM D2105
Axial Bending Strength	N/mm²	85	-	NOV FGS
Axial Bending Modulus	N/mm²	15500	9900	ASTM D2925
Shear Modulus	N/mm²	12100	11500	NOV FGS

Typical Physical Properties

Pipe Property	Units	Value	Method
Thermal Conductivity Pipe Wall	W/m°C	0.33	NOV FGS
Thermal Expansion @ 21°C	mm/mm°C	18×10^{-6}	ASTM D696
Thermal Expansion @ 93°C	mm/mm°C	24×10^{-6}	ASTM D696
Flow Efficient, Hazen Williams	-	150	-
Absolute Roughness	m	5.3×10^{-6}	-
Density	kg/m³	1800	-
Specific Gravity	-	1.8	ASTM D792
Specific Heat	J/kg°C	910	-
Grounding Resistance @ 500 Volt-Pipe	Ohm/m	$<1 \times 10^{-6}$	ASTM D257
Grounding Resistance @ 500 Volt-Ftg.	Ohm/ea	$<1 \times 10^{-6}$	ASTM D257
Shielding Capability	Volt	100	-

(1) value obtained at 65°C
(2) ν_{ha} = The ratio of axial strain to hoop strain resulting from stress in the hoop direction.
(3) ν_{ah} = The ratio of hoop strain to axial strain resulting from stress in the axial direction.

Stiffness Factor per ASTM D2412 @21°C (@70°F)

Pipe Size		Pressure Class (bar)								
inch	mm	2410 lb/in	2412 lb/in	2414 lb/in	2416 lb/in	2420 lb/in	2425 lb/in	2432 lb/in	2440 lb/in	2450 lb/in
2	50	114	114	114	114	114	114	114	238	429
3	80	114	114	114	114	114	208	344	768	1448
4	100	114	114	114	156	208	429	768	1665	3078
6	150	156	208	305	477	702	1347	2593	5368	10777
8	200	344	385	640	990	1554	2910	5879	12432	23944
10	250	528	768	1251	1902	2910	5879	11176	23944	48089
12	300	768	1251	2162	3252	4887	9637	18965	41958	81568
14	350	912	1554	2748	4436	6421	12871	25312	54790	108384
16	400	1251	2443	4014	6421	9637	19545	37266	67294	
18	450	1665	3252	5368	8580	12871	26015	50258	108384	
20	500	2299	4436	7295	11585	17293	35491	68640	147168	
24	600	3814	7295	13320	20138	30508	60828	119784		
28	700	6421	12432	21358	34626	51367	102966	202495		
30	750	7920	15220	26731	42941	63362	125772	250433		
32	800	9537	18396	32114	51367	77093	154029	305397		
36	900	13320	26015	44954	72785	108384	216750	429060		
40	1000	17612	36371	63362	101200	151719	301810			

Pipe Stiffness per ASTM D2412 @21°C (@70°F)

Pipe Size		Pressure Class (bar)								
inch	mm	2410 psi	2412 psi	2414 psi	2416 psi	2420 psi	2425 psi	2432 psi	2440 psi	2450 psi
2	50	602.8	602.8	602.8	602.8	602.8	602.8	602.8	1223.8	2149.5
3	80	171.6	171.6	171.6	171.6	171.6	308.9	502.7	1092.8	2003.0
4	100	81.9	81.9	81.9	111.7	147.8	299.7	527.7	1112.6	2001.4
6	150	33.0	43.7	63.8	98.8	144.5	273.2	516.2	1041.8	2028.4
8	200	32.0	35.8	59.1	90.8	141.3	260.9	516.8	1064.5	1991.9
10	250	24.7	35.8	57.9	87.4	132.7	263.9	492.9	1028.6	2003.6
12	300	21.2	34.3	58.9	88.0	131.2	254.9	492.4	1059.6	2000.5
14	350	19.0	32.2	56.6	90.6	130.3	257.2	496.5	1046.2	2008.4
16	400	17.5	33.9	55.3	87.9	130.9	261.4	489.5	866.6	
18	450	17.4	33.7	55.3	87.8	130.7	260.1	493.4	1036.0	
20	500	17.5	33.5	54.8	86.4	128.0	258.5	491.0	1025.3	
24	600	16.8	31.9	57.8	86.8	130.6	256.4	495.5		
28	700	16.0	30.7	52.4	84.4	124.3	245.4	473.7		
30	750	16.0	30.6	53.3	85.1	124.6	243.7	476.3		
32	800	16.1	30.5	52.8	83.9	124.9	245.9	478.5		
36	900	15.6	30.3	51.9	83.5	123.4	243.1	472.3		
40	1000	15.7	30.8	53.3	84.6	125.9	244.2			

Single Span Lengths

Pipe Size		Pressure Class (bar)								
inch	mm	2410 m	2412 m	2414 m	2416 m	2420 m	2425 m	2432 m	2440 m	2450 m
2	50	2.8	2.8	2.8	2.8	2.8	2.8	2.8	3.0	3.1
3	80	3.2	3.2	3.2	3.2	3.2	3.3	3.5	3.7	3.9
4	100	3.4	3.4	3.4	3.5	3.6	3.8	4.0	4.2	4.4
6	150	3.9	4.0	4.1	4.3	4.4	4.6	4.9	5.1	5.4
8	200	4.5	4.4	4.7	4.9	5.0	5.3	5.6	5.9	6.2
10	250	4.7	4.9	5.3	5.4	5.6	6.9	6.2	6.6	6.9
12	300	4.9	5.3	5.7	5.9	6.1	6.5	6.8	7.2	7.6
14	350	5.0	5.4	6.0	6.2	6.4	6.8	7.1	7.5	7.9
16	400	5.2	5.9	6.4	6.6	6.9	7.2	7.6	7.9	
18	450	5.4	6.2	6.7	7.0	7.2	7.6	8.0	8.5	
20	500	5.8	6.5	7.1	7.3	7.6	8.0	8.4	8.9	
24	600	6.2	7.0	7.8	8.1	8.3	8.8	9.2	9.8	
28	700	6.7	7.6	8.4	8.8	9.1	9.6	10.1		
30	750	7.0	7.9	8.7	9.2	9.4	9.9	10.5		
32	800	7.2	8.1	9.0	9.4	9.7	10.3	10.8		
36	900	7.6	8.6	9.5	10.0	10.3	10.9	11.5		
40	1000	8.0	9.1	10.1	10.6	10.9	11.4			

Continuous Span Lengths

Pipe Size		Pressure Class (bar)								
inch	mm	2410 m	2412 m	2414 m	2416 m	2420 m	2425 m	2432 m	2440 m	2450 m
2	50	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.5	4.7
3	80	4.8	4.8	4.8	4.8	4.8	5.0	5.2	5.5	5.8
4	100	5.1	5.1	5.1	5.2	5.4	5.7	5.9	6.3	6.5
6	150	5.8	6.0	6.2	6.4	6.6	6.9	7.3	7.7	8.1
8	200	6.7	6.7	7.0	7.3	7.5	7.9	8.3	8.8	9.2
10	250	7.3	7.6	7.9	8.1	8.4	8.9	9.3	9.8	10.3
12	300	7.9	8.2	8.6	8.9	9.2	9.7	10.2	10.8	11.3
14	350	8.2	8.6	9.0	9.3	9.6	10.1	10.7	11.3	11.8
16	400	8.7	9.2	9.6	9.9	10.3	10.8	11.4	11.9	
18	450	9.2	9.7	10.1	10.4	10.8	11.4	11.9	12.6	
20	500	9.7	10.2	10.6	11.0	11.3	12.0	12.6	13.3	
24	600	10.6	11.1	11.7	12.0	12.4	13.1	13.8	14.6	
28	700	11.6	12.2	12.7	13.2	13.6	14.4	15.1		
30	750	12.0	12.6	13.2	13.7	14.1	14.9	15.7		
32	800	12.4	13.0	13.6	14.1	14.6	15.4	16.2		
36	900	13.1	13.8	14.4	15.0	15.4	16.3	17.2		
40	1000	13.8	14.6	15.2	15.8	16.3	17.2			

Note: Span lengths are at 21°C (70°F).

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NOV Fiber Glass Systems

CI2400ENG - June 2014

Bondstrand™ Series 3000 Fiberglass Pipe for General Industrial Service

Uses and Applications

- Boiler feed water
- Bridge, roof and floor drains
- Brine and brackish water
- Chemical process piping
- Cooling water
- Demineralized water
- Electroplating
- Fuel oil piping
- General service piping
- Mild chemicals
- Municipal waste
- Oilfield gathering, transmission lines
- Power plant, steel mill and industrial plant piping
- Sewer lines and sewer force mains
- Source and recycle water
- Sump discharge
- Vent lines
- Water mains
- Water treatment

Performance

Working pressure to 450 psig depending on pipe size.

Operating surge pressure to 1.25 times rated operating pressure.

No thrust blocks are required at rated system pressure for most buried piping configurations and most soil conditions.

Temperatures to 150°F (66°C) maximum.

Full vacuum capabilities when buried and properly backfilled. For above ground use, refer to collapse pressures listed below under pipe pressure performance.

Recommended burial depth: 3 to 25 feet.

Recommended for water, waste water (pH 1 to 8.5), moderately corrosive liquids and mild chemicals. Consult corrosion guide or Applications Engineering for recommendations for your particular application.

Individual system components may not have the same ratings as the pipe. Refer to the detailed product information for the specific components to determine the pressure rating for the system as a whole.

Composition

Pipe

Filament-wound fiberglass reinforced epoxy pipe with integral epoxy liner and exterior coating.

Pipe Size		ASTM Designation	
in	mm	D2310	D2996
2 - 6	50 - 150	RTRP 11FX	RTRP 11FX-5420
8 - 16	200 - 400	RTRP 11FW	RTRP 11FW1-3210

Fittings

2 to 6 inch
Compression-molded fiberglass reinforced epoxy elbows and tees
Filament-wound and/or mitered crosses, wyes, laterals and reducers

8 to 16 inch
Filament-wound fiberglass reinforced epoxy elbows Filament-wound and/or mitered crosses, wyes, and laterals
Contact-molded reducers

Flanges

Flange rings:
Molded or filament-wound fiberglass

Stub ends:
Molded or centrifugally cast fiberglass

Blind flanges

Compression-molded fiberglass or epoxy-coated cast iron or steel.

Adhesive

Two-part epoxy adhesive for field fabrication. (Consult NOV Fiber Glass Systems for specifications.)

Joining Systems

2 to 16 inch
Bell and spigot taper/taper adhesive-bonded joint.

Pipe Lengths

Standard 20 and 39 ft. random lengths.

Other lengths available on request.

Typical Pipe Dimensions and Weights

Nominal Pipe Size		Outside Diameter[1]		Inside Diameter		Wall Thickness			
						Total		Structural	
in	mm	in	mm	in	mm	in	mm	in	mm
2	50	2.38	60	2.22	56	0.080	2.9	0.069	1.7
3	80	3.50	89	3.33	85	0.085	2.1	0.074	1.9
4	100	4.51	115	4.34	110	0.087	2.2	0.077	1.9
6	150	6.64	169	6.40	163	0.120	3.0	0.114	2.9
8	200	8.60	218	8.30	211	0.150	3.8	0.113	2.9
10	250	10.77	274	10.42	265	0.175	4.4	0.141	3.6
12	300	12.70	323	12.30	312	0.200	5.1	0.170	4.3
14	350	14.44	367	14.01	356	0.215	5.5	0.187	4.8
16	400	16.50	419	16.03	407	0.235	6.0	0.210	5.3

[1] Typical outside diameters of 2 through 12 inch pipe are within API, ASTM and ANSI fiberglass and steel pipe dimensions.

Nominal Pipe Size		Taper Angle	Taper Length		Pipe Weight	
in	mm	deg	in	mm	lb/ft	kg/m
2	50	1.75	1.5	38	0.5	0.75
3	80	1.75	1.7	43	0.7	1.05
4	100	1.75	1.9	48	1.0	1.50
6	150	1.75	2.8	71	1.9	2.85
8	200	2.00	2.6	66	3.1	4.60
10	250	2.00	3.1	79	4.5	6.70
12	300	2.00	3.6	91	6.1	9.10
14	350	2.00	4.2	107	7.5	11.15
16	400	2.00	4.7	119	9.4	14.00

Typical Pipe Performance

Nominal Pipe Size		Static Pressure Rating at 150°F		Ultimate Internal Pressure[1]		Ultimate Collapse Pressure[2]			
						80°F	27°C	150°F	99°C
in	mm	psig	bar	psig	bar	psig	bar	psig	bar
2	50	450	31	3,200	221	145	10.0	125	8.6
3	80	400	28	2,400	166	50	3.4	45	3.1
4	100	325	22	2,000	138	40	2.8	35	2.4
6	150	300	20	2,000	138	35	2.4	30	2.1
8	200	150	10	900	62	25	1.7	21	1.4
10	250	150	10	900	62	18	1.2	12	0.8
12	300	150	10	900	62	12	0.8	9	0.6
14	350	150	10	900	62	10	0.7	7.5	0.5
16	400	150	10	900	62	10	0.7	7.5	0.5

[1] Quality Control minimum

[2] For vacuum service above ground in sizes 10 inches and above consult NOV Fiber Glass Systems.

Fittings Pressure Ratings[3]

Nominal Pipe Size		Elbows[1]		Tees		Flanges[2]		Blind Flanges	
in	mm	psig	bar	psig	bar	psig	bar	psig	bar
2	50	450	31	350	24	450	31	450	31
3	80	400	28	300	21	400	28	400	28
4	100	325	22	225	16	325	22	325	22
6	150	300	21	200	14	300	21	300	21
8	200	150	10	150	10	150	10	150	10
10	250	150	10	150	10	150	10	150	10
12	300	150	10	150	10	150	10	150	10
14	350	150	10	150	10	150	10	150	10
16	400	150	10	150	10	150	10	150	10

Nominal Pipe Size		Adapters		Laterals, Wyes and Crosses		Saddles	
in	mm	psig	bar	psig	bar	psig	bar
2	50	450	30	200	13	300	20
3	80	375	25	200	13	300	20
4	100	300	20	200	13	200	13
6	150	300	20	200	13	150	10
8	200	150	10	150	10	150	10
10	250	—	—	150	10	100	8
12	300	—	—	150	10	75	5
14	350	—	—	150	10	50	3
16	400	—	—	150	10	50	3

(1) Ratings shown are for 90° and 45° elbows. Ratings in 8 to 16 inch sizes are also applicable to elbows of other angles.

(2) ANSI B16.5 CL150 psig bolt hole pattern

(3) Ratings at 150°F

Typical Physical Properties

Pipe Property	Units	Value	ASTM
Thermal conductivity	Btu-in/(h•ft^2•°F) W/m•°C	1.7 0.25	C177
Coefficient of thermal expansion (linear) (77°F to 210°F) (25°C to 65°C)	10^{-6} in/in/°F 10^{-6} cm/cm/°C	8.5 to 12 15.3 to 21.6	D696 E228
Flow coefficient	Hazen-Williams	150.0	—
Absolute roughness	10^{-6} ft 10^{-6}m	50.0 15.0	—
Specific gravity	—	1.81	D792

Typical Mechanical Properties

Pipe Property[(1)]	Units	Value[(1)] 2 - 6 in	Value[(1)] 8 - 16 in	ASTM
Tensile strength				
Longitudinal	10^3 psi	35.0	20.0	D2105
	MPa	240.0	138.0	
Circumferential	10^3 psi	70.0	40.0	D1599
	MPa	480.0	275.0	
Tensile modulus				
Longitudinal	10^6 psi	2.7	1.5	D2105
	GPa	18.6	10.3	
Circumferential	10^6 psi	4.2	2.3	—
	GPa	29.0	15.9	
Compressive strength				
Longitudinal	10^3 psi	35.0	20.0	—
	MPa	240.0	138.0	
Compressive modulus				
Longitudinal	10^6 psi	2.7	1.5	—
	GPa	18.6	10.3	
Long-Term Hydrostatic Design Basis[(3)]				
Static, Hoop Stress 95% LCL 20-year Life @150°F/65°C	10^3 psi	18.9	18.9	D2992 Procedure B
	MPa	130.3	130.3	
Cyclic, Hoop Stress 95% LCL 20-year Life @75°F/24°C	10^3 psi	6.4	—	D2992 Procedure A
	MPa	44.1	—	
Poisson's Ratio[(2)]				
ν_{yx}	—	0.17	0.17	—
ν_{xy}	—	0.15	0.15	—

(1) Based on structural wall thickness, at room temperature unless noted.

(2) The first subscript denotes the direction of applied stress and the second subscript the measured strain contraction.
x denotes longitudinal direction.
y denotes circumferential direction.

(3) Test fixtures were end type (full end thrust on samples).

Nominal Pipe Size		Change in Length Due to Pressure[(1)]		Stiffness Factor[(2)]	
in	mm	in/100 ft/100 psi	mm/10m/10 bar	lb•in³/in²	N•m
2	50	0.271	3.27	45	5.1
3	80	0.379	4.58	75	8.5
4	100	0.482	5.82	60	6.8
6	150	0.477	5.76	275	31.1
8	200	1.085	13.11	500	56.5
10	250	1.088	13.15	750	85.0
12	300	1.069	12.92	1,250	140.0
14	350	1.107	13.38	1,600	180.0
16	400	1.130	13.65	2,000	225.0

(1) In an unrestrained system due to pressure effects alone.

(2) At 5% deflection.

Support Spacing

(Values are based on a ½ inch (12 mm) deflection at mid span.)[4]

Nominal Pipe Size		Single Span[1]						Continuous Span[2]					
		Gases		1.00[3]		1.3[3]		Gases		1.00		1.3[3]	
in	mm	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m
2	50	13.9	4.2	9.9	3.0	9.4	2.9	16.5	5.0	11.8	3.6	11.2	3.4
3	80	17.5	5.3	11.2	3.4	10.6	3.2	20.8	6.3	13.3	4.1	12.6	3.8
4	100	19.5	6.0	12.1	3.7	11.4	3.5	23.2	7.1	14.3	4.4	13.6	4.1
6	150	24.2	7.4	14.4	4.4	13.7	4.2	28.8	8.8	17.2	5.2	16.3	5.0
8	200	23.1	7.0	13.6	4.1	12.8	3.9	27.5	8.4	16.2	4.9	15.2	4.6
10	250	26.1	8.0	15.1	4.6	14.2	4.3	31.0	9.5	17.9	5.5	16.9	5.1
12	300	28.4	8.7	16.2	4.9	15.3	4.7	33.8	10.3	19.3	5.9	18.2	5.5
14	350	30.1	9.3	17.4	5.3	16.4	5.0	36.1	11.0	20.7	6.3	19.5	5.9
16	400	32.5	9.9	18.4	5.6	17.4	5.3	38.7	11.8	21.9	6.7	20.6	6.3

(1) For fluid temperatures above 77°F (25°C) reduce span lengths 0.1-inch/°F (5 mm/°C)

(2) Beam fixed at both ends and uniformly distributed loads. Intermediate spans may be calculate by multiplying the single span length by 1.2.

(3) Fluid specific gravity.

Bending Radius[1]

Nominal Pipe Size		Minimum Bending Radius		Maximum Deflection per 39-ft Joint	Minimum Length Required for 10° Change	
in	mm	ft	m	deg	ft	m
2	50	64	20	35	11	3
3	80	175	53	13	30	9
4	100	277	85	8	48	15
6	150	277	84	8	48	15
8	200	277	84	8	48	15
10	250	395	120	6	69	21
12	300	497	152	4	87	26
14	350	649	198	3	113	35
16	400	846	258	3	148	45

(1) At rated pressure. Sharper bends may create excessive stress concentrations.
Do not bend pipe until adhesive has cured.

Guide Specification

Pipe Construction

Pipe—The structural wall of fiberglass pipe in 2 through 16 inch nominal pipe sizes shall be constructed of continuous glass fibers wound in a matrix of anhydride cured epoxy resin in a dual angle pattern that takes optimum advantage of the tensile strength of the filaments. Pipe produced by filament-winding shall have a smooth outer surface with an outside diametral tolerance not exceeding ±1.0%. The pipe shall incorporate an integral liner with a nominal thickness of 0.025 ± 0.005 inches for 2 through 16 inch nominal sizes. The pipe shall be manufactured in accordance with ASTM Standard D2996 for filament-wound reinforced thermosetting resin pipe (RTRP). When classified under ASTM Standard D2310, the pipe shall be Type 1, Grade 1, and Class F for 2 through 16 inch nominal pipe sizes.

Pipe shall be provided in standard lengths up to 40 feet, and shall be available in 60 ft. lengths on special request to minimize the number of field joints for rapid installation.

Pressure rating—Pipe in 2 through 16 inch sizes shall be rated for a minimum internal pressure of 150 psig at 150°F.

Fittings Construction

Fittings in 8 through 16 inch nominal sizes shall be filament wound and incorporate a resin-rich liner of equal or greater thickness than the pipe liner and shall be constructed of the same glass and resin type for corrosion and abrasion resistance equal to that of the pipe. Fittings in 2 through 6 inch nominal sizes may be compression molded from glass and resins similar to those used in the pipe. Sprayed-up fittings shall not be permitted.

Pipe and fittings shall be joined using bell and spigot taper/taper adhesive-bonded joints or mechanical screw-on type joints.

Physical and Mechanical Requirements

Values for physical and mechanical properties shall be no less than 95% of those shown tabulated above under Typical Physical Properties and Typical Mechanical Properties.

Workmanship

The pipe and fittings shall be free from all defects, including delamination, indentations, pinholes, foreign inclusions, bubbles and resin-starved areas which, due to their nature, degree or extent, detrimentally affect the strength and serviceability of the pipe or fittings. Pigments or dyes may be used in the resin as long as the product is sufficiently translucent to verify the structural integrity of the structural wall. The pipe and fittings shall be as uniform as commercially practicable in color, density and other physical properties.

Testing

Quality control testing—Samples of pipe and fittings shall be tested at random based on standard quality control practices to determine conformance of the materials to the following ASTM guidelines for testing fiberglass pipe products: ASTM D1599, D2105, D2925, D2992A or D2992B. Test samples may be hydrostatically tested by the manufacturer to 1.5 times the pressure rating for signs of leakage.

Marking

Each component shall be marked to show the following:

- Manufacturer's name and address
- Nominal pipe size
- Hydrostatic test pressure (if so ordered)
- Date and shift of manufacture (pipe only)

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NOV Fiber Glass Systems

CI3000 - July 2013

Bondstrand™ Series 3000A Fiberglass Pipe for General Industrial Service

Uses and Applications

- Alcohol solutions
- Boiler feed water
- Bridge, roof and floor drains
- Brine and brackish water
- Chemical process piping
- Cooling water
- Demineralized water
- Fuel oil piping
- General service piping
- Mild chemicals
- Municipal waste
- Oilfield piping
- Potable water - NSF 61 Listed
- Power plant, steel mill and industrial plant piping
- Sewer lines and sewer force mains
- Source and recycle water
- Sump discharge
- Vent lines
- Water mains
- Water treatment

Performance

Working pressure to 450 psig depending on pipe size.

No thrust blocks are required at rated system pressure for most buried piping configurations and most soil conditions.

Temperatures to 210°F (99°C) maximum.

For above ground use, refer to collapse pressures listed below under pipe pressure performance.

Recommended burial depth: 3 to 25 feet.

Recommended for water, waste water (pH 1 to 12), moderately corrosive liquids and mild chemicals. Consult corrosion guide or Applications Engineering for recommendations for your particular application.

Individual system components may not have the same ratings as the pipe. Refer to the detailed product information for the specific components to determine the pressure rating for the system as a whole.

Composition

Pipe

Filament-wound fiberglass reinforced epoxy pipe with integral epoxy liner and exterior coating.

Pipe Size		ASTM Designation	
in	mm	D2310	D2996
2 - 6	50 - 150	RTRP-11FU	RTRP-11FU1-6430
8 - 16	200 - 400	RTRP-11FU	RTRP-11FU1-3220

Fittings

2 to 6 inch
Compression-molded fiberglass reinforced epoxy elbows and tees
Filament-wound and/or mitered crosses, wyes, laterals and reducers

8 to 16 inch
Filament-wound fiberglass reinforced epoxy elbows. Filament-wound and/or mitered crosses, tees, wyes, and laterals.
Contact-molded reducers

Flanges

Flange rings:
Molded or filament-wound fiberglass

Stub Ends:
Molded or centrifugally cast fiberglass

Blind Flanges

Compression-molded fiberglass

Two-part epoxy adhesive for field fabrication. (Consult NOV Fiber Glass Systems for specifications.)

Joining Systems

2 to 16 inch
Bell and spigot taper/taper.

Pipe Lengths

Standard 20 and 39 ft. random lengths.

Other lengths available on request.

Typical Pipe Dimensions and Weights

Nominal Pipe Size		Outside Diameter[1]		Inside Diameter		Wall Thickness Total		Wall Thickness Structural	
in	mm	in	mm	in	mm	in	mm	in	mm
2	50	2.38	60	2.22	56	0.080	2.0	0.069	1.7
3	80	3.50	89	3.33	85	0.085	2.2	0.074	1.9
4	100	4.51	115	4.34	110	0.087	2.2	0.077	1.9
6	150	6.64	169	6.40	162	0.120	3.0	0.114	2.9
8	200	8.60	218	8.30	211	0.150	3.8	0.113	2.9
10	250	10.77	274	10.42	265	0.175	4.4	0.141	3.6
12	300	12.70	323	12.30	312	0.200	5.1	0.170	4.3
14	350	14.44	367	14.01	356	0.215	5.5	0.187	4.8
16	400	16.50	419	16.03	407	0.235	6.0	0.210	5.3

[1] Typical outside diameters of 2 through 12 inch pipe are within API, ASTM and ANSI fiberglass and steel pipe dimensions.

Nominal Pipe Size		Taper Angle	Taper Length		Pipe Weight	
in	mm	Degree	in	mm	lb/ft	kg/m
2	50	1.75	1.5	38	0.50	0.75
3	80	1.75	1.7	43	0.70	1.05
4	100	1.75	1.9	48	1.00	1.50
6	150	1.75	2.8	71	1.90	2.85
8	200	2.00	2.6	66	3.10	4.60
10	250	2.00	3.1	79	4.50	6.70
12	300	2.00	3.6	91	6.10	9.10
14	350	2.00	4.2	107	7.50	11.15
16	400	2.00	4.7	119	9.40	14.00

Typical Pipe Performance

Nominal Pipe Size		Static Pressure[3] Rating at 150°F		Ultimate Internal Pressure[1]		Ultimate Collapse Pressure[2] 80°F	27°C	210°F	99°C
in	mm	psig	bar	psig	bar	psig	bar	psig	bar
2	50	450	31	2,160	149	165	11.4	151	10.4
3	80	400	28	1,579	109	66	4.6	60	4.2
4	100	325	22	1,258	87	34	2.3	31	2.1
6	150	300	21	1,275	88	35	2.4	32	2.2
8	200	150	10	605	42	16	1.1	14	1.0
10	250	150	10	678	47	16	1.1	14	1.0
12	300	150	10	741	51	17	1.2	15	1.1
14	350	150	10	739	51	15	1.0	14	1.0
16	400	150	10	749	52	14	1.0	13	0.9

[1] Quality control minimum

[2] For vacuum service above ground in sizes 8 inches and above consult NOV Fiber Glass Systems.

[3] At 210°F, derate 2”-6” sizes by a factor of 0.73 and 8”-16“ sizes by a factor of 0.63. Linearly interpolate derating factors for temperatures between 150°F and 210°F.

Fittings Pressure Ratings[3]

Nominal Pipe Size		Elbows[1]		Tees		Flanges[2]		Blind Flanges	
in	mm	psig	bar	psig	bar	psig	bar	psig	bar
2	50	450	31	350	24	450	31	450	31
3	80	400	28	300	21	400	28	400	28
4	100	325	22	225	16	325	22	325	22
6	150	300	21	200	14	300	21	300	21
8	200	200	14	150	10	200	14	200	14
10	250	200	14	150	10	200	14	200	14
12	300	200	14	150	10	200	14	200	14
14	350	200	14	150	10	200	14	200	14
16	400	200	14	150	10	200	14	200	14

Nominal Pipe Size		Adapters		Laterals, Wyes and Crosses		Saddles	
in	mm	psig	bar	psig	bar	psig	bar
2	50	450	30	200	13	300	20
3	80	375	25	200	13	300	20
4	100	300	20	200	13	200	13
6	150	300	20	200	13	150	10
8	200	150	10	150	10	150	10
10	250	—	—	150	10	100	8
12	300	—	—	150	10	75	5
14	350	—	—	150	10	50	3
16	400	—	—	150	10	50	3

(1) Ratings shown are for 90° and 45° elbows in 2 to 16 inch sizes. Ratings in 8 to 16 inch sizes are also applicable to elbows of other angles.

(2) ANSI B16.5 Class 150 psig bolt pattern.

(3) At 210°F, derate 2”-6” sizes by a factor of 0.73 and 8”-16“ sizes by a factor of 0.63. Linearly interpolate derating factors for temperatures between 150°F and 210°F.

Typical Physical Properties
(Biaxial Reinforcement Structure Wall)

Pipe Property	Units	Value	ASTM
Thermal conductivity	Btu-in/(h•ft²•°F) W/m•°C	1.7 0.25	C177
Coefficient of thermal expansion linear (2 -16 inch - 77°F to 210°F)	10^{-6} in/in/°F 10^{-6} cm/cm/°C	10 to 13 18 to 24	D696 E228
Flow coefficient	Hazen-Williams	150.0	—
Absolute roughness	10^{-6} ft 10^{-6}m	50.0 15.0	—
Specific gravity	—	1.81	D792

Typical Mechanical Properties

Pipe Property[1]	Units	Value 2 - 6 in	Value 8 - 16 in	ASTM
Tensile Strength				
Longitudinal	10^3 psi	35	20	D2105
	MPa	240	138	
Circumferential	10^3 psi	70	40	D1599[4]
	MPa	483	276	
Tensile Modulus				
Longitudinal	10^6 psi	3.0	2.7	D2105
	GPa	21	19	
Circumferential	10^6 psi	4.2	3.6	—
	GPa	29	25	
Compressive Strength				
Longitudinal	10^3 psi	25	20	—
	MPa	169	138	
Compressive Modulus				
Longitudinal	10^6 psi	2.6	1.5	—
	GPa	18	10.3	
Long-Term Hydrostatic Design Basis[3]				
Static, Hoop Stress	10^3 psi	14.2	14.2	D2992 Procedure B
95% LCL 20-year Life @150°F/65°C	MPa	98.1	98.1	
Cyclic, Hoop Stress	10^3 psi	6.9	6.9	D2992 Procedure A
95% LCL 20-year Life @75°F/24°C	MPa	47.4	47.4	
Poisson's Ratio[2]				
ν_{yx}	—	0.17	0.17	—
ν_{xy}	—	0.15	0.15	—

(1) Based on structural wall thickness, at room temperature unless noted.

(2) The first subscript denotes the direction of applied stress and the second subscript the measured strain contraction
x denotes longitudinal direction.
y denotes circumferential direction.

(3) Test fixtures were free end type (full end thrust on samples)

Nominal Pipe Size		Change in Length Due to Pressure[1]		Stiffness Factor[2]	
in	mm	in/100 ft/100 psi	mm/10m/10 bar	lb•in³/in²	N•m
2	50	0.236	3.27	76	8.5
3	80	0.331	4.58	96	10.9
4	100	0.420	5.82	105	11.9
6	150	0.416	5.76	350	39.5
8	200	0.597	7.21	401	45.3
10	250	0.599	7.24	766	86.5
12	300	0.588	7.11	1,303	147.2
14	350	0.609	7.36	1,722	194.5
16	400	0.622	7.51	2,408	272.1

(1) In an unrestrained system due to pressure effects alone.

(2) At 5% deflection.

Support Spacing

(Values are based on a ½ inch (12 mm) deflection at mid span.)[4]

Nominal Pipe Size		Single Span[1]						Continuous Span[2]					
		Gases		1.00[3]		1.3[3]		Gases		1.00[3]		1.3[3]	
in	mm	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m
2	50	14.2	4.3	10.1	3.1	9.6	2.9	21.2	6.5	15.1	4.6	14.3	4.4
3	80	17.8	5.4	11.4	3.5	10.8	3.3	26.7	8.1	17.1	5.2	16.1	4.9
4	100	19.9	6.1	12.3	3.7	11.6	3.5	29.8	9.1	18.4	5.6	17.4	5.43
6	150	24.6	7.5	14.6	4.5	13.9	4.2	36.8	11.2	21.9	6.7	20.	6.3
8	200	27.9	8.5	16.4	5.0	15.5	4.7	41.8	12.7	24.6	7.5	23.1	7.0
10	250	31.4	9.6	18.1	5.5	17.1	5.2	46.9	14.3	27.1	8.2	25.5	7.8
12	300	34.0	10.4	19.4	5.9	18.3	5.6	50.9	15.5	29.0	8.8	27.3	8.3
14	350	36.2	11.0	20.7	6.3	19.5	5.9	54.2	16.5	31.0	9.5	29.2	8.9
16	400	38.7	11.8	21.9	6.7	20.6	6.3	57.9	17.6	32.8	10.0	30.9	9.4

(1) For fluid temperatures above 77°F (25°C) reduce span lengths 0.1-inch/°F (5 mm/°C)

(2) Beam fixed at both ends and uniformly distributed loads. Intermediate spans may be calculate by multiplying the single span length by 1.2.

(3) Fluid specific gravity.

Bending Radius

Nominal Pipe Size		Minimum Bending Radius		Maximum Deflection per 39-ft Joint	Minimum Length Required for 10° Change	
in	mm	ft	m	deg	ft	m
2	50	64	20	35	11	3
3	80	175	53	13	30	9
4	100	277	85	8	48	15
6	150	266	81	8	46	14
8	200	498	152	4	87	26
10	250	710	216	3	124	38
12	300	895	273	2	156	48
14	350	1,169	356	2	204	62
16	400	1,523	464	1	266	81

(1) At rated pressure. Sharper bends may create excessive stress concentrations.
Do not bend pipe until adhesive has cured.

Guide Specification

Pipe Construction

Pipe—The structural wall of fiberglass pipe in 2 through 16 inch nominal pipe sizes shall be constructed of continuous glass fibers wound in a matrix of aromatic amine cured epoxy resin in a dual angle pattern that takes optimum advantage of the tensile strength of the filaments. Pipe produced by filament-winding shall have a smooth outer surface with an outside diametric tolerance not exceeding ±1.0%. The pipe shall incorporate an integral liner with a nominal thickness of 0.005, to 0.010 inches for 2 through 6-inch nominal sizes, and 0.025, ± 0.005 inches for 8 through 16 inch nominal sizes. The pipe shall be manufactured in accordance with ASTM Standard D2996 for filament-wound reinforced thermosetting resin pipe (RTRP). When classified under ASTM Standard D2310, the pipe shall be Type 1, Grade 1, and Class F for 2 through 16 inch nominal pipe sizes.

Pipe shall be provided in standard lengths up to 40 feet, and shall be available in 60 ft lengths on special request to minimize the number of field joints for rapid installation.

Pressure Rating—Pipe in 2 through 16 inch sizes shall be rated for a minimum internal pressure of 150 psig at 150°F and capable of 210°F service conditions in accordance with the derating factor. In 2 through 6 inch sizes the pipe shall have a full vacuum capability at 80°F when installed above ground.

Fittings Construction

Fittings in 8 through 16 inch nominal sizes shall be filament wound and incorporate a resin-rich liner of equal or greater thickness than the pipe liner and shall be constructed of the same glass and resin type for corrosion and abrasion resistance equal to that of the pipe. Fittings in 2 through 6 inch nominal sizes may be compression molded from glass and resins similar to those used in the pipe. Contact molded, sprayed up or hand laid up fittings shall not be permitted.

Pipe and fittings shall be joined using bell and spigot taper/taper joints bonded with epoxy adhesive.

Physical and Mechanical Requirements

Measured values for physical and mechanical properties shall be within ±15% of those shown tabulated above under Typical Physical Properties and Typical Mechanical Properties.

Workmanship

The pipe and fittings shall be free from all defects, including delamination, indentations, pinholes, foreign inclusions, bubbles and resin-starved areas which, due to their nature, degree or extent, detrimentally affect the strength and serviceability of the pipe or fittings. Pigments or dyes may be used in the resin as long as the product is sufficiently translucent to verify the structural integrity of the structural wall. The pipe and fittings shall be as uniform as commercially practicable in color, density and other physical properties.

Testing

Quality control testing—Samples of pipe and fittings shall be tested at random based on standard quality control practices to determine conformance of the materials to the following ASTM guidelines for testing fiberglass pipe products: ASTM D1599, D2105, D2925, D2992A or D2992B. Test samples may be hydrostatically tested by the manufacturer to 1.5 times the pressure rating for signs of leakage.

Marking

Each component shall be marked to show the following:

- Manufacturer's name and address
- Nominal pipe size
- Hydrostatic test pressure (if so ordered)
- Date and shift of manufacture (pipe only)

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NOV Fiber Glass Systems

CI3010 - July 2013

Bondstrand™ Series 3200 Fiberglass Pipe *Class 200 Fire Protection and General Industrial Service (For 2 - 6 inch diameters, use Series 3000 pipe and Fittings)*

Uses and Applications

- Boiler feed water
- Brine and brackish water
- Chemical process piping
- Cooling water
- Demineralized water
- Electroplating
- Fire mains
- Industrial plant piping
- Municipal waste
- Oilfield gathering, transmission lines
- Power plant and steel mill piping
- Sewer lines and sewer force mains
- Source and recycle water
- Sump discharge
- Vent lines
- Water mains
- Water treatment

Performance

Pipe and fittings are rated at 200 psig.

Operating plus surge pressures to 1.25 times rated operating pressure occurring three times or less per 24-hour period.

Temperatures to 150°F (66°C) maximum. Sub-zero temperatures will not affect the physical properties.

Full vacuum capabilities when buried and properly backfilled. For above ground use, refer to collapse pressures listed below under pipe pressure Typical Pipe Performance.

Recommended burial depth: 3 to 25 feet.

Recommended for water, waste water (pH 1 to 8.5), and mild chemicals. Consult Chemical Resistance Guide or contact NOV Fiber Glass Systems for recommendations for your particular application.

Individual system components may not have the same ratings as the pipe. Refer to the detailed product information for the specific components to determine the pressure rating for the system as a whole.

Composition

Pipe

Filament-wound fiberglass reinforced epoxy pipe with integral epoxy liner and exterior coating.

Pipe Size		ASTM Designation	
in	mm	D2310	D2996
8 - 16	200 - 400	RTRP 11FW	RTRP 11FW1-3210

Fittings

8 to 16 inch:

Filament-wound fiberglass reinforced epoxy elbows

Mitered tees, crosses, wyes, and laterals

Flanges

Molded or filament-wound fiberglass flange rings

Molded or centrifugally cast fiberglass stub ends

Blind flanges

Compression-molded fiberglass or epoxy-coated cast iron or steel.

Adhesive

Two-part epoxy adhesive.

Joining Systems

8 through 16 inch:
Bell and spigot taper/taper adhesive-bonded joint.

Pipe Lengths

Standard 20 and 39 ft. random lengths.

Other lengths available on request.

Fittings

Elbows:
8-16 inch: 90°, 60°, 45°, 30°, 22½°, 11¼°
Tees, Flanges, Blind Flanges
Concentric Reducers, Reducer Bushings, Sleeve Couplings
For fittings dimensions, refer to the most recent release of product data sheets.

Typical Pipe Dimensions and Weights

Nominal Pipe Size		Outside Diameter[1]		Inside Diameter		Wall Thickness			
						Total		Structural	
in	mm	in	mm	in	mm	in	mm	in	mm
8	200	8.60	219	8.30	211	0.150	3.8	0.125	3.2
10	250	10.77	273	10.42	264	0.175	4.4	0.145	3.7
12	300	12.70	324	12.30	312	0.200	5.1	0.175	4.4
14	350	14.44	367	14.01	356	0.215	5.5	0.185	4.7
16	400	16.50	419	16.03	407	0.235	6.0	0.205	5.2

(1) Typical outside diameters of 8 through 12 inch pipe are within API, ASTM and ANSI fiberglass and steel pipe dimensions.

Nominal Pipe Size		Taper Angle	Taper Length		Pipe Weight	
in	mm	deg	in	mm	lb/ft	kg/m
8	200	2.00	2.6	66	3.1	4.60
10	250	2.00	3.1	79	4.5	6.70
12	300	2.00	3.6	91	6.1	9.10
14	350	2.00	4.2	107	7.5	11.15
16	400	2.00	4.7	119	9.4	14.00

Typical Pipe Performance

Nominal Pipe Size		Static Pressure Rating at 150°F		Ultimate Internal Pressure[1]		Ultimate Collapse Pressure[2]			
						80°F	27°C	150°F	65.6°C
in	mm	psig	bar	psig	bar	psig	bar	psig	bar
8	200	200	14	1200	83	25	1.7	21	1.4
10	250	200	14	1200	83	18	1.2	12	0.8
12	300	200	14	1200	83	12	0.8	9	0.6
14	350	200	14	1200	83	10	0.7	7.5	0.5
16	400	200	14	1200	83	10	0.7	7.5	0.5

(1) Quality control minimum, biaxially loading.

(2) For vacuum service above ground in sizes 10 inches and above consult NOV Fiber Glass Systems.

Fittings Pressure Ratings

Nominal Pipe Size		Elbows and Tees[1]		Flanges[2]		Blind Flanges	
in	mm	psig	bar	psig	bar	psig	bar
8	200	200	14	200	14	200	14
10	250	200	14	200	14	200	14
12	300	200	14	200	14	200	14
14	350	200	14	200	14	200	14
16	400	200	14	200	14	200	14

(1) Ratings shown are for 90° and 45° elbows. Ratings in 8 to 16 inch sizes are also applicable to elbows of other angles.

(2) ANSI B16.5 150psig bolt pattern

(3) At 210°F derate the pipe by a factor of 0.63, linearly interpolate derating factors for temperatures between 150°F and 210°F.

Typical Physical Properties

Pipe Property	Units	Value	ASTM
Thermal conductivity	Btu-in/(h•ft²•°F) W/m•°C	1.7 0.25	C177
Coefficient of thermal expansion (linear) (8 - 16 inch)	10^{-6} in/in/°F 10^{-6} cm/cm/°C	12.0 21.6	D696 D228
Flow coefficient	Hazen-Williams	150.0	—
Absolute roughness	10^{-6} ft 10^{-6}m	50.0 15.0	—
Specific gravity	—	1.81	D792

Typical Mechanical Properties

Pipe Property(1)	Units	Value(1)	ASTM
Tensile strength Longitudinal Circumferential	 10^3 psi MPa 10^3 psi MPa	 35.0 240.0 70.0 480.0	 D2105 D1599(4)
Tensile modulus Longitudinal Circumferential	 10^6 psi GPa 10^6 psi GPa	 2.7 18.6 4.2 29.0	 D2105 —
Compressive strength Longitudinal	 10^3 psi MPa	 35.0 240.0	 —
Compressive modulus Longitudinal	 10^6 psi GPa	 2.7 18.6	 —
Long-Term Hydrostatic Design Basis(3) Static, Hoop Stress 95% LCL 20-year Life @150°F/65°C Cyclic, Hoop Stress 95% LCL 20-year Life @75°F/24°C	 10^3 psi MPa 10^3 psi MPa	 18.9 130.3 6.4 44.1	 D2992 Procedure B D2992 Procedure A
Poisson's Ratio(2) ν_{yx} ν_{xy}	 — —	 0.17 0.15	 — —

(1) Based on structural wall thickness, at room temperature unless noted.
(2) The first subscript denotes the direction of applied stress and the second subscript the measured strain contraction.
x denotes longitudinal direction
y denotes circumferential direction
(3) Test fixtures were free-end type (full end thrust on samples).

Nominal Pipe Size		Change in Length Due to Pressure(1)		Stiffness Factor(2)	
in	mm	in/100 ft/100 psi	mm/30.5m/6.9bar	lb•in³/in²	N•m
8	200	0.565	6.82	500	56.5
10	250	0.612	7.39	750	84.7
12	300	0.599	7.24	1,250	141.2
14	350	0.646	7.81	1,600	180.8
16	400	0.668	8.07	2,000	226.0

(1) In an unrestrained system due to pressure effects alone.
(2) At 5% deflection.

Support Spacing

(Values are based on a ½ inch (12 mm) deflection at mid span.)

Nominal Pipe Size		Single Span[1]						Continuous Span[2]					
		Gases		1.00[3]		1.25		Gases		1.00		1.25	
in	mm	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m
8	200	26.8	8.2	15.7	4.8	14.8	4.5	40.0	12.2	23.5	7.2	22.0	6.7
10	250	30.2	9.2	17.4	5.3	16.4	5.0	45.2	13.8	26.1	8.0	24.6	7.5
12	300	32.9	10.0	18.8	5.7	17.7	5.4	49.3	15.0	28.1	8.6	26.5	8.1
14	350	35.2	10.7	20.1	6.1	18.9	5.8	52.6	16.0	30.1	9.2	28.3	8.6
16	400	37.7	11.5	21.4	6.5	20.1	6.1	56.4	17.2	31.9	9.7	30.1	9.2

(1) For fluid temperatures above 77°F (25°C) reduce span lengths 0.1-inch/°F (5 mm/°C)

(2) Beam fixed at both ends and uniformly distributed loads. Intermediate spans may be calculate by multiplying the single span length by 1.2.

(3) Fluid specific gravity.

Bending Radius

Nominal Pipe Size		Minimum Bending Radius		Maximum Deflection per 39-ft Joint	Minimum Length Required for 10° Change	
in	mm	ft	m	deg	ft	m
8	200	209	64	11	37	11
10	250	281	86	8	49	15
12	300	343	105	7	60	18
14	350	418	127	5	73	22
16	400	507	155	4	89	27

(1) At rated pressure. Sharper bends may create excessive stress concentrations. **Do not** bend pipe until adhesive has cured.

Guide Specification

This specification covers approval, performance, materials and physical properties requirements for general industrial service piping in 8 through 16 inch nominal pipe sizes at operating temperatures to 150°F.

Performance Requirements

Pipe, fittings and other components furnished under this specification shall be rated for service to 200 psig at 150°F. All components shall be rated at or above the design pressure of the system.

When classified in accordance with ASTM standards, the pipe shall meet the following cell limits:

Nominal Pipe Size		ASTM Designation	
in	mm	D2310	D2996
8 - 16	200 - 400	RTRP 11FW	RTRP 11FW1-3210

Materials

Liner—All filament-wound pipe shall incorporate an integral liner with a nominal thickness of 0.025 ±0.005 inches for 8 through 16 inch nominal sizes. The resin system used in the liner shall be a chemically resistant thermosetting epoxy resin suitable for the intended service.

Structural wall—Pipe shall be filament wound using continuous glass fiber reinforcements with a resin-compatible finish and a chemically resistant thermosetting epoxy resin. The glass filaments shall be wound in a dual-angle pattern that takes optimum advantage of the tensile strength of the filaments. The glass fiber content of the reinforced wall shall not be less than 60% by weight. Pigments or dies may be used in the resin as long as the product remains translucent.

External surface—The pipe shall have a typical 0.005-inch thick resin-rich coating with organic fibrous reinforcement. This protection must be provided for both above and below-ground pipe installations. All external surfaces must be resistant to anticipated corrosion imposed by the service and the environment.

Fittings—Fittings supplied under this specification shall be filament-wound, compression molded, centrifugally cast, or manufactured from mitered pipe sections. The glass fiber content of the structural portion of compression-molded and filament-wound fittings shall not be less than 55% by weight.

Joining Methods

Adhesive-Bonded Bell and Spigot—Both tapered bell and tapered spigot shall have matching taper angles and shall be joined by bonding with an epoxy adhesive. The nominal taper angle shall be 2° on 8 through 16 inch nominal pipe sizes. The adhesive shall be a two part epoxy supplied as a kit with all necessary application materials.

Flanges—Flanges shall be two-piece van Stone type provided with raised grooves on the sealing surface. Fiberglass-reinforced compression-molded or centrifugally cast stub ends are to be adhesive bonded to the pipe or fitting.

Pipe Construction

Pipe—Pipe shall be manufactured to steel pipe outside diameters in 8 through 12 inch nominal pipe sizes and should be based on nominal inside diameters in 14 inch sizes and above. Outside diameter tolerances shall not exceed ±1.0%. Pipe shall be provided in 40 feet random lengths (34 through 42 ft. unless otherwise specified. Up to 10% shorts may be included in any shipment unless otherwise agreed upon in writing between purchaser and manufacturer.

Wall thickness—The total wall thickness of pipe furnished to this specification shall not at any point less than 87.5 percent of the nominal thickness. Nominal wall thickness shall have dimensions as given in the manufacturer's published literature.

Fittings and flanges—Fittings and flanges shall have dimensions as given in the manufacturer's published literature. Flanges shall be drilled to match ANSI B16.5, Class 150 unless specified otherwise in the purchase order.

Physical and Mechanical Requirements

Values for physical and mechanical properties shall be no less than 95% of those shown tabulated above under Typical Physical Properties and Typical Mechanical Properties.

Workmanship

The pipe and fittings shall be free from all defects, including delamination, indentations, pinholes, foreign inclusions, bubbles and resin-starved areas which, due to their nature, degree or extent, detrimentally affect the strength and serviceability of the pipe or fittings. Pigments or dyes may be used in the resin as long as the product is sufficiently translucent to verify the structural integrity of the structural wall. The pipe and fittings shall be as uniform as commercially practicable in color, density and other physical properties.

Testing

Quality control testing—Samples of pipe and fittings shall be tested at random based on standard quality control practices to determine conformance of the materials to the following tests: weight, taper angle, short-term rupture strength, cyclic pressure performance, ring crush strength and degree of cure. Each item shall be visually inspected for workmanship.

Proof testing—All components shall be hydrostatically tested by the manufacturer to 1.5 times the pressure rating for signs of leakage or porosity.

Marking

Each component shall be marked to show the following:

- Manufacturer's name and address
- Nominal pipe size
- Pressure class
- Hydrostatic test pressure (if so ordered)
- Date and shift of manufacture (pipe only)

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NOV Fiber Glass Systems

CI3200 - July 2013

Bondstrand™ Series 3200A Fiberglass Pipe
(General Industrial Service)
(For sizes 2 through 6 inch, use Series 3000A pipe and fittings products)

Uses and Applications

- Boiler feed water
- Brine and brackish water
- Chemical process piping
- Cooling water
- Demineralized water
- Electroplating
- Industrial plant piping
- Municipal waste
- Oilfield piping
- Potable Water - NSF 61 Listed
- Power plant and steel mill piping
- Sewer lines and sewer force mains
- Source and recycle water
- Sump discharge
- Vent lines
- Water mains
- Water treatment

Performance

Pipe and fittings are rated at 200 psig.

Operating plus surge pressures to 1.25 times rated operating pressure occurring three times or less per 24-hour period.

No thrust blocks are required at rated system pressure for most buried piping configurations and most soil conditions. For above ground use, consult NOV Fiber Glass Systems.

Temperatures to 210°F (99°C) maximum. Sub-zero temperatures will not affect the physical properties. Water in pipe must not be allowed to freeze.

Vacuum to -14.7 psig when buried and properly backfilled. For above ground use, refer to collapse pressures listed below under pipe pressure Typical Pipe Performance.

Recommended burial depth: 3 to 25 feet.

Recommended for water, waste water (pH 1 to 12), and mild chemicals. Consult Bondstrand Corrosion Guide or contact NOV Fiber Glass Systems for recommendations for your particular application.

Individual system components may not have the same ratings as the pipe. Refer to the detailed product information for the specific components to determine the pressure rating for the system as a whole.

Composition

Pipe

Filament-wound fiberglass reinforced epoxy pipe with integral epoxy liner and exterior coating.

Pipe Size		ASTM Designation	
in	mm	D2310	D2996
8 - 16	200 - 400	RTRP 11FU	RTRP 11FU1-6430

Fittings

8 to 16 inch:

Filament-wound fiberglass reinforced epoxy elbows

Mitered tees, crosses, wyes, and laterals

Flanges

Flange rings - Filament-wound fiberglass

Stub ends - Centrifugally cast fiberglass

Blind flanges

Reference CI3050 for fittings dimensions

Adhesive

NOV Fiber Glass Systems two-part epoxy adhesive for field fabrication.

Joining Systems

8 to 16-inch:
Bell and spigot taper/taper adhesive-bonded joint.

Pipe Lengths

Standard 20 and 39 foot random lengths.

Other lengths available on request.

Typical Pipe Dimensions and Weights

Nominal Pipe Size		Outside Diameter[1]		Inside Diameter		Wall Thickness			
						Total		Structural	
in	mm	in	mm	in	mm	in	mm	in	mm
8	200	8.60	219	8.30	211	0.150	3.8	0.125	3.2
10	250	10.77	273	10.42	264	0.175	4.4	0.145	3.7
12	300	12.70	324	12.30	312	0.200	5.1	0.175	4.4
14	350	14.44	367	14.01	356	0.215	5.5	0.185	4.7
16	400	16.50	419	16.03	407	0.235	6.0	0.205	5.2

(1) Typical outside diameters of 8 through 12 inch pipe are within API, ASTM and ANSI fiberglass and steel pipe dimensions.

Nominal Pipe Size		Taper Angle	Taper Length		Pipe Weight	
in	mm	deg	in	mm	lb/ft	kg/m
8	200	2.00	2.6	66	3.10	4.60
10	250	2.00	3.1	79	4.50	6.70
12	300	2.00	3.6	91	6.10	9.10
14	350	2.00	4.2	107	7.50	11.15
16	400	2.00	4.7	119	9.40	14.00

Typical Pipe Performance

Nominal Pipe Size		Static Pressure Rating at 150°F[3]		Ultimate Internal Pressure[1]		Ultimate Collapse Pressure[2]			
						80°F	27°C	210°F	99°C
in	mm	psig	bar	psig	bar	psig	bar	psig	bar
8	200	200	14	1074	74	21	1.5	18	1.2
10	250	200	14	994	69	17	1.2	14	1.0
12	300	200	14	1017	70	18	1.2	15	1.1
14	350	200	14	945	65	15	1.0	12	0.8
16	400	200	14	916	63	13	0.9	11	0.8

(1) Quality control minimum, biaxial loading
(2) For vacuum service above ground consult NOV Fiber Glass Systems.
(3) At 210°F derate the pipe by a factor of 0.73, linearly interpolate derating factors for temperatures between 150°F and 210°F.

Fittings Pressure Ratings[3]

Nominal Pipe Size		Elbows and Tees[1]		Flanges[2]		Blind Flanges	
in	mm	psig	bar	psig	bar	psig	bar
8	200	200	14	200	14	200	14
10	250	200	14	200	14	200	14
12	300	200	14	200	14	200	14
14	350	200	14	200	14	200	14
16	400	200	14	200	14	200	14

(1) Ratings shown are for 90° and 45° elbows. Ratings in 8 to 16 inch sizes are also applicable to elbows of other angles.
(2) ANSI B16.5 150 psig bolt pattern
(3) At 210°F derate the pipe by a factor of 0.73, linearly interpolate derating factors for temperatures between 150°F and 210°F.

Typical Physical Properties

Pipe Property	Units	Value	ASTM
Thermal conductivity	Btu-in/(h•ft^2•°F) W/m•°C	1.7 0.25	C177
Coefficient of thermal expansion (linear) (8 - 16 inch)	10^{-6} in/in/°F 10^{-6} cm/cm/°C	10 to 13 18 to 24	D696 E228
Flow coefficient	Hazen-Williams	150.0	—
Absolute roughness	10^{-6} ft 10^{-6}m	50.0 15.0	—
Specific gravity	—	1.81	D792

Typical Mechanical Properties

Pipe Property(1)	Units	Value	ASTM
Tensile strength			
Longitudinal	10^3 psi MPa	35 240	D2105
Circumferential	10^3 psi MPa	70 483	D1599(4)
Tensile modulus			
Longitudinal	10^6 psi GPa	2.7 21	D2105
Circumferential	10^6 psi GPa	4.2 29	—
Compressive strength			
Longitudinal	10^3 psi MPa	25 169	—
Compressive modulus			
Longitudinal	10^6 psi GPa	2.7 18	—
Long-Term Hydrostatic Design Basis(3)			
Static, Hoop Stress 95% LCL 20-year Life @150°F/65°C	10^3 psi MPa	14.2 98.1	D2992 Procedure B
Cyclic, Hoop Stress 95% LCL 20-year Life @75°F/24°C	10^3 psi MPa	6.9 47.4	D2992 Procedure A
Poisson's Ratio(2)			
ν_{yx}	—	0.17	—
ν_{xy}	—	0.15	—

(1) Based on structural wall thickness.
(2) The first subscript denotes the direction of applied stress and the second subscript the measured strain contraction.
x denotes longitudinal direction.
y denotes circumferential direction.
(3) Test fixtures were free end type (full end thrust on samples)

Nominal Pipe Size		Change in Length Due to Pressure[1]		Stiffness Factor[2]	
in	mm	in/100 ft/100 psi	mm/10m/10 bar	lb•in³/in²	N•m
8	200	0.565	6.8	582	65.7
10	250	0.612	7.4	908	102.6
12	300	0.599	7.2	1,596	180.3
14	350	0.646	7.8	1,886	213.0
16	400	0.668	8.1	2,566	289.9

(1) In an unrestrained system due to pressure effects alone.

(2) At 5% deflection.

Support Spacing

(Values are based on a ½-inch (12 mm) deflection at mid span.)

Nominal Pipe Size		Single Span[1]						Continuous Span[2]					
		Gases		1.00[3]		1.3		Gases		1.00		1.3	
in	mm	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m
8	200	27.9	8.5	16.4	5.0	15.5	4.7	41.8	12.7	24.6	7.5	23.1	7.0
10	250	31.4	9.8	18.1	5.5	17.1	5.2	46.9	14.3	27.1	8.2	25.5	7.8
12	300	34.0	10.4	19.4	5.9	18.3	5.6	50.9	15.5	29.0	8.8	27.3	8.3
14	350	36.2	11.0	20.7	6.3	19.5	5.9	54.2	16.5	31.0	9.5	29.2	8.9
16	400	38.7	11.8	21.9	6.7	20.6	6.3	57.9	17.6	32.8	10.0	30.9	9.4

(1) For fluid temperatures above 77°F (25°C) reduce span lengths 0.1-inch/°F (5 mm/°C)

(2) Beam fixed at both ends and uniformly distributed loads. Intermediate spans may be calculate by multiplying the single span length by 1.2.

(3) Fluid specific gravity.

Bending Radius

Nominal Pipe Size		Minimum Bending Radius		Maximum Deflection per 39-ft Joint	Minimum Length Required for 10° Change	
in	mm	ft	m	deg	ft	m
8	200	209	64	11	37	11
10	250	281	86	8	49	15
12	300	343	105	7	60	18
14	350	418	127	5	73	22
16	400	507	155	4	89	27

(1) At rated pressure. Sharper bends may create excessive stress concentrations. **Do not** bend pipe until adhesive has cured.

Guide Specification

This specification covers approval, performance, materials and physical properties requirements for general industrial service piping in 8 through 16 inch nominal pipe sizes at operating temperatures to 210°F.

Performance Requirements

Pipe, fittings and other components furnished under this specification shall be rated for service to 200 psig at 150°F and capable of 210°F service conditions in accordance with the derating factor. All components shall be rated at or above the design pressure of the system.

Nominal Pipe Size		ASTM Designation	
in	mm	D2310	D2996
8 - 16	200 - 400	RTRP 11FU	RTRP 11FU-6430

Materials

Liner—All filament-wound pipe shall incorporate an integral liner with a nominal thickness of 0.025 ±0.005 inches for 8 through 16 inch nominal sizes. The resin system used in the liner shall be a chemically resistant thermosetting epoxy resin suitable for the intended service.

Structural Wall—Pipe shall be filament wound using continuous glass fiber reinforcements with a resin-compatible finish and a chemically resistant thermosetting epoxy resin. The glass filaments shall be wound in a dual-angle pattern that takes optimum advantage of the tensile strength of the filaments. The glass fiber content of the reinforced wall shall not be less than 60% by weight. Pigments or dies may be used in the resin as long as the product remains translucent.

External Surface—The pipe shall have a typical 0.005 inch thick resin-rich coating with organic fibrous reinforcement. This protection must be provided for both above and below-ground pipe installations. All external surfaces must be resistant to anticipated corrosion imposed by the service and the environment.

Fittings—Fittings supplied under this specification shall be filament-wound, compression molded, centrifugally cast, or manufactured from mitered pipe sections. The glass fiber content of the structural portion of compression-molded and filament-wound fittings shall not be less than 55% by weight.

Joining Methods

Adhesive-Bonded Bell and Spigot—Both tapered bell and tapered spigot shall have matching taper angles and shall be joined by bonding with an epoxy adhesive. The nominal taper angle shall be 2° on 8 through 16 inch nominal pipe sizes. The adhesive shall be a two-part epoxy supplied as a kit with all necessary application materials.

Flanges—Flanges shall be two-piece Van Stone type provided with raised grooves on the sealing surface. Fiberglass-reinforced, compression-molded or centrifugally cast stub ends are to be adhesive bonded to the pipe or fitting.

Adapters or Crossovers—The following adapters or crossovers shall be available on request:

Grooved end (8 inch nominal pipe sizes)

Cast iron pipe end (8 through 16 inch nominal pipe sizes)

Pipe Construction

Pipe—Pipe shall be manufactured to steel pipe outside diameters in 8 through 12 inch nominal pipe sizes and should be based on nominal inside diameters in 14 inch sizes and above. Outside diameter tolerances shall not exceed ±1.0%. Pipe shall be provided in 40 feet random lengths (34 through 42 ft) unless otherwise specified. Up to 10 percent shorts may be included in any shipment unless otherwise agreed upon in writing between purchaser and manufacturer.

Wall Thickness—The total wall thickness of pipe furnished to this specification shall not at any point be greater than 120 percent nor less than 87.5 percent of the nominal thickness. Nominal wall thickness shall have dimensions as given in the manufacturer's published literature.

Fittings and Flanges—Fittings and flanges shall have dimensions as given in the manufacturer's published literature. Flanges shall be drilled to match ANSI 816.5, Class 150 unless specified otherwise in the purchase order.

Physical and Mechanical Requirements

Values for physical and mechanical properties shall be within 15% of those shown tabulated above under Typical Physical Properties and Typical Mechanical Properties.

Workmanship

The pipe and fittings shall be free from all defects, including delamination, indentations, pinholes, foreign inclusions, bubbles and resin-starved areas which, due to their nature, degree or extent, detrimentally affect the strength and serviceability of the pipe or fittings. Pigments or dyes may be used in the resin as long as the product is sufficiently translucent to verify the structural integrity of the structural wall. The pipe and fittings shall be as uniform as commercially practicable in color, density and other physical properties.

Testing

Quality Control Testing—Samples of pipe and fittings shall be tested at random based on standard quality control practices to determine conformance of the materials to the following tests: weight, taper angle, short-term rupture strength, cyclic pressure performance, ring crush strength, Barcol hardness and degree of cure. Each item shall be visually inspected for workmanship.

Proof Testing—All components may be required to be hydrostatically tested by the manufacturer to 1.5 times the pressure rating for signs of leakage or porosity.

Marking

Each component shall be marked to show the following:

- Manufacturer's name and address
- Nominal pipe size
- Pressure class
- Hydrostatic test pressure (if so ordered)
- UL Listing Mark (if so ordered)
- ULC Listing Mark (if so ordered)
- Date and shift of manufacture (pipe only)

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NOV Fiber Glass Systems

CI3210 - July 2013

Bondstrand Series 3300 Fiberglass Pipe
(General Industrial Service)
(For sizes 2 through 6 inch, use Series 3000 pipe and fittings products)

Uses and Applications

- Boiler feed water
- Brine and brackish water
- Chemical process piping
- Cooling water
- Demineralized water
- Electroplating
- General service Class 300 piping
- Industrial plant piping
- Municipal waste
- Power plant and steel mill piping
- Sewer lines and sewer force mains
- Source and recycle water
- Sump discharge
- Vent lines
- Water mains
- Water treatment

Performance

Pipe and fittings are rated at 300 psig.

Operating plus surge pressures to 1.25 times rated operating pressure occurring three times or less per 24-hour period.

No thrust blocks are required at rated system pressure for most buried piping configurations and most soil conditions. For above ground use, consult NOV Fiber Glass Systems.

Temperatures to 150°F (66°C) maximum. Sub-zero temperatures will not affect the physical properties.

Full vacuum capability when buried and properly backfilled. For above ground use, refer to collapse pressures listed below under Typical Pipe Performance.

Recommended burial depth: 3 to 25 feet.

Recommended for water, waste water (pH 1 to 8.5), and mild chemicals. Consult Corrosion Guide or Applications Engineering for recommendations for your particular application.

Individual system components may not have the same ratings as the pipe. Refer to the detailed product information for the specific components to determine the pressure rating for the system as a whole.

Composition

Pipe

Filament-wound fiberglass reinforced epoxy pipe with integral epoxy liner and exterior coating.

Nominal Pipe Size		ASTM Designation	
in	mm	D2310	D2996
8 - 16	200 - 400	RTRP 11FW	RTRP 11FW1-3210

Fittings

8 to 16 inch: Filament-wound fiberglass reinforced epoxy elbows

Mitered tees, crosses, wyes, and laterals

Flanges

Filament-wound fiberglass flange rings

Filament wound fiberglass stub ends

Blind flanges

Compression-molded fiberglass or epoxy-coated cast iron or steel.

Adhesive

Two-part epoxy adhesive

Joining Systems

8 to 16 inch
Bell and spigot taper/taper adhesive-bonded joint.

Pipe Lengths

Standard 20 and 39 ft. random lengths.

Other lengths available on request.

Fittings

Elbows:

8 - 16 inch	90°	60°	45°	30°	22½°	11¼°

Tees Flanges Blind flanges

Concentric reducers Reducer bushings Sleeve couplings

For fittings dimensions, refer to the most recent release of product data sheets.

Typical Pipe Dimensions and Weights

Nominal Pipe Size		Outside Diameter		Inside Diameter		Wall Thickness			
						Total		Structural	
in	mm	in	mm	in	mm	in	mm	in	mm
8	200	8.64	219	8.30	211	0.170	4.3	0.140	3.6
10	250	10.85	273	10.42	264	0.215	5.5	0.185	4.7
12	300	12.78	324	12.30	312	0.240	6.1	0.210	5.3
14	350	14.53	367	14.00	356	0.265	6.7	0.235	6.0
16	400	16.65	419	16.03	407	0.310	7.9	0.282	7.2

Nominal Pipe Size		Taper Angle	Taper Length		Pipe Weight	
in	mm	deg	in	mm	lb/ft	kg/m
8	200	2.00	2.6	66	3.1	4.60
10	250	2.00	3.1	79	4.5	6.70
12	300	2.00	3.6	91	6.1	9.10
14	350	2.00	5.4	137	8.8	13.00
16	400	2.00	6.1	155	11.4	16.90

Typical Pipe Performance

Nominal Pipe Size		Static Pressure Rating at 150°F		Ultimate Internal Pressure[1]		Ultimate Collapse Pressure			
						80°F	27°C	150°F	65.6°C
in	mm	psig	bar	psig	bar	psig	bar	psig	bar
8	200	300	20.7	1,800	124	29	2.0	19	1.3
10	250	300	20.7	1,800	124	33	2.3	22	1.5
12	300	300	20.7	1,800	124	30	2.1	20	1.4
14	350	300	20.7	1,800	124	28	2.0	19	1.3
16	400	300	20.7	1,800	124	33	2.3	21	1.5

[1] Quality control minimum, biaxially loaded.

Typical Physical Properties

Pipe Property	Units	Value	ASTM
Thermal conductivity	Btu-in/(h•ft²•°F) W/m•°C	1.7 0.25	C177
Coefficient of thermal expansion (linear) 8 - 16 inch	10^{-6} in/in/°F 10^{-6} cm/cm/°C	12.0 21.6	D696 E228
Flow coefficient	Hazen-Williams	150.0	—
Absolute roughness	10^{-6} ft 10^{-6}m	50.0 15.0	—
Specific gravity	—	1.81	D792

Typical Mechanical Properties

Pipe Property(1)	Units	Value	ASTM
Tensile strength Longitudinal Circumferential	 10^3 psi MPa 10^3 psi MPa	 35 240 70 483	 D2105 D1599(4)
Tensile modulus Longitudinal Circumferential	 10^6 psi GPa 10^6 psi GPa	 2.7 18.5 4.2 29.0	 D2105 —
Compressive strength Longitudinal	 10^3 psi MPa	 35 240	 —
Compressive modulus Longitudinal	 10^6 psi GPa	 2.7 18.5	 —
Long-Term Hydrostatic Design Basis(3) Static, Hoop Stress 95% LCL 20-year Life @150°F/65°C Cyclic, Hoop Stress 95% LCL 20-year Life @75°F/24°C	 10^3 psi MPa 10^3 psi MPa	 18.9 130.3 6.4 44.1	 D2992 Procedure B D2992 Procedure A
Poisson's Ratio(2) ν_{yx} ν_{xy}	 — —	 0.17 0.15	 — —

(1) Based on structural wall thickness.

(2) The first subscript denotes the direction of applied stress and the second subscript the measured strain contraction.
x denotes longitudinal direction.
y denotes circumferential direction.

(3) Test fixtures were free-end type (full end thrust).

Nominal Pipe Size		Change in Length Due to Pressure(1)		Stiffness Factor(2)	
in	mm	in/100 ft/100 psi	mm/30.5 m/6.9 bar	lb•in³/in²	N•m
8	200	0.503	6.07	500	56.5
10	250	0.478	6.77	750	84.7
12	300	0.498	6.01	1,250	141.2
14	350	0.507	6.12	1,600	180.8
16	400	0.483	5.84	2,000	226.0

(1) In an unrestrained system due to pressure effects alone.

(2) At 5% deflection.

Support Spacing

(Values are based on a ½ inch (12 mm) deflection at mid span.)

Nominal Pipe Size		Single Span[1]						Continuous Span[2]					
		Gases		1.00[3]		1.25		Gases		1.00		1.25	
in	mm	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m
8	200	27.8	8.5	16.4	5.0	15.4	4.7	41.6	12.7	24.5	7.5	23.0	7.0
10	250	32.1	9.8	18.6	5.7	17.5	5.3	48.1	14.7	27.8	8.5	26.2	8.0
12	300	34.8	10.6	19.8	6.0	18.7	5.7	52.0	15.8	29.6	9.0	27.9	8.5
14	350	35.9	10.9	21.3	6.5	20.1	6.1	53.7	16.4	31.8	9.7	30.0	9.1
16	400	38.9	11.9	23.0	7.0	21.7	6.6	58.2	17.7	34.4	10.5	32.4	9.9

(1) For fluid temperatures above 77°F (25°C) reduce span lengths 0.1-inch/°F (5 mm/°C)

(2) Beam fixed at both ends and uniformly distributed loads. Intermediate spans may be calculate by multiplying the single span length by 1.2.

(3) Fluid specific gravity.

Bending Radius

Nominal Pipe Size		Minimum Bending Radius		Maximum Deflection per 39-ft Joint	Minimum Length Required for 10° Change	
in	mm	ft	m	deg	ft	m
8	200	293	89	8	51	16
10	250	364	111	6	63	19
12	300	472	144	5	82	25
14	350	570	174	4	100	30
16	400	626	191	4	109	33

(1) At rated pressure. Sharper bends may create excessive stress concentrations. **Do not** bend pipe until adhesive has cured.

Guide Specification

This specification covers performance, materials and physical properties requirements for general industrial service piping in 8 through 16 inch nominal pipe sizes at operating temperatures to 150°F.

Performance Requirements

Pipe, fittings and other components furnished under this specification shall be rated for service to 300 psig at 150°F. All components shall be rated at or above the design pressure of the system.

When classified in accordance with ASTM standards, the pipe shall meet the following cell limits:

Nominal Pipe Size		ASTM Designation	
in	mm	D2310	D2996
8 - 16	200 - 400	RTRP 11FW	RTRP 11FW1-3210

Materials

Liner—All filament-wound pipe shall incorporate an integral liner with a nominal thickness of 0.025 ± 0.005. The resin system used in the liner shall be a chemically resistant thermosetting epoxy resin suitable for the intended service.

Structural wall—Pipe shall be filament wound using continuous glass fiber reinforcements with a resin-compatible finish and a chemically resistant thermosetting epoxy resin. The glass filaments shall be wound in a dual-angle pattern that takes optimum advantage of the tensile strength of the filaments. The glass fiber content of the reinforced wall shall not be less than 60% by weight. Pigments or dies may be used in the resin as long as the product remains translucent.

External surface—The pipe shall have a typical 0.005-inch thick resin-rich coating with organic fibrous reinforcement. This protection must be provided for both above and below-ground pipe installations. All external surfaces must be resistant to anticipated corrosion imposed by the service and the environment.

Fittings—Fittings supplied under this specification shall be filament-wound, compression molded, centrifugally cast, or manufactured from mitered pipe sections. The glass fiber content of the structural portion of compression-molded and filament-wound fittings shall not be less than 55% by weight.

Joining Methods

Adhesive-bonded bell and spigot—Both tapered bell and tapered spigot shall have matching taper angles and shall be joined by bonding with an epoxy adhesive. The nominal taper angle shall be 2° on 8 through 16 inch nominal pipe sizes. The adhesive shall be a two part epoxy supplied as a kit with all necessary application materials.

Flanges—Flanges shall be two-piece van Stone type provided with raised grooves on the sealing surface. Fiberglass-reinforced compression-molded or centrifugally cast stub ends are to be adhesive bonded to the pipe or fitting.

Pipe Construction

Pipe—Outside diameter tolerances shall not exceed ±1.0%. Pipe shall be provided in 40-ft random lengths (34 through 42 ft) unless otherwise specified. Up to 10 percent shorts may be included in any shipment unless otherwise agreed upon in writing between purchaser and manufacturer.

Wall thickness—The total wall thickness of pipe furnished to this specification shall not at any point be greater than 120 percent nor less than 87.5 percent of the nominal thickness. Nominal wall thickness shall have dimensions as given in the manufacturer's published literature.

Fittings and flanges—Fittings and flanges shall have dimensions as given in the manufacturer's published literature. Flanges shall be drilled to match ANSI B16.5, Class 150 unless specified otherwise in the purchase order.

Physical and Mechanical Requirements

Values for physical and mechanical properties shall be no less than 95% of those shown tabulated above under Typical Physical Properties and Typical Mechanical Properties.

Workmanship

The pipe and fittings shall be free from all defects, including delamination, indentations, pinholes, foreign inclusions, bubbles and resin-starved areas which, due to their nature, degree or extent, detrimentally affect the strength and serviceability of the pipe or fittings. Pigments or dyes may be used in the resin as long as the product is sufficiently translucent to verify the structural integrity of the structural wall. The pipe and fittings shall be as uniform as commercially practicable in color, density and other physical properties.

Testing

Quality control testing—Samples of pipe and fittings shall be tested at random based on standard quality control practices to determine conformance of the materials to the following ASTM guidelines for testing fiberglass pipe products: ASTM D1599, D2105, D2925, D2992A or D2992B. Test samples may be hydrostatically tested by the manufacturer to 1.5 times the pressure rating for signs of leakage.

Marking

Each component shall be marked to show the following:

- Manufacturer's name and address
- Nominal pipe size
- Hydrostatic test pressure (if so ordered)
- Date and shift of manufacture (pipe only)

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NOV Fiber Glass Systems

CI3300 - July 2013

Bondstrand™ Series 3300A Fiberglass Pipe (General Industrial Service)

(For sizes 2 through 6 inch, use Series 3000A pipe and fittings products.)

Uses and Applications

- Boiler feed water
- Brine and brackish water
- Chemical process piping
- Cooling water
- Demineralized water
- Electroplating
- Industrial plant piping
- Municipal waste
- Oilfield piping
- Power plant and steel mill piping
- Sewer lines and sewer force mains
- Source and recycle water
- Sump discharge
- Vent lines
- Water mains
- Water treatment

Performance

Pipe and fittings are rated at 300 psig.

Operating plus surge pressures to 1.25 times rated operating pressure occurring three times or less per 24-hour period.

No thrust blocks are required at rated system pressure for most buried piping configurations and most soil conditions. For above ground use, consult NOV Fiber Glass Systems.

Temperatures to 210°F (99°C) maximum. Sub-zero temperatures will not affect the physical properties.

Full vacuum capabilities when buried and properly backfilled. For above ground use, refer to collapse pressures listed below under Typical Pipe Performance.

Recommended burial depth: 3 to 25 feet.

Recommended for water, waste water (pH 1 to 12), moderately corrosive liquids and mild chemicals. Consult Corrosion Guide or Applications Engineering for recommendations for your particular application.

Individual system components may not have the same ratings as the pipe. Refer to the detailed product information for the specific components to determine the pressure rating for the system as a whole.

Composition

Pipe

Filament-wound fiberglass reinforced epoxy pipe with integral epoxy liner and exterior coating.

Nominal Pipe Size		ASTM Designation	
in	mm	D2310	D2996
8 - 16	200 - 400	RTRP 11FU	RTRP 11FU1-6430

Fittings

8 to 16 inch:

Filament-wound fiberglass reinforced epoxy elbows.

Filament wound and/or mitered tees

Flanges

Filament-wound fiberglass flange rings

Filament wound fiberglass stub ends

Blind flanges

Compression-molded fiberglass or epoxy-coated cast iron or steel.

Adhesive

NOV Fiber Glass Systems' two-part epoxy adhesive for field fabrication.

Joining Systems

8 to 16 inch

Bell and spigot taper/taper adhesive-bonded joint.

Pipe Lengths

Standard 39 foot random lengths.

Other lengths available on request.

Typical Pipe Dimensions and Weights

Nominal Pipe Size		Outside Diameter		Inside Diameter		Wall Thickness			
						Total		Structural	
in	mm	in	mm	in	mm	in	mm	in	mm
8	200	8.65	220	8.30	211	0.170	4.3	0.140	3.6
10	250	10.85	276	10.41	264	0.215	5.5	0.185	4.7
12	300	12.80	323	12.30	312	0.240	6.1	0.210	5.3
14	350	14.55	370	14.01	356	0.270	6.8	0.240	6.1
16	400	16.63	422	16.01	407	0.310	7.9	0.282	7.2

Nominal Pipe Size		Taper Angle	Taper Length		Pipe Weight	
in	mm	deg	in	mm	lb/ft	kg/m
8	200	2.00	2.6	66	3.1	4.60
10	250	2.00	3.1	79	4.5	6.70
12	300	2.00	3.6	91	6.1	9.10
14	350	2.00	4.2	107	8.8	11.15
16	400	2.00	4.7	119	11.4	14.00

Typical Pipe Performance

Nominal Pipe Size		Static Pressure Rating at 150°F(1)		Ultimate Internal Pressure(2)		Ultimate Collapse Pressure			
						80°F	27°C	210°F	99°C
in	mm	psig	bar	psig	bar	psig	bar	psig	bar
8	200	300	20.7	1,200	82.8	29	2.02	25	1.7
10	250	300	20.7	1,264	87.1	34	2.37	29	2.0
12	300	300	20.7	1,215	83.8	31	2.10	26	1.8
14	350	300	20.7	1,221	84.2	31	2.14	26	1.8
16	400	300	20.7	1,256	86.6	34	2.32	28	2.0

(1) At 210°F, derate pipe by a factor of 0.73, linearly interpolate derating factors for temperatures between 150°F and 210°F.
(2) Quality control minimum biaxial loading.

Fittings Pressure Ratings(3)

Nominal Pipe Size		Elbows and Tees(1)		Flanges(2)		Blind Flanges	
in	mm	psig	bar	psig	bar	psig	bar
8	200	300	21	300	21	300	21
10	250	300	21	300	21	300	21
12	300	300	21	300	21	300	21
14	350	300	21	300	21	300	21
16	400	300	21	300	21	300	21

(1) Ratings shown are 90° and 45° elbows. Ratings in 8 through 16 inch sizes are also applicable to elbows of other angles.
(2) ANSI B16.5, 150 psig bolt pattern.
(3) At 210°F, derate by a factor of 0.73, linearly interpolate derating factors for temperatures between 150°F and 210°F.

Typical Physical Properties

Pipe Property	Units	Value	ASTM
Thermal conductivity	Btu-in/(h•ft^2•°F) W/m•°C	1.7 0.25	C177
Coefficient of thermal expansion (linear) 77°F to 210°F 25°C to 98.9°C	 10^{-6} in/in/°F 10^{-6} cm/cm/°C	 10 To 13 18 to 24	D696 E228
Flow coefficient	Hazen-Williams	150	—
Absolute roughness	10^{-6} ft 10^{-6}m	50 15	—
Specific gravity	—	1.81	D792

Typical Mechanical Properties

Pipe Property(1)	Units	Value	ASTM
Tensile strength			
Longitudinal	10^3 psi MPa	35 240	D2105
Circumferential	10^3 psi MPa	70 483	D1599(4)
Tensile modulus			
Longitudinal	10^6 psi GPa	2.7 21	D2105
Circumferential	10^6 psi GPa	4.2 29	—
Compressive strength			
Longitudinal	10^3 psi MPa	25 169	—
Compressive modulus			
Longitudinal	10^6 psi GPa	2.7 18	—
Long-Term Hydrostatic Design Basis(3)			
Static, Hoop Stress 95% LCL 20-year Life @150°F/65°C	10^3 psi MPa	14.2 98.1	D2992 Procedure B
Cyclic, Hoop Stress 95% LCL 20-year Life @75°F/24°C	10^3 psi MPa	6.9 47.4	D2992 Procedure A
Poisson's Ratio(2)			
ν_{yx}	—	0.17	—
ν_{xy}	—	0.15	—

(1) Based on structural wall thickness at room temperature unless noted.

(2) The first subscript denotes the direction of applied stress and the second subscript the measured strain contraction.
x denotes longitudinal direction.
y denotes circumferential direction.

(3) Test fixtures were free-end type (full end thrust on samples).

Nominal Pipe Size		Change in Length Due to Pressure(1)		Stiffness Factor(2)	
in	mm	in/100 ft/100 psi	mm/10m/10 bar	lb•in³/in²	N•m
8	200	0.503	6.1	817	92.3
10	250	0.477	5.8	1,886	213.0
12	300	0.498	6.0	2,758	311.6
14	350	0.496	6.0	4,117	465.2
16	400	0.483	5.8	6,679	754.6

(1) In an unrestrained system due to pressure effects alone.

(2) At 5% deflection.

Support Spacing
(Values are based on a ½ inch (12 mm) deflection at mid span.)

Nominal Pipe Size		Single Span(1)						Continuous Span(2)					
		Gases		1.0(3)		1.3		Gases		1.0		1.3	
in	mm	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m
8	200	29.0	8.8	17.1	5.2	16.0	4.9	43.4	13.2	25.5	7.8	24.0	7.3
10	250	33.2	10.1	19.2	5.8	18.1	5.5	49.6	15.1	28.6	8.7	27.0	8.2
12	300	36.1	11.0	20.6	6.3	19.4	5.9	53.9	16.4	30.8	9.4	29.0	8.8
14	350	37.0	11.3	21.9	6.7	20.6	6.3	55.3	16.8	32.8	10.0	30.9	9.4
16	400	39.6	12.1	23.5	7.1	22.1	6.7	59.3	18.1	35.1	10.7	33.0	10.1

(1) For fluid temperatures above 77°F (25°C), the span lengths decrease by (0.1 in/°F / 5mm/°C).

(2) Beam fixed at both ends and uniformly distributed loads. Intermediate spans may be calculated by multiplying the single span length by 1.2.

(3) Fluid specific gravity.

Bending Radius

Nominal Pipe Size		Minimum Bending Radius (1)		Maximum Deflection per 39-ft Joint	Minimum Length Required for 10° Change	
in	mm	ft	m	deg	ft	m
8	200	309	94	7	54	16
10	250	423	129	5	74	23
12	300	488	149	4	85	26
14	350	631	192	3	110	34
16	400	764	233	3	133	41

(1) At rated pressure. Sharper bends may create excessive stress concentrations. **Do not** bend pipe until adhesive has cured.

Guide Specification

This specification covers approval, performance, materials and physical properties requirements for fire protection piping and general industrial service piping in 8 through 16 inch nominal pipe sizes at operating temperatures to 210°F .

Performance Requirements

Pipe, fittings and other components furnished under this specification shall be rated for service to 300 psig at 150°F and capable of 210°F service conditions in accordance with the pressure derating factor. All components shall be rated at or above the design pressure of the system.

When classified in accordance with ASTM standards, the pipe shall meet the following cell limits:

Nominal Pipe Size		ASTM Designation	
in	mm	D2310	D2996
8 - 16	200 - 400	RTRP 11FU	RTRP 11FU1-6430

Materials

Liner—All filament-wound pipe shall incorporate an integral liner with a nominal thickness of 0.025 ±0.005. The resin system used in the liner shall be a chemically resistant thermosetting epoxy resin suitable for the intended service.

Structural wall—Pipe shall be filament wound using continuous glass fiber reinforcements with a resin-compatible finish and a chemically resistant thermosetting epoxy resin. The glass filaments shall be wound in a dual-angle pattern that takes optimum advantage of the tensile strength of the filaments. The glass fiber content of the reinforced wall shall not be less than 60% by weight. Pigments or dies may be used in the resin as long as the product remains translucent.

External surface—The pipe shall have a typical 0.005-inch thick resin-rich coating with organic fibrous reinforcement. This protection must be provided for both above and below-ground pipe installations. All external surfaces must be resistant to anticipated corrosion imposed by the service and the environment.

Fittings—Fittings supplied under this specification shall be filament-wound, compression molded, centrifugally cast, or manufactured from mitered pipe sections. The glass fiber content of the structural portion of compression-molded and filament-wound fittings shall not be less than 55% by weight.

Joining Methods

Adhesive Bonded Bell and Spigot—Both tapered bell and tapered spigot shall have matching taper angles and shall be joined by bonding with an epoxy adhesive. The nominal taper angle shall be 2°. The adhesive shall be a two part epoxy supplied as a kit with all necessary application materials.

Flanges—Flanges shall be two-piece Van Stone type provided with raised grooves on the sealing surface. Fiberglass-reinforced compression-molded or centrifugally cast stub ends are to be adhesive bonded to the pipe or fitting.

Pipe Construction

Pipe—Outside diameter tolerances shall not exceed ±1.0%. Pipe shall be provided in 40 feet random lengths (34 through 42 ft) unless otherwise specified. Up to 10 percent shorts may be included in any shipment unless otherwise agreed upon in writing between purchaser and manufacturer.

Wall thickness—The total wall thickness of pipe furnished to this specification shall not at any point be greater than 120 percent nor less than 87.5 percent of the nominal thickness. Nominal wall thickness shall have dimensions as given in the manufacturer's published literature.

Fittings and Flanges—Fittings and flanges shall have dimensions as given in the manufacturer's published literature. Flanges shall be drilled to match ANSI B16.5, Class 150 unless specified otherwise in the purchase order.

Physical and Mechanical Requirements

Values for physical and mechanical properties shall be no less than ±15% of those shown tabulated above under Typical Physical Properties and Typical Mechanical Properties.

Workmanship

The pipe and fittings shall be free from all defects, including delamination, indentations, pinholes, foreign inclusions, bubbles and resin-starved areas which, due to their nature, degree or extent, detrimentally affect the strength and serviceability of the pipe or fittings. The pipe and fittings shall be as uniform as commercially practicable in color, density and other physical properties.

Testing

Quality Control Testing—Samples of pipe and fittings shall be tested at random based on standard quality control practices to determine conformance of the materials to the following tests: weight, taper angle, short-term rupture strength, cyclic pressure performance, ring crush strength, Barcol hardness and degree of cure. Each item shall be visually inspected for workmanship.

Components may be hydrostatically tested by the manufacturer to 1.5 times the pressure rating for signs of leakage or porosity at a frequency agreed upon between the manufacturer and the purchaser.

Marking

Each component shall be marked to show the following:

- Manufacturer's name and address
- Nominal pipe size
- Hydrostatic test pressure (if so ordered)
- Date and shift of manufacture (pipe only)

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NOV Fiber Glass Systems

CI3310 - July 2013

Bondstrand™ 4000 Product Data
(Corrosive Industrial Service)

Uses and Applications

- Acid drains
- Chemical process piping
- Corrosive slurries
- Food processing
- Geothermal
- Nonoxidizing chemicals and acids

Listings

Meets USFDA requirements for food processing piping under Federal Regulations 21CFR175.105 and 21CFR177.2280 when bonded using Bondstrand PSX™•34 adhesive.

Performance

Working pressure from 150 to 300 psig (1.0 to 2.0 MPa) depending on pipe size.

Operating temperatures to 250°F (120°C), depending on fluid. Subzero temperatures will not adversely affect mechanical properties.

Excellent corrosion resistance over a wide temperature range. See most recent release of Bondstrand Corrosion Guide for specific applications.

Does not require thrust blocks at ambient temperatures when properly installed in most soils.

Smooth inner liner (Hazen-Williams C = 150) produces extremely low frictional loss for greater discharge and reduced pumping costs.

Individual system components may not have the same ratings as the pipe. Refer to the detailed product information for the specific components to determine the pressure rating for the system as a whole.

Composition

Pipe

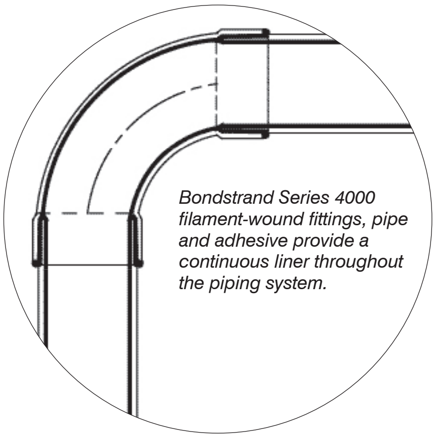
Filament-wound fiberglass reinforced epoxy pipe with nominal 0.050-inch (1.3 mm) resin-rich reinforced liner.

Nominal Pipe Size		ASTM Designation
in	mm	D2996
2-3	20-75	RTRP 11FE-2111
4-6	100-150	RTRP 11FE-2112
8-16	200-400	RTRP 11FE-2113

Joining Systems

Quick-Lock® straight/taper adhesive-bonded joint. Integral pipe stop in socket featured for predictable, precise laying length.

Flanges and flanged fittings.



Bondstrand Series 4000 filament-wound fittings, pipe and adhesive provide a continuous liner throughout the piping system.

Filament-wound fittings

Furnished with reinforced liner using same materials as pipe.

Tees	90° and 45° elbows
Crosses	Nipples and couplings
45° laterals	Tapered body reducers
Saddles (no liner)	Threaded adapters (2 to 6 inch)
Victaulic adapters (2 to 6 inch)	

Molded fittings (General Service only)

Tees	90° and 45° elbows
Reducing flanges	Reducer bushings
Endcaps	Plugs

Flanges

2 to 16-inch flanges match ANSI B16.5 bolt hole pattern for Cl 150 lb flanges.

Other flange drilling patterns such as DIN, ISO, JIS, ANSI B16.5 Cl 300, etc. available on special request.

Flanged fittings

2 to 12-inch filament-wound flanged fittings match ANSI B16.1 and ANSI B16.5 bolt hole pattern and laying length dimensions. ANSI 90° elbows must be specified as being either 'long' or 'short' when ordering.

Thermosetting adhesives

Bondstrand type PSX™•34 two-part epoxy adhesive for field fabrication.

Pipe Lengths

Nominal Pipe Size		Random Length	
in	mm	ft	m
2-6	50-150	20 or 30	6 or 9
8	200	20 or 30	6 or 9
10-16	250-400	20, 30 or 40	6, 9 or 12

Typical Pipe Dimensions and Weights

Nominal Pipe Size		Pipe I.D.		Nominal Wall Thickness(1)		Average(2) Sectional Area		Pipe Weight	
in	mm	in	mm	in	mm	in	mm	lb/ft	kg/m
2	50	2.10	53	.15	3.9	0.52	335	0.8	1.2
3	80	3.21	82	.16	4.0	0.81	525	1.1	1.7
4	100	4.14	105	.20	5.4	1.38	890	1.9	2.8
6	150	6.19	157	.20	5.4	2.63	1700	2.8	4.2
8	200	8.22	209	.23	5.7	5.83	3760	4.1	6.1
10	250	10.35	263	.23	5.7	7.31	4720	5.1	7.7
12	300	12.35	314	.23	5.7	8.69	5610	6.1	9.1
14	350	13.56	344	.25	6.4	10.40	6710	7.4	11.0
16	400	15.50	394	.29	7.3	13.40	8650	9.6	14.0

1) The minimum wall thickness shall not be less than 87.5% of nominal wall thickness in accordance with ASTM D2996.
2) Use these values for calculating longitudinal thrust.

Pressure Ratings

Nominal Pipe Size		Internal Pressure Rating(1)		Ultimate Collapse Pressure(2)	
in	mm	psig	MPa	psig	MPa
2	50	450	3.10	212	1.46
3	80	320	2.21	68	0.47
4	100	350	2.41	82	0.56
6	150	249	1.72	74	0.17
8	200	220	1.52	16	0.11
10	250	175	1.21	8	0.06
12	300	150	1.03	5	0.03
14	350	150	1.03	5	0.03
16	400	150	1.03	6	0.04

1) At 200°F (93°C) using Bondstrand type PSX™•34 adhesive. For sustained service above 200°F, reduce rating linearly from tabulated 200°F values to 50% of those values at 250°F (121°C). Above 250°F, reduce ratings linearly to 0 at 300°F (149°C).
2) At 70°F (21°C). Reduce linearly to 90% at 150°F (66°C), 80% at 200°F and 65% at 230°F (110°C).

Fittings Pressure Ratings

Nominal Pipe Size		Filament-Wound Elbows & Tees		Molded Elbows & Tees		Tapered Body Reducers & Flanges	
in	mm	psig	MPa	psig	MPa	psig	MPa
2	50	375	2.59	300	2.07	450	3.10
3	80	325	2.24	225	1.55	350	2.41
4	100	300	2.07	175	1.21	350	2.41
6	150	225	1.55	150	1.03	250	1.72
8	200	225	1.55	-	-	225	1.55
10	250	200	1.38	-	-	175	1.21
12	300	175	1.21	-	-	150	1.03
14	350	150	1.03	-	-	150	1.03
16	400	150	1.03	-	-	150	1.03

Nominal Pipe Size		Laterals		Crosses		Blind Flanges & Saddles	
in	mm	psig	MPa	psig	MPa	psig	MPa
2	50	275	1.90	150	1.03	150	1.03
3	80	250	1.72	150	1.03	150	1.03
4	100	200	1.38	150	1.03	150	1.03
6	150	150	1.03	100	0.69	150	1.03
8	200	150	1.03	100	0.69	150	1.03
10	250	150	1.03	100	0.69	150	1.03
12	300	150	1.03	100	0.69	150	1.03
14	350	150	1.03	-	-	150	1.03
16	400	150	1.03	-	-	150	1.03

1) All pressure ratings valid from room temperature to 225°F (107°C) using FGS epoxy adhesives. For service above 225°F, reduce the ratings shown linearly by 50% from 225°F to 250°F (121°C).

Typical Physical Properties

Typical Physical Properties

Pipe Property	Units	Value 2"-16"	ASTM
Thermal conductivity	Btu-in/(h•ft^2•°F) W/m•°C	2.23 0.33	C177
Coefficient of thermal expansion (linear) (2 -16 inch) 77°F to 150°F (25°C to 65°C)	10^{-6} in/in/°F 10^{-6} cm/cm/°C	10.00 18.00	D696
Flow coefficient	Hazen-Williams	150.00	—
Absolute roughness	10^{-6} ft 10^{-6} m	17.40 5.30	—
Specific gravity	—	1.80	D792
Density	lb/in^3	0.07	

Typical Mechanical Properties

Typical Mechanical Properties

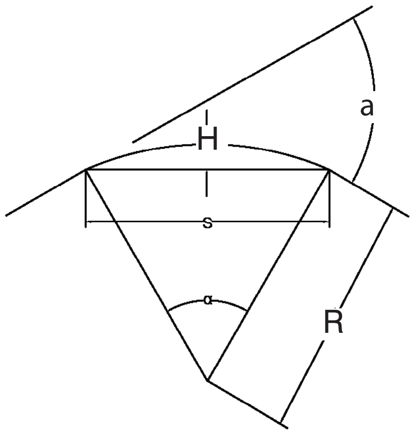
Pipe Property (1)	Units	Value 2" - 16"	ASTM
Tensile strength			
Longitudinal	10^3 psi	20.0	D2105
	MPa	138.0	
Circumferential	10^3 psi	40.0	D1599
	MPa	275.0	
Tensile modulus			
Longitudinal	10^6 psi	1.5	D2105
	GPa	10.3	
Circumferential	10^6 psi	2.3	—
	GPa	15.9	
Compressive strength			
Longitudinal	10^3 psi	20.0	—
	MPa	138.0	
Compressive modulus			
Longitudinal	10^6 psi	1.5	—
	GPa	10.3	
Long-term hydrostatic (3) Design basis			
Static, Hoop Stress	10^3 psi	18.9	D2992(B)
LCL 20 Year Life @150°F (65°C)	MPa	130.3	
Cyclic, Hoop Stress	10^3 psi	—	D2992(A)
LCL 20 Year Life @150°F (65°C)	MPa	—	
Poisson's Ratio (2)			
ν_{yx}	—	0.19	—
ν_{xy}	—	0.11	—

(1) Based on structural wall thickness, at room temperature unless noted.
(2) The first subscript denotes the direction of applied stress and the second that of measured contraction
x denotes longitudinal direction.
y denotes circumferential direction.
(3) Test fixtures were end type (full end thrust on samples).

Nominal Pipe Size		Stiffness Factor (1)		Pipe Stiffness (1)		Beam Moment of Inertia (2)	
in	mm	lb•in	N•m	psi	MPa	in^4	10^6 mm^4
2	50	371	42	1677	11.6	0.49	0.20
3	80	371	42	602	3.5	1.68	0.69
4	100	894	101	676	4.6	4.84	2.01
6	150	894	101	176	1.2	15.9	6.61
8	200	1288	146.0	114	0.78	40.10	16.70
10	250	1288	146.0	68	0.40	78.60	32.70
12	300	1288	146.0	35	0.24	132.00	55.00
14	350	1759	199.0	36	0.25	194.00	80.90
16	400	2761	312.0	38	0.26	338.00	141.00

1) Per ASTM D2412.
2) Use these values to calculate permissible spans.

Bending Radius



Nominal Pipe Size		Bending Radius(1) (R)		Maximum Allowable Deflection, H*		Turning Angle (a)
in	mm	ft	m	ft	m	deg
2	50	83	25	14.1	4.5	69
3	80	123	37	10.1	3.1	47
4	100	158	48	7.9	2.4	36
6	150	233	71	5.4	1.6	25
8	200	304	93.0	4.1	1.3	19
10	250	379	116.0	3.3	1.0	15
12	300	450	137.0	2.8	0.85	13
14	350	494	151.0	2.5	0.76	12
16	400	564	172.0	2.2	0.67	10

* For 100-ft (30m) Bending Length.
1) Do not bend pipe until adhesive has cured. At rated pressure sharper bends may create excessive stress concentrations.

Buried Installations

Thrust blocks: most properly bedded installations do not require thrust blocks at ambient operating temperatures. Consult FGS for information regarding blocking of buried pipelines for your specific application.

Live loads: when properly bedded in compacted sand in stable soils and provided with at least 3 ft (1 m) of cover, Bondstrand 4000 will carry H20 wheel loadings of at least 16,000 lb (7250 kg) per axle.

Span Lengths

Recommended maximum support spacings for Bondstrand Series 4000 pipe at various operating temperatures. Values based on 0.5-inch (12 mm) deflection at midspan for fluid specific gravity = 1.0.

Nominal Pipe Size		Continuous Spans ft				Single Spans ft			
in	mm	100°F	150°F	200°F	250°F	100°F	150°F	200°F	250°F
2	50	13.6	12.9	12.0	10.8	9.1	8.6	8.0	7.2
3	80	15.6	14.7	13.7	12.4	10.4	9.8	9.1	8.3
4	100	17.9	17.0	15.8	14.3	12.0	11.3	10.5	9.5
6	150	20.0	18.9	17.6	15.9	13.4	12.6	11.8	10.6
8	200	22.3	21.1	19.6	17.7	14.8	14.0	13.1	11.8
10	250	23.6	22.3	20.8	18.8	15.7	14.9	13.8	12.5
12	300	24.7	23.4	21.8	19.7	16.5	15.6	14.4	13.1
14	350	26.0	24.6	22.9	20.7	17.3	16.4	15.3	13.8
16	400	28.0	26.5	24.6	22.2	18.6	12.6	16.4	14.8

1) Span recommendations include no provision for weights (fittings,valves, flanges, etc.) or thrusts (branches, turns, etc.).
2) Span recommendations are calculated for a maximum long-term deflection of ½ inch to ensure good appearance and adequate drainage.
3)—Continuous spans are defined as interior (not end) spans that are uniform in length and free from structural rotation at the supports. Single spans are supported only at the ends and are hinged or free to rotate at the supports.

Field Testing

Bondstrand 4000 piping systems are designed for hydrostatic testing at 150% of rated operating pressure. Pneumatic testing is not recommended.

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NOV Fiber Glass Systems

CI4000 - April 2013

Bondstrand® Series 4000 Fiberglass Pipe and Fittings for General Industrial Service

Scope

Bondstrand Series 4000 pipe and fittings are available in 1”-16” diameters. The specification defines the reinforced thermosetting resin (RTR) piping system to be used in those sections of plant piping, general services, calling for fiberglass piping systems.

References, Quality Assurance

References are made to other standards and tests which are a part of this section as modified. Where conflict exists between the requirements of this specification and listed references, the specification shall prevail.

Physical and Mechanical Properties

Pipe Property	Units	70°F (21°C)	200°F (93°C)	ASTM Method
Circumferential Tensile Stress at Weeping	10^3 psi MPa	18.50 128.00	- -	D1599
Tensile Modulus	10^6 psi GPa	3.65 25.20	3.20 22.10	
Poisson’s Ratio		0.56	0.68	D2105
Longitudinal Tensile Strength	10^3 psi MPa	8.50 58.60	6.90 47.60	D2105
Tensile Modulus	10^6 psi GPa	1.60 11.10	1.24 8.60	D2105
Poisson’s Ratio		0.37	0.41	D2105
Beam Apparent-Elastic Modulus	10^6 si GPa	1.70 11.70	1.08 6.90	D2925
Hydrostatic Design Basis (Cyclic)	10^3 psi MPa	6.00 11.40	- -	D2992
Thermal Conductivity Pipe Wall	Btu•in/(hr•ft^2•°F) W/m•C	1.70 0.25	- -	C177
Thermal Expansion Linear	10^{-6} in/in/°F 10^{-6} mm/mm°C	8.50 15.30	- -	D696
Flow Coefficient	Hazen-Williams	150.00	-	
Absolute Roughness	10^{-6} ft	17.40 5.30	-	
Specific Gravity	-	1.80	-	D792
Density	lb/in^3	0.07	-	

Performance Requirements

Pipe shall be manufactured according to ASTM D2996 Specification for RTRP. When classified under ASTM D2310, the pipe shall meet Type I, Grade I and Class F (RTRP 11FE) cell limits in 2” through 16” nominal pipe sizes.

The piping systems must meet USFDA requirements for food processing piping under Federal Regulations 21CFR 175.105 and 21CFR 177.242 when bonded with RP6B adhesive.

Materials

Pipe Construction

Filament-wound fiberglass reinforced epoxy resin pipe shall be Bondstrand® 4000 as manufactured by NOV Fiber Glass Systems or approved equal. The integral reinforced corrosion barrier shall have a nominal 50-mil thickness and be constructed with the same epoxy resin as the pipe structural wall.

Structural Wall

The pipe shall have the following nominal wall thickness.

Diameter	Nominal Wall Thickness	
in	in	mm
2	.123	3.1
3	.126	3.2
4	.151	3.8
6	.181	4.6
8	.226	5.7
10	.226	5.7
12	.226	5.7
14	.250	6.4
16	.269	6.8

Pipe End Preparation Options

The piping manufacturer will provide 20' or 30" random length joints if the contractor requests them in sizes 2"-6" to reduce field labor time in those sections of the system where longer lengths may be employed. Additionally, the pipe manufacturer will provide pipe joints with the spigot ends already prepared for adhesive application to reduce field labor time on all pipe sizes (2"-16").

Pressure Rating

Aromatic amine cured epoxy resin piping shall be rated for a minimum of 150 psi at 200°F in sizes through 16".

Fittings

It is important to maintain compatibility of fittings, piping and adhesives to ensure that the system performs as specified. Pipe, fittings and adhesive shall be supplied by the same manufacturer.

Filament wound fittings in 1"-16" sizes shall be filament wound with a reinforced, resin-rich liner of equal or greater thickness than the pipe liner and shall be manufactured with the same resin type as the pipe.

Compression molded fittings in sizes 2"-6" may be used in some services; contact manufacturer. Where fast closure of valves may produce surges (water hammer), filament-wound fittings will be used. Contact molded, spray up or hand lay-up fittings shall not be allowed.

Testing

Inspection and testing of the piping will be performed in accordance with the requirements of ANSI B31.1. Hydrostatic testing of all installed piping shall be performed with water at a maximum of 1-1/2 times the system design pressure or of the lowest rated piping system component, whichever is lower.

Installation

Installation and techniques, as well as system design criteria including burial, anchoring, guiding and supporting, shall be in accordance with manufacturer's recommendations. Piping system installers and fitters will be trained by a direct factory employee of the piping system manufacturer and certified by the trainer prior to system assembly in the field.

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NOV Fiber Glass Systems

CI4001 April 2013

Bondstrand™ 5000/5000C Product Data
(Severely Corrosive Industrial Service and Oxidizing Acids

Uses and Applications

- Acid drains
- Bleach processing
- Chemical process piping
- Chlorinated water
- Chlorine
- Corrosive slurries
- Food processing plant
- Organic chemicals
- Oxidizing chemicals and acids
- Phosphoric acid
- Water Treatment/Purification
- General industrial service for severely corrosive liquids

Listings

Meets USFDA requirements for food processing piping under Federal Regulations 21CFR175.105 and 21CFR177.2420 when assembled with RP-105B vinyl ester adhesive for 5000 andn RP-106 for 5000C (conductive).

Performance

Working pressure from 150 to 450 psig (1 to 3.1 MPa) depending on pipe size.

Operating temperatures to 200°F (93°C). Subzero temperatures will not adversely affect mechanical properties.

Excellent corrosion resistance over a wide temperature range. See most recent release of Bondstrand Corrosion Guide for specific applications.

Does not require thrust blocks at ambient temperatures when properly installed in most soils.

Smooth inner liner (Hazen-Williams C = 150) produces extremely low frictional loss for greater discharge and reduced pumping costs.

Low thermal conductivity minimizes heat losses.

Individual system components may not have the same ratings as the pipe. Refer to the detailed product information for the specific components to determine the pressure rating for the system as a whole.

Optional: The system can be supplied conductive - Bondstrand 5000C
For Conductive ASTM D-2310 Classification: RTRP-11FW for pipes or RTRP-11FE as applicable.

Composition

Pipe

Filament-wound fiberglass-reinforced vinyl ester pipe with integral 0.050-inch (1.3 mm) resin-rich reinforced liner.

Nominal Pipe Size		ASTM Designation
in	mm	D2996
2-6	50-150	RTRP 11FW-1012/11FE-1012
8-16	200-400	RTRP 11FW-1013/11FE-1013

Filament-wound fittings

Tees
90° and 45° elbows
Crosses
Nipples and couplings
45° laterals
Tapered body reducers

Molded fittings

Tees (2 to 6 inch only)
90° and 45° elbows (2 to 6 inch only)
Reducing flanges
Plugs and end-caps

Flanges

Filament-wound or molded flanges with ANSI B16.1 and ANSI B16.5 drilling
Molded reducing and blind flanges

Thermosetting adhesives

RP105B two-part vinyl ester for 5000
RP106 two-part vinyl ester for 5000C

Joining systems

Quick-Lock® straight/taper adhesive-bonded joint featuring integral pipe stop in bell for predictable, precise laying lengths.

Flanges and flanged fittings.

Pipe Lengths

Nominal Pipe Size		Random Lengths	
in	mm	ft	m
2-8	50-150	30	9
10-16	200-400	20	6

Elbows
Tees
Flanges, blind flanges and reducing flanges
Plugs and end-caps
Crosses
Nipples and couplings
45° laterals
Tapered body reducers

Tapered body reducers, tees and 90° and 45° elbows are available with any combination of Quick-Lock female and filament-wound or molded flange ends.

Laying lengths of filament-wound fittings with Quick-Lock ends match those of ANSI B16.9 steel buttwelding fittings. Flanged ends match ANSI B16.1 and B16.5 center-to-face and face-to-face dimensions.

Typical Pipe Dimensions and Weights

Nominal Pipe Size(1)		Pipe I.D.		Nominal Wall Thickness(2)		Average Sectional Area(3)		Pipe Weight	
in	mm	in	mm	in	mm	in	mm²	lb/ft	kg/m
2	50	2.10	53	.15	3.9	1.13	730	1.0	1.2
3	80	3.22	82	.16	4.0	1.70	1100	1.5	1.7
4	100	4.14	105	.20	5.1	2.73	1760	2.4	2.8
6	150	6.20	159	.20	5.1	4.06	2620	3.5	4.2
8	200	8.22	209	.226	5.7	5.83	3760	5.0	6.1
10	250	10.35	263	.226	5.7	7.31	4710	6.2	7.7
12	300	12.35	314	.226	5.7	8.69	5600	7.4	9.1
14	350	13.56	344	.250	6.4	10.85	7000	8.7	11.0
16	400	15.50	394	.286	7.3	14.18	9150	11.2	14.0

1) For availability of 1, 1½, 14 and 16-inch (25, 40, 350 and 400 mm) sizes, consult your FGS representative.
2) Minimum wall thickness shall not be less than 87.5% of nominal wall thickness in accordance with ASTM D2996.
3) Use these values for calculating longitudinal thrust.

Typical Pipe Performance

Nominal Pipe Size		Internal Pressure Rating		Collapse Pressure Rating(1)	
in	mm	psig	Mpa	psig	Mpa
2	50	450	3.10	212	1.46
3	80	320	2.21	68	0.47
4	100	350	2.41	82	0.56
6	150	249	1.72	24	0.17
8	200	225	1.55	16	0.11
10	250	175	1.21	8	0.06
12	300	150	1.03	5	0.03
14	350	150	1.02	5	0.03
16	400	150	1.02	6	0.04

1) At 70°F (21°C). Reduce linearly to 84% at 140°F (60°C), 76% at 170°F and 50% at 200°F (93°C).

Fittings Pressure Ratings

Nominal Pipe Size		Elbows & Tees				Tapered Body Reducers & Flanges		Blind Flanges & Bushed Saddles	
		Filament-Wound		Molded					
in	mm	psig	MPa	psig	MPa	psig	MPa	psig	MPa
2	50	300	2.07	200	1.38	450	3.10	150	1.03
3	80	275	1.89	150	1.03	350	2.41	150	1.03
4	100	200	1.38	150	1.03	350	2.41	150	1.03
6	150	175	1.21	150	1.03	250	1.72	150	1.03
8	200	225	1.03	-	-	225	1.55	150	1.03
10	250	150	1.03	-	-	175	1.21	150	1.03
12	300	150	1.03	-	-	150	1.03	150	1.03
14	350	150	1.03	-	-	150	1.03	150	1.03
16	400	150	1.03	-	-	150	1.03	150	1.03

1) Use Bondstrand Series 2000 epoxy saddles with 316 stainless steel outlet. Other outlet materials available on special order.

Nominal Pipe Size		Laterals		Crosses		Reducer Bushing	
in	mm	psig	MPa	psig	MPa	psig	MPa
2	50	275	1.90	150	1.03	50	.35
3	80	250	1.72	150	1.03	50	.35
4	100	200	1.38	150	1.03	50	.35
6	150	150	1.03	100	0.69	50	.35
8	200	150	1.03	100	0.69	50	.35
10	250	150	1.03	100	0.69	50	.35
12	300	150	1.03	100	0.69	50	.35
14	350	150	1.03	100	0.69	50	.35
16	400	150	1.03	100	0.69	50	.35

1) Reducer bushings bonded into flanges will have the same rating as the flange. Otherwise, rated as shown.

Typical Physical Properties

Typical Physical Properties

Pipe Property	Units	Value	ASTM
Thermal conductivity	Btu-in/(h•ft²•°F) W/m•°C	2.0 0.28	C177
Coefficient of thermal expansion (linear) (2 -16 inch) 77°F to 150°F (25°C to 65°C)	10^{-6} in/in/°F 10^{-6} cm/cm/°C	10 18	D696
Flow coefficient	Hazen-Williams	150.00	—
Absolute roughness	10^{-6} ft 10^{-6} m	17.40 5.30	—
Specific gravity	—	1.80	D792
Density	lb/in³	0.07	

Typical Physical Properties

Typical Mechanical Properties

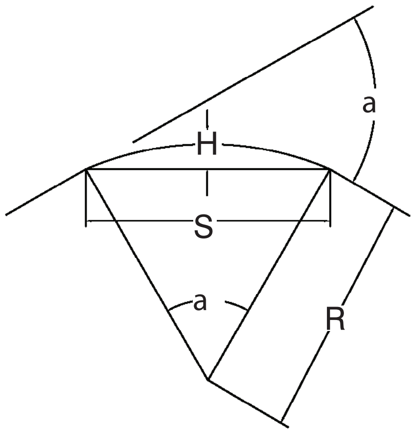
Pipe Property(1)	Units	Value 2" - 16"	ASTM
Tensile strength			
Longitudinal	10^3 psi	7.0	D2105
	MPa	48.3	
Circumferential	10^3 psi	18.5	D1599
	MPa	128.0	
Tensile modulus			
Longitudinal	10^6 psi	1.45	D2105
	GPa	10.1	
Circumferential	10^6 psi	3.13	—
	GPa	21.6	
Compressive strength			
Longitudinal	10^3 psi	20.0	—
	MPa	138.0	
Compressive modulus			
Longitudinal	10^6 psi	1.5	—
	GPa	10.3	
Long-term hydrostatic(3) Design basis			
Static, Hoop Stress	10^3 psi	12.8	D2992(B)
LCL 20 Year Life @150°F (65°C)	MPa	88.2	
Cyclic, Hoop Stress	10^3 psi	—	D2992(A)
LCL 20 Year Life @150°F (65°C)	MPa	—	
Poisson's Ratio(2)			
ν_{yx}	—	0.19	—
ν_{xy}	—	0.11	—

(1) Based on structural wall thickness, at room temperature unless noted.
(2) The first subscript denotes the direction of applied stress and the second that of measured contraction
x denotes longitudinal direction.
y denotes circumferential direction.
(3) Test fixtures were end type (full end thrust on samples).

Nominal Pipe Size		Stiffness Factor(1)		Pipe Stiffness(1)		Beam Moment of Inertia(2)	
in	mm	lb•in	N•m	psi	MPa	in^4	10^6 mm^4
2	50	340	38.4	1540	10.6	0.48	0.20
3	80	340	38.4	460	3.2	1.61	0.67
4	100	820	92.6	530	3.7	4.7	1.96
6	150	820	92.6	160	1.1	15.5	6.40
8	200	1180	133.3	105	0.72	39	16.3
10	250	1180	133.3	53	0.37	77	32
12	300	1180	133.3	31	0.23	129	54
14	350	1330	150.2	36	0.25	209	88
16	400	2190	247.4	38	0.26	368	154

1) Per ASTM D2412.
2) Use these values to calculate permissible spans.

Bending Radius



Nominal Pipe Size		Bending Radius[1] (R)		Maximum Allowable[(2)] (H)		Turning Angle
in	mm	lb•in	N•m	ft	m	a
2	50	69.4	21	17.5	5.3	84
3	80	101.1	31	12.1	3.7	57
4	100	129.9	40	9.5	2.9	44
6	150	191.8	58	6.5	1.9	30
8	200	250	76	5.0	1.5	23
10	250	312	95	4.0	1.2	18
12	300	370	113	3.4	1.0	15
14	350	410	125	3.2	0.9	14
16	400	410	143	2.7	0.8	12

1) Do not bend pipe until adhesive has cured. At rated pressure sharper bends may create excessive stress concentrations.
2) For 100-ft (30m) bending length, S

Buried Installations

Live loads
Bondstrand 5000/5000C will carry H20 wheel loadings of at least 16.000 lb (7250 kg) per axle when properly bedded in compacted sand in stable soils and provided with at least 3 ft (1 m) of cover.

Thrust blocks
Most properly bedded installations do not require thrust blocks. Consult FGS for recommendations for systems operating at elevated temperatures.

Nominal Pipe Size		Maximum Earth Cover[1]					
		100 psi	0.69 MPa	125 psi	0.86 MPa	150 psi	1.03 MPa
in	mm	ft	m	ft	m	ft	m
2	50	30	9.14	30	9.14	30	9.14
3	80	30	9.14	30	9.14	30	9.14
4	100	30	9.14	30	9.14	30	9.14
6	150	30	9.14	24	7.32	23	7.01
8	200	23	7.01	22	6.71	21	6.40
10	250	23	7.01	21	6.40	19	5.79
12	300	23	7.01	21	6.40	18	5.49
14	350	23	7.01	21	6.40	17	5.18
16	400	23	7.01	20	6.10	16	4.88

1) Based on a 120lb/ft3 (1925 kg/m3) soil density and 1000 psi (6.9 MPa) modulus of soil reaction.

Span Lengths

Recommended maximum support spacings for Bondstrand 5000/5000C vinyl ester pipe at various operating temperatures. Values based on 0.5-inch (12 mm) deflection at midspan for fluid specific gravity = 1.0. For fully continuous spans, values may be increased up to 20%. Decrease values by 20% for single spans.

Nominal Pipe Size		Spans (ft)			
in	mm	100°F	140°F	170°F	200°F
2	50	12.1	10.8	9.4	7.5
3	80	13.7	12.3	10.7	8.6
4	100	16.1	14.5	12.6	10.0
6	150	18.1	16.1	14.2	11.2
8	200	20.1	18.1	15.5	12.6
10	250	21.4	19.2	16.6	13.5
12	300	22.3	20.2	17.5	13.9
14	350	23.1	20.7	18.1	14.4
16	400	24.3	21.6	18.9	15.0

1) Span recommendations are intended for normal horizontal piping support arrangements, but include no provision for weights (fittings, valves, flanges, etc) or thrusts (branches, turns, etc.).

2) Span recommendations are calculated for a maximum long-term deflection of ½ inch to ensure good appearance and adequate drainage.

Field Testing

Bondstrand 5000/5000C piping systems are designed for hydrostatic field testing at 150% of rated operating pressure. Pneumatic testing is not recommended.

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NOV Fiber Glass Systems

CI5000 - April 2013

Bondstrand™ 5000/5000C Product Data
(Severely Corrosive Industrial Service and Oxidizing Acids

Uses and Applications

- Acid drains
- Bleach processing
- Chemical process piping
- Chlorinated water
- Chlorine
- Corrosive slurries
- Food processing plant
- Organic chemicals
- Oxidizing chemicals and acids
- Phosphoric acid
- Water Treatment/Purification
- General industrial service for severely corrosive liquids

Listings

Meets USFDA requirements for food processing piping under Federal Regulations 21CFR175.105 and 21CFR177.2420 when assembled with RP-105B vinyl ester adhesive for 5000 andn RP-106 for 5000C (conductive).

Performance

Working pressure from 150 to 450 psig (1 to 3.1 MPa) depending on pipe size.

Operating temperatures to 200°F (93°C). Subzero temperatures will not adversely affect mechanical properties.

Excellent corrosion resistance over a wide temperature range. See most recent release of Bondstrand Corrosion Guide for specific applications.

Does not require thrust blocks at ambient temperatures when properly installed in most soils.

Smooth inner liner (Hazen-Williams C = 150) produces extremely low frictional loss for greater discharge and reduced pumping costs.

Low thermal conductivity minimizes heat losses.

Individual system components may not have the same ratings as the pipe. Refer to the detailed product information for the specific components to determine the pressure rating for the system as a whole.

Optional: The system can be supplied conductive - Bondstrand 5000C
For Conductive ASTM D-2310 Classification: RTRP-11FW for pipes or RTRP-11FE as applicable.

Composition

Pipe
Filament-wound fiberglass-reinforced vinyl ester pipe with integral 0.050-inch (1.3 mm) resin-rich reinforced liner.

Nominal Pipe Size		ASTM Designation
in	mm	D2996
2-6	50-150	RTRP 11FW-1012/11FE-1012
8-16	200-400	RTRP 11FW-1013/11FE-1013

Filament-wound fittings
Tees
90° and 45° elbows
Crosses
Nipples and couplings
45° laterals
Tapered body reducers

Molded fittings
Tees (2 to 6 inch only)
90° and 45° elbows (2 to 6 inch only)
Reducing flanges
Plugs and end-caps

Flanges
Filament-wound or molded flanges with ANSI B16.1 and ANSI B16.5 drilling
Molded reducing and blind flanges

Thermosetting adhesives
RP105B two-part vinyl ester for 5000
RP106 two-part vinyl ester for 5000C

Joining systems

Quick-Lock® straight/taper adhesive-bonded joint featuring integral pipe stop in bell for predictable, precise laying lengths.

Flanges and flanged fittings.

Pipe Lengths

Nominal Pipe Size		Random Lengths	
in	mm	ft	m
2-8	50-150	30	9
10-16	200-400	20	6

Elbows
Tees
Flanges, blind flanges and reducing flanges
Plugs and end-caps
Crosses
Nipples and couplings
45° laterals
Tapered body reducers

Tapered body reducers, tees and 90° and 45° elbows are available with any combination of Quick-Lock female and filament-wound or molded flange ends.

Laying lengths of filament-wound fittings with Quick-Lock ends match those of ANSI B16.9 steel buttwelding fittings. Flanged ends match ANSI B16.1 and B16.5 center-to-face and face-to-face dimensions.

Typical Pipe Dimensions and Weights

Nominal Pipe Size(1)		Pipe I.D.		Nominal Wall Thickness(2)		Average Sectional Area(3)		Pipe Weight	
in	mm	in	mm	in	mm	in	mm²	lb/ft	kg/m
2	50	2.10	53	.15	3.9	1.13	730	1.0	1.2
3	80	3.22	82	.16	4.0	1.70	1100	1.5	1.7
4	100	4.14	105	.20	5.1	2.73	1760	2.4	2.8
6	150	6.20	159	.20	5.1	4.06	2620	3.5	4.2
8	200	8.22	209	.226	5.7	5.83	3760	5.0	6.1
10	250	10.35	263	.226	5.7	7.31	4710	6.2	7.7
12	300	12.35	314	.226	5.7	8.69	5600	7.4	9.1
14	350	13.56	344	.250	6.4	10.85	7000	8.7	11.0
16	400	15.50	394	.286	7.3	14.18	9150	11.2	14.0

1) For availability of 1, 1½, 14 and 16-inch (25, 40, 350 and 400 mm) sizes, consult your FGS representative.
2) Minimum wall thickness shall not be less than 87.5% of nominal wall thickness in accordance with ASTM D2996.
3) Use these values for calculating longitudinal thrust.

Typical Pipe Performance

Nominal Pipe Size		Internal Pressure Rating		Collapse Pressure Rating(1)	
in	mm	psig	Mpa	psig	Mpa
2	50	450	3.10	212	1.46
3	80	320	2.21	68	0.47
4	100	350	2.41	82	0.56
6	150	249	1.72	24	0.17
8	200	225	1.55	16	0.11
10	250	175	1.21	8	0.06
12	300	150	1.03	5	0.03
14	350	150	1.02	5	0.03
16	400	150	1.02	6	0.04

1) At 70°F (21°C). Reduce linearly to 84% at 140°F (60°C), 76% at 170°F and 50% at 200°F (93°C).

Fittings Pressure Ratings

Nominal Pipe Size		Elbows & Tees				Tapered Body Reducers & Flanges		Blind Flanges & Bushed Saddles	
		Filament-Wound		Molded					
in	mm	psig	MPa	psig	MPa	psig	MPa	psig	MPa
2	50	300	2.07	200	1.38	450	3.10	150	1.03
3	80	275	1.89	150	1.03	350	2.41	150	1.03
4	100	200	1.38	150	1.03	350	2.41	150	1.03
6	150	175	1.21	150	1.03	250	1.72	150	1.03
8	200	225	1.03	-	-	225	1.55	150	1.03
10	250	150	1.03	-	-	175	1.21	150	1.03
12	300	150	1.03	-	-	150	1.03	150	1.03
14	350	150	1.03	-	-	150	1.03	150	1.03
16	400	150	1.03	-	-	150	1.03	150	1.03

1) Use Bondstrand Series 2000 epoxy saddles with 316 stainless steel outlet. Other outlet materials available on special order.

Nominal Pipe Size		Laterals		Crosses		Reducer Bushing	
in	mm	psig	MPa	psig	MPa	psig	MPa
2	50	275	1.90	150	1.03	50	.35
3	80	250	1.72	150	1.03	50	.35
4	100	200	1.38	150	1.03	50	.35
6	150	150	1.03	100	0.69	50	.35
8	200	150	1.03	100	0.69	50	.35
10	250	150	1.03	100	0.69	50	.35
12	300	150	1.03	100	0.69	50	.35
14	350	150	1.03	100	0.69	50	.35
16	400	150	1.03	100	0.69	50	.35

1) Reducer bushings bonded into flanges will have the same rating as the flange. Otherwise, rated as shown.

Typical Physical Properties

Typical Physical Properties

Pipe Property	Units	Value	ASTM
Thermal conductivity	Btu-in/(h•ft^{2}•°F) W/m•°C	2.0 0.28	C177
Coefficient of thermal expansion (linear) (2 -16 inch) 77°F to 150°F (25°C to 65°C)	10^{-6} in/in/°F 10^{-6} cm/cm/°C	10 18	D696
Flow coefficient	Hazen-Williams	150.00	—
Absolute roughness	10^{-6} ft 10^{-6} m	17.40 5.30	—
Specific gravity	—	1.80	D792
Density	lb/in^{3}	0.07	

Typical Physical Properties

Typical Mechanical Properties

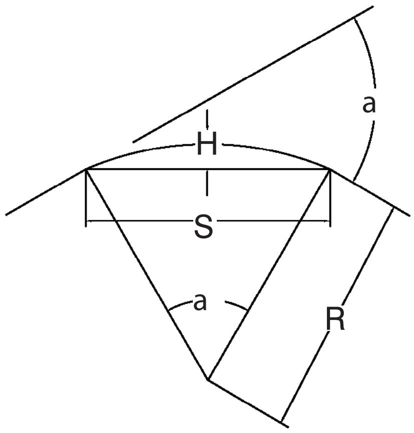
Pipe Property[1]	Units	Value 2" - 16"	ASTM
Tensile strength			
Longitudinal	10^3 psi	7.0	D2105
	MPa	48.3	
Circumferential	10^3 psi	18.5	D1599
	MPa	128.0	
Tensile modulus			
Longitudinal	10^6 psi	1.45	D2105
	GPa	10.1	
Circumferential	10^6 psi	3.13	—
	GPa	21.6	
Compressive strength			
Longitudinal	10^3 psi	20.0	—
	MPa	138.0	
Compressive modulus			
Longitudinal	10^6 psi	1.5	—
	GPa	10.3	
Long-term hydrostatic[3]			
Design basis			
Static, Hoop Stress	10^3 psi	12.8	D2992(B)
LCL 20 Year Life @150°F (65°C)	MPa	88.2	
Cyclic, Hoop Stress	10^3 psi	—	D2992(A)
LCL 20 Year Life @150°F (65°C)	MPa	—	
Poisson's Ratio[2]			
ν_{yx}	—	0.19	—
ν_{xy}	—	0.11	—

(1) Based on structural wall thickness, at room temperature unless noted.
(2) The first subscript denotes the direction of applied stress and the second that of measured contraction
x denotes longitudinal direction.
y denotes circumferential direction.
(3) Test fixtures were end type (full end thrust on samples).

Nominal Pipe Size		Stiffness Factor[1]		Pipe Stiffness[1]		Beam Moment of Inertia[2]	
in	mm	lb•in	N•m	psi	MPa	in^4	10^6 mm^4
2	50	340	38.4	1540	10.6	0.48	0.20
3	80	340	38.4	460	3.2	1.61	0.67
4	100	820	92.6	530	3.7	4.7	1.96
6	150	820	92.6	160	1.1	15.5	6.40
8	200	1180	133.3	105	0.72	39	16.3
10	250	1180	133.3	53	0.37	77	32
12	300	1180	133.3	31	0.23	129	54
14	350	1330	150.2	36	0.25	209	88
16	400	2190	247.4	38	0.26	368	154

1) Per ASTM D2412.
2) Use these values to calculate permissible spans.

Bending Radius



Nominal Pipe Size		Bending Radius[1] (R)		Maximum Allowable[(2)] (H)		Turning Angle
in	mm	lb•in	N•m	ft	m	a
2	50	69.4	21	17.5	5.3	84
3	80	101.1	31	12.1	3.7	57
4	100	129.9	40	9.5	2.9	44
6	150	191.8	58	6.5	1.9	30
8	200	250	76	5.0	1.5	23
10	250	312	95	4.0	1.2	18
12	300	370	113	3.4	1.0	15
14	350	410	125	3.2	0.9	14
16	400	410	143	2.7	0.8	12

1) Do not bend pipe until adhesive has cured. At rated pressure sharper bends may create excessive stress concentrations.
2) For 100-ft (30m) bending length, S

Buried Installations

Live loads

Bondstrand 5000/5000C will carry H20 wheel loadings of at least 16.000 lb (7250 kg) per axle when properly bedded in compacted sand in stable soils and provided with at least 3 ft (1 m) of cover.

Thrust blocks

Most properly bedded installations do not require thrust blocks. Consult FGS for recommendations for systems operating at elevated temperatures.

Nominal Pipe Size		Maximum Earth Cover[1]					
		100 psi	0.69 MPa	125 psi	0.86 MPa	150 psi	1.03 MPa
in	mm	ft	m	ft	m	ft	m
2	50	30	9.14	30	9.14	30	9.14
3	80	30	9.14	30	9.14	30	9.14
4	100	30	9.14	30	9.14	30	9.14
6	150	30	9.14	24	7.32	23	7.01
8	200	23	7.01	22	6.71	21	6.40
10	250	23	7.01	21	6.40	19	5.79
12	300	23	7.01	21	6.40	18	5.49
14	350	23	7.01	21	6.40	17	5.18
16	400	23	7.01	20	6.10	16	4.88

1) Based on a 120lb/ft3 (1925 kg/m3) soil density and 1000 psi (6.9 MPa) modulus of soil reaction.

Span Lengths

Recommended maximum support spacings for Bondstrand 5000/5000C vinyl ester pipe at various operating temperatures. Values based on 0.5-inch (12 mm) deflection at midspan for fluid specific gravity = 1.0. For fully continuous spans, values may be increased up to 20%. Decrease values by 20% for single spans.

Nominal Pipe Size		Spans (ft)			
in	mm	100°F	140°F	170°F	200°F
2	50	12.1	10.8	9.4	7.5
3	80	13.7	12.3	10.7	8.6
4	100	16.1	14.5	12.6	10.0
6	150	18.1	16.1	14.2	11.2
8	200	20.1	18.1	15.5	12.6
10	250	21.4	19.2	16.6	13.5
12	300	22.3	20.2	17.5	13.9
14	350	23.1	20.7	18.1	14.4
16	400	24.3	21.6	18.9	15.0

1) Span recommendations are intended for normal horizontal piping support arrangements, but include no provision for weights (fittings, valves, flanges, etc) or thrusts (branches, turns, etc.).

2) Span recommendations are calculated for a maximum long-term deflection of ½ inch to ensure good appearance and adequate drainage.

Field Testing

Bondstrand 5000/5000C piping systems are designed for hydrostatic field testing at 150% of rated operating pressure. Pneumatic testing is not recommended.

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NOV Fiber Glass Systems

CI5000 - April 2013

Bondstrand® Guide Specification

Pipe Construction

The structural wall of fiberglass pipe in 2 through 16 inch sizes shall have continuous glass fibers wound at a 54¾ helical angle in a matrix of premium vinyl ester resin.

The integral, reinforced resin-rich liner shall consist of Nexus veil and a resin-/hardener system identical to that of the structural wall, and shall have a 50-mil nominal thickness. Non-reinforced pure resin-type corrosion barriers (liners) shall not be allowed due to their potential for severe fracturing during transportation, installation and operation of the pipe.

Pipe in 2 through 16 inch sizes shall be rated for a minimum of 150 psig at 200°F. In 2 through 8 inch sizes the pipe shall have full vacuum capability at 70°F, when installed above ground with a safety factor of 3:1.

Pipe shall be manufactured according to ASTM D2996 specification for filament-wound Reinforced Thermosetting Resin Pipe (RTRP). When classified under ASTM ED2310, the pipe shall meet Type 1, Grade 2 and Class E (RTRP-12ED) cell limited in 2 through 16 inch nominal pipe sizes.

Filament-wound vinyl ester fiberglass pipe shall be gray.

Pipe in 2 through 8 inch sizes shall be furnished in 30 ft length to minimize the number of field-bonded joints for rapid installation.

Standard Fittings Construction

Fittings in 2 through 16 inch sizes shall be filament wound with a reinforced resin-rich liner of equal or greater thickness than the pipe liner and of the same glass resin type as the pipe.

Compression-molded fittings in 2, 3, 4 and 6 inch nominal sizes may also be allowed upon agreement between purchaser and manufacturer.

Contact-molded, spray-up or hand lay-up fittings shall not be allowed. Pipe and Fittings shall be joined using a straight spigot by socket with a 0.5° taper angle and a pipe stop inside the socket to allow precise makeup.

Workmanship

The pipe and fittings shall be free from all defects, including delaminations, indentations, pinholes, foreign inclusions, bubbles and resin-starved areas which, due to their nature, degree or extent, detrimentally affect the strength and serviceability of the pipe or fittings. The pipe and fittings shall be as uniform as commercially practicable in color, density and other physical properties.

Testing

Samples of pipe and couplings shall be tested at random, based on standard quality control practices to determine conformance of the materials to American Society for Testing of Materials guidelines for testing fiberglass pipe products: ASTM D1599, D2105, D2925, D2992A or D2992B.

Test samples may be hydrostatically tested by the manufacturer to 1.5 times the pressure rating for signs of leakage.

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NOV Fiber Glass Systems

CI5001 - April 2013

Bondstrand™ 7000 Antistatic Pipe Product Data

(For Industrial Service)

Uses and Applications

Above ground jet fuel lines
Double-contained jet fuel lines
General industrial service where static electrical charge build-up is possible or through hazardous areas (Class 1,Div. 1 and 2)

Listings and Approvals

MIL-P-29206A for jet fuels and petroleum liquids

Performance

Bondstrand Series 7000 fiberglass pipe, fittings and flanges incorporate high-strength conductive filaments to prevent accumulation and discharge of potentially dangerous levels of static electrical charges. Series 7000 piping systems are made electrically continuous by using a conductive adhesive in the adhesive-bonded joint and for mounting flanges. Accumulated charges are dissipated from the fiberglass pipe system by stainless steel cables embedded in fiberglass grounding saddles. The grounding saddles are adhesive bonded to the pipe at appropriate locations to assure resistance to ground is less than one MEG OHM.

System rating of 150 psig at 210°F (10 bar at 99°C).

Individual system components may not have the same ratings as the pipe. Refer to the detailed product information for the specific components to determine the pressure rating for the system as a whole.

Composition

Pipe: Filament-wound fiberglass reinforced epoxy resin pipe with conductive filaments in the pipe wall.

Fittings: Wide range of filament-wound epoxy resin fittings reinforced with fiberglass strands and conductive veils employing Quick-Lock® adhesive joint or flanged ends.

Flanges: Filament-wound epoxy reinforced with fiberglass strands and conductive filaments.

Blind flanges: Injection molded non-conductive epoxy in 2 through 12-inch (50 to 300 mm) sizes.

Grounding saddles: Filament-wound fiberglass with stainless steel grounding cable.

Adhesive: PSX•60 two-part thermosetting electrically conductive epoxy.

Joining Systems

Quick-Lock straight/taper adhesive-bonded joint featuring integral pipe stop in bell for precise laying lengths.

One-piece flanges in hubbed (standard) and hubless (heavy duty) configuration. All pipe is shipped ready for assembly with Quick-Lock bell x shaved spigot.

Static Electricity Generation and Accumulation

Static electricity accumulation is most likely to be a problem in pipes conveying non conducting fluids at high velocities (less than 1000 pico-Siemens per meter). Measurable amounts of electricity can be generated in the fluid when the flow velocity exceeds 9 ft/sec in fiberglass pipe and 20 ft/sec in metallic systems. Filtration units and valves typically experience the highest rate of static electricity accumulation when high flow rates occur. Charge densities are affected by the conductivity of the fluid,the pipe and the filter media. Depending on the media, flow through filters generally tends to give rise to charge densities 5 to 1000 times greater than flow through unrestricted pipes.

Pipe Lengths

Bondstrand pipe is produced in different lengths depending on pipe size and location of manufacture. Pipe can be cut to specified lengths at the factory. Consult your FGS representative.

Nominal Pipe Size		Standard Length	
in	mm	ft	m
2 - 6	50 - 150	20 - 30	6 - 9
8	200	20 - 30	6 - 9
10 - 16	250 - 400	40	12

Fittings and Flanges

90° and 45° elbows

Tees and reducing tees, reducers

Reducing saddles furnished with:
- Quick-Lock spigot outlet
- Flanged outlet
- Metallic bushing outlet

Grounding saddles

45°laterals

Crosses

Nipples and couplings

Flanges are produced with ANSI B16.5 Class 150 drilling. Other drill patterns as well as blank flanges are available.

Typical Pipe Dimensions and Weight

Nominal Pipe Size		Pipe Inside Diameter		Nominal Wall Thickness		Shipping Weight	
in	mm	in	mm	in	mm	lb/ft	kg/m
2	50	2.09	53	0.16	4.1	1.0	1.5
3	80	3.22	82	0.16	4.1	1.5	2.3
4	100	4.14	105	0.20	5.2	2.4	3.5
6	150	6.26	159	0.20	5.2	3.5	5.2
8	200	8.22	209	0.25	6.5	5.0	7.4
10	250	10.35	263	0.32	8.1	6.2	9.3
12	300	12.35	314	0.38	9.6	7.4	11.0
14	350	13.56	344	0.41	10.5	8.7	14.7
16	400	15.50	394	0.47	11.9	11.2	19.0

Typical Pipe Performance

Nominal Pipe Size		Internal Pressure Rating*		Ultimate Collapse Pressure**		Designation per ASTM D2996
in	mm	psig	MPa	psig	MPa	
2	50	450	3.10	500	3.46	RTRP-11FE-1112
3	80	425	2.93	400	2.76	RTRP-11FE-1112
4	100	400	2.76	400	2.76	RTRP-11FE-1113
6	150	300	2.07	163	1.12	RTRP-11FE-1113
8	200	250	1.72	150	1.03	RTRP-11FE-1114
10	250	200	1.38	150	1.03	RTRP-11FE-1114
12	300	170	1.17	150	1.03	RTRP-11FE-1114
14	350	165	1.14	150	1.03	RTRP-11FE-1115
16	400	165	1.14	150	1.03	RTRP-11FE-1116

*At 21°F(99°C) using Bondstrand PSX•60 adhesive.
**At 70°F (21°C).Reduce linearly to 90% at 150°F(66°C) and 80% at 200°F(93°C).

Typical Mechanical Properties

Typical Pipe Property	Units	70°F (21°C)	200°F (93°C)	ASTM Method
Circumferential Tensile Stress at Weeping	10^3 psi MPa	24.0 165.0	- -	D1599
Circumferential Tensile Modulus	10^6 psi GPa	3.65 25.5	3.20 22.1	
Circumferential Poisson's Ratio	-	0.56	0.70	
Longitudinal Tensile Strength	10^3 psi MPa	8.50 59.0	6.90 44.6	D2105
Longitudinal Tensile Modulus	10^6 psi GPa	1.6 11.0	1.24 8.5	D2105
Longitudinal Poisson's Ratio	-	0.37	0.41	
Hydrostatic Design Basis(cyclic) (at 150°F(66•C))	10^3 psi MPa	6.0 41.4		D2992(A)
Beam Apparent Elastic Modulus	10^6 psi GPa	1.7 11.7	1.0 6.9	D2925
	Value			
Flow Coefficient	Hazen Williams 150			
Thermal Conductivity Pipe Wall	BTU-in./(hr.ft.²°F) W/M °C		2.3 0.33	
Grounding Resistance at 1500 volts	10^6 ohms		1.0 max.	
Coefficient of Thermal Expansion,Linear	10^{-6}in./in.°F 10^{-6}mm/mm/ 24°C		10 18	D696

(1) Based on structural wall thickness, at room temperature unless noted.
(2) The first subscript denotes the direction of applied stress and the second that of measured contraction
x denotes longitudinal direction.
y denotes circumferential direction.
(3) Test fixtures were end type (full end thrust on samples).
(4) Circumferentially loaded only.

Support Spacing

Recommended maximum support spacing for Bondstrand Series 7000 pipe at various operating temperatures. Values based on 0.5 inch (12 mm) deflection at mid-span for fluid specific gravity = 1.0.

Nominal Pipe Size		Span in Feet (m)* Temperature in °F (°C)					
in	mm	100	(38)	150	(66)	200	(93)
2	50	11.8	3.6	11.2	3.4	10.4	3.2
3	80	13.6	4.1	12.8	3.9	11.9	3.6
4	100	15.4	4.7	14.6	4.5	13.6	4.1
6	150	17.2	5.2	16.4	5.0	15.1	4.6
8	200	19.2	5.9	18.1	5.5	16.9	5.2
10	250	20.3	6.2	19.2	5.9	17.9	5.5
12	300	21.3	6.5	20.1	6.1	18.7	5.7
14	350	22.3	6.8	21.2	6.5	19.6	6.0
16	400	23.3	7.1	22.3	6.8	20.5	6.2

*Span recommendations are intended for normal horizontal piping support arrangements,a compromise between continuous spans and simple spans, but include no provision for weight such as fittings, valves, flanges,etc. or thrust from branches and turns. Fully continuous spans may be installed with support spacing up to 20% greater than values shown for this deflection; for simple spans the support spacing should be reduced by 20% from tabulated values.

Typical Pipe Performance

Nominal Pipe Size		Stiffness Factor*		Pipe Stiffness		Beam Moment of Inertia**	
in	mm	lb•in	N•m	psi	MPa	in^4	$10^6 mm^4$
2	50	620	70	2900	20.0	0.59	0.25
3	80	620	70	860	5.93	1.99	0.83
4	100	1360	154	890	6.14	5.50	2.29
6	150	1360	154	270	1.86	18.10	7.53
8	200	1890	214	170	1.17	45.10	18.80
10	250	1890	214	86	0.59	88.60	36.90
12	300	1890	214	51	0.35	149.00	62.00
14	350	2230	252	46	0.32	208.00	86.60
16	400	3250	367	45	0.31	353.00	147.00

* Per ASTM D2412
** Use these values to calculate permissible spans

Typical Physical Properties

Typical Physical Properties

Pipe Property	Units	Value	ASTM
Thermal conductivity	Btu-in/(h•ft^2•°F) W/m•°C	2.3 0.33	FGS
Coefficient of thermal expansion (linear) (2 -16 inch) 77°F to 150°F (25°C to 65°C)	10^{-6} in/in/°F 10^{-6} cm/cm/°C	10.00 18.00	FGS
Flow coefficient	Hazen-Williams	150.00	—
Absolute roughness	10^{-6} ft 10^{-6} m	17.40 5.30	—
Specific gravity	—	1.79	D792
Density	lb/in^3	0.07	
Grounding resistance @ 1500 volts	10^6 ohms	1.0*	
Shielding capability	Volts	100*	

*Maximum values when measured in accordance with Annexes 2 and 3 of proposed ASTM standard for marine antistatic pipe.

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NOV Fiber Glass Systems

CI7000 - April 2013

Bondstrand 7000 Specification Guide

Scope

This specification defines the reinforced thermosetting resin (RTR) piping system to be used in those services that may produce a dangerous build-up of static electrical charges. Such services include above-ground jet fuel lines, double contained jet fuel lines,and transmission of refined petroleum products, gases, or non-polar fluids at high velocities.

References, Quality Assurance

References are made to other standards and tests which are a part of this section as modified. Where conflict exists between the requirements of this specification and listed references, the specification shall prevail.

Physical and Mechanical Properties

Typical Pipe Property	Units	70°F (21°C)	200°F (93°C)	ASTM Method
Circumferential Tensile Stress at Weeping	10^3 psi MPa	24.0 165.0	- -	D1599
Circumferential Tensile Modulus	10^6 psi GPa	3.65 25.5	3.20 22.1	
Circumferential Poisson's Ratio	-	0.56	0.70	
Longitudinal Tensile Strength	10^3 psi MPa	8.50 59.0	6.90 44.6	D2105
Longitudinal Tensile Modulus	10^6 psi GPa	1.6 11.0	1.24 8.5	D2105
Longitudinal Poisson's Ratio	-	0.37	0.41	
Hydrostatic Design Basis(cyclic) (at 150°F(66•C))	10^3 psi MPa	6.0 41.4		D2992(A)
Beam Apparent Elastic Modulus	10^6 psi GPa	1.7 11.7	1.0 6.9	D2925
	Value			
Flow Coefficient	Hazen Williams 150			
Thermal Conductivity Pipe Wall	BTU-in./(hr.ft.^{2}°F) W/M °C		2.3 0.33	
Grounding Resistance at 1500 volts	10^6 ohms		1.0 max.	
Coefficient of Thermal Expansion,Linear	10^{-6}in./in.°F 10^{-6}mm/mm/ 24°C		10 18	D696

The pipe shall meet or exceed the requirements of MIL-P-29206A and ASTM 05677-95. Pipe dimensions must conform to Iron Pipe Size (IPS) outside diameters. In sizes 2" through 16" the piping must be rated for a minimum internal pressure rating of 165 psig at 200°F. In 2" through 16" sizes the pipe shall have full vacuum capabilities at 70°F when installed above ground.

Pipe shall be manufactured in accordance with ASTM 02996 Specifications for RTRP, with designations as follows:

2", 3"	RTRP-11AE-1112	8",10",12"	RTRP-11AE-1114
4", 6"	RTRP-11AE-1113	14"	RTRP-11AE-1115
		16"	RTRP-11AE-1116

Materials

Pipe Construction

The conductive filament wound fiberglass reinforced epoxy resin pipe shall be Bondstrand 7000 as manufactured by FGS Fiberglass Pipe Group or approved equal. The piping system will be made electrically continuous by using conductive filaments in the pipe wall,conductive adhesive in the bonded joints,and may be grounded by use of filament wound fiberglass saddles with stainless steel grounding cable. External or field installed techniques such as conductive wire or mesh, for achieving conductivity along the length of the pipe shall not be allowed.

Structural wall

The pipe shall have the following nominal wall thickness:

Nominal Pipe Diameter	Nominal Wall Thickness	
in	in	mm
2	0.16	4.1
3	0.16	4.1
4	0.20	5.2
6	0.20	5.2
8	0.25	6.3
10	0.32	8.1
12	0.38	9.6
14	0.41	10.4
16	0.47	11.9

Pipe end preparation options

The piping manufacturer will provide standard pipe joint lengths up to 30 feet RL in sizes 2” through 8” to reduce field labor assembly time The pipe manufacturer will prepare the bell end and the spigot end of each joint in the factory to reduce field labor assembly time.

Fittings

It is important to maintain compatibility of fittings, piping and adhesives to ensure that the system performs as specified. Pipe, fittings and adhesive shall be supplied by the same manufacturer.

Fittings will be constructed with epoxy resin and conductive material, filament wound to specific dimensions. Flanges will be filament wound with epoxy resin and conductive filaments.

Spray up or hand lay-up fittings shall not be allowed.

Testing

The RTRP manufacturer will provide test and repair procedures in the event field repairs are required. The installed piping shall be hydrostatically tested with water at 1½ times the design pressure of the lowest rated piping system component.

Hydrostatic and conductivity testing of buried systems will be completed prior to backfill.

Installation

Installation procedures and techniques as well as system design criteria including burial, anchoring, guiding and supporting shall be in accordance with manufacturer’s recommendations.

Piping system installers and fitters will be trained by a direct factory employee of the piping system manufacturer and certified by the trainer prior to system assembly in the field.

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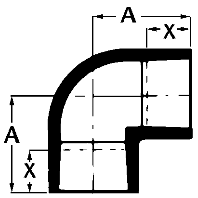
NOV Fiber Glass Systems

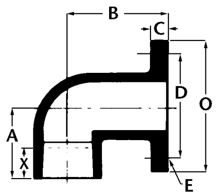
CI7001 - April 2013

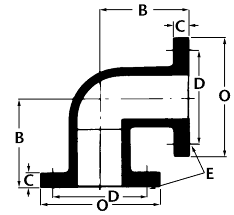
EPOXY FITTINGS NOMINAL DIMENSIONS

2”-16” Green Thread™ HP fittings are be used with both Green Thread HP and Red Thread™ HP piping. Refer to “Chemical Resistance Guide”, Bulletin No. ENG5615, for chemical recommendations.
2”-16” Red Thread HP fittings may be used only on Red Thread HP piping.
1”-1½” fittings are available in Green Thread HP products only. All fitting ratings are for 200°F (93°C). Red Thread fittings are serviceable up to 210°F (98.9°C) by applying a 0.92 de-rating factor. Green Thread fittings are serviceable up to 230°F (110°C) by applying a 0.76 de-rating factor.

90º ELBOWS(1) 1”-16” parts are available in Green Thread HP only.





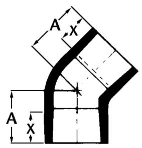


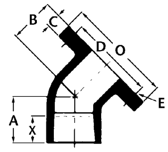
Pipe Size	A	B	C	D	E Bolt Hole Size	O(3)	X(2) GT Pipe	X(2) RT Pipe	Wt. BxB	Wt. BxF	Wt. FxF	Steady Pressure
in	in	in	in	in	in	in	in	in	lbs	lbs	lbs	psig
1	2 ¾	3 ½	¾	3 ⅛	⅝ - 4 holes	4 ¼	1	-	0.4	1.0	1.7	435
1 ½	3 ⅜	4	¾	3 ⅞	⅝ - 4 holes	5	1 ⅛	-	0.6	1.5	2.4	435
2	3 ⅜	4 ½	¾	4 ¾	¾ - 4 holes	6	1 ⅝	1 ⅝	1.2	2.5	3.6	435
3	4 ⅝	5 ½	1 ⅜	6	¾ - 4 holes	7 ½	1 ⅞	1 ¾	2.3	4.6	10.0	435
4	5 ⅛	6 ½	1 ⅜	7 ½	¾ - 8 holes	9	2	1 ⅝	3.3	6.4	15.9	232
6	6 ⅛	8	1 ½	9 ½	⅞ - 8 holes	11	2 ¼	2 ¼	7.2	11.8	15.9	232
8	11 ⅝	9	1 ¾	11 ¾	⅞ - 8 holes	13 ½	3	3 ⅜	10.9	15.4	19.9	232
10	13	11	2	14 ¼	1 - 12 holes	16	3 ¼	3 ½	14.9	23.8	32.8	232
12	14	12	2 ¼	17	1 - 12 holes	19	3 ⅜	3 ⅞	22.6	38.3	54.0	232
14	19	14	2 ½	18 ¾	1⅛ - 12 holes	20 ¾	5 ⅜	5 ½	26.5	45.0	65.0	232
16	20 ¼	15	2 ½	21 ¼	1⅛ - 16 holes	23 ¼	5 ½	5 ½	45.0	65.0	108.0	232

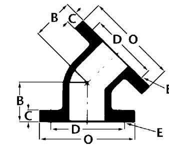
mm	mm	mm	mm	mm	mm	mm	mm	mm	kg	kg	kg	bar
25	70	89	19	79	16 - 4 holes	108	25	-	0.18	0.45	0.77	30
40	86	102	19	98	16 - 4 holes	127	29	-	0.27	0.68	1.09	30
50	86	114	19	121	19 - 4 holes	152	41	41	0.54	1.13	1.63	30
80	117	140	35	152	19 - 4 holes	190	48	44	1.04	2.09	4.54	30
100	130	165	35	190	19 - 8 holes	229	51	41	1.50	2.90	7.21	16
150	156	203	38	241	22 - 8 holes	279	57	57	3.27	5.35	7.21	16
200	295	229	44	298	22 - 8 holes	343	76	86	4.94	6.99	9.02	16
250	330	279	51	362	25 - 12 holes	406	83	89	6.76	10.80	14.88	16
300	356	305	57	432	25 - 12 holes	483	86	98	10.25	17.37	24.49	16
350	483	356	64	476	29 - 12 holes	527	137	140	12.02	20.41	29.48	16
400	514	381	64	540	29 - 16 holes	591	140	140	20.41	29.48	48.99	16

(1) ”A” dimensions shown are for GREEN THREAD HP fittings. 1”-6” fittings are compression molded; 8”-16” fittings are filament wound. 1”-6” filament wound fittings are in CI1370.
(2) Nominal make-up dimension for drawing layout work only using non-threaded spigots. Do not use for assembly dimensions.
(3) Flanges should be joined to flat-faced flanges. When joining to raised-faced flange connections, consult installation or engineering manuals. Bolt torque, gasket thickness and hardness recommendations are in Manual INS6000.

45º ELBOWS(1) 1”-16” parts are available in Green Thread HP only.







Pipe Size	A	B	C	D	E Bolt Hole Size	O(3)	X (2) GT Pipe	X (2) RT Pipe	Wt. BxB	Wt. BxF	Wt. FxF	Steady Pressure
in.	in.	in.	in.	in.	in.	in.	in.	in.	lbs.	lbs.	lbs.	psig
1	2 ⅜	2	¾	3 ⅛	⅝ - 4 holes	4 ¼	1	-	0.3	0.8	1.4	435
1 ½	2 ⅞	2 ¼	¾	3 ⅞	⅝ - 4 holes	5	1 ⅛	-	0.4	1.2	2.0	435
2	2 ⅝	2 ½	¾	4 ¾	¾ - 4 holes	6	1 ⅝	1 ⅝	0.9	1.9	2.8	435
3	3 ¾	3	1⅜	6	¾ - 4 holes	7 ½	1 ⅞	1 ¾	1.6	3.5	7.9	435
4	3 ⅞	4	1⅜	7 ½	¾ - 8 holes	9	2	1 ⅝	2.4	5.1	13.1	232
6	4 ⅜	5	1½	9 ½	⅞ - 8 holes	11	2 ¼	2 ¼	4.8	8.4	12.5	232
8	8 ⅛	5 ½	1 ¾	11 ¾	⅞ - 8 holes	13 ½	3	3 ⅜	6.9	11.9	16.8	232
10	8 ⅝	6 ½	2	14 ¼	1 - 12 holes	16	3 ¼	3 ½	8.9	18.5	28.2	232
12	9 ½	7 ½	2 ¼	17	1 - 12 holes	19	3 ⅜	3 ⅞	14.0	32.6	47.2	232
14	12 ½	7 ½	2 ½	18 ¾	1 ⅛ - 12 holes	20 ¾	5 ⅜	5 ½	17.0	46.0	73.0	232
16	13 ¼	8	2 ½	21 ¼	1 ⅛ - 16 holes	23 ¼	5 ½	5 ½	25.0	56.0	84.0	232

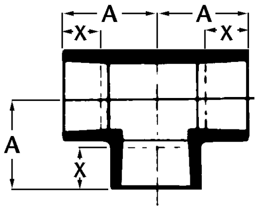
mm	mm	mm	mm	mm	mm	mm	mm	mm	kg	kg	kg	bar
25	60	51	19	79	16 - 4 holes	108	25	-	0.14	0.36	0.64	30
40	73	57	19	98	16 - 4 holes	127	29	-	0.18	0.54	0.91	30
50	67	64	19	121	19 - 4 holes	152	41	41	0.41	0.86	1.27	30
80	95	76	35	152	19 - 4 holes	190	48	44	0.73	1.59	3.58	30
100	98	102	35	190	19 - 8 holes	229	51	41	1.09	2.31	5.94	16
150	111	127	38	241	22 - 8 holes	279	57	57	2.18	3.81	5.67	16
200	206	140	44	298	22 - 8 holes	343	76	86	3.11	5.40	7.62	16
250	219	165	51	362	25 - 12 holes	406	83	89	4.04	8.39	12.79	16
300	241	190	57	432	25 - 12 holes	483	86	98	6.35	14.78	21.41	16
350	318	191	64	476	29 - 12 holes	527	137	140	7.71	20.87	33.11	16
400	337	203	64	540	29 - 16 holes	591	140	140	11.3	25.40	38.10	16

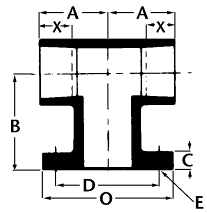
(1) ”A” dimensions shown are for GREEN THREAD HP fittings. 1”-6” fittings are compression molded; 8”-16” fittings are filament wound. 1”-6” filament wound fittings are in CI1370.

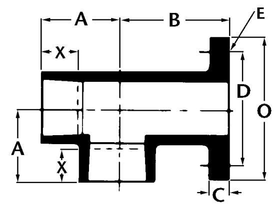
(2) Nominal make-up dimension for drawing layout work only using non-threaded spigots. Do not use for assembly dimensions.

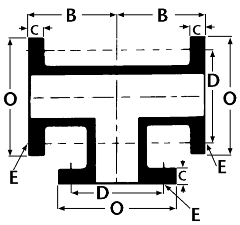
(3) Flanges should be joined to flat-faced flanges. When joining to raised-faced flange connections, consult installation or engineering Manuals INS1000 & ENG1000. Bolt torque, gasket thickness and hardness recommendations are in Manual INS1000.

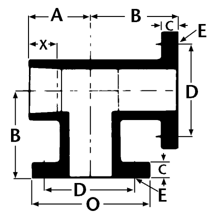
TEES(1) 1”-16” parts are available in Green Thread HP only.

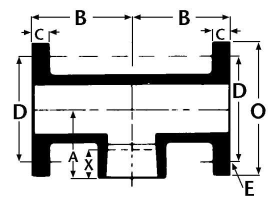










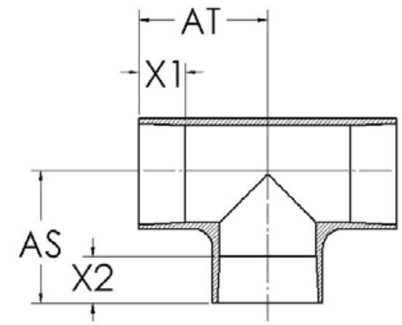


Pipe Size	A	B	C	D	E Bolt Hole Size	O(3)	X (2) GT Pipe	X (2) RT Pipe	Wt. 3B	Wt. 1F	Wt. 2F	Wt. 3F	Steady Pressure
in.	in.	in.	in.	in.	in.	in.	in.	in.	lbs.	lbs.	lbs.	lbs.	psig
1	2 ¾	3 ½	¾	3 ⅛	⅝ - 4 holes	4 ¼	1	-	0.5	1.1	1.8	2.5	435
1 ½	3 ⅜	4	¾	3 ⅞	⅝ - 4 holes	5	1 ⅛	-	0.9	1.9	2.8	3.6	435
2	3 ⅜	4 ½	¾	4 ¾	¾ - 4 holes	6	1 ⅝	1 ⅝	1.9	3.1	4.8	5.5	435
3	4 ⅝	5 ½	1 ⅜	6	¾ - 4 holes	7 ½	1 ⅞	1 ¾	3.6	5.8	8.0	14.5	435
4	5 ⅛	6 ½	1 ⅜	7 ½	¾ - 8 holes	9	2	1 ⅝	4.9	8.0	11.3	22.7	232
6	6 ⅛	8	1 ½	9 ½	⅞ - 8 holes	11	2 ¼	2 ¼	10.1	14.3	19.0	22.3	232
8	11 ⅝	9	1 ¾	11 ¾	⅞ - 8 holes	13 ½	3	3 ⅜	16.1	20.4	24.6	28.9	232
10	13	11	2	14 ¼	1 - 12 holes	16	3 ¼	3 ½	26.2	34.1	42.0	49.8	232
12	14	12	2 ¼	17	1 - 12 holes	19	3 ⅜	3 ⅞	31.8	47.1	62.5	77.8	232
14	19	14	2 ½	18 ¾	1 ⅛ - 12 holes	20 ¾	5 ⅜	5 ½	52.0	75.5	99.5	127.0	232
16	20 ¼	15	2 ½	21 ¼	1 ⅛ - 16 holes	23 ¼	5 ½	5 ½	68.0	107.0	135.0	170.0	232

mm	mm	mm	mm	mm	mm	mm	mm	mm	kg	kg	kg	kg	bar
25	70	89	19	79	16 - 4 holes	108	25	-	0.2	0.5	0.8	1.1	30
40	86	102	19	98	16 - 4 holes	127	29	-	0.4	0.9	1.3	1.6	30
50	86	114	19	121	19 - 4 holes	152	41	41	0.9	1.4	2.2	2.5	30
80	117	127	35	152	19 - 4 holes	190	48	44	1.6	2.6	3.6	6.6	30
100	130	165	35	190	19 - 8 holes	229	51	41	2.2	3.6	5.1	10.3	16
150	156	203	38	241	22 - 8 holes	279	57	57	4.6	6.5	8.6	10.1	16
200	295	229	44	298	22 - 8 holes	343	76	86	7.3	9.3	11.2	13.1	16
250	330	279	51	362	25 - 12 holes	406	83	89	11.9	15.5	19.1	22.6	16
300	356	305	57	432	25 - 12 holes	483	86	98	14.4	21.4	28.3	35.3	16
350	483	356	64	476	29 - 12 holes	527	137	140	23.6	34.2	45.1	57.6	16
400	514	381	64	540	29 - 16 holes	591	140	140	30.8	48.5	61.2	77.1	16

(1) ”A” dimensions shown are for Green Thread HP fittings. 1”-6” fittings are compression molded; 8”-16” fittings are filament wound. 1”-6” filament wound fittings are in CI1370.
(2) Nominal make-up dimension for drawing layout work only using non-threaded spigots. Do not use for assembly dimensions.
(3) Flanges should be joined to flat-faced flanges. When joining to raised-faced flange connections, consult installation or engineering Manuals INS1000 & ENG1000. Bolt torque, gasket thickness and hardness recommendations are in Manual INS1000.

REDUCING TEES

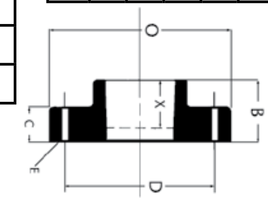


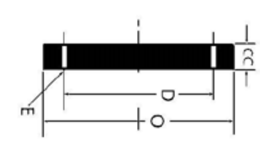
Size	AT	X_1 GT Pipe(1)	X_1 RT Pipe(1)	AS	X_2 GT Pipe(1)	X_2 RT Pipe(1)	Wgt.	Steady Pressure	Size	AT	X_1 GT Pipe(1)	X_1 RT Pipe(1)	AS	X_2 GT Pipe(1)	X_2 RT Pipe(1)	Wt.	Steady Pressure
in.	in.	in.	in.	in.	in.	in.	lbs.	psig	mm	mm	mm	mm	mm	mm	mm	kg	bar
8x6	11 ⅝	3	3 ⅜	10 ¼	2 ⅞	2 ⅞	23	232	200x150	295	76	86	260	73	73	10.4	16
8x4	11 ⅝	3	3 ⅜	10 ¼	4 ⅜	4	21	232	200x100	295	76	86	260	111	102	9.5	16
8x3	11 ⅝	3	3 ⅜	9 ⅞	3	2 ⅞	20	232	200x80	295	76	86	251	76	73	9.1	16
8x2	11 ⅝	3	3 ⅜	9 13/16	1 ½	1 ½	19	232	200x50	295	76	86	249	38	38	8.6	16
10x8	13 1/16	3 ¼	3 ½	13 ⅝	3	3 ⅜	39	232	250x200	332	83	89	346	76	86	17.7	16
10x6	13 1/16	3 ¼	3 ½	11 ¾	2 ⅞	2 ⅞	36	232	250x150	332	83	89	298	73	73	16.3	16
10x4	13 1/16	3 ¼	3 ½	11 ¾	4 ⅜	4	33	232	250x100	332	83	89	298	111	102	14.9	16
10x3	13 1/16	3 ¼	3 ½	11 ⅜	3	2 ⅞	32	232	250x80	332	83	89	289	76	73	14.5	16
12x10	13 15/16	3 ⅜	3 ⅞	15 1/16	3 ¼	3 ½	51	232	300x250	354	86	98	383	83	89	23.1	16
12x8	13 15/16	3 ⅜	3 ⅞	15 ⅛	3	3 ⅜	48	232	300x200	354	86	98	383	76	86	21.8	16
12x6	13 15/16	3 ⅜	3 ⅞	13 ¼	2 ⅞	2 ⅞	45	232	300x150	354	86	98	337	73	73	20.4	16
12x4	13 15/16	3 ⅜	3 ⅞	13 ¼	4 ⅜	4	42	232	300x100	354	86	98	337	111	101	19.1	16
14x12	19 1/16	5 ⅜	5 ½	15 15/16	3 ⅜	3 ⅞	67	232	350x300	484	137	140	405	86	98	30.4	16
14x10	19 1/16	5 ⅜	5 ½	15 9/16	3 ¼	3 ½	64	232	350x250	484	137	140	395	83	89	29.0	16
14x8	19 1/16	5 ⅜	5 ½	15 ⅝	3	3 ⅜	60	232	350x200	484	137	140	390	76	86	27.2	16
14x6	19 1/16	5 ⅜	5 ½	13 ¾	2 ⅞	2 ⅞	57	232	350x150	484	137	140	349	73	73	25.9	16
16x14	20 ¼	5 ½	5 ½	19 ½	5 ⅜	5 ½	103	232	400x350	514	140	140	495	137	140	46.7	16
16x12	20 ¼	5 ½	5 ½	16 15/16	3 ⅜	3 ⅞	99	232	400x300	514	140	140	430	86	98	44.9	16
16x10	20 ¼	5 ½	5 ½	16 ⅝	3 ¼	3 ½	94	232	400x250	514	140	140	422	83	89	42.6	16
16x8	20 ¼	5 ½	5 ½	16 ⅝	3	3 ⅜	90	232	400x200	514	140	140	422	76	86	40.8	16

(1) Nominal make-up dimension for drawing layout work only using non-threaded spigots. Do not use for assembly dimensions.

FLANGES

All flanges meet ANSI B16.5 Class 150 Bolt Hole Standards. The following flanges are available as standard parts:		
Flanges:	1"-12" Green Thread HP	Compression Molded (M) or Filament Wound (FW)
	2"-6" Red Thread HP	Filament Wound (FW)
	14"-16" Red Thread or Green Thread HP	Filament Wound (FW)
Blind Flanges:	1"-12" Green Thread HP	Compression Molded (M)
	14"-16" Red Thread or Green Thread HP	Contact Molded (M)





Pipe Size	B	C	CC	D	E Bolt Hole Size	O	X[1] for GT Pipe		X[1] for RT Pipe		Bolt Torque [2]		Weight Flange		Wt. Blind Flg.	Steady Pressure Rating		
							M	FW	M	FW	Min.	Max.	M	FW		M	FW	Blind[3]
in	in	in	in	in	in - no.		in	in	in	in	ft-lbs		lbs	lbs	lbs	psig		
1	1 3/4	3/4	3/4	3 1/8	5/8 - 4 holes	4 1/4	1	1	-	-	20	25	0.6	0.6	0.8	435	435	300
1 1/2	1 3/4	3/4	3/4	3 7/8	5/8 - 4 holes	5	1	1 1/8	-	-	20	25	0.9	0.9	0.9	435	435	300
2	2 1/4	3/4	3/4	4 3/4	3/4 - 4 holes	6	1 5/8	1 5/8	1 5/8	1 5/8	25	30	1.3	1.3	1.3	435	435[4]	300
3	2 5/8	1 3/8	1	6	3/4 - 4 holes	7 1/2	1 7/8	1 7/8	1 3/4	1 3/4	25	30	2.6	3.4	3.0	435	300[4]	300
4	2 5/8	1 3/8	1	7 1/2	3/4 - 8 holes	9	2	2 3/8	1 5/8	1 5/8	25	30	3.6	4.9	4.0	232	232[4]	150
6	3	1 1/2	1 1/8	9 1/2	7/8 - 8 holes	11	2 1/2	2 1/4	2 1/4	2 1/4	25	30	4.4	6.5	6.6	232	232[4]	150
8	4	1 3/4	1 1/8	11 3/4	7/8 - 8 holes	13 1/2	2 3/8	2 1/8	2 7/8	2 5/8	80	100	9.3	11.0	10.6	232	232	135
10	4 3/4	2	1 1/4	14 1/4	1 - 12 holes	16	3 7/8	3 1/8	4 1/8	3 3/8	80	100	16.0	15.8	16.3	232	232	95
12	5	2 1/4	1 1/4	17	1 - 12 holes	19	3 7/8	2 7/8	4	3 1/8	80	100	24.0	25.8	24.0	232	232	65
14	3 1/8	2 1/2	1 7/8	18 3/4	1 1/8 - 12 holes	20 3/4	-	3	-	3	80	100	-	30.7	44.8	-	232	150
16	3 1/8	2 1/2	2 1/4	21 1/4	1 1/8 - 16 holes	23 1/4	-	3	-	3	80	100	-	37.0	67.3	-	232	150

mm	mm	mm	mm	mm	mm	mm	mm[1]	mm[1]	mm[1]	mm[1]		N-m[2]	kg	kg	kg	bar	bar	bar
25	44	19	19	79	16 D - 4 holes	108	25	25	-	-	27	34	0.27	0.27	0.36	30	30	20.7
40	44	19	19	98	16 D - 4 holes	127	25	29	-	-	27	34	0.41	0.41	0.41	30	30	20.7
50	57	19	19	121	19 D - 4 holes	152	41	41	41	41	34	41	0.59	0.59	0.59	30	30[4]	20.7
80	67	35	25	152	19 D - 4 holes	191	48	48	44	44	34	41	1.18	1.54	1.36	30	21[4]	20.7
100	67	35	25	191	19 D - 8 holes	229	51	60	41	41	34	41	1.63	2.22	1.81	16	16[4]	10.3
150	76	38	29	241	22 D - 8 holes	279	64	57	57	57	34	41	2.00	2.95	2.99	16	16[4]	10.3
200	102	44	29	298	22 D - 8 holes	343	60	54	73	67	41	135	4.22	4.99	4.81	16	16	9.3
250	121	51	32	362	25 D - 12 holes	406	98	79	105	86	108	135	7.26	7.17	7.39	16	16	6.5
300	127	57	32	432	25 D - 12 holes	483	98	73	102	79	108	135	10.89	11.70	10.89	16	16	4.5
350	79	64	48	476	28 D - 12 holes	527	-	76	-	76	108	135	-	13.93	20.32	-	16	10.3
400	79	64	57	540	28 D - 16 holes	594	-	76	-	76	108	135	-	16.78	30.53	-	16	10.3

Heavy Duty Flange Dimensions		
Sizes	B	C
In	In	In
2	3	2 3/4
3	3 1/4	3
4	4 3/4	3 1/2
6	4 1/4	4

(1)Nominal make-up dimension for drawing layout work only using non-threaded spigots. Do not use for assembly dimension

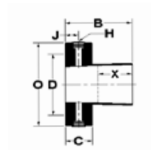
(2) Flanges should be joined to flat-faced flanges. When joining to raised-faced flange connections, consult FGS installation or engineering Manuals INS1000 & ENG1000. Bolt torque, gasket thickness and hardness recommendations are in Manual INS1000.

(3)Steel back-up plates must be used to achieve pressure ratings equivalent to the pipe.

(4)Heavy duty ANSI 16.5 Class 150 and 300 flanges rated to 450 psig (3.10 MPa) are available. Dimensions are shown in the "Heavy Duty Flange Dimensions" table. The maximum bolt torque for 2"-6" is 100 ft. lbs.

ORIFICE FLANGES (2”-8” parts are available in Green Thread HP only)

Orifice Flange



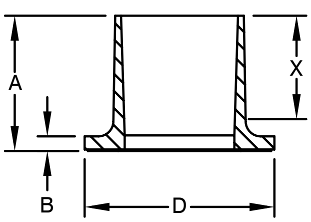
Note: the 2” orifice flange has only one orifice

Pipe Size	B	C	D	E Bolt Hole Size	H	J	O	X(1) GT Pipe	X(1) RT Pipe	Flange Bolt-Torque(2) ft-lbs		Wt.	Steady Pressure
in	in	in	in	in	in	in	in	in	in	To Seal	Max.	lbs	psig
2	4 ¼	2	4 ¾	¾ - 4 holes	½ NPT	1	6	1 ⅝	1 ⅝	25	30	3.6	435
3	5	2	6	¾ - 4 holes	½ NPT	1	7 ½	1 ⅞	1 ⅜	25	30	5.3	435
4	5	2	7 ½	¾ - 8 holes	½ NPT	1	9	1 ⅝	2	25	30	6.6	232
6	6	2	9 ½	⅞ - 8 holes	½ NPT	1	11	2 ¼	2 ¼	25	30	8.8	232
8	8 ¾	2	11 ¾	⅞ - 8 holes	½ NPT	1	13 ½	3 ⅛	3 ½	30	100	14.5	232

mm	mm	mm	mm	mm	mm	mm	mm	mm(1)	mm(1)	N-m(2)	N-m(2)	kg	bar
50	108	51	121	19 - 4 holes	12.7 NPT	25	152	41	41	34	41	1.6	30
80	127	51	152	19 - 4 holes	12.7 NPT	25	191	48	35	34	41	2.4	30
100	127	51	191	19 - 8 holes	12.7 NPT	25	229	41	51	34	41	3.0	16
150	152	51	241	22 - 8 holes	12.7 NPT	25	279	57	57	34	41	4.0	16
200	222	51	298	22 - 8 holes	12.7 NPT	25	343	79	89	41	135	6.6	16

(1) Nominal make-up dimension for drawing layout work only using non-threaded spigots.
Do not use for assembly dimensions.
(2) Flanges should be joined to flat-faced flanges. When joining to raised-faced flange connections, consult installation or engineering Manuals INS1000 & ENG1000.
Gasket thickness and hardness recommendations are in Manual INS1000.

STUB ENDS

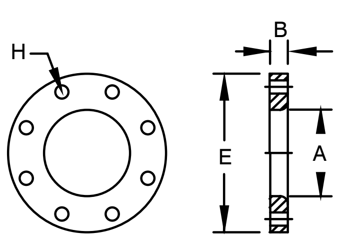


Nominal Pipe Size	Pressure Rating	Bolt Torque	A	B	D	X	Wgt.
in	psi	ft-lb	in	in	in	in	lbs.
2	250	66	2.75	0.27	3.91	2.13	0.5
3	200	66	2.88	0.28	5.16	2.26	0.7
4	150	66	2.88	0.28	6.66	2.10	1.0
6	150	111	3.88	0.39	8.53	3.69	2.4

mm	bar	kg-mm	mm	mm	mm	mm	kg
50	17	98	70	7	99	54	0.22
80	14	98	73	7	131	57	0.31
100	10	98	73	7	169	53	0.45
150	10	165	99	10	217	94	1.08

FLANGE RINGS

ANSI B16.5 Class 150

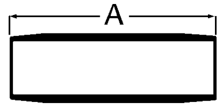


Nominal Pipe Size	A	B	E	Bolt Hole Size	No. of Holes	Wgt.
in	in	in	in	in	#	lbs.
2	2.78	0.82	6.00	3/4	4	1.10
3	3.90	1.10	7.50	3/4	4	2.10
4	4.90	1.10	9.00	3/4	8	2.90
6	7.26	1.25	11.00	7/8	8	3.80

mm	mm	mm	mm	mm	#	kg
50	71	21	152	19	4	0.50
70	99	28	191	19	4	0.95
100	124	28	229	19	8	1.32
150	184	32	279	22	8	1.73

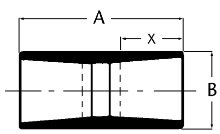
NIPPLES

GT - Green Thread HP
RT - Red Thread HP
- Standard Available Size



Size	Close		4”		6”		8”		10”		12”		16”		24”		36”	
In.	GT	RT	GT	RT	GT	RT	GT	RT	GT	RT	GT	RT	GT	RT	GT	RT	GT	RT
1	2 ½	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-
1 ½	3 ⅛	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-
2	4 ½	X	-	X(3)	X	X	X	X	-	X	-	X	-	-	-	-	-	-
3	5 ⅛	5 ⅛	-	-	X	X(4)	X	X	-	X	-	X	-	-	-	-	-	-
4	5 ⅜	5 ⅜	-	-	X	X	X	X	-	X	-	X	-	-	-	-	-	-
6	6 ⅛	6 ⅛	-	-	X(4)	X(5)	X	X	-	X	X	X	-	-	-	-	-	-
8	8 ⅝	9 ⅜	-	-	-	-	-	-	-	-	X	X	X	X	-	X	-	-
10	9 ⅜	9 ⅜	-	-	-	-	-	-	-	-	X	X	X	X	-	X	-	X
12	9 ⅜	10 ¼	-	-	-	-	-	-	-	-	X	X	X	X	-	X	-	X
14	-	X	-	-	-	-	-	-	-	-	-	-	X	X	-	X	-	X
16	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	X	-	□

SLEEVE COUPLINGS



(3)Actual length 4 ¼”
(4)Actual length 6 ¼”
(5)Actual length 6 ⅛”

Green Thread HP Couplings

Pipe Size	A	B	X(1)	Wt.	Steady Pressure
in.	in.	in.	in.	lbs.	psig
1	2 ¾	1 ½	1	0.1	435
1 ½	3 ¼	2	1 ⅛	0.1	435
2	4 ⅞	2 ⅝	1 ⅝	0.4	435
3	5	3 ¾	2	0.8	435
4	5	4 ¾	2	0.9	232
6	7	6 ⅞	2 ¼	1.9	232
8	10	9	3 ⅛	3.4	232
10	10 ½	11	3 ⅛	5.2	232
12	11	13 ⅛	3 ¼	7.5	232
14	12 ½	15	3 ⅞	11.2	232
16	13	17 ⅛	4 ⅛	16.0	232

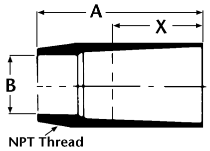
mm	mm	mm	mm(1)	kg	bar
25	70	38	25	0.05	30
40	83	52	29	0.05	30
50	124	67	41	0.18	30
80	127	95	51	0.36	30
100	127	121	51	0.41	16
150	178	175	57	0.86	16
200	254	229	79	1.54	16
250	268	279	79	2.36	16
300	279	333	83	3.40	16
350	318	381	98	5.08	16
400	330	435	105	7.26	16

Red Thread HP Couplings

Pipe Size	A	B	X(1)	Wt.	Steady Pressure
in.	in.	in.	in.	lbs.	psig
1	-	-	-	-	-
1 ½	-	-	-	-	-
2	6	2 ⅝	1 ⅝	0.4	435
3	6	3 ¾	1 ⅞	0.8	435
4	7	4 ⅞	2	1.4	435
6	8 ⅜	7 ⅛	2 ¾	2.8	435
8	10	9	2 ⅞	3.3	232
10	10 ½	11 ⅛	3 ⅜	4.7	232
12	11	13 ⅛	3 ½	6.8	232
14	12 ½	15	4	11.2	232
16	13	17 ⅛	4 ⅛	16.0	232

mm	mm	mm	mm(1)	kg	bar
25	-	-	-	-	-
40	-	-	-	-	-
50	152	67	41	0.18	30
80	152	95	48	0.36	30
100	178	124	51	0.64	30
150	213	181	70	1.27	30
200	254	229	73	1.50	16
250	268	283	86	2.13	16
300	279	333	89	3.08	16
350	318	381	102	5.08	16
400	330	435	105	7.26	16

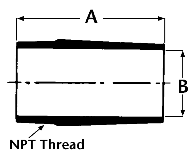
ADAPTERS - 1” and 1 ½” parts are available in Green Thread only; 2”-8” parts are available in Green Thread or Red Thread HP



Bell X Male

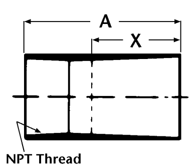
(1) Nominal make-up dimension for drawing layout work only using non-threaded spigots. Do not use for assembly dimensions.

Pipe Size	A	B	X(1) GT Pipe	X(1) RT Pipe	Wt. GT	Wg. RT	Steady Pressure	Pipe Size	A	B	X(1) GT Pipe	X(1) RT Pipe	Wt. GT	Wt. RT	Steady Pressure
in.	in.	in.	in.	in.	lbs.	lbs.	psig	mm	mm	mm	mm	mm	kg	kg	bar
1	3 ½	1	1	-	0.1	-	435	25	89	25	25	-	0.05	-	30
1 ½	3 ¾	1 ½	1 ⅛	-	0.3	-	435	40	99	38	29	-	0.14	-	30
2	4 ¼	2	1 ⅝	1 ⅜	0.4	0.3	435	50	108	51	41	35	0.18	0.14	30
3	5 ½	3	1 ⅞	1 ⅜	0.9	0.6	300	80	140	76	48	35	0.41	0.27	20.7
4	5 ½	4	2	1 ⅝	1.6	1.0	232	100	140	102	51	41	0.73	0.45	16
6	6	6	2 ¼	2 ¼	2.6	1.8	232	150	152	152	57	57	1.18	0.82	16
8	9 ¼	8	3 ⅛	3 ½	7.2	6.6	232	200	235	203	79	89	3.27	2.99	16



Spigot X Male

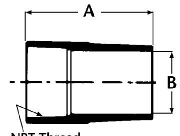
Pipe Size	A	B	X(1) GT Pipe	X(1) RT Pipe	Wt. GT	Wt. RT	Steady Pressure	Pipe Size	A	B	X(1) GT Pipe	X(1) RT Pipe	Wt. GT	Wt. RT	Steady Pressure
in.	in.	in.	in.	in.	lbs.	lbs.	psig	mm	mm	mm	mm	mm	kg	kg	bar
1	2 ⅝	1	-	-	0.1	-	435	25	67	25	-	-	0.05	-	30
1 ½	2 ¾	1 ¼	-	-	0.3	-	435	40	70	38	-	-	0.14	-	30
2	3 ⅝	2	-	-	0.4	0.3	435	50	92	51	-	-	0.18	0.1	30
3	4 ⅝	3	-	-	0.9	0.6	300	80	117	76	-	-	0.41	0.2	20.7
4	4 ⅞	4	-	-	1.1	1.0	232	100	124	102	-	-	0.50	0.4	16
6	6 ⅞	6	-	-	2.6	2.0	232	150	175	152	-	-	1.18	0.9	16
8	8	8	-	-	5.6	4.9	232	200	203	203	-	-	2.54	2.2	16



Bell X Female

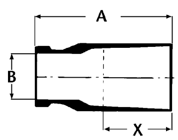
Pipe Size	A	B	X(1) GT Pipe	X(1) RT Pipe	Wt. GT	Wgt. RT	Steady Pressure	Pipe Size	A	B	X(1) GT Pipe	X(1) RT Pipe	Wt. GT	Wt. RT	Steady Pressure
in.	in.	in.	in.	in.	lbs.	lbs.	psig	mm	mm	mm	mm	mm	kg	kg	bar
1	2 ⅝	-	1	-	0.1	-	435	25	67	-	25	-	0.05	-	30
1 ½	2 ¾	-	1 ⅛	-	0.3	-	435	40	70	-	29	-	0.14	-	30
2	3 ½	-	1 ⅝	1 ⅜	0.6	0.3	435	50	89	-	41	35	0.27	0.1	30
3	4 ½	-	1 ⅞	1 ⅜	0.6	0.5	300	80	114	-	48	35	0.27	0.2	20.7
4	4 ½	-	2	1 ⅝	0.6	0.5	232	100	114	-	51	41	0.27	0.2	16
6	5 ½	-	2 ¼	2 ¼	1.9	1.3	232	150	140	-	57	57	0.86	0.6	16
8	7	-	3 ⅛	3 ½	5.1	3.5	150	200	178	-	79	89	2.31	1.6	10.3

ADAPTERS - 1” and 1½” parts are available in Green Thread only; 2”-8” parts are available in Green Thread or Red Thread HP; 10” and 12” are available in Red Thread HP.



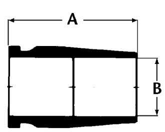
Spigot X Female

Pipe Size	A	B	X(1) GT Pipe	X(1) RT Pipe	Wt. GT	Wt. RT	Steady Pressure	Pipe Size	A	B	X(1) GT Pipe	X(1) RT Pipe	Wt. GT	Wt. RT	Steady Pressure
in.	in.	in.	in.	in.	lbs.	lbs.	psig	mm	mm	mm	mm	mm	kg	kg	bar
1	3 ⅝	1	-	-	0.2	-	435	25	92	25	-	-	0.09	-	30
1 ½	4	1 ½	-	-	0.3	-	435	40	102	38	-	-	0.14	-	30
2	3 ⅞	2	-	-	0.4	0.3	435	50	98	51	-	-	0.18	0.14	30
3	4 ¾	3 ⅛	-	-	0.8	0.5	290	80	121	76	-	-	0.36	0.23	20.7
4	4 ⅞	4 ⅛	-	-	1.0	.6	232	100	124	102	-	-	0.45	0.27	16
6	6 ¾	6	-	-	3.4	2.6	232	150	171	152	-	-	1.54	1.18	16
8	10	8	-	-	8.0	7.1	150	200	254	203	-	-	3.63	3.22	10



Bell X Grooved(2)

Pipe Size	A	B	X(1) GT Pipe	X(1) RT Pipe	Wt. GT	Wt. RT	Steady Pressure	Pipe Size	A	B	X(1) GT Pipe	X(1) RT Pipe	Wt. GT	Wt. RT	Steady Pressure
in.	in.	in.	in.	in.	lbs.	lbs.	psig	mm	mm	mm	mm	mm	kg	kg	bar
1	3 ½	⅞	1	-	0.3	-	435	25	89	22	25	-	0.14	-	30
1 ½	3 ⅞	1½	1 ⅛	-	0.5	-	435	40	98	38	29	-	0.23	-	30
2	4 ¼	2	1 ⅝	1 ⅜	0.5	0.3	435	50	108	51	41	35	0.23	0.14	30
3	5	3	1 ⅞	1 ⅜	0.9	0.6	290	80	127	76	48	35	0.41	0.27	20.7
4	5	4	2	1 ⅝	1.0	0.8	232	100	127	102	51	41	0.45	0.63	16
6	5 ⅝	6	2 ¼	2 ¼	2.3	1.8	232	150	143	152	57	57	1.04	0.84	16
8	8 ¼	8	3 ⅛	3 ½	5.8	4.9	232	200	210	203	79	89	2.63	2.22	16
10	8 ¼	10 ⅛	-	3 ¾	-	6.3	190	250	210	257	-	95	-	2.86	13.1

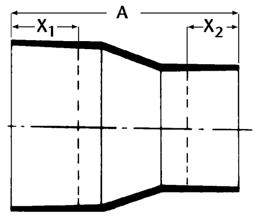


Spigot X Grooved(2)

Pipe Size	A	B	X(1) GT Pipe	X(1) RT Pipe	Wt. GT	Wt. RT	Steady Pressure	Pipe Size	A	B	X(1) GT Pipe	X(1) RT Pipe	Wt. GT	Wg. RT	Steady Pressure
in.	in.	in.	in.	in.	lbs.	lbs.	psig	mm	mm	mm	mm	mm	kg	kg	bar
1	2 ¾	⅞	-	-	0.1	-	435	25	70	22	-	-	0.05	-	30
1 ½	3 ⅛	1 ½	-	-	0.2	-	435	40	79	38	-	-	0.09	-	30
2	3 ⅝	2	-	-	0.3	0.3	435	50	92	51	-	-	0.14	0.14	30
3	4 ¼	3	-	-	0.9	0.6	290	80	127	76	-	-	0.41	0.27	20
4	4 ½	4	-	-	1.0	0.9	232	100	114	102	-	-	0.45	0.41	16
6	5	6	-	-	2.6	2.0	232	150	127	152	-	-	1.18	0.91	16
8	7	8	-	-	4.4	4.1	232	200	178	203	-	-	2.00	1.86	16
10	7	10 ⅛	-	-	-	5.6	190	250	178	257	-	-	-	2.54	13.1
12	7	12	-	-	-	6.8	150	300	178	305	-	-	-	3.08	10.3

(1) Nominal make-up dimension for drawing layout work only using non-threaded spigots. Do not use for assembly dimensions.
(2) Compatible with Victaulic® HP70ES couplings.

CONCENTRIC REDUCERS (1”-16 parts are available in Green Thread HP only.)

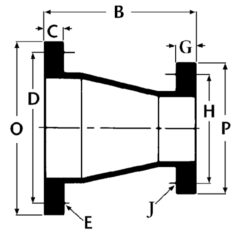


Bell x Bell

Pipe Size	A	X_1 [1] GT Pipe	X_2 [1] GT Pipe	X_1 [1] RT Pipe	X_2 [1] RT Pipe	Wt.	Steady Pressure	Pipe Size	A	X_1 [1] GT Pipe	X_2 [1] GT Pipe	X_1 [1] RT Pipe	X_2 [1] RT Pipe	Wt.	Steady Pressure
in.	in.	in.	in.	in.	in.	lbs.	psig	mm	mm	mm	mm	mm	mm	kg	bar
2x1	5 ½	1 ⅝	1	1 ⅝	NA	0.6	435	50x25	140	41	25	41	NA	0.27	30
2x1 ½	5	1 ⅝	1 ⅛	1 ⅝	NA	0.6	435	50x40	127	41	29	41	NA	0.27	30
3x1	6 ¼	1 ⅞	1	1 ⅞	NA	1.0	435	80X25	159	48	25	48	NA	0.45	30
3x1 ½	6 ¼	1 ⅞	1 ⅛	1 ¾	NA	1.1	435	80x40	159	48	29	44	NA	0.50	30
3x2	6	1⅞	1 ⅛	1 ⅞	1⅝	1.1	435	80x50	152	48	29	48	41	0.50	30
4X1 ½	7 ⅜	2	1 ⅛	1 ⅝	NA	1.8	232	100X40	187	51	29	41	NA	0.82	16
4x2	8¼	2	1 ⅝	1 ⅝	1 ⅝	2.0	232	100x50	210	51	41	41	41	0.91	16
4x3	7	2	1 ⅞	1 ⅝	1 ⅞	1.7	232	100x80	178	51	48	41	48	0.77	16
6x3	10 ⅞	2 ⅞	1 ⅞	2 ⅞	1 ⅞	4.3	232	150x80	276	73	48	73	48	1.95	16
6x4	9	2 ¼	2	2 ¼	1 ⅝	3.4	232	150x100	229	57	51	57	41	1.54	16
8x4	14	3	2	3 ⅜	1 ⅝	6.7	232	200x100	356	76	51	86	41	3.04	16
8x6	15 ¼	3	2 ⅞	3 ⅜	2 ⅞	7.3	232	200x150	387	76	73	86	73	3.31	16
10x6	15 ¼	3 ¼	2 ⅞	3 ½	2 ⅝	10.5	232	250x150	387	83	73	89	67	4.76	16
10x8	16 ½	3 ¼	3	3 ½	3 ⅜	11.1	232	250x200	419	83	76	89	86	5.03	16
12x8	18 ⅜	3 ⅜	3	3 ⅞	3 ⅜	17.0	232	300x200	467	86	76	98	86	7.71	16
12x10	17 ¾	3 ⅜	3 ¼	3 ⅞	3 ½	16.4	232	300x250	451	86	83	98	89	7.44	16
14x10	22 ⅞	5 ⅜	3 ¼	5 ½	3 ½	21.9	232	350x250	581	137	83	140	89	9.93	16
14x12	22 ¾	5 ⅜	3 ⅜	5 ½	3 ⅞	21.8	232	350x300	578	137	86	140	98	9.89	16
16x12	25	5 ½	3 ⅜	5 ½	3 ⅞	27.7	232	400x300	635	140	86	140	98	12.56	16
16x14	28	7 ¼	7	7 ¼	7	31.1	232	400x350	711	184	178	184	178	14.11	16

NOTE: MULTI-STEP reducers are available through 16” sizes. Information is available on request.
(1) Nominal make-up dimension for drawing layout work only using non-threaded spigots. Do not use for assembly dimensions.
(2) Flanges should be joined to flat-faced flanges. When joining to raised-faced flange connections, consult installation or engineering manuals. Bolt torque, gasket thickness and hardness recommendations are in manual INS1000.
These comments also apply to the flanged concentric reducers on the following page.

CONCENTRIC REDUCERS (1”-16” parts are available in Green Thread HP only.)

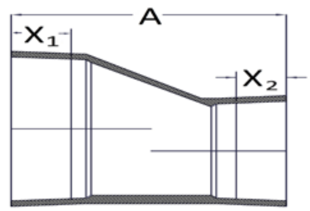


Flanged[(2)]

Pipe Size	B	C	D	E Bolt Hole Size	O	G	H	J Bolt Hole Size	P	Wt.	Steady Pressure
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	lbs.	psig
2x1	5	¾	4 ¾	¾ - 4 holes	6	¾	3 ⅞	⅝ - 4 holes	4 ¼	2.6	300
2x1½	5	¾	4 ¾	¾ - 4 holes	6	¾	3 ⅞	⅝ - 4 holes	5	2.6	300
3x1½	6	1 ⅜	6	¾ - 4 holes	7 ½	¾	4 ¾	¾ - 4 holes	5	4.4	190
3x2	6	1 ⅜	6	¾ - 4 holes	7 ½	¾	4 ¾	¾ - 4 holes	6	4.4	190
4x2	7	1 ⅜	7 ½	¾ - 8 holes	9	1 ⅜	6	¾ - 4 holes	6	7.1	150
4x3	7	1 ⅜	7 ½	¾ - 8 holes	9	1 ⅜	6	¾ - 4 holes	7 ½	7.1	150
6x3	9	1 ½	9 ½	⅞ - 8 holes	11	1 ⅜	7 ½	¾ - 8 holes	7 ½	11.0	150
6x4	9	1 ½	9 ½	⅞ - 8 holes	11	1 ⅜	7 ½	¾ - 8 holes	9	11.0	150
8x4	11	1 ¾	11 ¾	⅞ - 8 holes	13 ½	1 ½	9 ½	⅞ - 8 holes	9	17.6	232
8x6	11	1 ¾	11 ¾	⅞ - 8 holes	13 ½	1 ½	9 ½	⅞ - 8 holes	11	17.6	232
10x6	12	2	14 ¼	1 - 12 holes	16	1 ¾	11 ¾	⅞ - 8 holes	11	28.2	232
10x8	12	2	14 ¼	1 - 12 holes	16	1 ¾	11 ¾	⅞ - 8 holes	13 ½	28.2	232
12x8	14	2 ¼	17	1 - 12 holes	19	2	14 ¼	1 - 12 holes	13 ½	43.0	232
12x10	14	2 ¼	17	1 - 12 holes	19	2	14 ¼	1 - 12 holes	16	43.0	232
14x10	16	2 ½	18 ¾	1 ⅛ - 12 holes	20 ¾	2 ¼	17	1 - 12 holes	16	55.0	232
14x12	16	2 ½	18 ¾	1 ⅛ - 12 holes	20 ¾	2 ¼	17	1 - 12 holes	19	55.0	232
16x12	18	2 ½	21 ¼	1 ⅛ - 16 holes	23 ¼	2 ½	18 ¾	1⅛ - 12 holes	19	89.5	232
16x14	18	2 ½	21 ¼	1 ⅛ - 16 holes	23 ¼	2 ½	18 ¾	1⅛ - 12 holes	20 ¾	89.5	232

mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	kg	bar
50x25	127	19	121	19 - 4 holes	152	19	98	16 - 4 holes	108	1.18	20.7
50x40	127	19	121	19 - 4 holes	152	19	98	16 - 4 holes	127	1.18	20.7
80x40	152	35	152	19 - 4 holes	191	19	121	19 - 4 holes	127	2.00	13.1
80x50	152	35	152	19 - 4 holes	191	19	121	19 - 4 holes	152	2.00	13.1
100x50	178	35	191	19 - 8 holes	229	35	152	19 - 4 holes	152	3.22	10.3
100x80	178	35	191	19 - 8 holes	229	35	152	19 - 4 holes	191	3.22	10.3
150x80	229	38	241	22 - 8 holes	279	35	191	19 - 8 holes	191	4.99	10.3
150x100	229	38	241	22 - 8 holes	279	35	191	19 - 8 holes	229	4.99	10.3
200x100	279	44	298	22 - 8 holes	343	38	241	22 - 8 holes	229	7.98	16
200x150	279	44	298	22 - 8 holes	343	38	241	22 - 8 holes	279	7.98	16
250x150	305	51	362	25 - 12 holes	406	44	298	22 - 8 holes	279	12.79	16
250x200	305	51	362	25 - 12 holes	406	44	298	22 - 8 holes	343	12.79	16
300x200	356	57	432	25 - 12 holes	483	51	362	25 - 12 holes	343	19.50	16
300x250	356	57	432	25 - 12 holes	483	51	362	25 - 12 holes	406	19.50	16
350x250	406	64	476	29 - 12 holes	527	57	432	25 - 12 holes	406	24.95	16
350x300	406	64	476	29 - 12 holes	527	57	432	25 - 12 holes	483	24.95	16
400x305	457	64	540	29 - 16 holes	591	64	476	29 - 12 holes	483	40.60	16
406x350	457	64	540	29 - 16 holes	591	64	476	29 - 12 holes	527	40.60	16

ECCENTRIC REDUCERS (1”-16” parts are available in Green Thread HP only.)

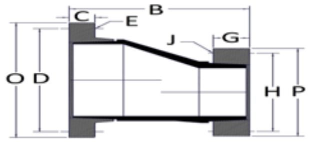


Bell x Bell

Pipe Size	A	X_1 (1) GT Pipe	X_2 (1) GT Pipe	X_1 (1) RT Pipe	X_2 (1) RT Pipe	Wt.	Steady Pressure	Pipe Size	A	X_1 (1) GT Pipe	X_2 (1) GT Pipe	X_1 (1) RT Pipe	X_2 (1) RT Pipe	Wt.	Steady Pressure
in.	in.	in.	in.	in.	in.	lbs.	psig	mm	mm	mm	mm	mm	mm	kg	bar
2x1	5 ½	1 ⅝	1	1 ⅝	NA	0.6	435	50x25	140	41	25	41	NA	0.27	30
2x1½	5 ½	1 ⅝	1 ⅛	1 ⅝	NA	0.6	435	50x40	140	41	29	41	NA	0.27	30
3x1	6 ¼	1 ⅞	1	1 ⅞	NA	1.0	435	80X25	159	48	25	48	NA	0.45	30
3x1½	6 ¼	1 ⅞	1 ⅛	1 ¾	NA	1.1	435	80x40	159	48	29	44	NA	0.50	30
3x2	7 1/8	1⅞	1 ⅛	1 ⅞	1⅝	1.1	435	80x50	181	48	29	48	41	0.50	30
4X1½	7 ⅜	2	1 ⅛	1 ⅝	NA	1.8	232	100X40	187	51	29	41	NA	0.82	16
4x2	8¼	2	1 ⅝	1 ⅝	1 ⅝	2.0	232	100x50	210	51	41	41	41	0.91	16
4x3	8	2	1 ⅞	1 ⅝	1 ⅞	1.7	232	100x80	203	51	48	41	48	0.77	16
6x3	10 ⅞	2 ⅞	1 ⅞	2 ⅞	1 ⅞	4.3	232	150x80	276	73	48	73	48	1.95	16
6x4	10 ¾	2 ¼	2	2 ¼	1 ⅝	3.4	232	150x100	273	57	51	57	41	1.54	16
8x4	14	3	2	3 ⅜	1 ⅝	6.7	232	200x100	356	76	51	86	41	3.04	16
8x6	15 ¼	3	2 ⅞	3 ⅜	2 ⅞	7.3	232	200x150	387	76	73	86	73	3.31	16
10x6	15 ¼	3 ¼	2 ⅞	3 ½	2 ⅝	10.5	232	250x150	387	83	73	89	67	4.76	16
10x8	16 ½	3 ¼	3	3 ½	3 ⅜	11.1	232	250x200	419	83	76	89	86	5.03	16
12x8	18 ⅜	3 ⅜	3	3 ⅞	3 ⅜	17.0	232	300x200	467	86	76	98	86	7.71	16
12x10	17 ¾	3 ⅜	3 ¼	3 ⅞	3 ½	16.4	232	300x250	451	86	83	98	89	7.44	16
14x10	22 ⅞	5 ⅜	3 ¼	5 ½	3 ½	21.9	232	350x250	581	137	83	140	89	9.93	16
14x12	22 ¾	5 ⅜	3 ⅜	5 ½	3 ⅞	21.8	232	350x300	578	137	86	140	98	9.89	16
16x12	25	5 ½	3 ⅜	5 ½	3 ⅞	27.7	232	400x300	635	140	86	140	98	12.56	16
16x14	28	7 ¼	7	7 ¼	7	31.1	232	400x350	711	184	178	184	178	14.11	16

NOTE: MULTI-STEP reducers are available through 16” sizes. Information is available on request.
(1) Nominal make-up dimension for drawing layout work only using non-threaded spigots. Do not use for assembly dimensions.
(2) Flanges should be joined to flat-faced flanges. When joining to raised-faced flange connections, consult installation or engineering manuals. Bolt torque, gasket thickness and hardness recommendations are in manual INS1000.
These comments also apply to the flanged concentric reducers on the following page.

ECCENTRIC REDUCERS (1”-16” parts are available in Green Thread HP only.)

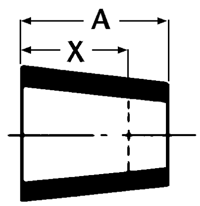


Flanged[(2)]

Pipe Size	B	C	D	E Bolt Hole Size	O	G	H	J Bolt Hole Size	P	Wt.	Steady Pressure
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	lbs.	psig
2x1	5	¾	4 ¾	¾ - 4 holes	6	¾	3 ⅞	⅝ - 4 holes	4 ¼	2.6	300
2x1½	5	¾	4 ¾	¾ - 4 holes	6	¾	3 ⅞	⅝ - 4 holes	5	2.6	300
3x1	6	1 ⅜	6	¾ - 4 holes	7 ½	¾	4 ¾	¾ - 4 holes	5	4.4	190
3x1½	6	1 ⅜	6	¾ - 4 holes	7 ½	¾	4 ¾	¾ - 4 holes	5	4.4	190
3x2	6	1 ⅜	6	¾ - 4 holes	7 ½	¾	4 ¾	¾ - 4 holes	6	4.4	190
4x1½	7	1 ⅜	7 ½	¾ - 8 holes	9	1 ⅜	6	¾ - 4 holes	6	7.1	150
4x2	7	1 ⅜	7 ½	¾ - 8 holes	9	1 ⅜	6	¾ - 4 holes	6	7.1	150
4x3	7	1 ⅜	7 ½	¾ - 8 holes	9	1 ⅜	6	¾ - 4 holes	7 ½	7.1	150
6x3	9	1 ½	9 ½	⅞ - 8 holes	11	1 ⅜	7 ½	¾ - 8 holes	7 ½	11.0	150
6x4	9	1 ½	9 ½	⅞ - 8 holes	11	1 ⅜	7 ½	¾ - 8 holes	9	11.0	150
8x4	11	1 ¾	11 ¾	⅞ - 8 holes	13 ½	1 ½	9 ½	⅞ - 8 holes	9	17.6	232
8x6	11	1 ¾	11 ¾	⅞ - 8 holes	13 ½	1 ½	9 ½	⅞ - 8 holes	11	17.6	232
10x6	12	2	14 ¼	1 - 12 holes	16	1 ¾	11 ¾	⅞ - 8 holes	11	28.2	232
10x8	12	2	14 ¼	1 - 12 holes	16	1 ¾	11 ¾	⅞ - 8 holes	13 ½	28.2	232
12x8	14	2 ¼	17	1 - 12 holes	19	2	14 ¼	1 - 12 holes	13 ½	43.0	232
12x10	14	2 ¼	17	1 - 12 holes	19	2	14 ¼	1 - 12 holes	16	43.0	232
14x10	16	2 ½	18 ¾	1 ⅛ - 12 holes	20 ¾	2 ¼	17	1 - 12 holes	16	55.0	232
14x12	16	2 ½	18 ¾	1 ⅛ - 12 holes	20 ¾	2 ¼	17	1 - 12 holes	19	55.0	232
16x12	18	2 ½	21 ¼	1 ⅛ - 16 holes	23 ¼	2 ½	18 ¾	1⅛ - 12 holes	19	89.5	232
16x14	18	2 ½	21 ¼	1 ⅛ - 16 holes	23 ¼	2 ½	18 ¾	1⅛ - 12 holes	20 ¾	89.5	232

mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	kg	bar
50x25	127	19	121	19 - 4 holes	152	19	98	16 - 4 holes	108	1.18	20.7
50x40	127	19	121	19 - 4 holes	152	19	98	16 - 4 holes	127	1.18	20.7
80x25	375	35	152	19 - 4 holes	191	19	121	19 - 4 holes	127	2.00	13
80x40	152	35	152	19 - 4 holes	191	19	121	19 - 4 holes	127	2.00	13.1
80x50	152	35	152	19 - 4 holes	191	19	121	19 - 4 holes	152	2.00	13.1
100x40	391	35	191	19 - 8 holes	229	35	152	19 - 4 holes	152	3.20	10.0
100x50	178	35	191	19 - 8 holes	229	35	152	19 - 4 holes	152	3.22	10.3
100x80	178	35	191	19 - 8 holes	229	35	152	19 - 4 holes	191	3.22	10.3
150x80	229	38	241	22 - 8 holes	279	35	191	19 - 8 holes	191	4.99	10.3
150x100	229	38	241	22 - 8 holes	279	35	191	19 - 8 holes	229	4.99	10.3
200x100	279	44	298	22 - 8 holes	343	38	241	22 - 8 holes	229	7.98	16
200x150	279	44	298	22 - 8 holes	343	38	241	22 - 8 holes	279	7.98	16
250x150	305	51	362	25 - 12 holes	406	44	298	22 - 8 holes	279	12.79	16
250x200	305	51	362	25 - 12 holes	406	44	298	22 - 8 holes	343	12.79	16
300x200	356	57	432	25 - 12 holes	483	51	362	25 - 12 holes	343	19.50	16
300x250	356	57	432	25 - 12 holes	483	51	362	25 - 12 holes	406	19.50	16
350x250	406	64	476	29 - 12 holes	527	57	432	25 - 12 holes	406	24.95	16
350x300	406	64	476	29 - 12 holes	527	57	432	25 - 12 holes	483	24.95	16
400x305	457	64	540	29 - 16 holes	591	64	476	29 - 12 holes	483	40.60	16
406x350	457	64	540	29 - 16 holes	591	64	476	29 - 12 holes	527	40.60	16

REDUCER BUSHING

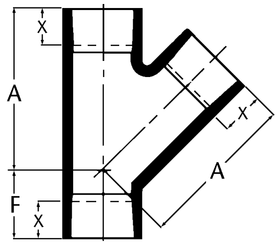


Reducer Bushing

Pipe Size	A	X(1) GT Pipe	X(1) RT Pipe	Wt.	Steady Pressure	Pipe Size	A	X(1) GT Pipe	X(1) RT Pipe	Wt.	Steady Pressure
in.	in.	in.	in.	lbs	psig	mm	mm	mm	mm	kg	bar
*	1 ⅛	-	-	0.1	435	*	29	-	-	0.05	30
**	1 ⅜	1	-	0.1	435	**	35	25	-	0.05	30
2x1	2 ¼	1	-	0.4	435	50x25	57	25	-	0.18	30
2x1 NPT	1 ¾	-	-	0.4	435	50x25	44	-	-	0.18	30
2x1¼ NPT	1 ¾	-	-	0.4	435	50x30	44	-	-	0.18	30
2x1 ½	2	1 ⅛	-	0.1	435	50x40	51	29	-	0.05	30
2x1 ½ NPT	1 ¾	-	-	0.1	435	50x40	44	-	-	0.05	30
3x2	2 ¼	1 ⅝	1 ⅝	0.8	435	80x50	57	41	41	0.36	30
4x3	2 ⅝	1 ⅞	1 ⅜	1.0	232	100x80	67	48	35	0.45	16
6x4	3 ⅛	2	1 ½	3.9	232	150x100	79	51	38	1.77	16
8x6	3 ¼	3	2 ⅜	6.8	232	200x150	83	76	60	3.08	16
10x8	4	2 ⅝	3	9.9	232	250x200	102	67	76	4.49	16
12x10	4 ½	3	3 ¼	11.8	232	300x250	114	76	83	5.35	16
14x12	5 ½	3 ⅞	4 ⅛	20.2	232	350x300	140	98	105	9.16	16
16x14	6	4 ½	4 ½	28.9	232	400x350	152	114	114	13.11	16

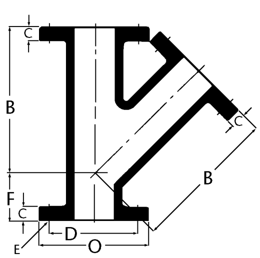
* 1x ¼ NPT, 1x ½ NPT, 1x ¾ NPT, 1 ½x ½ NPT, 1 ½x ¾ NPT
**1 ½x1NPT, 1 ½x1(X-GT), 1 ½x1 ¼ NPT
NOTE: MULTI-STEP and ECCENTRIC reducers are available through 16" sizes. Information available on request.
(1) Nominal make-up dimension for drawing layout work only using non-threaded spigots. Do not use for assembly dimensions.

LATERALS



45º Lateral Belled

Pipe Size	A	F	X[1] GT Pipe	X[1] RT Pipe	Wt.	Steady Pressure	Pipe Size	A	F	X[1] GT Pipe	X[1] RT Pipe	Wt.	Steady Pressure
in.	in.	in.	in.	in.	lbs.	psig	mm	mm	mm	mm	mm	kg	bar
1	3 ⅞	2 ½	1	-	0.6	150	25	98	64	25	-	0.27	10.3
1 ½	5 ¼	3 ¼	1	-	1.3	150	40	133	83	25	-	0.59	10.3
2	6 ⅝	2 ¾	1 ½	1 ½	4.1	150	50	168	70	38	38	1.86	10.3
3	7 ¾	4 ¼	1 ⅞	1 ¾	4.4	150	80	197	108	48	44	2.00	10.3
4	9	4 ⅜	2	1 ⅝	7.8	150	100	229	111	51	41	3.54	10.3
6	12 ½	5 ¾	2 ¼	2 ¼	13.7	135	150	318	146	57	57	6.21	9.3
8	16 ¼	7 ⅜	3 ⅛	3 ½	33.7	135	200	413	187	79	89	15.29	9.3
10	19 ⅝	8 ¾	3 ⅛	3 ⅜	53.3	120	250	498	222	79	86	24.17	8.3
12	24 ¾	11 ¾	3 ¼	3 ½	96.0	90	300	629	298	83	89	43.54	6.2
14	32 ½	15 ¾	3 ⅞	4	154.2	75	350	826	400	98	102	69.94	5.2
16	35 ¾	17 ¾	4 ⅛	4 ⅛	222.6	75	400	908	451	105	105	101	5.2



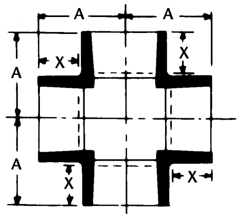
45º Lateral Flanged[2]

Pipe Size	B	C	D	E Bolt Hole Size	F	O	Wt.	Steady Press.	Pipe Size	B	C	D	E Bolt Hole Size	F	O	Wt.	Steady Press.
in.	in.	in.	in.	in.	in.	in.	lbs.	psig	mm	mm	mm	mm	mm	mm	mm	kg	bar
1	6	¾	3 ¼	⅝-4 holes	4 ½	4 ¼	2.8	150	25	152	19	83	16-4 holes	114	108	1.27	10.3
1 ½	8 ½	¾	3 ⅞	⅝-4 holes	5 ½	5	4.4	150	40	216	19	98	16-4 holes	140	127	2.00	10.3
2	8 ⅞	¾	4 ¾	¾-4 holes	6 ⅜	6	7.8	150	50	225	19	121	19-4 holes	162	152	3.54	10.3
3	11 ¾	1 ⅜	6	¾-4 holes	8	7 ½	13.4	150	80	298	35	152	19-4 holes	203	191	6.08	10.3
4	12 ⅞	1 ⅜	7 ½	¾-8 holes	8 ½	9	19.2	150	100	327	35	191	19-8 holes	216	229	8.71	10.3
6	18	1 ½	9 ½	⅞-8 holes	11	11	35	135	150	457	38	241	22-8 holes	279	279	15.9	9.3
8	21 ¾	1 ¾	11 ¾	⅞-8 holes	13 ¾	13 ½	65.3	135	200	552	44	298	22-8 holes	349	343	29.6	9.3
10	26 ⅝	2	14 ¼	1-12 holes	16 ⅝	16	112	120	250	676	51	362	25-12 holes	422	406	50.8	8.3
12	32	2 ¼	17	1-12 holes	20	19	172	90	300	813	57	432	25-12 holes	508	483	78	6.2
14	36	2 ½	18 ¾	1⅛-12 holes	22	20 ¾	209	75	350	914	64	476	29-12 holes	559	527	94.6	5.2
16	40	2 ½	21 ¼	1⅛-16 holes	24	23 ¼	267	75	400	1,016	64	540	29-16 holes	610	594	121	5.2

(1) Nominal make-up dimension for drawing layout work only using non-threaded spigots. Do not use for assembly dimensions.

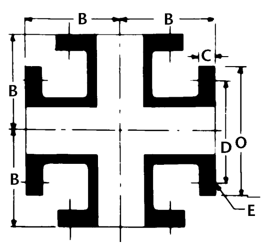
(2) Flanges should be joined to flat-faced flanges. When joining to raised-faced flange connections, consult installation or engineering Manuals INS1000 & ENG1000. Bolt torque, gasket thickness and hardness recommendations are in Manual INS1000.

CROSSES



Cross - Belled

Pipe Size	A	X(1) GT Pipe	X(1) RT Pipe	Wt.	Steady Pressure	Pipe Size	A	X(1) GT Pipe	X(1) RT Pipe	Wt.	Steady Pressure
in.	in.	in.	in.	lbs.	psig	mm	mm	mm	mm	kg	bar
1	2 ¾	1	-	1.4	300	25	70	25	-	0.64	20.7
1 ½	3 ⅜	1 ⅛	-	2.0	300	40	86	29	-	0.91	20.7
2	3 ⅜	1 ⅝	1 ½	3.4	300	50	86	41	38	1.54	20.7
3	4 ⅝	1 ⅞	1 ¾	8.5	190	80	117	48	44	3.86	13.1
4	5 ⅛	2	1 ⅝	10.7	150	100	130	51	41	4.85	10.3
6	6 ⅛	2 ¼	2 ¼	17.3	150	150	156	57	57	7.85	10.3
8	11 ⅝	3 ⅛	3 ½	30.8	150	200	295	79	89	13.97	10.3
10	13 ⅛	3 ¼	3 ½	42.7	150	250	333	83	89	19.37	10.3
12	14	3 ⅜	3 ⅞	73.2	150	300	356	86	98	33.20	10.3
14	16	3 ⅞	4	104	150	350	406	98	102	47.27	10.3
16	17 ¼	4 ⅛	4 ⅛	143	150	400	438	105	105	64.86	10.3

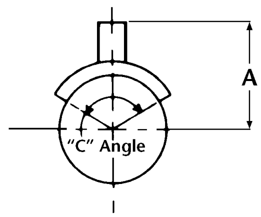


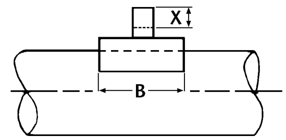
Cross - Flanged(2)

Pipe Size	B	C	D	E Bolt Hole Size	O	Wt.	Steady Pres-sure	Pipe Size	B	C	D	E Bolt Hole Size	O	Wt.	Steady Pres-sure
in.	in.	in.	in.	in.	in.	lbs.	psig	mm	mm	mm	mm	mm	mm	kg	bar
1	3 ½	¾	3 ⅛	⅝ -4 holes	4 ¼	3.8	300	25	89	19	79	16 -4 holes	108	1.7	20.7
1 ½	4	¾	3 ⅛	⅝ -4 holes	5	5.4	300	40	102	19	79	16 -4 holes	127	2.5	20.7
2	4 ½	¾	4 ¾	¾ -4 holes	6	8.6	300	50	114	19	121	19 -4 holes	152	3.9	20.7
3	5 ½	1 ⅜	6	¾ -4 holes	7 ½	15.1	190	80	140	35	152	19 -4 holes	191	6.8	13.1
4	6 ½	1 ⅜	7 ½	¾ -8 holes	9	22.8	150	100	165	35	191	19 -8 holes	229	10.3	10.3
6	8	1 ½	9 ½	⅞ -8 holes	11	34.9	150	150	203	38	241	22 -8 holes	279	15.8	10.3
8	9	1 ¾	11 ¾	⅞ -8 holes	13 ½	61.2	150	200	229	44	298	22 -8 holes	343	27.8	10.3
10	11	2	14 ¼	1 -12 holes	16	83.5	150	250	279	51	362	25 -12 holes	406	37.9	10.3
12	12	2 ¼	17	1 -12 holes	19	145	150	300	305	57	432	25 -12 holes	483	65.8	10.3
14	14	2 ½	18 ¾	1⅛ -12 holes	20 ¾	224	150	350	356	64	476	29 -12 holes	527	102	10.3
16	15	2 ½	21 ¼	1 ⅛ -16 holes	23 ¼	303	150	400	381	64	540	29 -16 holes	594	137	10.3

(1) Nominal make-up dimension for drawing layout work only using non-threaded spigots. Do not use for assembly dimensions.
(2) Flanges should be joined only to flat-faced flanges. When joining to raised-faced flange connections, consult installation or engineering Manuals INS1000 & ENG1000. Bolt torque, gasket thickness and hardness recommendations are in Manual INS1000.

SADDLES (Parts are available in Green Thread HP only.)



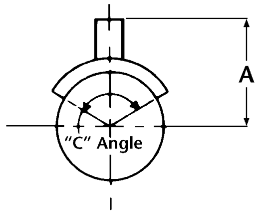


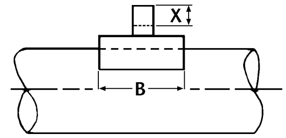
Belled Side Outlet

Size	A	B	C Angle	X[1] GT Pipe	X[1] RT Pipe	Wt.	Steady Pressure	Size	A	B	X[1] GT Pipe	X[1] RT Pipe	Wt.	Steady Pressure
in.	in.	in.	Degree	in.	in.	lbs.	psig	mm	mm	mm	mm	mm	kg	bar
2x1	2 ⅞	4	180	1	-	0.6	435	50x25	73	102	25	-	0.27	30
2x1 ½	2 ⅞	4	180	1 ⅛	-	0.5	232	50x40	73	102	29	-	0.23	16
3x1	3 ½	6	180	1	-	1.5	300	80x25	89	152	25	-	0.68	20.7
3x1 ½	3 ½	6	180	1 ⅛	-	0.9	232	80x40	89	152	29	-	0.41	16
3x2	4	6	180	1 ⅝	1 ⅝	1.4	232	80x50	102	152	41	41	0.64	16
4x1	4	6	180	1	-	1.4	232	100x25	102	152	25	-	0.64	16
4x1 ½	4	6	180	1 ⅛	-	1.5	232	100x40	102	152	29	-	0.68	16
4x2	4 ½	6	180	1 ⅝	1 ⅝	1.5	232	100x50	114	152	41	41	0.68	16
4x3	5 ¼	6	180	1 ⅞	1 ¾	1.6	200	100x80	133	152	48	44	0.73	13.8
6x1	5	6	120	1	-	1.4	232	150x25	127	152	25	-	0.64	16
6x1 ½	5	6	120	1 ⅛	-	1.3	232	150x40	127	152	29	-	0.59	16
6x2	5 ½	6	120	1 ⅝	1 ⅝	1.5	232	150x50	140	152	41	41	0.68	16
6x3	6 ¼	6	120	1 ⅞	1 ¾	1.6	150	150x80	159	152	48	44	0.73	10.3
6x4	6 ⅜	8	140	2	1 ⅝	2.4	125	150x100	162	203	51	41	1.09	8.6
8x1[2]	7 ⅛	9	120	1	-	3.1	232	200x25	181	229	25	-	1.41	16
8x1 ½[2]	7 ⅛	9	120	1 ⅛	-	2.8	232	200x40	181	229	29	-	1.27	16
8x2	7	9	180	1 ⅝	1 ⅝	2.7	232	200x50	178	229	41	41	1.22	16
10x1[2]	8 ⅛	9	95	1	-	3.1	232	250x25	206	229	25	-	1.41	16
10x1½[2]	8 ⅛	9	95	1 ⅛	-	2.8	232	250x40	206	229	29	-	1.27	16
10x2	8	9	180	1 ⅝	1 ⅝	2.7	232	250x50	203	229	41	41	1.22	16
10x3	9	14	150	1 ⅞	1 ¾	6.1	232	250x80	229	356	48	44	2.77	16
12x1[2]	9 ⅛	10	90	1	-	3.6	232	300x25	232	254	25	-	1.63	16
12x1½[2]	9 ⅛	10	90	1 ⅛	-	3.3	232	300x40	232	254	29	-	1.50	16
12x2	9	10	180	1 ⅝	1 ⅝	3.2	232	300x50	229	254	41	41	1.45	16
12x3	10	14	125	1 ⅞	1 ¾	6.1	232	300x80	254	356	48	44	2.77	16
12x4	9 ⅜	17	155	2	1 ⅝	8.6	232	300x100	238	432	51	41	3.90	16
14x1[2]	10	12	95	1	-	4.7	232	350x25	254	305	25	-	2.13	16
14x1½[2]	10	12	95	1 ⅛	-	4.4	232	350x40	254	305	29	-	2.00	16
14x2	10	12	95	1 ⅝	1 ⅜	4.3	232	350x50	254	305	41	35	1.95	16
14x3	10 ⅞	15	120	1 ⅞	1 ¾	6.9	232	350x80	276	381	48	44	3.13	16
14x4	10 ¼	17	135	2	1 ⅝	8.4	232	350x100	260	432	51	41	3.81	16
16x1[2]	11	13	90	1	-	5.4	232	400x25	279	330	25	-	2.45	16
16x1½[2]	11	13	90	1 ⅛	-	5.1	232	400x40	279	330	29	-	2.31	16
16x2	11	13	90	1 ⅝	1 ⅜	5	232	400x50	279	330	41	35	2.27	16

(1) Nominal make-up dimension for drawing layout work only using non-threaded spigots. Do not use for assembly dimensions.
(2) Saddle is manufactured by bonding a reducer bushing into a saddle with a 2" outlet.

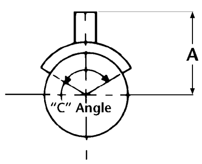
SADDLES, Continued (Parts are available in Green Thread HP only.)

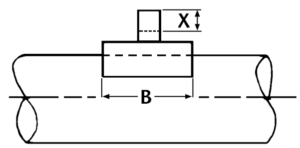




Size	A	B	C Angle	X(1) GT Pipe	X(1) RT Pipe	Wt.	Steady Pressure	Size	A	B	X(1) GT Pipe	X(1) RT Pipe	Wt.	Steady Pressure
in.	in.	in.	Degree	in.	in.	lbs.	psig	mm	mm	mm	mm	mm	kg	bar
16x3	11 ⅞	15	105	1 ⅞	1 ¾	6.9	232	400x80	302	381	48	44	3.13	16
16x4	11 ¼	17	120	2	1 ⅝	8.6	232	400x100	286	432	51	41	3.90	16

THREADED SIDE OUTLET NPT INTERNAL THREADS





Size	A	B	C Angle	Wt.	Steady Pressure	Size	A	B	Wt.	Steady Pressure
in.	in.	in.	Degree	lbs.	psig	mm	mm	mm	kg	bar
2x1	2 ⅞	4	180	0.6	435	50x25	73	102	0.27	30
2x1 ¼	2 ⅞	4	180	0.6	232	50x30	73	102	0.27	16
2x1 ½	2 ⅞	4	180	0.5	232	50x40	73	102	0.23	16
3x1	3 ½	6	180	1.1	300	80x25	89	152	0.50	20.7
3x1 ¼	3 ½	6	180	1.0	232	80x30	89	152	0.45	16
3x1 ½	3 ½	6	180	1.0	232	80x40	89	152	0.45	16
4x1	4	6	180	1.6	232	100x25	102	152	0.73	16
4x1 ¼	4	6	180	1.5	232	100x30	102	152	0.68	16
4x1 ½	4	6	180	1.4	232	100x40	102	152	0.64	16
6x1	5	6	120	1.5	232	150x25	127	152	0.68	16
6x1 ¼	5	6	120	1.4	232	150x30	127	152	0.64	16
6x1 ½	5	6	120	1.5	232	150x40	127	152	0.68	16
8x1	7 ⅛	9	120	3.1	232	200x25	181	229	1.41	16
10x1	8 ⅛	9	95	3.1	232	250x25	206	229	1.41	16
12x1	9 ⅛	10	90	3.6	232	300x25	232	254	1.63	16
14x1	10	12	95	4.7	232	350x25	254	305	2.13	16
16x1	11	13	90	5.4	232	400x25	279	330	2.45	16

Green Thread HP16 Branch Table

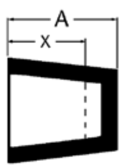
Header Diameter (inch)		Branch Diameter (inch)										
		1	1.5	2	3	4	6	8	10	12	14	16
	1	T	-	-	-	-	-	-	-	-	-	-
	1.5	RBT	T	-	-	-	-	-	-	-	-	-
	2	S	S/RBT	T	-	-	-	-	-	-	-	-
	3	S	S/RBT	S/RBT	T	-	-	-	-	-	-	-
	4	S	S	S/RBT	S*/RBT	T	-	-	-	-	-	-
	6	S	S	S	S*/RBT	S*/RBT	T	-	-	-	-	-
	8	S	S	S/T	T	T	T	T	-	-	-	-
	10	S	S	S/T	S/T	T	T	T	T	-	-	-
	12	S	S	S/T	S/T	S/T	T	T	T	T	-	-
	14	S	S	S	S/T	S/T	T	T	T	T	T	-
	16	S	S	S	S/T	S/T	T	T	T	T	T	T

S - Saddle, T - Tee, S/T - Tee or Saddle, S/RBT - Saddle or compression molded Tee with Reducer Bushing.

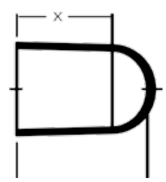
Notes:
1. In general, saddles are limited to branch sizes that are 1/3 of the header size or smaller.
2. Saddles are limited to outlet size of 6 inch or less.
3. Saddles are rated the same as Tees unless otherwise noted by *.

END CAPS (Parts are available in GREEN THREAD HP only.)

1"-4" End Cap



6"-16" End Cap



Pipe Size	A	X(1) GT Pipe	X(1) RT Pipe	Wt.	Steady Pressure	Pipe Size	A	X(1) GT Pipe	X(1) RT Pipe	Wt.	Steady Pressure
in.	in.	in.	in.	lbs.	psig	mm	mm	mm	mm	kg	bar
1	2 ¾	1	-	0.3	435	25	70	25	-	0.14	30
1 ½	2 ⅝	1 ⅛	-	0.6	435	40	67	29	-	0.27	30
2	2 ¾	1 ⅝	1 ⅝	1.4	435	50	70	41	41	0.64	30
3	3 ¼	1 ⅞	1 ¾	1.9	435	80	83	48	44	0.86	30
4	3 ¾	2	1 ⅝	3.0	232	100	95	51	41	1.36	16
6	7	2 ⅝	2 ½	4.2	232	150	178	67	64	1.91	16
8	8 ¾	2 ⅞	3 ½	5.6	232	200	222	60	86	2.54	16
10	9 ⅞	5 ⅜	5 ⅝	8.4	232	250	251	111	143	3.81	16
12	11	4 ⅝	4 7/8	12.5	232	300	279	95	124	5.67	16
14	12	5 ⅞	5 ⅞	15.6	232	350	305	137	140	7.08	16
16	13	5 ½	5 ½	19.5	232	400	330	140	140	8.85	16

(1) Nominal make-up dimension for drawing layout work only using non-threaded spigots. Do not use for assembly dimensions.

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Dubai, UAE
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NOV Fiber Glass Systems

CI1350ENG - November 2015

HP 16 Large Diameter (LD) Epoxy Fittings

(232 psi unless noted)

CHEMICAL & INDUSTRIAL

Standard 90° Elbow

(Bell x Bell)

Pipe Size		A		X[1]		Weight	
in	mm	in	mm	in	mm	lbs	kg
18	450	21.75	552	8.0	203	140	64
20	500	25.25	641	9.1	231	200	91
24	600	29.00	737	10.0	254	250	114
30	750	36.50	927	13.9	353	450	204
36	900	43.50	1,105	16.8	427	800	364

Standard 45° Elbow

(Bell x Bell)

Pipe Size		A		X[1]		Weight	
in	mm	in	mm	in	mm	lbs	kg
18	450	14.75	375	8.0	203	100	45
20	500	17.60	447	9.1	231	140	64
24	600	20.20	513	10.0	254	200	91
30	750	24.80	630	13.9	353	375	170
36	900	29.40	747	16.8	427	700	318
42	1050	35.30	897	18.7	475	1,100	500

30° Elbow

(Bell x Bell)

Pipe Size		A		X[1]		Weight	
in	mm	in	mm	in	mm	lbs	kg
30	750	21.90	556	13.9	353	300	136
36	900	25.90	658	16.8	427	600	272
42	1050	30.60	777	18.7	475	950	431

[1] This is a nominal make-up dimension for drawing layout work only. Do not use for assembly dimensions.

NOTE: When rated according to ASTM D5685 criteria, the pressure rating for 36" diameter and smaller fittings is 16 bar and the pressure rating for 42" is 14 bar.

When rated according to ISO 14692, the pressure rating for 30" and 36" is 14.7 bar and the pressure rating for 42" is 12.7 bar

Long Radius 90° Elbow

(Bell x Bell, Long Radius 1.5D)

Pipe Size		A		X[1]		Weight	
in	mm	in	mm	in	mm	lbs	kg
18	450	36.75	933	8.0	203	167	76
20	500	42.25	1,073	9.1	231	225	102
24	600	50.00	1,270	10.0	254	258	117

Long Radius 45° Elbow

(Bell x Bell, Long Radius 1.5D)

Pipe Size		A		X[1]		Weight	
in	mm	in	mm	in	mm	lbs	kg
18	450	20.90	531	8.0	203	100	45
20	500	24.70	627	9.1	231	135	61
24	600	28.90	734	10.0	254	155	70

22.5° Elbow

(Bell x Bell)

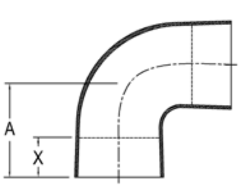
Pipe Size		A		X[1]		Weight	
in	mm	in	mm	in	mm	lbs	kg
30	750	20.50	521	13.9	353	250	113
36	900	24.30	617	16.8	427	525	238
42	1050	31.90	810	18.7	475	800	363

11.25° Elbow

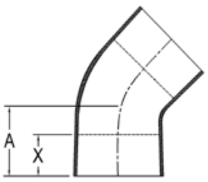
(Bell x Bell)

Pipe Size		A		X[1]		Weight	
in	mm	in	mm	in	mm	lbs	kg
30	750	19.10	485	13.9	353	225	102
36	900	22.30	566	16.8	427	450	204
42	1050	28.20	716	18.7	475	675	306

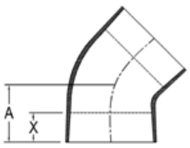
View of Fitting Illustrations



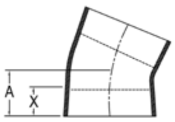
90° Elbow



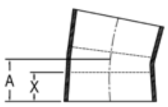
45° Elbow



30° Elbow



22.5° Elbow



11.25° Elbow

Tees

(Bell x Bell x Bell)

Pipe Size		A		X(1)		Weight	
in	mm	in	mm	in	mm	lbs	kg
18	450	22.38	568	8.0	203	320	145
20	500	26.25	667	9.1	231	360	163
24	600	28.00	711	10.0	254	450	204
30	750	36.50	927	13.9	353	750	340
36	900	40.50	1,029	16.8	427	1,200	545

Sleeve Coupling

(Bell x Bell)

Pipe Size		A		X(1)		Weight	
in	mm	in	mm	in	mm	lbs	kg
18	450	21.00	533	8.0	203	51	23
20	500	26.00	660	9.1	231	76	35
24	600	29.50	749	10.0	254	122	55
30	750	35.00	889	13.9	353	200	91
36	900	41.00	1,041	16.8	427	320	145
42	1050	46.00	1,168	18.7	475	500	227

Reducing Tees

Pipe Size		AT		AS		X_1(1)		X_2(1)		Weight	
in	mm	in	mm	in	mm	in	mm	in	mm	lbs	kg
18 x 14	450 x 350	22.38	568	20.50	521	8.0	203	6.4	163	280	127
18 x 16	450 x 400	22.38	568	21.00	533	8.0	203	6.6	167	300	136
20 x 16	500 x 400	26.25	667	22.50	572	9.1	231	6.6	167	320	145
20 x 18	500 x 450	26.25	667	22.75	578	9.1	231	8.0	203	340	154
24 x 18	600 x 450	28.00	711	25.25	641	10.0	254	8.0	203	400	182
24 x 20	600 x 500	28.00	711	27.75	705	10.0	254	9.1	231	420	191

Concentric Reducers

(Bell x Bell)

Pipe Size		A		X(1)		X(2)		Weight	
in	mm	in	mm	in	mm	in	mm	lbs	kg
18 x 16	450 x 400	28.75	730	8.0	203	6.8	173	110	50
20 x 18	500 x 450	32.00	813	9.1	231	8.0	203	140	64
24 x 20	600 x 500	46.25	1,175	10.0	254	9.1	231	190	86
30 x 24	750 x 600	50.50	1283	13.9	353	10.0	254	300	136
36 x 30	900 x 750	56.00	1422	16.8	427	13.9	352	450	205
42 x 36	1050 x 900	61.50	1562	18.7	475	16.8	428	750	340

Nipples

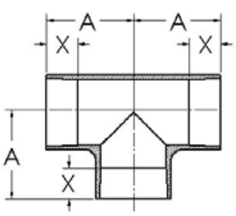
(X = Available Lengths)

Pipe Size		Overall Length		
in	mm	24" (610 mm)	36" (914 mm)	42" (1067 mm)
18	450	X	X	
20	500	X	X	
24	600		X	
30	750		X	
36	900			X
42	1050			X

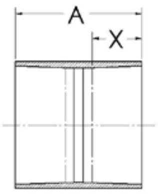
NOTE: When rated according to ASTM D5685 criteria, the pressure rating for 36" diameter and smaller fittings is 16 bar and the pressure rating for 42" is 14 bar.

When rated according to ISO 14692, the pressure rating for 30" and 36" is 14.7 bar and the pressure rating for 42" is 12.7 bar

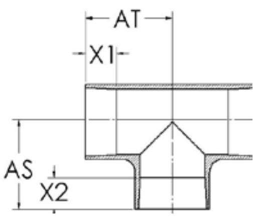
View of Fitting Illustrations



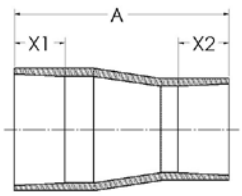
Tee



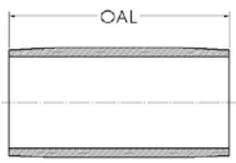
Sleeve Coupling



Reducing Tee



Concentric Reducer



Nipple

Flanges

(Filament Wound (FW) and Blind Flange ANSI B16.5 Class 150)

Pipe Size		B		C		CC		D		E Bold Hole Size Number of Bolts		O		FW Flange X[1]		Bolt Torque		FW Flange Weight		Blind Flange Weight	
in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	ft•lbs	N•m	lbs	kg	Blind	kg
18	450	9.0	229	2.75	70	2.50	64	22.75	578	1.25 - 16	32 - 16	25.0	635	6.8	173	200	271	76	35	125	57
20	500	11.0	279	2.75	70	2.75	70	25.00	635	1.25 - 20	32 - 20	27.5	699	7.8	198	200	271	92	42	140	64
24	600	13.0	330	3.00	76	3.31	84	29.50	749	1.38 - 20	35 - 20	32.0	813	9.5	241	200	271	124	56	155	70

[1] This is a nominal make-up dimension for drawing layout work only. Do not use for assembly dimensions.

Van Stone Flanges

(ANSI B16.5 Class 150 (18"-24"), ANSI B16.1 Class 125 (30"-42"))

Pipe Size		A		B		X[1]		D		E		F		G		H		I		Max. Bolt Torque		Nom. Weight Hub		Nom. Weight Bolt Ring	
in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	ft•lbs	N•m	lbs	kg	lbs	kg
18	450	21.4	545	19.9	506	7.5	191	9.00	229	8.50	216	2.25	57	1.25	32	22.75	578	25.00	635	200	271	39	18	98	44
20	500	23.7	602	21.9	557	8.5	216	9.88	251	9.38	238	2.25	57	1.25	32	25.00	635	27.50	699	200	271	53	24	114	52
24	600	28.1	713	25.9	658	10.0	254	11.75	298	11.25	286	2.25	57	1.38	35	29.50	749	32.00	813	200	271	79	36	140	64
30	750	34.6	880	N/A	N/A	10.0	254	10.00	254	9.50	241	2.25	57	1.38	35	36.00	914	38.75	984	400	543	121	55	192	87
36	900	41.1	1043	N/A	N/A	13.0	330	13.00	330	12.50	318	2.25	57	1.63	41	42.75	1,086	46.00	1,168	400	543	208	94	270	122
42	1050	47.8	1214	N/A	N/A	19.5	495	19.50	495	19.00	483	3.00	76	1.63	41	49.50	1,257	53.00	1,346	400	543	440	200	445	202

[1] All 18” - 42” (450-1050 mm) Van Stone Flanges will have to be custom fit to spigot.

Saddles

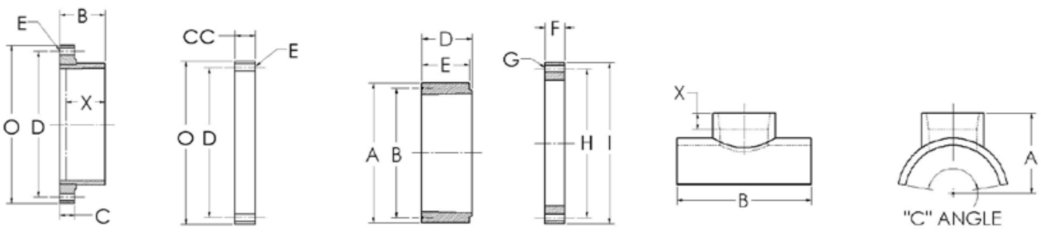
Pipe Size		A		B		C	X_1[1] W/RT Pipe		X_1[1] W/GT Pipe	
in	mm	in	mm	in	mm	deg	in	mm	lbs	kg
18 x 2	450 x 50	12.75	324	13	330	90	1.6	41	1.6	41
18 x 3	450 x 75	13.25	381	15	337	90	1.8	46	1.9	48
20 x 2	500 x 50	13.75	349	13	330	90	1.6	41	1.6	41
20 x 3	500 x 75	14.25	362	15	381	90	1.8	46	1.9	48
24 x 2	600 x 50	16.00	406	13	330	70	1.6	41	1.6	41
24 x 3	600 x 75	16.25	413	15	381	70	1.8	46	1.9	48

[1] This is a nominal make-up dimension for drawing layout work only. Do not use for assembly dimensions.

NOTE: When rated according to ASTM D5685 criteria, the pressure rating for 36” diameter and smaller fittings is 16 bar and the pressure rating for 42” is 14 bar.

When rated according to ISO 14692, the pressure rating for 30” and 36” is 14.7 bar and the pressure rating for 42” is 12.7 bar

View of Fitting Illustrations



Flange - Filament Wound / Blind **Van StoneFlange** **Saddle**

Fiber Glass Systems
17115 San Pedro Avenue, Ste 200
San Antonio, Texas 78232 USA
Phone: 210 477 7500
Fax: 210 477 7560

CI1351ENG June 2016

HP 25 Epoxy Fittings

(Filament wound with reinforced epoxy inner liner - Compatible with Red Thread and Green Thread HP 25 piping systems)

OIL & GAS MINING

90° Elbow

Pipe Size		A		X[1]		Weight	
in	**mm**	**in**	**mm**	**in**	**mm**	**lbs**	**kg**
2	50	6.31	160	2.44	62	8	4
3	80	7.94	202	2.46	63	14	6
4	100	9.75	248	2.98	76	22	10
6	150	12.81	325	2.70	69	28	13
8	200	19.50	495	5.87	149	40	18
10	250	23.25	591	6.79	172	60	27
12	300	27.00	686	7.43	189	90	41
14	350	30.00	762	6.87	175	135	61
16	400	34.00	864	7.65	194	180	82
18	450	40.75	1035	11.88	302	480	216
20	500	47.25	1200	13.92	354	550	250
24	600	57.00	1448	17.10	434	650	295

Tees

Pipe Size		A		X[1]		Weight	
in	**mm**	**in**	**mm**	**in**	**mm**	**lbs**	**kg**
2	50	5.56	141	2.44	62	13	6
3	80	6.25	159	2.46	63	21	9
4	100	7.44	189	2.98	76	29	13
6	150	9.56	243	2.70	69	36	16
8	200	13.50	343	5.87	149	60	27
10	250	15.75	400	6.79	172	90	41
12	300	17.00	432	7.43	189	130	59
14	350	19.50	495	6.87	175	190	86
16	400	21.25	540	7.65	194	250	113
18	450	26.38	670	11.88	302	600	272
20	500	31.25	794	13.92	354	700	318
24	600	35.00	889	17.10	434	800	363

45° Elbow

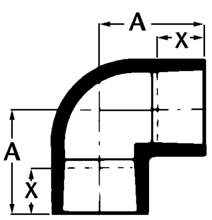
Pipe Size		A		X[1]		Weight	
in	**mm**	**in**	**mm**	**in**	**mm**	**lbs**	**kg**
2	50	4.55	116	2.44	62	6	3
3	80	5.25	133	2.46	63	10	5
4	100	6.25	159	2.98	76	17	8
6	150	7.50	191	2.70	69	21	9
8	200	12.47	317	5.87	149	24	11
10	250	14.46	367	6.79	172	36	16
12	300	16.46	418	7.43	189	50	23
14	350	17.70	450	6.87	175	85	38
16	400	19.94	506	7.65	194	120	54
18	450	24.93	633	11.88	302	290	132
20	500	29.68	754	13.92	354	330	150
24	600	35.91	912	17.10	434	400	181

Sleeve Couplings

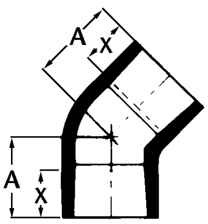
Pipe Size		A		X[1]		Weight	
in	**mm**	**in**	**mm**	**in**	**mm**	**lbs**	**kg**
2	50	6.00	152	1.61	41	1	0.5
3	80	6.00	152	1.72	44	3	1.5
4	100	7.00	178	2.52	64	7	3
6	150	8.38	213	2.97	75	14	6
8	200	12.50	318	4.77	121	15	7
10	250	16.50	419	5.87	149	17	8
12	300	18.00	457	6.52	166	25	11
14	350	16.00	406	6.30	160	30	14
16	400	18.00	457	5.75	146	36	16
18	450	29.00	737	11.88	302	125	57
20	500	36.00	914	13.92	354	160	73
24	600	43.50	1105	17.10	434	195	88

[1] Nominal make-up dimension for drawing layout work only using non-threaded spigots. Do not use for assembly dimensions.

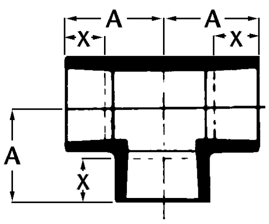
View of Fitting Illustrations



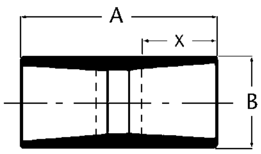
90° Elbow



45° Elbow



Tee



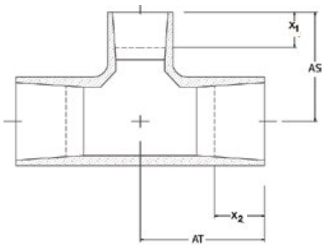
Sleeve Coupling

Reducing Tees

Pipe Size		AT		X_1 [1]		AS		X_2 [1]		Weight	
in	mm	in	mm	in	mm	in	mm	in	mm	lbs	kg
3x2	80x50	6.22	158	2.46	62	6.99	178	2.44	62	19	9.0
4x2	100x50	7.46	189	2.98	76	7.46	189	2.44	62	28	13.0
4x3	100x80	7.46	189	2.98	76	7.46	189	2.46	62	31	14.0
6x2	150x50	9.53	242	2.70	69	8.45	215	2.44	62	36	16.0
6x3	150x80	9.53	242	2.70	69	8.55	217	2.46	62	38	17.0
6x4	150x100	9.53	242	2.70	69	8.91	226	2.98	76	45	20.0
8x2	200x50	13.50	343	5.87	149	9.81	249	2.44	62	39	18.0
8x3	200x80	13.50	343	5.87	149	9.91	252	2.46	62	41	18.0
8x4	200x100	13.50	343	5.87	149	10.27	261	2.98	76	45	20.0
8x6	200x150	13.50	343	5.87	149	10.28	261	2.70	69	50	22.0
10x3	250x40	15.75	400	6.79	172	11.41	290	2.46	62	58	26.0
10x4	250x100	15.75	400	6.79	172	11.77	299	2.98	76	60	27.0
10x6	250x150	15.75	400	6.79	172	11.78	299	2.70	69	65	29.0
10x8	250x200	15.75	400	6.79	172	15.50	394	5.87	149	70	32.0
12x4	300x100	17.00	432	7.43	189	13.27	337	2.98	76	77	35.0
12x6	300x150	17.00	432	7.43	189	13.28	337	2.70	69	81	36.0
12x8	300x200	17.00	432	7.43	189	17.00	432	5.87	149	89	40.0
12x10	300x250	17.00	432	7.43	189	17.75	451	6.79	172	94	43.0
14x6	350x150	19.50	495	6.87	174	13.80	351	2.70	69	130	59.0
14x8	350x200	19.50	495	6.87	174	17.52	445	5.87	149	137	62.0
14x10	350x250	19.50	495	6.87	174	18.27	464	6.79	172	144	65.0
14x12	350x300	19.50	495	6.87	174	19.02	483	7.43	189	152	68.0
16x8	400x200	21.25	540	7.65	194	18.53	471	5.87	149	168	76.0
16x10	400x250	21.25	540	7.65	194	19.28	490	6.79	172	174	78.0
16x12	400x300	21.25	540	7.65	194	20.03	509	7.43	189	183	82.0
16x14	400x350	21.25	540	7.65	194	20.03	509	6.87	174	192	86.0
18x10	450x250	26.38	670	11.88	302	22.27	566	6.79	172	340	153.0
18x12	450x300	26.38	670	11.88	302	23.02	585	7.43	189	355	160.0
18x14	450x350	26.38	670	11.88	302	21.02	534	6.87	174	370	167.0
18x16	450x400	26.38	670	11.88	302	22.02	559	7.65	194	390	176.0
20x12	500x300	31.25	794	13.92	354	24.52	623	7.43	189	380	171.0
20x14	500x350	31.25	794	13.92	354	22.52	572	6.87	174	390	176.0
20x16	500x400	31.25	794	13.92	354	23.52	597	7.65	194	410	185.0
20x18	500x400	31.25	794	13.92	354	26.77	680	11.88	302	440	198.0
24x14	600x350	35.00	889	17.10	434	25.02	636	6.87	174	490	221.0
24x16	600x400	35.00	889	17.10	434	26.02	661	7.65	194	500	225.0
24x18	600x450	35.00	889	17.10	434	29.27	743	11.88	302	520	234.0
24x20	600x500	35.00	889	17.10	434	32.77	832	13.92	354	550	248.0

[1] Nominal make-up dimension for drawing layout work only using non-threaded spigots. Do not use for assembly dimensions.

View of Fitting Illustrations



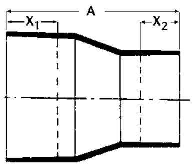
Reducing Tee

Concentric Reducers

Pipe Size		A		X_1 [1]		X_2 [1]		Weight	
in	**mm**	**in**	**mm**	**in**	**mm**	**in**	**mm**	**lbs**	**kg**
3x2	80x50	6.22	158	2.46	62	6.99	178	19	9.0
4x2	100x50	7.46	189	2.98	76	7.46	189	28	13.0
4x3	100x80	7.46	189	2.98	76	7.46	189	31	14.0
6x2	150x50	9.53	242	2.70	69	8.45	215	36	16.0
6x3	150x80	9.53	242	2.70	69	8.55	217	38	17.0
6x4	150x100	9.53	242	2.70	69	8.91	226	45	20.0
8x2	200x50	13.50	343	5.87	149	9.81	249	39	18.0
8x3	200x80	13.50	343	5.87	149	9.91	252	41	18.0
8x4	200x100	13.50	343	5.87	149	10.27	261	45	20.0
8x6	200x150	13.50	343	5.87	149	10.28	261	50	22.0
10x3	250x40	15.75	400	6.79	172	11.41	290	58	26.0
10x4	250x100	15.75	400	6.79	172	11.77	299	60	27.0
10x6	250x150	15.75	400	6.79	172	11.78	299	65	29.0
10x8	250x200	15.75	400	6.79	172	15.50	394	70	32.0
12x4	300x100	17.00	432	7.43	189	13.27	337	77	35.0
12x6	300x150	17.00	432	7.43	189	13.28	337	81	36.0
12x8	300x200	17.00	432	7.43	189	17.00	432	89	40.0
12x10	300x250	17.00	432	7.43	189	17.75	451	94	43.0
14x6	350x150	19.50	495	6.87	174	13.80	351	130	59.0
14x8	350x200	19.50	495	6.87	174	17.52	445	137	62.0
14x10	350x250	19.50	495	6.87	174	18.27	464	144	65.0
14x12	350x300	19.50	495	6.87	174	19.02	483	152	68.0
16x8	400x200	21.25	540	7.65	194	18.53	471	168	76.0

[1] Nominal make-up dimension for drawing layout work only using non-threaded spigots. Do not use for assembly dimensions.

View of Fitting Illustrations



Concentric Reducer

Flanges

Pipe Size		A		B		D		O		X[1]		Hole Size		# of Bolts	Max Bolt Torque		Weight	
in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm		ft•lbs	N•m	lbs	kg
ANSI 150																		
2	50	2.92	74	2.75	70	4.75	121	6.19	157	2.39	61	0.750	19	4	100	135	3	1.3
3	80	3.21	82	3.00	76	6.00	152	7.69	195	3.57	91	0.750	19	4	100	135	5	2.4
4	100	3.74	95	3.50	89	7.50	191	9.19	233	4.60	117	0.750	19	8	100	135	9	4.0
6	150	4.22	107	3.95	100	9.50	241	11.19	284	6.70	170	0.875	22	8	100	135	14	6.1
ANSI 300																		
2	50	3.00	76	2.75	70	5.00	127	6.50	165	2.67	68	0.750	19	8	100	135	3	1.4
3	80	3.25	83	3.00	76	6.63	168	8.25	210	2.83	72	0.875	22	8	100	135	6	2.7
4	100	3.75	95	3.50	89	7.88	200	10.00	254	3.30	85	0.875	22	8	100	135	10	4.5
6	150	4.25	108	4.00	102	10.63	270	12.50	317	3.78	96	0.875	22	12	100	135	15	6.8

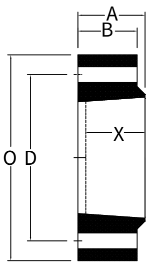
Van Stone Flanges

Pipe Size		A		B		C		D		O		X[1]		Hole Size		# of Bolts	Max Bolt Torque		Weight[2]	
in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm		ft•lbs	N•m	lbs	kg
ANSI 150																				
2	50	2.92	74	2.75	70	0.75	19	4.75	121	6.00	152	2.67	68	0.75	19	4	100	135	6	3
3	80	3.21	82	3.00	76	0.75	19	6.00	152	7.50	191	2.83	72	0.75	19	4	100	135	10	4
4	100	3.74	95	3.50	89	1.00	25	7.50	191	9.00	229	3.30	84	0.75	19	8	100	135	15	7
6	150	4.22	107	3.95	100	1.00	25	9.50	241	11.00	279	3.78	96	0.88	22	8	100	135	24	11
8	200	5.00	127	4.75	121	1.50	38	11.75	298	13.50	343	4.50	114	0.88	22	8	200	271	46	21
10	250	6.25	159	6.00	152	1.88	48	14.25	362	16.00	406	5.75	146	1.00	25	12	200	271	74	34
12	300	7.50	191	7.25	184	1.88	48	17.00	432	19.00	483	7.00	178	1.00	25	12	200	271	114	52
14	350	7.00	178	6.50	165	1.88	48	18.75	476	20.75	527	6.25	159	1.13	29	12	200	271	124	56
16	400	7.87	200	7.38	187	2.25	57	21.25	540	23.25	591	7.12	181	1.13	29	16	200	271	180	82
18	450	9.00	229	8.50	216	2.25	57	22.75	578	25.00	635	8.00	203	1.25	32	16	200	271	191	87
20	500	9.88	251	9.38	238	2.25	57	25.00	635	27.50	699	8.88	226	1.25	32	20	200	271	235	107
24	600	11.75	298	11.25	286	2.25	57	29.50	749	32.00	813	10.45	265	1.38	35	20	200	271	303	137

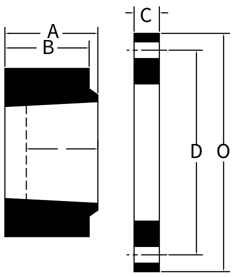
(1) X dimension is a nominal make-up dimension for drawing layout work only. Do not use for assembly dimensions.

(2) Weights are for the fiberglass Stub End and 2-piece Galvanized steel bolt ring combination.

View of Fitting Illustrations



Flange



Van Stone Flange

Van Stone Flanges

Pipe Size		A		B		C		D		O		X[1]		Hole Size		# of Bolts	Max Bolt Torque		Weight[2]	
in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm		ft•lbs	N•m	lbs	kg
									ANSI 300											
2	50	2.92	74	2.75	70	0.75	19	5.00	127	6.50	165	2.67	68	0.75	19	8	100	135	7	3
3	80	3.21	82	3.00	76	0.75	19	6.63	168	8.25	210	2.83	72	0.88	22	8	100	135	12	5
4	100	3.74	95	3.50	89	1.00	25	7.88	200	10.00	254	3.30	84	0.88	22	8	100	135	19	8
6	150	4.22	107	3.95	100	1.00	25	10.63	270	12.50	318	3.78	96	0.88	22	12	100	135	32	14
8	200	5.00	127	4.75	121	1.50	38	13.00	330	15.00	381	4.50	114	1.00	25	12	200	271	51	23
10	250	6.25	159	6.00	152	1.88	48	15.25	387	17.50	445	5.75	146	1.13	29	16	200	271	78	36
12	300	7.50	191	7.25	184	1.88	48	17.75	451	20.50	521	7.00	178	1.25	32	16	200	271	113	51
14	350	7.00	177	6.50	165	1.88	48	20.25	514	23.00	584	6.25	159	1.25	32	20	200	271	130	59
16	400	7.87	200	7.38	187	2.25	57	22.50	572	25.50	648	7.12	181	1.38	35	20	200	271	174	79
18	450	9.00	229	8.50	216	2.25	57	24.75	629	28.00	711	8.00	203	1.38	35	24	200	271	250	113
20	500	9.88	251	9.38	238	2.25	57	27.00	686	30.50	775	8.88	226	1.38	35	24	200	271	296	134
24	600	11.75	298	11.25	286	2.25	57	32.00	813	36.00	914	10.45	265	1.63	41	24	200	271	447	203

[1] X dimension is a nominal make-up dimension for drawing layout work only. Do not use for assembly dimensions.

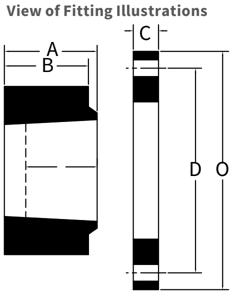
[2] Weights are for the fiberglass Stub End and 2-piece Galvanized steel bolt ring combination.

Nipples

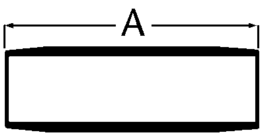
Pipe Size		4	6	8	10	12	16	24	36	48	54
in	mm	100	150	200	250	300	400	600	900	1200	1350
2	50		X	X							
3	80		X	X							
4	100		X	X							
6	150		X	X		X	X				
8	200						X	X			
10	250						X	X	X		
12	300						X	X	X		
14	350						X	X	X		
16	400						X	X	X		
18	450								X		
20	500								X		
24	600								X		

X - Standard available size

View of Fitting Illustrations



Van Stone Flange



Nipple

Fiber Glass Systems
17115 San Pedro Avenue, Ste 200
San Antonio, Texas 78232 USA
Phone: 210 477 7500
Fax: 210 477 7560

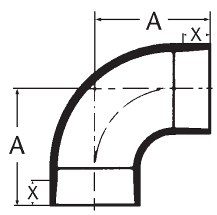
CI1360ENG November 2016

GREEN THREAD™ HP 32/40 Fittings

2"-16" Fittings and Accessories

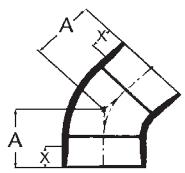
Fittings are filament wound with a reinforced epoxy inner liner and compatible with HP 32/40 bar piping systems. Sizes 2"-12" are rated to 40 bar, and 14" and 16" are rated to 32 bar

90° Elbows
Bell x Bell



Diameter		A		X[1]		Weight	
in	mm	in	mm	in	mm	lbs	kg
2	50	6.25	159	2.50	64	8.0	3.6
3	75	9.00	229	3.25	83	12.0	5.4
4	100	11.25	286	4.00	102	16.0	7.3
6	150	14.75	375	4.50	114	24.0	10.9
8	200	21.75	552	7.75	197	46.3	21.0
10	250	26.00	660	8.88	225	92.6	42.0
12	300	30.50	775	10.25	260	140	63.5
14	350	33.00	838	8.75	222	447	203
16	400	37.00	940	10.00	254	587	267

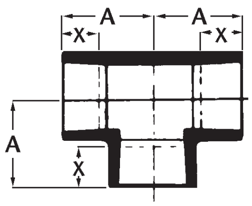
45° Elbows
Bell x Bell



Diameter		A		X[1]		Weight	
in	mm	in	mm	in	mm	lbs	kg
2	50	4.50	114	2.50	64	13.7	6.2
3	75	6.25	159	3.25	83	17.1	7.8
4	100	7.75	197	4.00	102	27.5	12.5
6	150	9.50	241	4.50	114	32.7	14.9
8	200	14.75	375	7.75	197	92.5	42.0
10	250	17.00	432	8.88	225	145	65.8
12	300	20.00	508	10.25	260	200	90.7
14	350	20.75	527	8.75	222	235	107
16	400	23.00	584	10.00	254	309	140

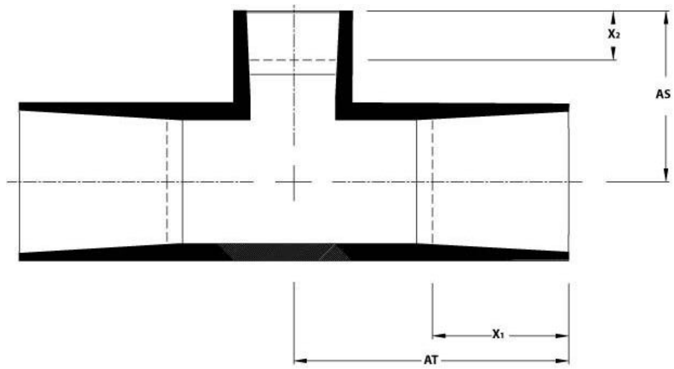
[1] This is a nominal make-up dimension for drawing layout work only. Do not use for assembly dimensions.

Tees
Bell x Bell x Bell



Diameter		A		X(1)		Nominal Weight	
in	mm	in	mm	in	mm	lbs	kg
2	50	5.50	140	2.50	64	13.7	6.2
3	75	7.25	184	3.25	83	20.5	9.3
4	100	9.00	229	4.00	102	27.3	12.4
6	150	11.50	292	4.50	114	55.7	25.3
8	200	15.75	400	7.75	197	119	53.9
10	250	18.50	470	8.88	225	164	74.4
12	300	20.50	521	10.25	260	258	117
14	350	22.50	521	8.75	222	352	160
16	400	24.50	622	10	254	440	200

Reducing Tees
Bell x Bell x Bell

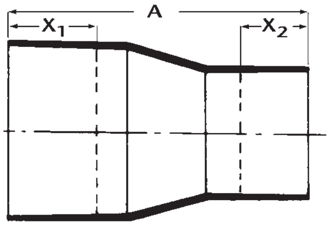


Diameter		AT		AS		X_1(1)		X_2(1)	
in	mm	in	mm	in	mm	in	mm	in	mm
3x2	75x50	7.19	183	7.01	178	3.25	83	2.50	64
4x3	100x75	8.87	225	8.45	215	4.00	102	3.25	83
4x2	100x50	8.87	225	7.48	190	4.00	102	2.50	64
6x4	150x100	11.50	292	10.39	264	4.50	114	4.00	102
6x3	150x75	11.50	292	9.51	242	4.50	114	3.25	83
8x6	200x150	15.75	400	12.25	311	7.75	197	4.50	114
8x4	200x100	15.75	400	11.75	298	7.75	197	4.00	102
10x8	250x200	18.38	467	17.75	451	8.87	225	7.75	197
10x6	250x150	18.38	467	13.75	349	8.87	225	4.50	114
12x10	300x250	20.50	521	20.38	518	10.25	260	8.87	225
12x8	300x200	20.50	521	19.25	489	10.25	260	7.75	197
14x12	350x300	22.50	571	22.52	572	8.75	222	10.25	260
14x10	350x250	22.50	571	20.90	531	8.75	222	8.75	222
16x14	400x350	24.38	619	23.03	585	9.75	251	8.75	222
16x12	400x300	24.38	619	23.53	598	9.75	251	10.25	260

(1)Nominal make-up dimension for drawing layout work only. Do not use for assembly dimensions.

Concentric Reducer

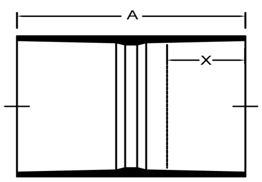
Bell x Bell



Diameter		A		X_1 (1)		X_2 (1)		Weight	
in	mm	in	mm	in	mm	in	mm	lbs	kg
3x2	75x50	9.25	235	3.25	83	2.50	64	8.1	3.7
4x3	100x75	11.75	298	4.00	102	3.25	83	11.7	5.3
6x4	150x100	15.00	381	4.50	114	4.00	102	15.4	7.0
8x6	200x150	21.00	533	7.75	167	4.50	114	27.0	12.2
10x8	250x200	26.00	660	8.875	229	7.75	167	44.5	20.2
12x10	300x250	29.75	756	10.25	261	8.875	225	69.4	31.5
14x12	350x300	32.75	834	8.875	225	10.25	261	107	48.4
16x14	400x350	35.75	906	10.00	254	8.75	222	154	70.1

Sleeve Couplings

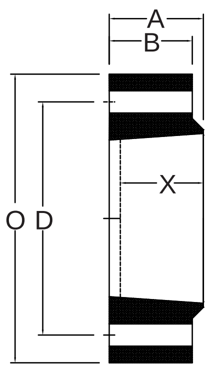
Bell x Bell



Diameter		A		X (1)		Weight	
in	mm	in	mm	in	mm	lbs	kg
2	50	6.50	161	2.50	64	0.9	0.4
3	75	8.00	203	3.25	83	1.9	0.8
4	100	9.50	241	4.00	102	2.0	0.9
6	150	10.50	266	4.50	114	4.4	2.0
8	200	18.50	470	7.75	197	11.5	5.2
10	250	20.75	527	8.88	225	17.6	8.0
12	300	24.00	610	10.25	260	25.4	11.5
14	350	25.00	635	8.75	222	156	71.0
16	400	27.25	692	10.00	254	206	93.4

Flanges

ANSI 16.5
Class #150



Diameter	A	B	D	O	X (1)	Bolt Size & Quantity		Max Bolt Torque	Wgt.
in	in	in	in	in	in	in	Bolts	ft • lbs	lbs
2	3.00	2.75	4.75	6.00	2.75	0.75	4	100	4.75
3	3.25	3.00	6.00	7.50	3.00	0.75	4	100	7.5
4	3.75	3.50	7.50	9.00	3.50	0.75	8	150	11.9
6	4.25	4.00	9.50	11.00	4.00	0.88	8	150	17.4

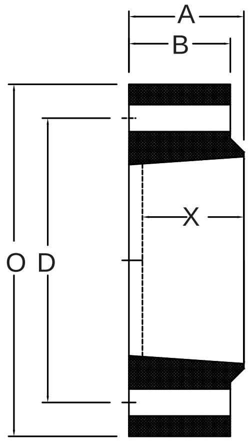
Diameter	B	C	D	O	X (1)	Bolt Size & Quantity		Max Bolt Torque	Wgt.
mm	mm	mm	mm	mm	mm	mm	Bolts	N • M	kg
50	74	70	121	152	70	19.0	4	136	2.2
75	82	76	152	190	76	19.0	4	136	3.4
100	95	89	191	228	89	19.0	8	204	5.4
150	107	100	241	279	101	22.2	8	204	7.9

(1) This is a nominal make-up dimension for drawing layout work only. Do not use for assembly dimensions.

Flanges

ANSI 16.5
Class #300

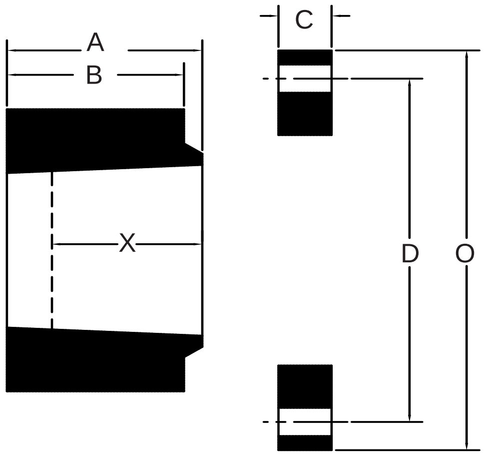
Diameter	A	B	D	O	X[(1)]	Bolt Size & Quantity		Max Bolt Torque	Wgt.
in	in	in	in	in	in	in	Bolts	ft • lbs	lbs
2	3.00	2.75	5.00	6.50	2.75	0.75	8	100	5.4
3	3.25	3.00	6.63	8.25	3.00	0.88	8	100	9
4	3.75	3.50	7.88	10.00	3.50	0.88	8	150	16
6	4.25	4.00	10.63	12.50	4.00	0.88	12	150	25.5



Diameter	A	B	D	O	X[(1)]	Bolt Size & Quantity		Max Bolt Torque	Wgt.
mm	mm	mm	mm	mm	mm	mm	Bolts	N • M	kg
50	74	70	127	165	68	19	8	136	2.5
75	82	76	168	210	75	22	8	136	4.1
100	95	89	200	254	89	22	8	204	7.1
150	107	100	270	317	101	22	12	204	11.6

Van Stone Flanges

ANSI 16.5
Class #300



[(1)]Nominal make-up dimension for drawing layout work only. Do not use for assembly dimensions.

Diameter	A	B	C	D	O	X[(1)]	Bolt Size & Quantity		Max Bolt Torque	Wgt.
in	in	in	in	in	in	in	in	Bolts	ft • lbs	lbs
8	5.00	4.75	1.50	13.00	15.00	5.00	1.00	12	200	50.7
10	6.25	6.00	1.88	15.25	17.50	6.00	1.125	16	200	78.4
12	7.50	7.25	1.88	17.75	20.50	7.50	1.25	16	200	113
14	7.00	6.50	2.25	20.25	23.00	7.00	1.25	20	250	130
16	7.88	7.38	2.25	22.50	25.50	7.75	1.375	20	250	174
mm	mm	mm	mm	mm	mm	mm[(1)]	mm	Bolts	N • m	kg
200	127	121	38	330	381	124	25	12	272	23.0
250	159	152	48	387	445	156	28	16	272	35.6
300	191	184	48	451	521	187	31	16	272	51.3
350	178	165	57	514	584	175	31	20	340	58.9
400	200	187	57	572	648	197	35	20	340	78.9

CI1370 June 2013

SILVER STREAK™ FITTINGS DIMENSIONS

- **Silver Streak** piping and fittings are designed especially for abrasive and corrosive services such as limestone and gypsum slurries, found in flue gas desulfurization (FGD) scrubber applications.

- **Silver Streak** piping systems are designed to operate at temperatures up to 225°F and pressures up to 225 psig.

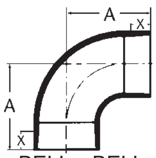
- All bell end and assembled flanged* **Silver Streak** fittings are rated for service up to 225 psig.

- A complete line of standard long-radius fittings are available. Odd degree elbows are available on special order.

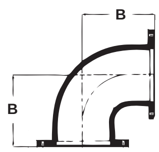
- Fittings are constructed with the same abrasion-resistant additives as the pipe.

- All fittings, except compression molded, have a nominal corrosion/abrasion barrier of 100 mils.

90° Elbow



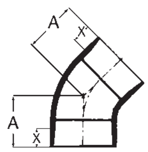
BELL x BELL



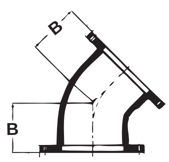
FLANGE x FLANGE

Nominal Pipe Size (In.)	225 psig A (In.)	150 psig B (In.)	225 psig B (In.)	X(1) (In.)	B x B Weight (lbs)	F x F Weight (lbs)
2	6.31	--	9.50	2.64	8.80	11.80
3	8.00	--	11.62	2.86	13.20	19.20
4	9.75	--	13.50	3.13	17.60	26.20
6	12.75	--	17.00	2.76	26.50	38.00
8	19.50	16.12	24.5*	5.28	35.00	45.00
10	23.25	19.88	29.0*	5.12	67.00	86.00
12	27.00	23.12	33.0*	6.40	101	138
14	30.00	24.50	34.0*	4.55	198	256
16	34.00	27.87	38.0*	5.61	260	322
18	36.75	--	47.0	6.63	353	468
20	42.25	--	53.0	7.75	470	609
24	50.00	--	63.0	9.25	672	866

45° Elbow



BELL x BELL



FLANGE x FLANGE

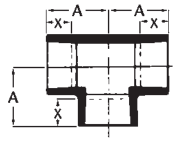
Nominal Pipe Size (In.)	225 psig A (In.)	150 psig B (In.)	225 psig B (In.)	X(1) (In.)	B x B Weight (lbs)	F x F Weight (lbs)
2	4.56	--	7.50	2.64	5.0	8.40
3	5.25	--	8.62	2.86	8.1	14.10
4	6.25	--	9.62	3.13	10.8	19.40
6	7.50	--	11.37	2.76	16.2	27.70
8	12.50	9.00	17.5*	5.28	21.6	32.00
10	14.50	11.12	20.3*	5.12	43.0	62.00
12	16.50	12.62	23.0*	6.40	65.0	102
14	17.62	12.25	22.0*	4.55	109	167
16	20.00	13.75	24.0*	5.61	144	206
18	20.93	--	31.0	6.63	209	324
20	24.68	--	36.0	7.75	259	398
24	28.91	--	42.0	9.25	389	583

B = BELL   F=FLANGE

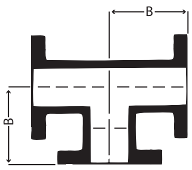
(1) This is a nominal make-up dimension for drawing layout work only. Do not use for assembly dimensions.

* Special Order

Tee



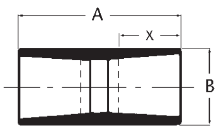
BELL x BELL x BELL



FLANGE x FLANGE x FLANGE

Nominal Pipe Size (In.)	225 psig A (In.)	150 psig B (In.)	225 psig B (In.)	X(1) (In.)	B x B x B Weight (lbs)	F x F x F Weight (lbs)
2	5.56	--	8.37	2.64	6.8	11.2
3	6.25	--	9.37	2.86	10.1	19.1
4	7.50	--	10.62	3.13	13.5	26.4
6	9.50	--	13.12	2.76	27.5	45.0
8	13.50	9.00	13.5	5.28*	41.0	56.0
10	15.75	11.00	15.8	5.12*	56.0	85.0
12	17.00	12.00	17.0	6.40*	88.0	144
14	19.50	14.00	19.5	4.55*	120	207
16	21.25	15.00	21.3	5.61*	150	243
18	22.38	--	33.0	6.63	195	300
20	26.25	--	38.0	7.75	255	371
24	28.00	--	41.0	9.25	356	496

Sleeve Coupling

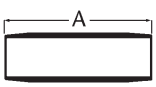


BELL x BELL

NOTE 18"-24" Couplings: If coupling length "A" is critical for a piping system design, please specify "A" dimension when ordering.

Nominal Pipe Size (In.)	A (In.)	B (In.)	X(2) (In.)	Max. Operating Pressure (psig)	B x B Weight (lbs)
2	4.87	2.50	1.84	225	0.4
3	6.50	3.87	2.36	225	0.8
4	6.50	4.87	1.99	225	0.9
6	8.00	7.00	2.87	225	1.9
8	10.50	9.12	3.47	225	3.4
10	11.00	11.12	4.34	225	5.2
12	12.50	13.12	4.82	225	7.5
14	15.00	15.12	5.47	225	11.2
16	17.00	17.25	6.27	225	16.0
18	16.00	18.75	6.88	225	22.7
20	19.00	20.75	8.00	225	27.5
24	23.00	25.00	10.00	225	38.0

Nipple



Nominal Pipe Size (In.)	Nipple Length (In.)											
	6	(lbs)	8	(lbs)	12	(lbs)	16	(lbs)	24	(lbs)	36	(lbs)
2	♦	0.6	♦	0.7	--	--	--	--	--	--	--	--
3	♦	0.8	♦	1.1	--	--	--	--	--	--	--	--
4	--	--	♦	1.4	--	--	--	--	--	--	--	--
6	--	--	♦	2.1	♦	3.1	♦	4.1	--	--	--	--
8	--	--	--	--	♦	4.8	♦	6.4	--	--	--	--
10	--	--	--	--	♦	6.1	♦	8.1	--	--	--	--
12	--	--	--	--	--	--	♦	10.0	--	--	--	--
14	--	--	--	--	--	--	♦	13.3	--	--	--	--
16	--	--	--	--	--	--	♦	17.1	--	--	--	--
18	--	--	--	--	--	--	--	--	--	--	♦	30.0
20	--	--	--	--	--	--	--	--	--	--	♦	37.0
24	--	--	--	--	--	--	--	--	--	--	♦	51.0

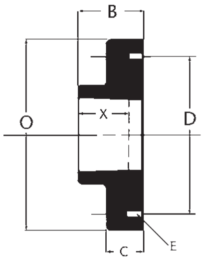
B = BELL F=FLANGE

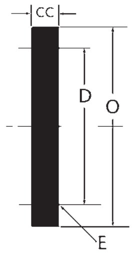
♦ Standard stock.

(1) This is a nominal make-up dimension for drawing layout work only. Do not use for assembly dimensions.

* Special order.

Flange



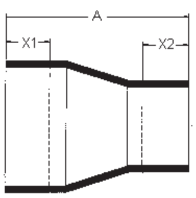


Nominal Pipe Size (In.)	B	C	CC(1)	D	E	O	X(1)	Max. Operation Pressure (psig)		Weight (lbs)	
								Flange	Blind Flange	Flange	Blind Flange
2	2.25	.75	.75	4.75	.75 D-4 holes	6.00	1.75	225	150	1.3	1.3
3	2.62	1.37	1.00	6.00	.75 D-4 holes	7.50	2.25	225	150	2.6	3.0
4	2.62	1.37	1.00	7.50	.75 D-8 holes	9.00	2.25	225	150	3.6	4.0
6	3.00	1.50	1.12	9.50	.875 D-8 holes	11.00	2.75	225	150	4.4	6.6
8	4.00	1.75	1.12	11.75	.875 D-8 holes	13.50	3.25	225	135	9.3	10.6
10	4.75	2.00	1.25	14.25	1 D-12 holes	16.00	3.75	225	95	16.0	16.3
12	5.00	2.25	1.25	17.00	1 D-12 holes	19.00	3.75	225	65	24.0	24.0
14	3.12	2.50	1.62	18.75	1.125 D-12 holes	20.75	3.00	225	150	30.0	45.0
16	3.12	2.50	1.87	21.25	1.125 D-16 holes	23.25	3.00	225	150	37.0	67.0
18	9.00	2.75	2.50	22.75	1.25 D-16 holes	25.00	6.88	225	150	76.0	125
20	11.00	2.75	2.75	25.00	1.25 D-20 holes	27.50	8.00	225	150	92.0	140
24	13.00	3.00	3.37	29.50	1.375 D-20 holes	32.00	10.00	225	150	124.0	155

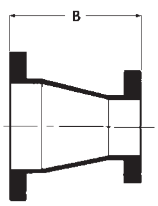
Note: All flanges are ANSI B16.5-150 lb. Bolt Hole Circle.

(1)Steel back-up plates must be used to achieve pressure ratings equivalent to the pipe.

Concentric Reducer



BELL x BELL



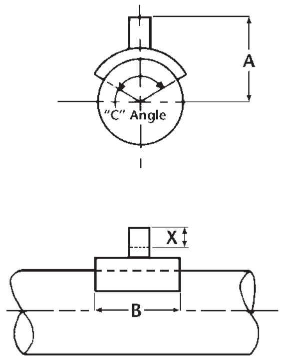
FLANGE x FLANGE

Nominal Reducer Size (In.)	A	Max. Pressure (psig)	X1(1)	X2(1)	B	B x B Weight (lbs)	F x F Weight (lbs)
3 x 2	7.50	225	2.81	2.63	14.75*	7.4	14.0
4 x 3	9.25	225	3.13	2.63	15.38*	10.7	20.6
4 x 2	9.00	225	3.13	2.63	17.00*	10.1	22.2
6 x 4	11.50	225	2.75	3.13	18.13*	14.1	26.6
6 x 3	11.25	225	2.75	2.68	19.63*	13.4	28.8
6 x 2	11.00	225	2.75	2.63	21.25*	12.7	27.8
6 x 4	11.50	225	2.75	3.13	18.13*	14.1	26.6
8 x 6	16.75	225	5.25	2.75	25.00*	17.1	34.0
8 x 4	16.75	225	5.25	3.13	24.13*	16.4	32.0
8 x 3	16.25	225	5.25	2.81	24.13*	15.6	31.0
8 x 2	16.00	225	5.25	2.63	24.13*	14.8	29.7
10 x 8	21.00	225	5.06	5.25	12.00	28.2	43.0
10 x 6	18.00	225	5.06	2.75	12.00	24.4	42.2
12 x 10	23.50	225	6.40	5.12	14.00	44.0	72.0
14 x 12	26.25	225	4.50	6.38	16.00	67.0	115
14 x 10	26.00	225	4.50	5.06	16.00	60.0	106
16 x 14	29.50	225	5.56	4.50	18.00	98.0	158
16 x 12	29.00	225	5.56	6.38	18.00	88.8	147.4
18 x 16	29.75	225	6.63	5.56	46.00*	110	204
18 x 14	29.38	225	6.63	4.50	46.00*	100	199.1
20 x 18	32.00	225	7.75	6.63	53.00*	140	229
20 x 16	32.88	225	7.75	5.56	53.00*	106	223.1
24 x 20	46.25	225	9.25	7.75	70.00*	190	275
24 x 18	36.00	225	9.25	6.63	70.00*	133	268.4

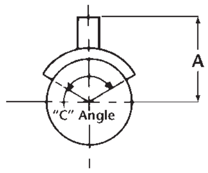
* Nipples and flanges

(1) This is a nominal make-up dimension for drawing layout work only. Do not use for assembly dimensions.

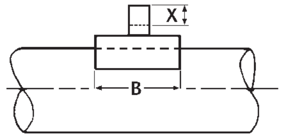
Saddles



Size	A	B	Angle C	X	Steady Pressure Rating
In.	In.	In.	Degree	In.	psi
2x1	2.88	4.00	180	1.00	225
2x1½	2.88	4.00	180	1.38	225
3x1	3.50	6.00	180	1.00	225
3x1½	3.50	6.00	180	1.38	225
3x2	4.00	6.00	180	2.64	225
4x1	4.00	6.00	180	1.00	225
4x1½	4.00	6.00	180	1.38	225
4x2	4.50	6.00	180	2.64	225
4x3	5.25	6.00	180	2.88	150
6x1	5.00	6.00	120	1.00	225
6x1½	5.00	6.00	120	1.38	225
6x2	5.50	6.00	120	2.64	225
6x3	6.25	6.00	120	2.88	150
6x4	6.38	8.00	140	3.13	150
8x2	8.25	9.00	120	2.64	225
8x3	8.25	14.00	180	2.88	225
8x4	8.64	14.00	180	3.13	225
8x6	8.64	14.00	180	2.75	125
10x2	9.25	9.00	95	2.64	225
10x3	9.25	14.00	150	2.88	225
10x4	9.64	16.75	180	3.13	225
10x6	9.64	16.75	180	2.75	190
10x8	13.88	16.75	180	5.25	100
12x2	10.25	10.00	90	2.64	225
12x3	10.25	14.00	125	2.88	225
12x4	10.64	17.00	155	3.13	225
12x6	10.64	21.00	180	2.75	225
12x8	14.88	21.00	180	5.25	150
12x10	15.64	21.00	180	5.13	100

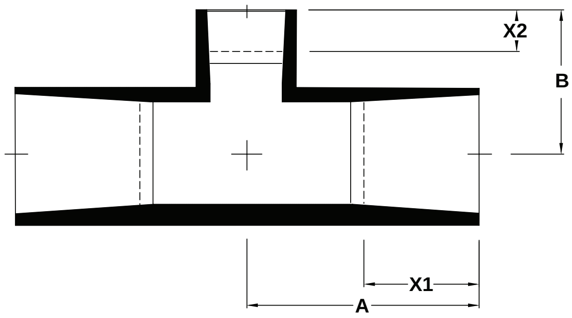


Saddles, Cont'd.



Size	A	B	Angle C	X	Steady Pressure Rating
In.	In.	In.	Degree	In.	psi
14x2	11.00	12	95	2.64	225
14x3	11.13	15	120	2.88	225
14x4	11.50	17	135	3.50	225
14x6	11.64	21	165	2.75	225
14x8	15.75	21	165	5.25	190
14x10	15.64	26	180	5.13	225
14x12	17.25	26	180	6.38	100
16x2	12.00	13	90	2.64	225
16x3	12.13	15	105	2.88	225
16x4	12.50	17	120	3.13	225
16x6	12.64	21	145	2.75	225
16x8	16.75	26	180	5.25	225
16x10	17.64	26	180	5.13	190
16x12	18.25	26	180	6.38	150
18x2	12.88	13	90	2.64	225
18x3	13.25	15	90	2.88	225
18x4	13.25	17	110	3.13	225
18x6	14.50	21	130	2.75	225
18x8	16.00	26	160	5.25	225
18x10	15.88	28	180	5.13	225
18x12	16.25	32	180	6.38	190
20x2	13.88	13	90	2.64	225
20x3	14.25	15	90	2.88	225
20x4	14.25	17	95	3.50	225
20x6	15.50	21	120	2.75	225
20x8	17.00	26	150	5.25	225
20x10	17.00	28	160	5.13	225
20x12	17.25	32	180	6.38	190
24x2	16.00	13	70	2.64	225
24x3	16.25	15	70	2.88	225
24x4	16.25	17	80	3.13	225
24x6	17.64	21	100	2.75	225
24x8	19.13	26	120	5.25	225
24x10	19..00	28	130	5.13	225
24x12	19.38	32	150	6.38	190

REDUCING TEES



(1) This is a nominal make-up dimension for drawing layout work only. Do not use for assembly dimensions.

Nom. Size	A	X1(1)	B	X2(1)	Nom. Wgt.	Steady Pressure
In	In	In	In	In	Lbs	psig
8x6	13.50	5.30	10.25	2.80	36	225
8x4	13.50	5.30	10.25	3.10	33	225
8x3	13.50	5.30	9.88	2.90	31	225
8x2	13.50	5.30	9.81	2.60	28	225
10x8	15.75	5.10	13.50	5.30	48	225
10x6	15.75	5.10	11.75	2.80	44	225
10x4	15.75	5.10	11.75	3.10	41	225
10x3	15.75	5.10	11.38	2.90	37	225
12x10	17.00	6.40	15.75	5.10	72	225
12x8	17.00	6.40	15.00	5.30	65	225
12x6	17.00	6.40	13.25	2.80	60	225
12x4	17.00	6.40	13.25	3.10	55	225
14x12	19.56	4.60	17.00	6.40	93	225
14x10	19.56	4.60	16.25	5.10	85	225
14x8	19.56	4.60	15.50	5.30	77	225
14x6	19.56	4.60	13.75	2.80	71	225
16x14	21.25	5.60	20.00	4.60	111	225
16x12	21.25	5.60	18.00	6.40	101	225
16x10	21.25	5.60	17.25	5.10	91	225
16x8	21.25	5.60	16.50	5.30	83	225

Laterals, crosses, and eccentric reducers available upon request.

All dimensions listed in this bulletin are nominal in nature and should only be used for system layout and take off. Actual fittings and fabrication work should be measured before bonding to ensure dimensional accuracy. Fiber Glass Systems does not warrant and is in no way responsible for the workmanship of any distributor, contractor or others involved in the installation of the goods.

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NOV Fiber Glass Systems

CI1450 - December 2010

SILVER STREAK® LD FITTINGS DIMENSIONS

Silver Streak LD piping and fittings are designed especially for abrasive and corrosive services such as limestone and gypsum slurries found in flue gas desulfurization (FGD) scrubber applications.

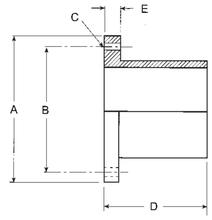
Silver Streak LD piping systems are designed to operate at temperatures up to 200°F and pressures up to 150 psig.

Sweep elbows are available in 30 ° diameters only.

Fittings are constructed with the same abrasion-resistant additives as the pipe.

All fittings have a nominal corrosion/abrasion barrier of 100 mils.

Stub Flange



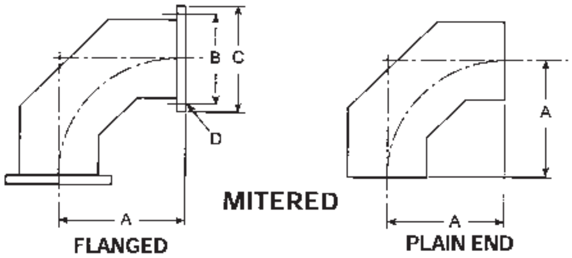
Nominal Pipe Size	A	B	C	D	Bolts	E (psi)		
In	In	In	In	In	Size - No	50	75	100
30	38 ¾	36	1 3/8	15	1 ¼ - 28	1 7/8	2 1/8	2 ¼*
36	46	42 ¾	1 5/8	15	1 ½ - 32	2	2 3/8	2 ½*
42	53	49 ½	1 5/8	15	1 ½ - 36	2 1/8	2 5/8*	2 7/8*
48	59 ½	56	1 5/8	18	1 ½ - 44	2 ¼	2 ¾*	3 1/8*

*Flange has special “O” ring type seal. Consult factory for design of each of these flange connections since only one flange face is grooved for placement of the seating “O” ring. Quotations or information on gasket requirements available on request. Flanges meet O.D., bolt circle diameter, number of holes and bolt hole diameter dimensions for ANSI B16.1 125 lb.

Weights Per Fitting

Nominal Pipe Size	Plain Ends			Flanged			Flange Stub End Drilled
	Elbow	Elbow	Tee	Elbow	Elbow	Tee	
In	90°	45°	BBB	90°	45°	FFF	
30	280	140	280	455	315	545	125
36	445	220	420	710	490	820	185
42	665	330	600	1050	730	1190	265
48	945	475	870	1460	985	1640	355

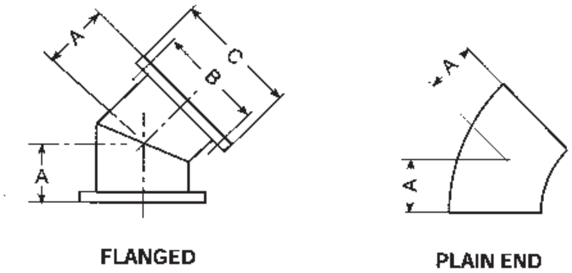
90° Elbow



Nominal Pipe Size	A	B	C	Bolt Holes D	Bolts .
In	In	In	In	Diameter	Size/No.
30	45	36	38 ¾	1 3/8	1 ¼ - 28
36	54	42 ¾	46	1 5/8	1 ½ - 32
42	63	49 ½	53	1 5/8	1 ½ - 36
48	72	56	59½	1 5/8	1 ½ - 44

Elbows will be mitered construction using pipe for the mitered sections. Elbows shall have a minimum of 2 miters. Sweep elbows available in 30" only.

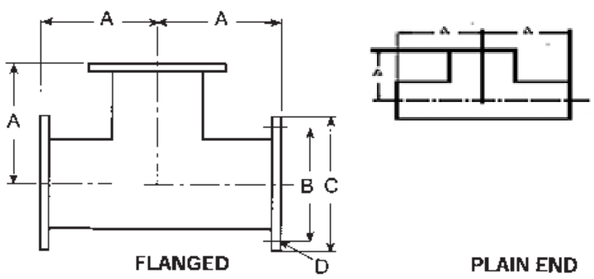
45° Elbow



Nominal Pipe Size	A	B	C	Bolt Holes D	Bolts .
In	In	In	In	Diameter	Size/No.
30	18 5/8	36	38 ¾	1 3/8	1 ¼ - 28
36	22 ½	42 ¾	46	1 5/8	1 ½ - 32
42	26	49 ½	53	1 5/8	1 ½ - 36
48	29 7/8	56	59 ½	1 5/8	1 ½ - 44

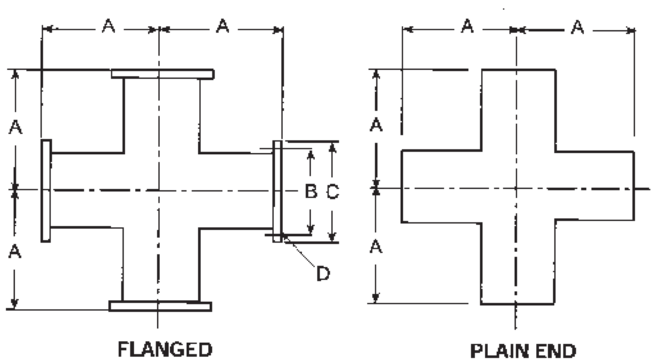
Elbows will be mitered construction using pipe for the mitered sections. All mitered elbows shall have 1 miter, 2 sections. Sweep elbows available in 30" only.

Tee



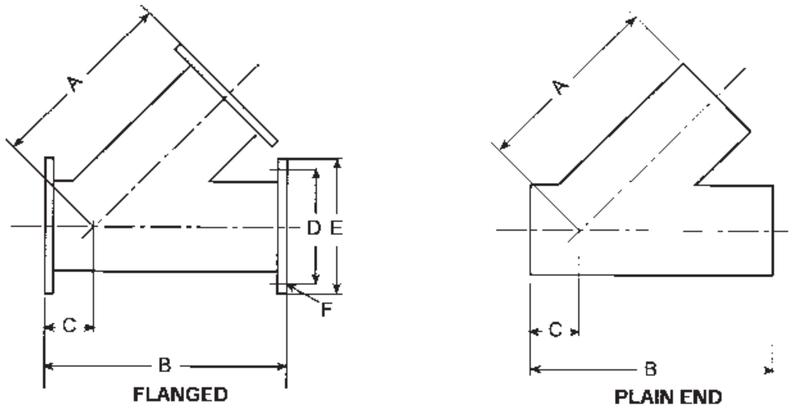
Nominal Pipe Size	A	B	C	Bolt Holes D	Bolts .
In	In	In	In	Diameter	Size/No.
30	30	36	38 ¾	1 3/8	1 ¼ - 28
36	33	42 ¾	46	1 5/8	1 ½ - 32
42	36	49 ½	53	1 5/8	1 ½ - 36
48	42	56	59½	1 5/8	1 ½ - 44

Cross



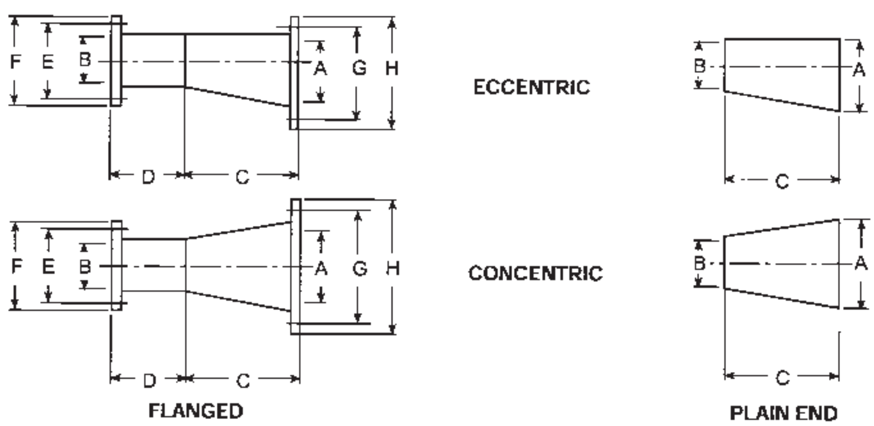
Nominal Pipe Size	A	B	C	Bolt Holes D	Bolts .
In	In	In	In	Diameter	Size/No.
30	30	36	38 ¾	1 3/8	1 ¼ - 28
36	33	42 ¾	46	1 5/8	1 ½ - 32
42	36	49 ½	53	1 5/8	1 ½ - 36

Lateral



Nominal Pipe Size	A	B	C	D	E	F	Bolts .
In	In	In	In	In	In	In	Size/No.
30	52	72	20	36	38 ¾	1 3/8	1 ¼ - 28
36	62	84	22	42 ¾	46	1 5/8	1 ½ - 32
42	72	96	24	49 ½	53	1 5/8	1 ½ - 36

Reducer



Nominal Pipe Size A/B	C	D	E	F	G	H
In	In	In	In	In	In	In
30 x 20	25	12	25	27 ½	36	38 ¾
30 x 24	15	12	29 ½	32	36	38 ¾
36 x 24	30	12	29 ½	32	42 ¾	46
36 x 30	15	15	38 ¾	36	42 ¾	46
42 x 30	30	15	38 ¾	36	49 ½	53
42 x 36	15	15	42 ¾	46	49 ½	53

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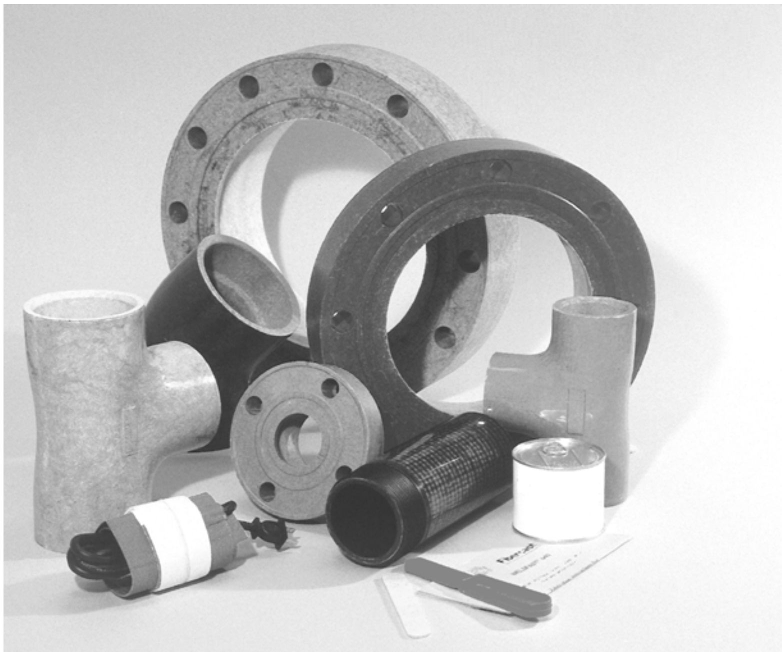
NOV Fiber Glass Systems

CI1440 February 2009

1”-14” Fittings and Accessories

Centricast™ Piping Systems

NOV Fiber Glass Systems offers a complete line of fittings manufactured from both epoxy and vinyl ester resins. These fittings and adhesives provide the same corrosion resistance and temperature ratings as the compatible grade of pipe. Press molded fittings are manufactured from a resin-rich compound which is corrosion resistant throughout the fitting wall. Hand layup fittings have a 100 mil resin-rich corrosion barrier. Epoxy RB fittings are color-coded brown; Z-CORE fittings are dark green or black; CL vinyl ester fittings are off-white. Because the fittings are designed for the most severe services, they are suitable for the broad range of chemicals shown in the **Chemical Resistance Guide**. All 1”-14” fittings are available with either a socket fitting or flanged type connection for easy field assembly. Adapters to iron pipe threads are also available.



Order by figure (Fig.) number prefixed with CL for vinyl ester, RB for epoxy and ZC for Z-Core followed by construction type (if applicable), diameter, and outlet sizes.

Example Fig. 34C HLU 3x2

PM - Represents Press Molded Fittings
HLU - Represents Hand Layup Fittings

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PRESSURE RATINGS

Pressure Rating of CL Vinyl Ester Fittings
up to 200°F based on Weldfast™
CL-200 and/or CL-200QS Adhesive
Uninsulated Piping

Size (In.)	Elbows, Tees, Reducers Couplings, Flanges, End Caps, Socket and Threaded Nipples		Laterals, Crosses, and Saddles (psi)
	Socket Ftgs. (psi)	Flanged Ftgs. (psi)	
1	300	300	--
1 ½	300	300	--
2	275	200	125
3	200	150	125
4	150	150	100
6	150	150	100
8	150	150	100
10	150	150	75
12	150	150	75
14	125	150	--

Reduce pressure by 25% for 175°F to 200°F operating temperatures.

Pressure Rating of RB Epoxy Fittings
up to 225°F based on
Weldfast ZC-275 Adhesive
Uninsulated Piping

Size (In.)	Elbows, Tees, Reducers Couplings, Flanges, End Caps, Socket and Threaded Nipples		Flanges (psi)	Laterals, Crosses, and Saddles (psi)
	Socket Ftgs. (psi)	Flanged Ftgs. (psi)		
1	300	300	300	--
1 ½	300	150	300	--
2	300	150	300	125
3	275	150	200	125
4	150	150	150	100
6	150	150	150	100
8	150	150	150	100
10	150	150	150	75
12	150	150	150	75
14	125	150	150	--

For insulated and/or heat traced piping systems, use 100% of uninsulated piping recommendations up to 200°F and reduce these ratings 50% for 200°F to 250°F operating temperatures. For uninsulated CENTRICAST PLUS RB-2530 piping, reduce these ratings 30% for 225°F to 250°F operating temperatures.

Pressure Rating of ZC Epoxy Fittings
up to 225°F based on
Weldfast ZC-275 Adhesive
Uninsulated Piping

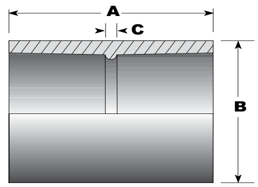
Size (In.)	Elbows, Tees, Reducers Couplings, Flanges, End Caps, Socket and Threaded Nipples		Flanges (psi)	Laterals and Crosses (psi)
	Socket Ftgs. (psi)	Flanged Ftgs. (psi)		
1	300	300	300	--
1 ½	300	150	300	--
2	300	150	300	125
3	275	150	200	125
4	150	150	150	100
6	150	150	150	100
8	150	150	150	100
10	150	150	150	75
12	150	150	150	75
14	125	150	150	--

For insulated and/or heat traced piping systems, use 100% of uninsulated piping recommendations up to 225°F and reduce these ratings 25% for 225°F to 275°F operating temperatures. For uninsulated ZC piping, reduce these ratings 25% for 250°F to 275°F operating temperatures.

Note: Quotations for specially fabricated higher pressure fittings are available on request.

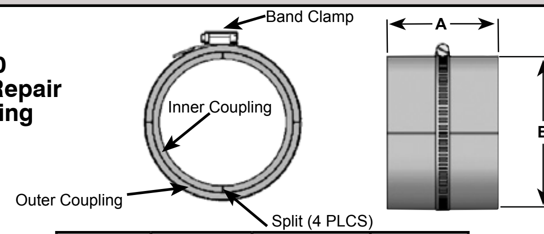
COUPLINGS

Fig. 14
Socket



Size (In)	A ± 1/8 (In.)	B		C Ref (In.)	Wt. † (Lb.)
		PM Ref (In.)	HLU Ref (In.)		
1	3	2 1/8	--	5/8	0.5
1 1/2	3	2 3/4	--	3/8	0.5
2	4	3 1/16	--	3/8	0.7
3	4	4 3/16	--	3/8	1.0
4	4	5 1/4	--	3/8	1.5
6	4	8	--	3/8	3.2
8	5 5/8	9 7/8	--	3/8	4.4
10	8 3/8	--	11 3/8	3/8	13.2
12	8 3/8	--	13 1/2	3/8	14.0
14*	8 3/8	15 9/16	-	3/8	17.2

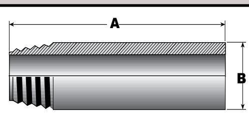
Fig. 30
RSR Repair
Coupling



Size (In)	A ± 1/8 (In.)	B Ref (In.)	Wt. † (Lb.)
1	2 5/8	2 3/8	1.0
1 1/2	3 1/4	3	1.0
2	4	3 7/16	1.4
3	4	4 9/16	2.0
4	4	5 9/16	3.0
6	4 3/4	7 11/16	6.5
8	5 1/4	9	8.8
10	5 3/4	11 1/8	26
12	6 1/4	13 1/8	28
14	6 1/4	15 1/8	34

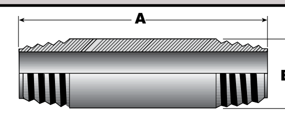
NIPPLES

Fig. 6S
Iron Pipe
Male Thread



Size (In)	A ±1/8 (In.)	B (In.)	Wt. † (Lb.)
1	8	1 5/16	0.5
1 1/2	8	1 15/16	0.8
2	8	2 3/8	1.1
3	8	3 1/2	1.9
4	8	4 1/2	2.6
6	8	6 5/8	5.0

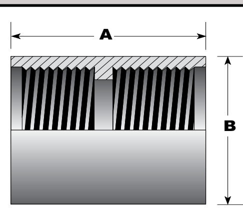
Fig. 3S*
Iron Pipe



Size (In)	A ±1/8 (In.)	B (In.)	Wt. † (Lb.)
1	8	1 5/16	0.5
1 1/2	8	1 15/16	0.8
2	8	2 3/8	1.1
3	8	3 1/2	1.9
4	8	4 1/2	2.6
6	8	6 5/8	5.0

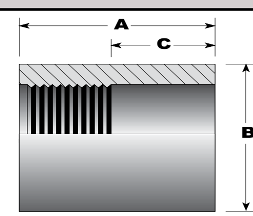
THREADED ADAPTERS

Fig. 2
Iron Pipe Thread



Size (In)	A ± 3/16 (In.)	B + 0 -1/16 (In.)	Wt. † (Lb.)
1*	3	2 11/16	0.7
1 1/2*	4	3 1/8	0.7
2	3 1/16	3 1/2	1.0
3	4	4 1/2	1.5
4	4 1/2	5 3/4	2.9

Fig. 29S*
Iron Pipe Thread x
Socket

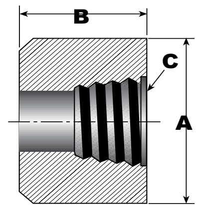


Size (In)	A+1/8-1/16 (In.)	B ± 1/8 (In.)	C ±1/16 (In.)	Wt. † (Lb.)
2	3 1/16	3 1/2	1 1/2	1.0
3	4	4 1/2	1 13/16	1.4
4	4 1/2	5 3/4	1 13/16	2.8
6	4 1/4	7 1/4	1 13/16	1.6

* Available on order only - nonreturnable.
† CL weight, multiply by 1.07 for RB, 1.1 for ZC.

THREADED INSERT

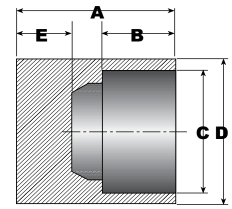
Fig. 33S
Insert



Size (In)	A Ref (In.)	B ± 1⁄16 (In.)	C Ref (In.)	Wt. † (Lb.)
1 x blank*	1 5⁄16	1 ¼	--	0.1
1½ x blank*	1 15⁄16	1 ½	--	0.2
2 x blank*	2 ⅜	1 ½	--	0.4
3 x blank*	3 ½	2	--	1.2
2 x ¼	2 ⅜	1 ½	¼ I.P.	0.4
2 x ½	2 ⅜	1 ½	½ I.P.	0.4
2 x ¾	2 ⅜	1 ½	¾ I.P.	0.3
2 x 1	2 ⅜	1 ½	1 I.P.	0.3
2 x 1¼	2 ⅜	1 ½	1 ¼ I.P.	0.3
2 x 1½	2 ⅜	1 ½	1 ½ I.P.	0.2
3 x 1	3 ½	2	1 I.P.	1.0
3 x 1½	3 ½	2	1 ½ I.P.	0.8

END CAP

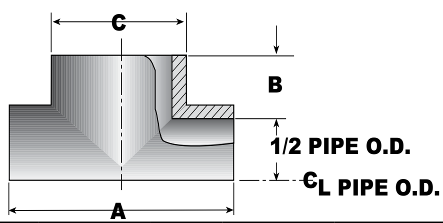
Fig. 101C
Socket Pipe Cap



Size (In)	A ± ⅜ (In.)	B ± 1⁄16 (In.)	C Ref (In.)	D Ref (In.)	E Ref (In)	Wt. † (Lb.)
1	3 1⁄16	1 3⁄16	1 5⁄16	2 1⁄16	1 ¼	0.7
1 ½	3 3⁄16	1 5⁄16	1 15⁄16	2 11⁄16	1 ½	0.9
2	4	1 13⁄16	2 ⅜	3 ⅛	1 ½	1.2
3	4	1 13⁄16	3 ½	4 3⁄16	1 ½	2.2
4	4	1 13⁄16	4 ½	5 ¼	1 ½	3.7
6	4	1 13⁄16	6 ⅝	7 ⅞	1 ½	7.4
8	5 ⅝	2 ⅝	8 ⅝	9 ⅞	2 ⅝	12.4
10*	8 ⅜	4	10 ¾	12 ¼	2	15
12*	8 ⅜	4	12 ¾	14 3⁄16	2	--

SADDLE

Fig. 13
Pipe Saddle



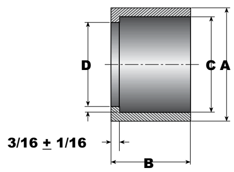
Size (In)	A ±¼ (In.)	B ±1⁄16 (In.)	C Ref (In.)									Wt.† (Lb.)
				1	1 ½	2	3	4	6	8	10	
2	4 ¼	¾	2	X	X							0.4
3	5 ¾	2	3 ⅜			X						1.5
4	8	2	4 1⁄16			X	X					2.6
6	9	2	5 ⅛			X		X				4.8
8	10 ½	2	7 7⁄16			X			X			8.1
10	13 ½	3 ⅛	10 ⅛			X				X		23.1
12	15 ½	3 ⅛	12 3⁄16			X					X	32.8

Note: For Threaded Outlets or Cement Socket Outlets greater than one size reduction, see Assembled Fittings section.
Figure 13 weights based on blank saddle. Saddles available in CL and RB only.

* Available on order only - nonreturnable
† CL weight, multiply by 1.07 for RB, 1.1 for ZC

REDUCERS

Fig. 33
Insert Socket

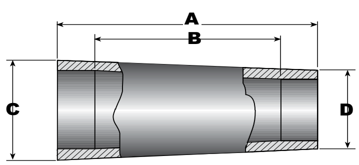


Reducer inserts which reduce greater than two pipe sizes are available on order only. Reducer inserts 8" and larger which reduce greater than one pipe size may have a reduced pressure rating. Consult factory for specific recommendations.

Size (In)	A ±1/16 (In.)	B ± ⅛ (In.)	C Ref (In.)	D Ref (In.)	Wt. † (Lb.)
1 ½ x 1	1 15/16	1 ½	1 5/16	1	0.2
2 x 1	2 ⅜	1 ½	1 5/16	1	0.3
2 x 1 ½	2 ⅜	1 ½	1 ⅞	1 ½	0.2
3 x 1	3 ½	2	1 5/16	1	0.9
3 x 1 ½	3 ½	2	1 ⅞	1 ½	0.9
3 x 2	3 ½	2	2 ⅜	2	0.6
4 x 2	4 ½	2	2 ⅜	2	1.3
4 x 3	4 ½	2	3 ½	3	0.7
6 x 2	6 ⅝	2	2 ⅜	2	3.5
6 x 3	6 ⅝	2	3 ½	3	2.9
6 x 4	6 ⅝	2	4 ½	4	2.2
8 x 2	8 ⅝	2 ½	2 ⅜	2	7.4
8 x 3	8 ⅝	2 ½	3 ½	3	7.1

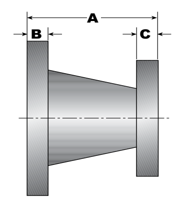
Size (In)	A ± 1/16 (In.)	B ± ⅛ (In.)	C Ref (In.)	D Ref (In.)	Wt. † (Lb.)
8 x 4	8 ⅝	2 ½	4 ½	4	6.3
8 x 6	8 ⅝	2 ½	6 ⅝	6 ⅛	3.5
10 x 2	10 ¾	4 3/16	2 ⅜	2	20.9
10 x 3	10 ¾	4 3/16	3 ½	3	19.9
10 x 4	10 ¾	4 3/16	4 ½	4	17.9
10 x 6	10 ¾	4 3/16	6 ⅝	6 ⅛	13.8
10 x 8	10 ¾	4 3/16	8 ⅝	8 ⅛	7.8
12 x 2	12 ¾	4 3/16	2 ⅜	2	34.9
12 x 3	12 ¾	4 3/16	3 ½	3	33.1
12 x 4	12 ¾	4 3/16	4 ½	4	29.8
12 x 6	12 ¾	4 3/16	6 ⅝	6 ⅛	22.9
12 x 8	12 ¾	4 3/16	8 ⅝	8 ⅛	16.9
12 x 10	12 ¾	4 3/16	10 ¾	10 ¼	12.1

Fig. 34C
Concentric Tapered Socket,
Hand Layup Construction



Size (In.)	A Ref (In.)	B ± ⅜ (In.)	C Ref (In.)	D Ref (In.)	Wt. † (Lb.)
1½ x 1*	6	3 3/16	3 ⅛	2 11/16	1.6
2 x 1	6	3	3 ⅛	2 11/16	2.0
2 x 1½	6	2 ⅞	3 ⅛	2 11/16	1.2
3 x 1½	5 11/16	2 9/16	4 13/16	3 ⅛	2.1
3 x 2	6	2 ⅜	4 13/16	3 ⅛	1.9
4 x 2	7 ¼	3 ⅝	5 ¼	3 ⅛	2.6
4 x 3	7 ¼	3 ⅜	5 ¼	4 3/16	2.9
6 x 3	9 9/16	5 15/16	7 ⅞	5 ¼	6.8
6 x 4	9 ⅜	5 ⅜	7 ⅞	5 ¼	6.2
8 x 4	15 7/16	11	9 ½	5 ¼	10.7
8 x 6	15 7/16	11	9 ½	7 ½	9.5
10 x 6	13 7/16	7 ⅜	11 ½	7 ½	10.0
10 x 8	14	7 ⅜	11 ½	9 ½	11.5
12 x 8	16	9 ⅜	13 ½	9 ½	17.2
12 x 10	16 ⅜	9 ⅜	13 ½	11½	20.7
14 x 12	17 3/16	9 3/16	15	13 ¾	22.8

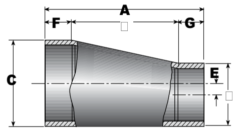
Fig. 34F(1)
Concentric Tapered Socket



Size (In)	A Ref (In.)	B ± 1/16 (In.)	C Ref (In.)	Wt. † (Lb.)
1½ x 1*	6	1 3/16	⅞	2.3
2 x 1	6	1 3/16	⅞	2.8
2 x 1½	6	1 3/16	1 3/16	3.4
3 x 1½	6	1 3/16	1 3/16	5.1
3 x 2	6	1 3/16	1 3/16	5.2
4 x 2	7	1 ½	1 3/16	7.5
4 x 3	7	1 ½	1 3/16	8.8
6 x 3	9	1 9/16	1 3/16	10.1
6 x 4	9	1 9/16	1 ½	13.9
8 x 4	11	2 1/16	1 ½	18.5
8 x 6	11	2 1/16	1 9/16	20.2
10 x 6	12	3 1/16	1 9/16	30.4
10 x 8	12	3 1/16	2 1/16	35.5
12 x 8	14	3 1/16	2 1/16	46.9
12 x 10	14	3 1/16	3 1/16	56.3
14 x 12*	25 13/16	4 ⅜	3 1/16	93.0

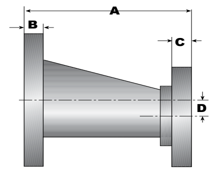
* Available on order only - nonreturnable
(1) See Fig. 18 for flange dimensions.
†CL weight, multiply by 1.07 for RB, 1.1 for ZC

Fig. 35C
Eccentric Tapered
Socket



Size (In)	A Ref (In.)	B ± ⅜ (In.)	C Ref (In.)	D Ref (In.)	E Ref (In.)	F ±⅜ (In.)	G ±⅛ (In.)	Wt. † (Lb.)
3 x 2	6 ⅝	2 15/16	4	2 ⅞	½	1 13/16	1 13/16	1.3
4 x 2	6 ⅝	2 15/16	5	2 ⅞	1	1 13/16	1 13/16	1.5
4 x 3	6 ⅝	2 15/16	5	4	½	1 13/16	1 13/16	1.6
6 x 3	9	5 ⅜	7 ⅛	4	1 ½	1 13/16	1 13/16	6.3
6 x 4	9	5 ⅜	7 ⅛	5	1	1 13/16	1 13/16	5.5
8 x 4	11 13/16	7 ⅜	9 ⅛	5	2	2 ⅝	1 13/16	9.5
8 x 6	11 13/16	7 ⅜	9 ⅛	7 ⅛	1	2 ⅝	1 13/16	7.3
10 x 6	13 3/16	7 ⅜	11 ¼	7 ⅛	2	4	1 13/16	13.7
10 x 8	14	7 ⅜	11 ¼	9 ⅛	1	4	2 ⅝	12.9
12 x 8	16	9 ⅜	13 ¼	9 ⅛	2	4	2 ⅝	16.8
12 x 10	16 ⅜	8 ⅜	13 ¼	11 ¼	1	4	4	20.0

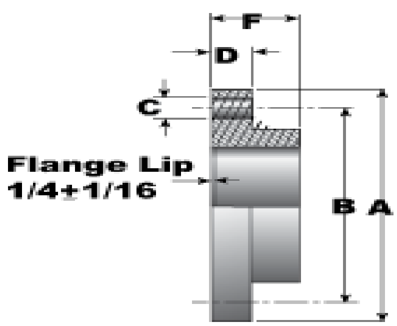
Fig. 35F (1)
Eccentric Tapered
Flanged

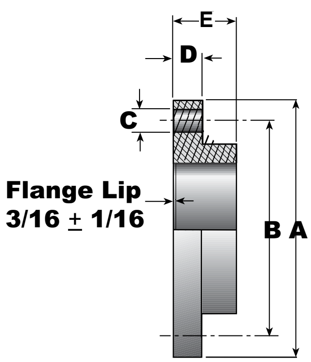


Size (In)	A ± ⅛ (In.)	B Ref (In.)	C Ref (In.)	D Ref (In.)	Wt. † (Lb.)
2 x 1*	6	1 3/16	⅞	½	3.4
3 x 2	10 ¾	1 3/16	1 3/16	½	6.2
4 x 2	10 ¾	1 ½	1 3/16	1	8.2
4 x 3	10 ¾	1 ½	1 3/16	½	9.2
6 x 3	9	1 9/16	1 3/16	1 ½	10.0
6 x 4	9	1 9/16	1 ½	1	12.0
8 x 4	11	2 1/16	1 ½	2	16.1
8 x 6	11	2 1/16	1 9/16	1	19.7
10 x 6	12	3 1/16	1 9/16	2	30.9
10 x 8	12	3 1/16	2 1/16	1	35.2
12 x 8	14	3 1/16	2 1/16	2	46.4
12 x 10	14	3 1/16	3 1/16	1	54.8

FLANGES

Fig. 18 and Fig. 18L* Flange Socket





Size (In)	A Ref (In.)	B Ref (In.)	C Ref (In.)	D±1/16 (In.)	E±1/16 (In.)	F±1/16 (In.)	Wt. † (Lb.)	Bolts No/Size
1	4 ¼	3 ⅛	⅝	⅞	1 7/16	--	0.6	4-½
1 ½	5	3 ⅞	⅝	1 3/16	1 9/16	--	1.1	4-½
2	6	4 ¾	¾	1 3/16	2 1/16	3 11/16	1.6	4-⅝
3	7 ½	6	¾	1 3/16	2 1/16	3 11/16	2.5	4-⅝
4	9	7 ½	¾	1 ½	2 1/16	3 15/16	4.2	8-⅝
6	11	9 ½	⅞	1 9/16	2 1/16	4 7/16	5.3	8-¾
8	13 ½	11 ¾	⅞	2 1/16	2 9/16	4 7/16	9.9	8-¾
10	16	14 ¼	1	3 1/16	4 ¼	--	19.6	12-⅞
12	19	17	1	3 1/16	4 ¼	--	27.8	12-⅞
14	21	18 ¾	1 ⅛	4 ⅜	4 ⅜	--	45.5	12-1

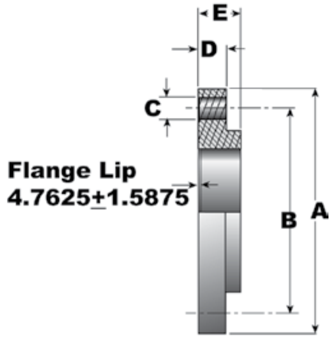
Fig. 18R * Reducer Socket

Size (In)	A Ref (In.)	B Ref (In.)	C Ref (In.)	D ±1/16 (In.)	E ±1/16 (In.)	Wt. † (Lb.)	Bolts No/Size
1½ x 1	5	3 ⅞	⅝	1 3/16	1 9/16	1.3	4-½
2 x 1	6	4 ¾	¾	1 3/16	2 1/16	1.4	4-⅝
2 x 1½	6	4 ¾	¾	1 3/16	2 1/16	1.7	4-⅝
3 x 2	7 ½	6	¾	1 3/16	2 1/16	3.3	4-⅝
4 x 2	9	7 ½	¾	1 ½	2 1/16	5.4	8-⅝
4 x 3	9	7 ½	¾	1 ½	2 1/16	4.9	8-⅝
6 x 2	11	9 ½	⅞	1 9/16	2 1/16	7.6	8-¾
6 x 3	11	9 ½	⅞	1 9/16	2 1/16	8.0	8-¾
6 x 4	11	9 ½	⅞	1 9/16	2 1/16	8.8	8-¾
8 x 2	13 ½	11 ¾	⅞	2 1/16	2 9/16	17.6	8-¾
8 x 3	13 ½	11 ¾	⅞	2 1/16	2 9/16	17.0	8-¾
8 x 4	13 ½	11 ¾	⅞	2 1/16	2 9/16	16.0	8-¾
8 x 6	13 ½	11 ¾	⅞	2 1/16	2 9/16	13.4	8-¾
10 x 6	16	14 ¼	1	3 1/16	4 ¼	33.4	12-⅞
10 x 8	16	14 ¼	1	3 1/16	4 ¼	27.3	12-⅞
12 x 8	16	17	1	3 1/16	4 ¼	49.9	12-⅞
12 x 10	16	17	1	3 1/16	4 ¼	43.3	12-⅞

Flanges meet O.D. bolt circle diameter, number of holes, and bolt hole diameter dimensions for ANSI B16.1 125 lb. cast iron sizes 1”-72” and ANSI B16.5 lb. steel for 1”-24” diameters.

* Available on order only - nonreturnable
(1) See Fig. 18 for flange dimensions.
† CL weight, multiply by 1.07 for RB, 1.1 for ZC

Fig. 18M*
Flange Metric Socket



Size		A Ref	B Ref	C Ref	D ±1.588	E ±1.588	Bolts
(mm)	(In.)	(mm)	(mm)	(mm)	(mm)	(mm)	No/Size
25	1	115	85	14	22.225	34.925	4-12mm
40	1 ½	150	110	18	30.163	38.100	4-16mm
50	2	165	125	18	30.163	50.800	4-16mm
80	3	200	160	18	30.163	50.800	8-16mm
100	4	220	180	18	38.100	50.800	8-16mm
150	6	279	241	23	39.100	50.800	8-20mm
200	8	343	298	23	52.388	60.325	8-20mm
250	10	406	350	23	77.788	106.363	12-20mm
300	12	483	400	23	77.788	106.363	12-20mm

Fig. 22 Blind Flange

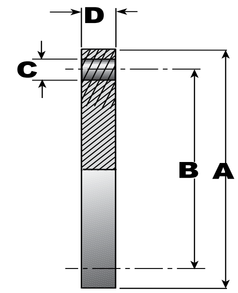
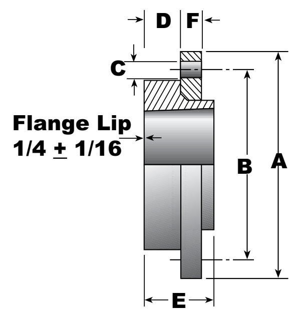


Fig 22S(2) Iron Pipe Tapped

Size (In)	A ±⅛ (In.)	B ±1/16 (In.)	C Ref (In.)	D ±1/16 (In.)	Wt. † (Lb.)	Bolts No/Size
1	4 ¼	3 ⅛	⅝	⅞	0.6	4-½
1 ½	5	3 ⅞	⅝	1 3/16	1.2	4-½
2	6	4 ¾	¾	1 3/16	1.8	4-⅝
3	7 ½	6	¾	1 3/16	3.0	4-⅝
4	9	7 ½	¾	1 ½	5.2	8-⅝
6	11	9 ½	⅞	1 9/16	8.2	8-¾
8	13 ½	11 ¾	⅞	2 1/16	16.6	8-¾
10	16	14 ¼	1	3 1/16	34.3	12-⅞
12	19	17	1	3 1/16	49.1	12-⅞

Fig. 21/24/25*
Van Stone Flange

						Fig. 24	Fig. 25
						F	
Size (In)	A Ref (In.)	B Ref (In.)	C Ref (In.)	D ±1/16 (In.)	E ±1/16 (In.)	Fiberglass Ring ±1/16	Steel Ring ±⅛
2	6	4 ¾	¾	1	2	⅞	⅝
3	7 ½	6	¾	1	2	⅞	⅝
4	9	7 ½	¾	1	2	⅞	⅝
6	11	9 ½	⅞	1	2	⅞	¾



ELBOWS

Fig. 255C
90 ° Short Radius
Elbow, Socket

Size (In.)	A ±1/16 (In.)	B ±1/16 (In.)	Wt. † (Lb.)
1	2 ½	1 3/16	0.4
1½	2 ¾	1 5/16	0.6
2	3 13/16	1 13/16	1.5
3	4 7/16	1 13/16	2.4
4	5 1/16	1 13/16	3.5
6	6	1 13/16	7.6
8	7 ½	2 ⅝	12.0

Sizes 1" - 6" PM Construction

8" HLU Construction

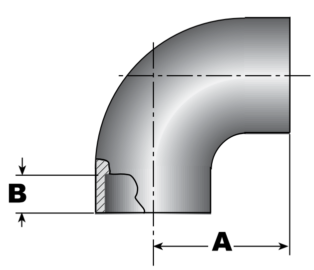


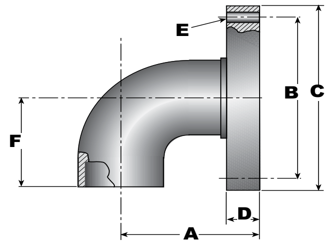
Fig. 257C
90 ° Long Radius
Elbow, Socket

Size (In.)	A ±3/16 (In.)	B ±⅛ (In.)	Wt. † (Lb.)
1	5	1 3/16	1.0
1½	6	1 5/16	1.5
2	6 ½	1 13/16	1.9
3	7 ¾	1 13/16	2.2
4	9	1 13/16	3.6
6	10 13/16	1 13/16	7.6
8	14 ⅝	2 ⅝	13.8
10	17 11/16	4	22.8
12	20 3/16	4	31.4
14	22	4	41.0

HLU Construction

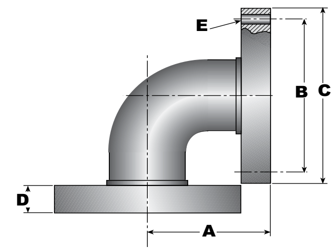
* Available on order only - nonreturnable
(2) Maximum Iron Pipe Thread size = 1"
† CL weight, multiply by 1.07 for RB, 1.1 for ZC

Fig. 255S*
90 ° Short Radius
Elbow, Flange x Socket



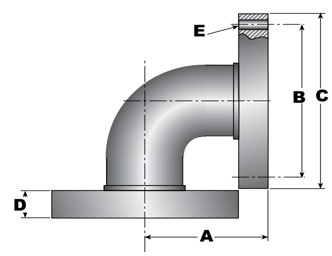
Size (In.)	A ±1/16 (In.)	B Ref (In.)	C Ref (In.)	D Ref (In.)	E Ref (In.)	F Ref (In.)	Wt. † (Lb.)	Bolts No/Size
1	3 15/16	3 ⅛	4 ¼	⅞	⅝	2 ½	1.1	4-½
1½	4 5/16	3 ⅞	5	1 3/16	⅝	2 ¾	1.9	4-½
2	5 ⅞	4 ¾	6	1 3/16	¾	3 13/16	3.3	4-⅝
3	6 ½	6	7 ½	1 3/16	¾	4 7/16	5.1	4-⅝
4	7 ⅛	7 ½	9	1 ½	¾	5 1/16	8.3	8-⅝
6	8 1/16	9 ½	11	1 9/16	⅞	6	14.2	8-¾
8	10 1/16	11 ¾	13 ½	2 1/16	⅞	7 ½	25	8-¾

Fig. 255F
90 ° Short Radius
Elbow, Flanged



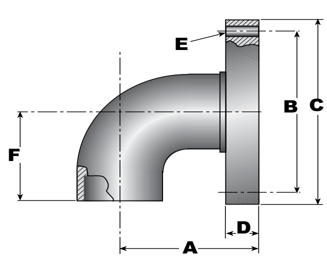
Size (In.)	A ±1/16 (In.)	B Ref (In.)	C Ref (In.)	D Ref (In.)	E Ref (In.)	Wt. † (Lb.)	Bolts No/Size
1	3 15/16	3 ⅛	4 ¼	⅞	⅝	1.8	4-½
1½	4 13/16	3 ⅞	5	1 3/16	⅝	3.3	4-½
2	4 ½	4 ¾	6	1 1/16	¾	4.4	4-⅝
3	5 ½	6	7 ½	1 ¼	¾	8.3	4-⅝
4	6 ½	7 ½	9	1 ⅜	¾	13.0	8-⅝
6	8	9 ½	11	1 9/16	⅞	20.8	8-¾
8	9	11 ¾	13 ½	2 1/16	⅞	36.4	8-¾
10	11	14 ¼	16	3 1/16	1	52.6	12-⅞
12	12	17	19	3 1/16	1	73.4	12-⅞

Fig. 257F
90 ° Long Radius
Elbow, Flanged



Size (In.)	A ±1/16 (In.)	B Ref (In.)	C Ref (In.)	D Ref (In.)	E Ref (In.)	Wt. † (Lb.)	Bolts No/Size
1	6 7/16	3 ⅛	4 ¼	⅞	⅝	2.4	4-½
1½	7 9/16	3 ⅞	5	1 3/16	⅝	4.2	4-½
2	8 9/16	4 ¾	6	1 3/16	¾	5.2	4-⅝
3	9 13/16	6	7 ½	1 3/16	¾	9.1	4-⅝
4	11 1/16	7 ½	9	1 ½	¾	14.6	8-⅝
6	11 ½	9 ½	11	1 9/16	⅞	17.1	8-¾
8	14	11 ¾	13 ½	2 1/16	⅞	29.3	8-¾
10	16 ½	14 ¼	16	3 1/16	1	52.6	12-⅞
12	19	17	19	3 1/16	1	72.2	12-⅞
14	26 ⅜ **	18 ¾	21	4 ⅜	1 ⅛	134.6	12-1

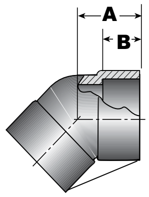
Fig. 257S*
90 ° Long Radius
Elbow, Flange x Socket



Size (In.)	A ±⅛ (In.)	B Ref (In.)	C Ref (In.)	D Ref (In.)	E Ref (In.)	F±⅛ (In.)	Wt. † (Lb.)	Bolts No/Size
1	6 7/16	3 ⅛	4 ¼	⅞	⅝	5	1.7	4-½
1½	7 9/16	3 ⅞	5	1 3/16	⅝	6	2.8	4-½
2	8 9/16	4 ¾	6	1 3/16	¾	6 ½	3.3	4-⅝
3	9 13/16	6	7 ½	1 3/16	¾	7 ¾	5.8	4-⅝
4	11 1/16	7 ½	9	1 ½	¾	9	8.5	8-⅝
6	12 ⅞	9 ½	11	1 9/16	⅞	10 3/16	14.4	8-¾
8	17 3/16	11 ¾	13 ½	2 1/16	⅞	14 ⅝	25.7	8-¾
10	21 15/16	14 ¼	16	3 1/16	1	17 11/16	49.7	12-⅞
12	24 7/16	17	19	3 1/16	1	20 3/16	65.2	12-⅞
14*	26 ⅜	18 ¾	21	4 ⅜	1⅛	22	105.1	12-1

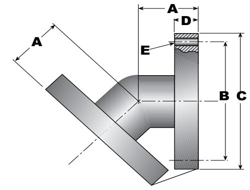
* Available on order only - nonreturnable
** Tolerance exception - Fig. 257F x 14 - A ±⅛
† CL weight, multiply by 1.07 for RB, 1.1 for ZC

Fig. 265C
45 ° Short Radius
Elbow, Socket



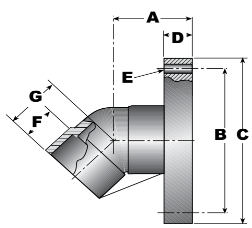
Size (In.)	A PM ±1/16 (In.)	A HLU ±⅛ (In.)	B Ref* (In.)	Wt. † (Lb.)
1	2 ½	1 ¾*	1 3/16	0.7
1½	2 5/16	2 ¼*	1 5/16	0.6
2	3 ¼	2 ½*	1 13/16	1.3
3	3 ¾	3*	1 13/16	2.1
4	4 1/16	4*	1 13/16	3.4
6	4 ¾	5*	1 13/16	7.0
8	--	5 15/16	2 ⅝	7.7
10	--	7 11/16	4	15.8
12	--	8 11/16	4	20.2
14	--	9 ⅜	4	24.5

Fig. 265F
45 ° Short Radius
Elbow, Flanged



Size (In.)	A PM ±1/16	A HLU ±⅛	B Ref (In.)	C Ref (In.)	D Ref (In.)	E Ref (In.)	Wt. † (Lb.)	Bolts No/Size
1	3 15/16	3 3/16*	3 ⅛	4 ¼	⅞	⅝	2.1	4-½
1½	4 ⅜	3 13/16*	3 ⅞	5	1 3/16	⅝	3.3	4-½
2	2 ½	4 9/16*	4 ¾	6	1 1/16	¾	5.4	4-⅝
3	3	5 1/16*	6	7 ½	1 ¼	¾	6.6	4-⅝
4	4	6 1/16*	7 ½	9	1 ⅜	¾	13.0	8-⅝
6	6 13/16	7 1/16*	9 ½	11	1 9/16	⅞	20.3	8-¾
8	--	5 ½	11 ¾	13 ½	2 1/16	⅞	23.8	8-¾
10	--	6 ½	14 ¼	16	3 1/16	1	56	12-⅞
12	--	7 ½	17	19	3 1/16	1	77	12-⅞
14	--	13 ¾	18 ¾	21	4 ⅜	1⅛	115	12-1

Fig. 265S*
45 °Elbow,
Flange x Socket



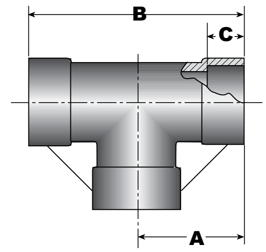
Size (In.)	A PM ±1/16 (In.)	A HLU ±⅛ (In.)	B Ref (In.)	C Ref (In.)	D Ref (In.)	E Ref (In.)	F (In.)	G PM ±1/16 (In.)	G HLU ±⅛ (In.)	Wt. † (Lb.)	Bolts No/Size
1	3 15/16	3 3/16*	3 ⅛	4 ¼	⅞	⅝	1 3/16	2 ½	1 ¾	1.3	4-½
1½	3 ⅞	3 13/16*	3 ⅞	5	1 3/16	⅝	1 5/16	2 5/16	2 ¼	2.0	4-½
2	5 5/16	4 9/16*	4 ¾	6	1 3/16	¾	1 13/16	3 ¼	2 ½	3.2	4-⅝
3	5 13/16	5 1/16*	6	7 ½	1 3/16	¾	1 13/16	3 ¾	3	4.9	4-⅝
4	6 ⅛	6 1/16*	7 ½	9	1 ½	¾	1 13/16	4 1/16	4	8.0	8-⅝
6	6 13/16	7 1/16*	9 ½	11	1 9/16	⅞	1 13/16	4 ¾	5	13.7	8-¾
8	--	8 ½	11 ¾	13 ½	2 1/16	⅞	2 ⅝	--	5 15/16	15.9	8-¾
10	--	11 15/16	14 ¼	16	3 1/16	1	4	--	7 11/16	39.3	12-⅞
12	--	12 15/16	17	19	3 1/16	1	4	--	8 11/16	57.5	12-⅞
14	--	13 ¾	18 ¾	21	4 ⅜	1⅛	4	--	9 ⅜	70	12-1

* Available on order only - nonreturnable
† CL weight, multiply by 1.07 for RB, 1.1 for ZC

TEES

Size (In.)	A PM ±1/16 (In.)	A HLU ±1/8 (In.)	B PM ±1/16 (In.)	B HLU ±1/8 (In.)	C ±1/8 (In.)	Wt. † (Lb.)
1	2 ½	3 ½*	5	7	1 3/16	0.8
1½	2 ¾	4*	5 ½	8	1 5/16	0.9
2	3 13/16	4 ½*	7 ⅝	9	1 13/16	2.1
3	4 7/16	5 ½*	8 ⅞	11	1 13/16	3.4
4	5 1/16	6 ½*	10 ⅛	13	1 13/16	5.3
6	--	8	--	16	1 13/16	11.2
8	--	7 11/16	--	15 ⅜	2 ⅝	15.5
10	--	12 3/16	--	24 ⅜	4	29.3
12	--	13 3/16	--	26 ⅜	4	38.8
14	--	13 ⅝	--	27¼	4	40.8

Fig. 275C
Tee, Socket



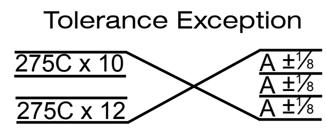
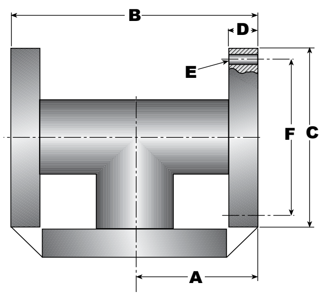


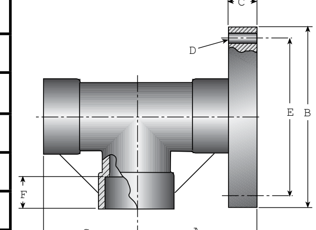
Fig. 275F
Tee, Flanged



Size (In.)	A PM ±1/16 (In.)	A HLU ±1/8 (In.)	B PM ±1/16 (In.)	B HLU ±1/8 (In.)	C Ref (In.)	D Ref (In.)	E Ref (In.)	F Ref (In.)	Wt. † (Lb.)	Bolts No/Size
1	3 15/16	4 15/16	7 ⅞	9 ⅞	4 ¼	⅞	⅝	3 ⅛	2.9	4-½
1½	4 13/16	5 9/16	9 ⅝	11 ⅛	5	1 3/16	⅝	3 ⅞	5.0	4-½
2	4 ½	6 9/16	9	13 ⅛	6	1 1/16	¾	4 ¾	7.6	4-⅝
3	5 ½	7 9/16	11	15 ⅛	7 ½	1 ¼	¾	6	12.6	4-⅝
4	6 ½	8 9/16	13	17 ⅛	9	1 ⅜	¾	7 ½	19.0	8-⅝
6	--	8	--	16	11	1 9/16	⅞	9 ½	32.7	8-¾
8	--	9	--	18	13 ½	2 1/16	⅞	11 ¾	51.7	8-¾
10	--	11	--	22	16	3 1/16	1	14 ¼	90	12-⅞
12	--	12	--	24	19	3 1/16	1	17	125	12-⅞
14	--	18	--	36	21	4 ⅜	1 ⅛	18 ¾	180	12-1

Size (In.)	A PM ±1/16 (In.)	A HLU ±1/8 (In.)	B Ref (In.)	C Ref (In.)	D Ref (In.)	E Ref (In.)	F Ref (In.)	G PM ±1/16 (In.)	G HLU ±1/8 (In.)	Wt. † One Flg (Lb.)	Wt. † Two Flgs (Lb.)
1	3 15/16	4 15/16*	4 ¼	⅞	⅞	3 ⅛	1 3/16	2 ½	3 ½	1.5	2.2
1½	4 5/16	5 9/16*	5	1 13/16	⅝	3 ⅞	1 5/16	2 ¾	4	2.2	3.5
2	5 ⅞	6 9/16*	6	1 13/16	¾	4 ¾	1 13/16	3 13/16	4 ½	3.9	5.8
3	6 ½	7 9/16*	7 ½	1 13/16	¾	6	1 13/16	4 7/16	5 ½	7.0	10.6
4	7 ⅛	8 9/16*	9	1 ½	¾	7 ½	1 13/16	--	6 ½	11.4	17.4
6♦	--	10 1/16	11	1 9/16	⅞	9 ½	1 13/16	6	8	19.3	27.5
8	--	10 ¼	13 ½	2 1/16	⅞	11 ¾	2 ⅝	--	7 11/16	22.2	28.9
10	--	16 7/16	16	3 1/16	1	14 ¼	4	--	12 3/16	60	90
12	--	17 7/16	19	3 1/16	1	17	4	--	13 3/16	95	140

Fig. 275S*
Tee, Flanged x Socket



♦6" PM available in CL only
* Available on order only - nonreturnable
†CL weight, multiply by 1.07 for RB, 1.1 for ZC

LATERALS

Fig. 266C
Lateral, Socket

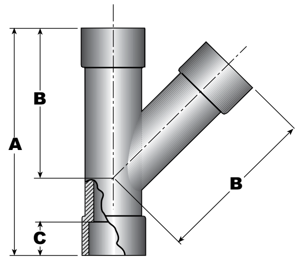
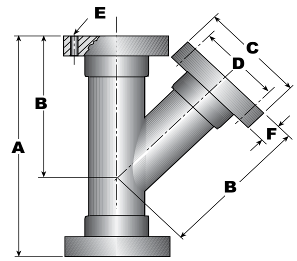


Fig. 266F*
Lateral, Flanged



Size (In)	A ±1/4 (In.)	B ±1/4 (In.)	C ±1/8 (In.)	Wt. † (Lb.)
2	10 1/8	7 1/2	1 13/16	2.0
3	11 7/8	8 15/16	1 13/16	3.7
4	13 11/16	11	1 13/16	8
6	24 1/2	17 3/8	1 13/16	13.9
8	29 1/4	21 5/16	2 5/8	35.5
10	36 7/8	26 7/16	4	51.7
12	43 1/4	31 15/16	4	69.1

Size (In.)	A ±1/8 (In.)	B ±1/8 (In.)	C Ref (In.)	D Ref (In.)	E Ref (In.)	F Ref (In.)	Wt.† (Lb.)	Bolts No/Size
2	12 1/2	8 11/16	6	4 3/4	3/4	1 1/16	7.6	4-5/8
3	14 1/2	10 1/8	7 1/2	6	3/4	1 1/4	12.6	4-5/8
4	16 11/16	12 1/2	9	7 1/2	3/4	1 3/8	19.0	8-5/8
6	28 5/8	19 7/16	11	9 1/2	7/8	1 9/16	32.7	8-3/4
8	31 3/4	22 9/16	13 1/2	11 3/4	7/8	2 1/16	51.7	8-3/4
10	45 3/8	30 11/16	16	14 1/4	1	3 1/16	112	12-7/8
12	51 3/4	36 3/16	19	17	1	3 1/16	152	12-7/8

Note: Reducing Laterals and crosses are available on request.

CROSSES

Fig. 285C
Cross, Socket

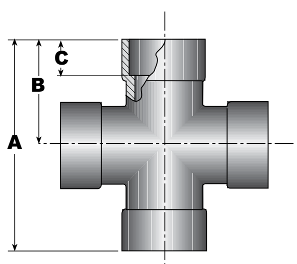
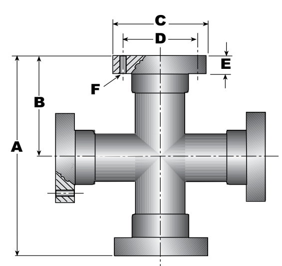


Fig. 285F*
Cross, Flanged



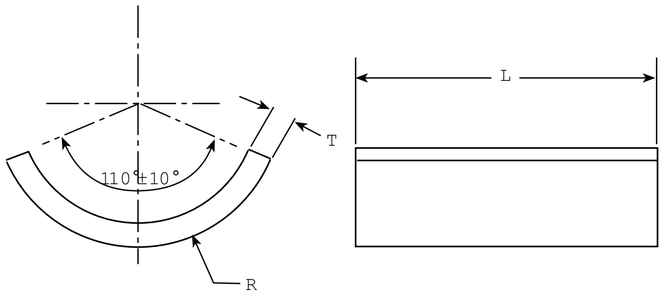
Size (In)	A ±1/4 (In.)	B ±1/8 (In.)	C ±1/8 (In.)	Wt.† (Lb.)
2	6 3/8	3 3/16	1 13/16	1.4
3	8	4	1 13/16	2.3
4	10 5/8	5 5/16	1 13/16	5.5
6	16	8	1 13/16	15.7
8	15 3/8	7 11/16	2 5/8	15.5
10	24 3/8	12 3/16	4	45.6
12	26 3/8	13 3/16	4	57.2

Size (In.)	A ±1/8 (In.)	B ±1/8 (In.)	C Ref (In.)	D Ref (In.)	E Ref (In.)	F Ref (In.)	Wt. † (Lb.)	Bolts No/Size
2	8 3/4	4 3/8	6	4 3/4	1 3/16	3/4	9.3	4-5/8
3	10 3/8	5 3/16	7 1/2	6	1 3/16	3/4	13.9	4-5/8
4	13 5/8	6 13/16	9	7 1/2	1 1/2	3/4	23.5	8-5/8
6	16	8	11	9 1/2	1 9/16	7/8	57.5	8-3/4
8	18	9	13 1/2	11 3/4	2 1/16	7/8	71.7	8-3/4
10	22	11	16	14 1/4	3 1/16	1	126	12-7/8
12	24	12	19	17	3 1/16	1	170	12-7/8

* Available on order only - nonreturnable.
† CL weight, multiply by 1.07 for RB, 1.1 for ZC

PIPE SUPPORT/WEAR PAD

Fig. 391
Pipe Support



Size (In)	R	L ± ⅛ (In.)	T Ref (In.)
1	1-1/16	3	13/32
1 ½	1-⅜	3	7/16
2	1-17/32	4	11/32
3	2-3/32	4	11/32
4	2-⅝	4	⅜
6	3-15/16	4	⅝
8	4-15/16	5-⅝	⅝
10	6-⅛	8-⅜	¾
12	7-3/32	8-⅜	23/32
14*	7-25/32	8-⅜	25/32

*Available on order only - nonreturnable.

FLOOR DRAIN

Fig. 203
Sealable Floor Drain

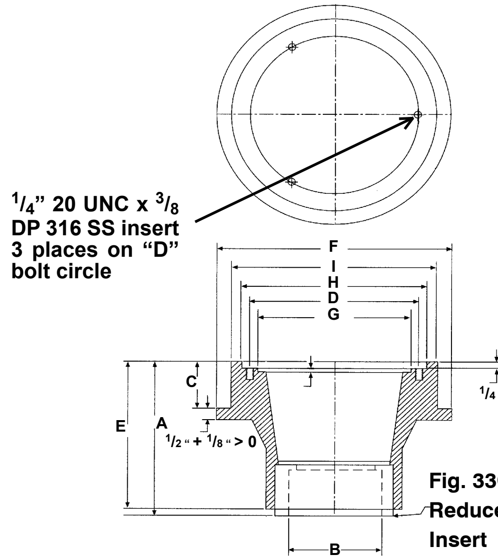


Fig. 33C Reducer Insert required for 6x2, 6x3, 12x4 and 12x6 sizes.

Sealable Drain Dimensional Data

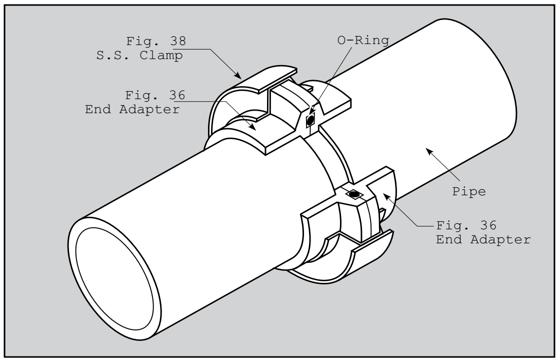
Size (In.)	A ±⅛ (In.)	B (In.)	C (In.)	D (In.)	E (In.)	F ±⅛ (In.)	G (In.)	H (In.)	I (In.)
6 x 2	6 ¼	2 ⅜	2	6 ⅜	6	8 ⅞	5 ¾	7	7 ¾
6 x 3	6 ¼	3 ½	2	6 ⅜	6	8 ⅞	5 ¾	7	7 ¾
6 x 4	6	4 ½	2	6 ⅜	6	8 ⅞	5 ¾	7	7 ¾
12 x 4	8 11/16	4 ½	1 9/16	13 ⅜	8	15 ½	12 ¾	14	14 ½
12 x 6	8 11/16	6 ⅝	1 9/16	13 ⅜	8	15 ½	12 ¾	14	14 ½
12 x 8	8	8 ⅝	1 9/16	13 ⅜	8	15 ½	12 ¾	14	14 ½

Note: Standard outlet straight socket. 2" - 6" FNPT outlet available on request.

Sealable Drain Standard Configurations

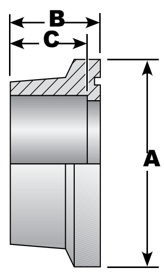
Description	Figure	Viton Plug	¼ Solid Cover Plate with O-Ring Seal	¼" Drilled Drain Grate	16 Gauge Strainer Basket
Clean Out	203CO				
Floor Drain	203FD				
Equipment Drain	203ED				

Physical Data



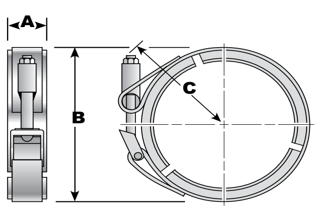
Size (In.)	Pressure Rating		Max Rec. Torque (In-Lbs.)	Precision O-Ring Size	Wrench Size (In.)
	EP @225°	VE @175°			
2	150	150	50	333	7/16
3	150	150	75	342	7/16
4	150	150	150	428	½
6	150	150	150	441	½
8	150	125	175	448	½

Fig. 36*
End Adapter



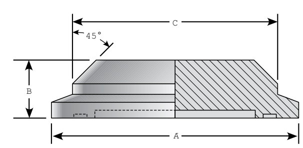
Size (In.)	A Ref (In.)	B Ref (In.)	C Ref (In.)	Wt. † (Lb.)
2	3 ¾	2 1/16	1 13/16	0.5
3	5	2 1/16	1 13/16	0.7
4	6 ⅜	2 1/16	1 13/16	1.2
6	8 ⅞	2 1/16	1 13/16	2.2
8	11 ½	2 1/16	1 13/16	3.8

Fig. 38*
SS Clamp



Size (In.)	A Ref (In.)	B Ref (In.)	C Ref (In.)	Nut(s)		Wt. † (Lb.)
				No.	Size (In.)	
2	1 5/16	4	3	1	7/16	0.5
3	1 ⅜	5 ¼	3 ⅝	1	7/16	0.7
4	1 ¾	7	5	1	½	1.2
6	2 1/16	9 ¼	5 ⅝	1	½	2.4
8	2 9/16	12	7 ½	1	½	5.5

Fig. 39*
Blind Flange

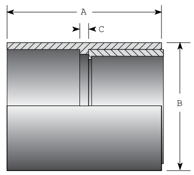


Size (In.)	A Ref (In.)	B Ref (In.)	C Ref (In.)
2	3 ¾	1 1/16	3 ⅛
3	5	1 ⅛	4 5/16
4	6 ⅜	1 ¼	5 5/16
6	8 ⅞	1 ½	7 15/16
8	11 ½	2	10 5/16

* Available on order only - nonreturnable.
† CL weight, multiply by 1.07 for RB, 1.1 for ZC

ASSEMBLED FITTINGS REFERENCE DIMENSIONS

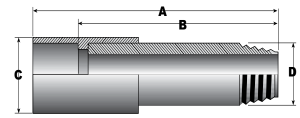
Fig. 8C*
Reducer
Socket



Size (In.)	A Ref (In.)	B Ref (In.)	C Ref (In.)	Wt. † (Lb.)
1½ x 1	3 3⁄16	2 11⁄16	9⁄16	0.7
2 x 1	4	3 ⅛	9⁄16	1.3
2 x 1½	4	3 ⅛	9⁄16	0.9
3 x 2	4 3⁄16	4 3⁄16	9⁄16	1.6
4 x 2	4 3⁄16	5 ¼	9⁄16	2.7
4 x 3	4 3⁄16	5 ¼	9⁄16	2.4
6 x 4	4 3⁄16	7 ⅞	9⁄16	5.4
8 x 4	5 ⅝	9 ⅞	9⁄16	7.8
8 x 6	5 ⅝	9 ⅞	9⁄16	6.7

Assemble using Fig. 14 Socket Coupling and Fig. 33 Reducer Bushing

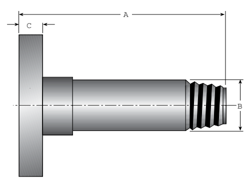
Fig. 6*
Adapter
Iron Pipe Male x
Socket Female



Size (In.)	A (In.)	B Ref (In.)	C (In.)	D (In.)	Wt. † (Lb.)
1	9 13⁄16	8 ⅝	2 1⁄16	1 5⁄16	0.8
1½	9 11⁄16	8 ⅜	2 11⁄16	1 15⁄16	1.1
2	10 3⁄16	8 ⅜	3 ⅛	2 ⅜	1.6
3	10 3⁄16	8 ⅜	4 3⁄16	3 ½	2.6
4	10 3⁄16	8 ⅜	5 ¼	4 ½	3.6
6	10 3⁄16	8 ⅜	7 ⅞	6 ⅝	6.6

Assemble using Fig. 6S Adapter and Fig. 14 Socket Coupling

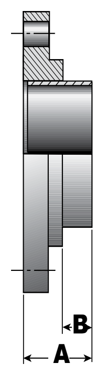
Fig. 244*
Nipple
Flange Iron
Pipe Thread



Size (In.)	A Ref (In.)	B Ref (In.)	C Ref (In.)	Wt. † (Lb.)
1	8 ¼	1 5⁄16	⅞	1.0
1 ½	8 ¼	1 15⁄16	1 3⁄16	1.8
2	8 ¼	2 ⅜	1 3⁄16	2.5
3	8 ¼	3 ½	1 3⁄16	4.1
4	8 ¼	4 ½	1 ½	6.5
6	8 ¼	6 ⅝	1 9⁄16	9.3

Assemble using Fig. 18 Socket Flange and Fig. 6S Iron Pipe Adapter

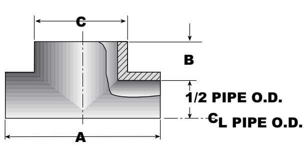
Fig. 19
Stub Flange



Size (In.)	A ±⅛ (In.)	B ±⅛ (In.)	Wt. † (Lb.)
1	2 ⅝	1 3⁄16	0.7
1½	3 ⅞	1 5⁄16	1.3
2	3 ⅞	1 13⁄16	2.0
3	3 ⅞	1 13⁄16	3.0
4	3 ⅞	1 13⁄16	4.9
6	3 ⅞	1 13⁄16	6.5
8	5 3⁄16	2 ⅝	11.7
10	8 ¼	4	23.9
12	8 ¼	4	33.9
14	8 ⅜	4	36.9

Assemble using Fig. 18 Socket Flange and Fig. 17 Pipe Stub

Fig. 13*
Pipe Saddle



Size (In.)	A ±¼ (In.)	B ±⅛ (In.)	C Ref (In.)	Threaded Outlet NPT						Cement Outlet							
				¼	½	¾	1	1¼	1½	1	1¾	2	3	4	6	8	10
2	4 ¼	¾	2 ⅜							S							
3	5 ¾	2	3 ⅜	X	X	X	X	X	X	V	V	S					
4	8	2	4 1⁄16	XV	XV	XV	X	XV	X	V	V	S	S				
6	9	2	5 ⅛	XV	XV	XV	XV	XV	XV	W	W	S	V	S			
8	10 ½	2	7 7⁄16	XV	XV	XV	XV	XV	XV	W	W	S	V	V	S		
10	13 ½	3 ⅛	10 ⅛	XV	XV	XV	XV	XV	XV	W	W	S	V	V	V	S	
12	8 ⅜	3 ⅛	12 3⁄16	XV	XV	XV	XV	XV	XV	W	W	S	V	V	V	V	S

X=Fabricated using Fig 13 Cement Socket Outlet Pipe Saddle and Fig 33S Threaded Bushing Insert.

V=Fabricated using Fig 13 Cement Socket Outlet Pipe Saddle and Fig 33 Socket Reducer Bushing Insert.

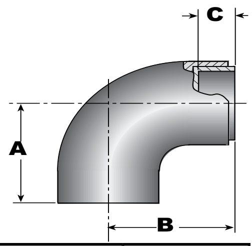
S=Standard Pipe Saddle, no fabrication needed.

XV=Fabricated using Fig 13 Cement Socket Outlet Pipe Saddle, Fig 33 Socket Reducer Bushing and Fig 33S Threaded Bushing Insert.

W=Fabricated using Fig 13 Cement Socket Outlet Pipe Saddle and 2 or more Fig 33 Socket Reducer Bushing Inserts.

* Available on order only - nonreturnable.
† CL weight, multiply by 1.07 for RB, 1.1 for ZC

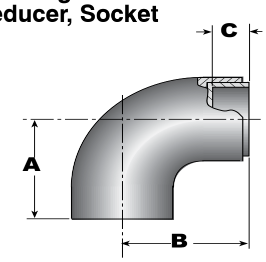
Fig. 255CR*
90° Short Radius Reducer, Socket



Size (In.)	A Ref (In.)	B Ref (In.)	C Ref (In.)
1½	2 ¾	2 15/16	1 5/16
2	3 13/16	3 ½	1 5/16
3	4 7/16	4 ⅝	1 13/16
4	5 1/16	5 ¼	1 13/16
6	6	6 3/16	1 13/16
8	7 ½	7 ½	2 5/16

Assemble using Fig. 255C Elbow and Fig. 33 Reducer Bushing

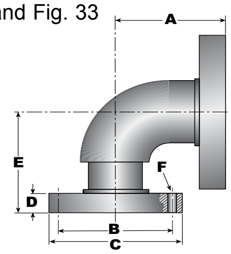
Fig. 257CR*
90° Long Radius Reducer, Socket



Size (In.)	A Ref (In.)	B Ref (In.)	C Ref (In.)
6	10 13/16	11	1 13/16
8	14 ⅝	14 ⅝	2 5/16
10	17 11/16	17 ⅞	4
12	20 3/16	20 ⅜	4

Assemble using Fig. 257C Elbow and Fig. 33 Reducer Bushing

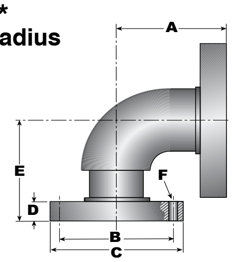
Fig. 255FR*
90° Short Radius Reducer, Flanged



Size (In.)	A Ref (In.)	B Ref (In.)	C Ref (In.)	D Ref (In.)	E Ref (In.)	F Ref (In.)	Bolts No/Size
1½ x 1	4 5/16	3 ⅛	4 ¼	⅞	6 3/16	⅝	4-½
2 x 1½	5 ⅞	3 ⅞	5	1 3/16	7	⅝	4-⅝
3 x 2	6 ½	4 ¾	6	1 3/16	7 ⅝	¾	4-⅝
4 x 3	7 ⅛	6	7 ½	1 3/16	8 ¼	¾	4-⅝
6 x 4	8 1/16	7 ½	9	1 ½	9 ½	¾	8-⅝
8 x 6	10 1/16	9 ½	11	1 9/16	10 ½	⅞	8-¾

Assemble using Fig. 255C Elbow and Fig. 33 Reducer Bushing, Fig. 17 Pipe Stub and Fig. 18 Socket Flange

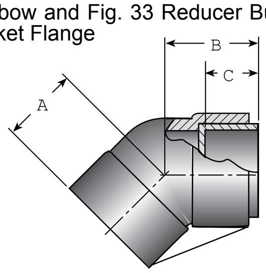
Fig. 257FR*
90° Long Radius Reducer, Flanged



Size (In.)	A Ref (In.)	B Ref (In.)	C Ref (In.)	D Ref (In.)	E Ref (In.)	F Ref (In.)	Bolts No/Size
6 x 4	12 ⅞	7 ½	9	1 ½	14 5/16	¾	8-⅝
8 x 6	17 3/16	9 ½	11	1 9/16	17 ⅜	⅞	8-¾
10 x 8	21 15/16	11 ¾	13 ½	2 1/16	21 ¼	⅞	8-¾
12 x 10	24 7/16	14 ¼	16	3 1/16	26 ⅜	1	12-⅞

Assemble using Fig. 257C Elbow, Fig. 33 Reducer Bushing, Fig. 17 Pipe Stub and Fig. 18 Socket Flange

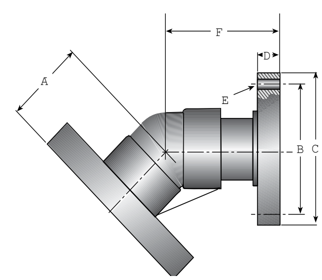
Fig. 265CR(3)
45° Reducer, Socket



Size (In.)	A		B		C Ref (In.)
	PM± 1/16 (In.)	HLU± ⅛ (In.)	PM Ref (In.)	HLU Ref (In.)	
1 1/2	2 5/16	2 ¼	2 ½	2 7/16	1 5/16
2	3 ¼	2 ½	2 15/16	2 3/16	1 5/16
3	3 ¾	3	3 15/16	3 3/16	1 13/16
4	4 1/16	4	4 ¼	4 3/16	1 13/16
6	4 ¾	5	4 15/16	5 3/16	1 13/16
8	--	5 15/16	--	5 13/16	2 5/16
10	--	7 11/16	--	7 ⅞	4
12	--	8 11/16	--	8 ⅞	4

Assemble using Fig. 265C Elbow and Fig. 33 Reducer Bushing

Fig. 265FR(3)*
45° Reducer, Flanged



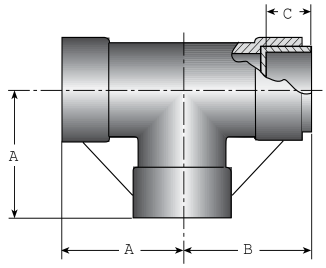
Size (In.)	A		B Ref (In.)	C Ref (In.)	D Ref (In.)	E Ref (In.)	F Ref (In.)	Bolts No/Size
	PM± 1/16 (In.)	HLU± ⅛ (In.)						
1½ x 1	3 ⅞	3 13/16	3 ⅛	4 ¼	⅞	⅝	5 ¾	4-½
2 x 1½	5 5/16	4 9/16	3 ⅞	5	1 3/16	⅝	7 5/16	4-⅝
3 x 2	5 13/16	5 1/16	4 ¾	6	1 3/16	¾	7 13/16	4-⅝
4 x 3	6 ⅛	6 1/16	6	7 ½	1 3/16	¾	8 ⅛	8-⅝
6 x 4 ♦	6 13/16	7 1/16	7 ½	9	1 ½	⅞	8 ¼	8-¾
8 x 6	--	8 ½	9 ½	11	1 9/16	⅞	8 11/16	8-¾
10 x 8	--	11 15/16	11 ¾	13 ½	2 1/16	1	11 ¼	12-⅞
12 x 10	--	12 15/16	14 ¼	16	3 1/16	1	14 ⅞	12-⅞

Assemble using Fig. 265F Elbow and Fig. 33 Reducer Bushing, Pipe Stubs and Fig 18 Socket Flanges

♦ 6" PM available in CL only
* Available on order only - nonreturnable.
(3) Reductions beyond one pipe size for reduced pressure applications are available. (See Fig. 33)

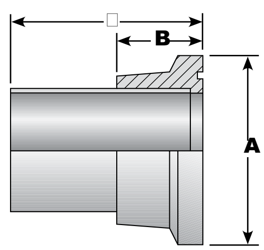
Fig. 275CR*
Reducer, Socket

Assemble using Fig 275C and Fig 33 Reducer Bushing



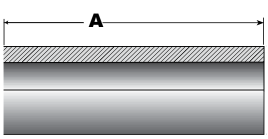
Size (In.)	A		B		C Ref
	PM ±1⁄16	HLU ± 1⁄8	PM Ref	HLU Ref	
1 ½	2 ¾	4	2 15⁄16	4	1 5⁄16
2	3 13⁄16	4 ½	3 ½	4 3⁄16	1 5⁄16
3	4 7⁄16	5 ½	4 ⅝	5 11⁄16	1 13⁄16
4	5 1⁄16	6 ½	5 ¼	6 11⁄16	1 13⁄16
6 ♦	6	8	6 3⁄16	8 3⁄16	1 13⁄16
8	--	7 11⁄16	--	7 9⁄16	2 5⁄16
10	--	12 3⁄16	--	12 ⅜	4
12	--	13 3⁄16	--	13 ⅜	4

Fig. 37*
Adapter Nipple



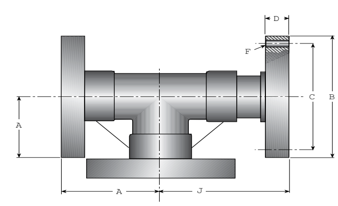
Size (In.)	A Ref (In.)	B Ref (In.)	C Ref (In.)	Wt. † (Lb.)
2	3 ¾	2 1⁄16	4 13⁄16	1.0
3	5	2 1⁄16	4 13⁄16	1.7
4	6 ⅜	2 1⁄16	4 13⁄16	2.2
6	8 ⅞	2 1⁄16	4 13⁄16	4.0
8	11 ½	2 1⁄16	4 13⁄16	6.3

Fig. 17
Assembly Pipe Stubs



Size (In.)	A (In.)
1	2 ⅜
1 ½	2 ⅝
2	3 ⅝
3	3 ⅝
4	3 ⅝
6	3 ⅝
8	5 ¼
10	8
12	8
14	8

Fig. 275FR(3)*
Reducer,
Flanged
Single Size Reduction Shown



Size (In.)	A		B Ref (In.)	C Ref (In.)	D Ref (In.)	F Ref (In.)	J Ref (In.)
	PM Ref	HLU Ref					
1 ½ x 1	4 5⁄16	5 9⁄16	4¼	3⅛	⅞	⅝	6 3⁄16
2 x 1 ½	5 ⅞	6 9⁄16	5	3⅞	1 3⁄16	⅝	7
3 x 2	6 ½	7 9⁄16	6	4¾	1 3⁄16	¾	7 ⅝
4 x 3	7 ⅛	8 9⁄16	7½	6	1 3⁄16	¾	8 ¼
6 x 4	8 1⁄16	10 1⁄16	9	7½	1½	¾	9 ½
8 x 6		10 ¼	11	9½	1 9⁄16	⅞	10 9⁄16
10 x 8		16 7⁄16	13½	11¾	2 1⁄16	⅞	15 11⁄16
12 x 10		17 7⁄16	16	14¼	3 1⁄16	1	19 ⅜

♦ 6” PM available in CL only
* Available on order only - nonreturnable.
(3) Reductions beyond one pipe size for reduced pressure applications are available. (See Fig. 33)

DIMENSIONS

Take off Dimensions for Adhesive Socket Fittings

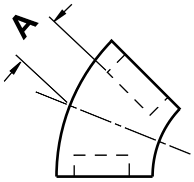


Fig. 265C

45 °Elbow

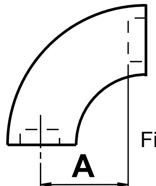
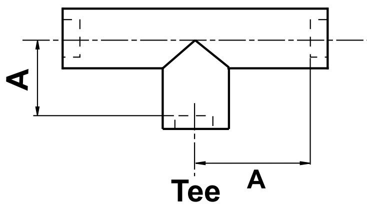


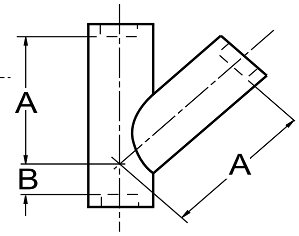
Fig. 255C

90°Short or Long Radius Elbow



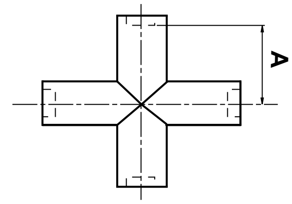
Tee

Fig. 275C



Lateral

Fig. 266C



Cross

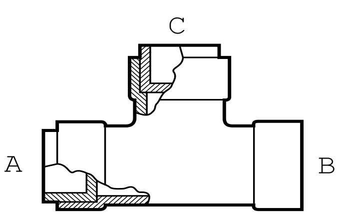
Fig. 285C

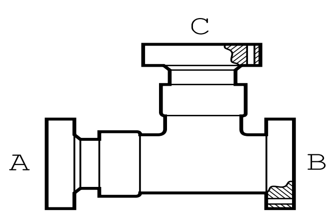
Pipe Stop to Fittings' Center Line Dimensions

Size (In.)	45° Elbow		Short Radius 90° Elbow	Long Radius 90° Elbow	Tee		Lateral		Cross
	PM A (In.)	HLU A (In.)	A (In.)	A (In.)	PM A (In.)	HLU A (In.)	A (In.)	B (In.)	A (In.)
1	1 5/16	9/16	1 5/16	3 13/16	1 5/16	2 5/16	--	--	--
1 ½	1	15/16	1 7/16	4 11/16	1 7/16	2 11/16	--	--	--
2	1 7/16	11/16	2	4 11/16	2	2 11/16	5 11/16	13/16	1 3/8
3	1 15/16	1 3/16	2 5/8	5 15/16	2 5/8	3 11/16	7 1/8	1 1/8	2 3/16
4	2 ¼	2 3/16	3 ¼	7 3/16	3 ¼	4 11/16	9 3/16	7/8	3 ½
6	2 15/16	3 3/16	4 3/16	9	--	6 3/16	15 9/16	5 5/16	6 3/16
8	--	3 5/16	4 7/8	12	--	5 1/16	18 11/16	5 5/16	5 1/16
10	--	3 11/16	--	13 11/16	--	8 3/16	22 7/16	6 7/16	8 3/16
12	--	4 11/16	--	16 3/16	--	9 3/16	27 15/16	7 5/16	9 3/16
14	--	5 3/8	--	18	--	9 5/8	--	--	--

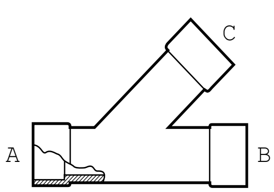
How to Read Flanged or Reducing Fittings

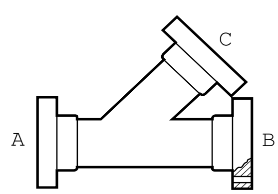
TEE





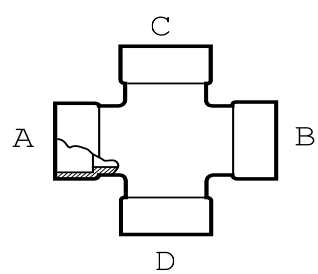
Run x Run x Branch
(A x B x C)

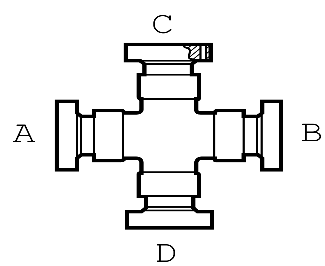




Run x Run x Branch
(A x B x C)

CROSS





Run x Run x Branch x Branch
(A x B x C x D)

The sequences illustrated should be used when describing fitting outlets. Drawings or sketches showing outlet types, locations, sizes and dimensional requirements are required for more complicated fitting configurations.

Special Configuration Fittings

Contact NOV Fiber Glass Systems for Details

- 1 1/16 through 12" Orifice flanges, 150# & 300#
- Odd degree elbows, 15, 22 1/2, 30 & 60 degree
- 5D Socket & Flanged Elbows
- Sump Fittings
- 4" thru 10" Reducing Lateral, Socket, Fig. 266CR
- 2" thru 12" Fig 267F Long Turn Tee, Socket, Fig. 267C
- 2" thru 12" Long Turn Tee, Flanged, Fig 267F
- 2" thru 12" 45° Double Y Branch, Socket, Fig. 268C
- 2" thru 12" 45° Double Y Branch, Flanged, Fig. 268F
- 2" thru 12" 90° Double Y Branch, Socket, Fig. 269C
- 2" thru 12" 90° Double Y Branch, Flanged, Fig. 269F

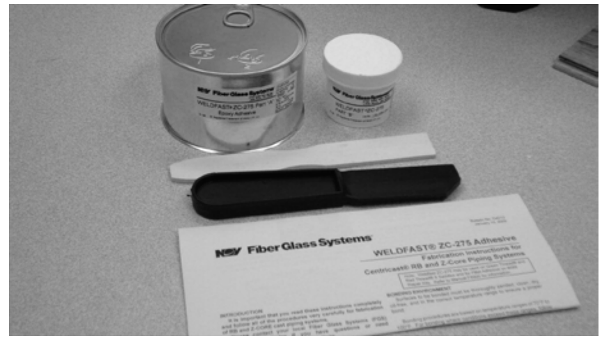
ADHESIVES

Weldfast ZC-275 Epoxy Adhesive for Adhesive Socket Joints

Order for Z-Core epoxy piping systems. Weldfast ZC-275 adhesive can also be used to bond RB and CL pipe and fittings. Usage should be limited to applications recommended for both Z-Core product and the pipe and fittings grade being used.

Contents:
- Adhesive (Part A)
- Hardener (Part B)
- Wooden Stir Stick
- Plastic Putty Knife
- Fabrication Instructions

No. 1 Kit Size-½ Pint	
Number of Bonds Per Kit	
Joints	Pipe Size
12	1” connections
10	1½” connections
8	2” connections
5	3” connections
3	4” connections
2	6” connections
1	8” connections
½	10” connections
½	12” connections



For complete instructions, refer to fab Bulletin D4090 included in each kit of WELDFAST ZC-275 Adhesive.

Weldfast CL-200-QS Part “C”

Accelerator used with WELDFAST CL-200 to provide a quick set vinyl ester adhesive. Joints fabricated with this quick set adhesive can be made and quickly cured in as little as one hour (at room temperature) compared to 24 hours (at room temperature) for conventional adhesives.

Weldfast CL-200

Contents:
- Adhesive (Part A)
- Catalyst
- Wooden Stir Stick
- Plastic Putty Knife
- Fabrication Instructions

Order for CL-2030 and CL-1520 vinyl ester piping systems.

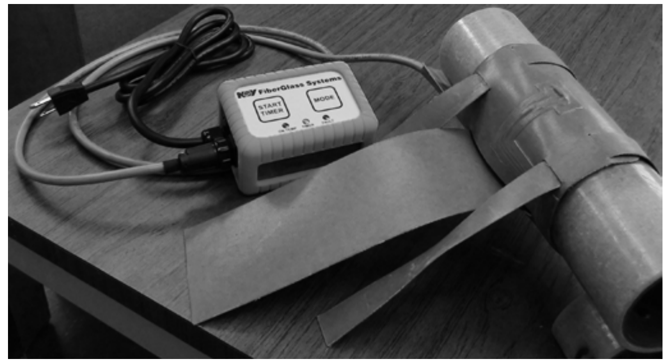
No. 1 Kit Size-½ Pint	
Number of Bonds Per Kit	
Joints	Pipe Size
12	1” connections
10	1½” connections
8	2” connections
5	3” connections
3	4” connections
2	6” connections
1	8” connections
½	10” connections
½	12” connections
⅓	14” connections

For complete instructions refer to fab Bulletin D4210 included in each kit of WELDFAST CL-200.

ACCESSORIES

Strap Clamp Kit*

Silicone Rubber Heat Blanket*



For Heat Curing 1”-20” connections

Pipe Size	Model Number for Pipe Size
1 - 3 inches	B
4 - 8 inches	C
10 - 14 inches	D
16 - 20 inches	E

* Available on order only - nonreturnable

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www.fgspipe.com • fgspipe@nov.com

NOV Fiber Glass Systems

CI1650 July 2015

Bondstrand™ 2000, 4000, 5000 and 7000 Fittings Dimensions

Introduction

The Quick-Lock bell end has a 1/2° taper and is the standard end configuration. All other end configurations, including size reductions, are made to order. Flanges are drilled in accordance with ANSI B16.5, Class 150. Other drilling specifications are available upon request. For pressure and temperature ratings; refer to product data sheet for specific series.

Tolerance for centerline-to-face dimensions on fittings with flanged ends is ±1/8 inch; for centerline-to-face dimensions with bell-end fittings ±1/16 inch: and for angular measures is ±1°.

Shipping weights are approximate.

Manufacturing Methods

	Material	Applicable Fittings
Filament winding	· Epoxy resin · Vinyl ester resin · Glass fibers	· Elbows, tees, couplings · Flanges, laterals, nipples · Saddles, crosses, reducers · Maintenance couplings · Special angle fittings
Compression molding	· Epoxy resin · Vinyl ester resin · Discontinuous glass fibers	· Flanges, bushings, plugs · Caps, blind flanges · Elbows, 45°, 90°; tees · Eccentric reducers
Machining	· 316 stainless steel	· Orifice flanges · Saddles for reductions

Assembly Instructions

Consult the following publications for installation details regarding Bondstrand Series 2000, 4000, 5000 and 7000 piping systems.

Quick-Lock Adhesive-bonded Bell and Spigot Joints, Contains instructions for preparing the Quick-Lock adhesive joint, using end preparation tools, applying and curing adhesives and mounting Bondstrand flanges on fiberglass pipe. Usage instructions for the various Bondstrand adhesives are included in the adhesive kits.

Assembly Instructions for Bondstrand fiberglass flanges, Contains information pertinent to selection of gaskets, nuts, washers, and bolts when joining Bondstrand fiberglass flanges to fiberglass flanges and to flanges of other materials. Includes recommended bolt torques and bolt tightening sequence diagrams.

Maintenance Coupling Assembly for butt-end joints, Assembly instructions for the Bondstrand maintenance coupling.

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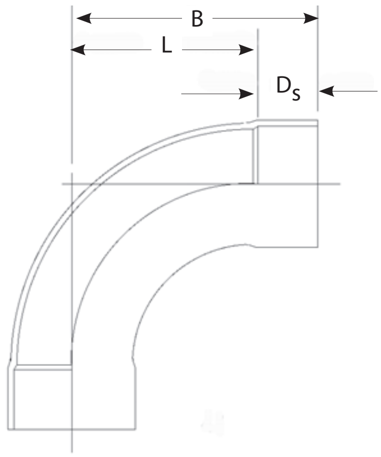
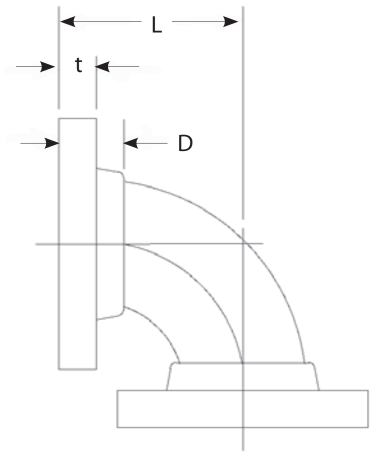
90° Elbows



Fittings are filament wound unless otherwise indicated. Fittings marked with an asterisk (*) are molded.

Nom Pipe Size		Laying Length (L)		Overall Length (B)		Socket Depth (D_S)		Approx Wt	
in.	mm	in.	mm	in.	mm	in.	mm	lb.	kg
1	25	2.56	65	3.62	92	1.06	27	1	0.5
1 1/2	40	3.19	81	4.44	113	1.25	32	1	0.5
2	50	3.00	76	4.82	122	1.82	46	1	0.5
		2.01*	51	3.83	97	1.82	46	1	0.5
3	80	4.50	114	6.32	161	1.82	46	3	1.4
		2.61*	66	4.43	113	1.82	46	2	0.9
4	100	6.00	152	7.82	199	1.82	46	4	1.8
		3.69*	94	5.51	140	1.82	46	3	1.4
6	150	9.00	229	11.25	286	2.25	57	8	3.6
		5.25*	133	7.50	191	2.25	57	7	3.2
8	200	12.00	305	14.50	368	2.50	64	15	6.8
10	250	15.00	381	17.75	451	2.75	70	25	11.3
12	300	18.00	457	21.00	533	3.00	76	41	18.6
14	350	14.12	359	17.62	448	3.50	89	37	16.8
16	400	15.62	397	19.62	498	4.00	102	68	30.8

90° Flanged Elbows

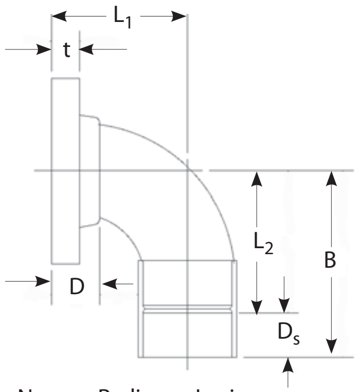


Flanged 90° elbows feature filament-wound bodies and filament-wound (f/w) or molded (m) flanges. They are available in ANSI short-radius (s/r) or long-radius (l/r) laying lengths. Flanged short-radius elbows meeting ANSI laying lengths are not available in 1, 1 1/2, 14 or 16 inch sizes. Fittings marked with two asterisks (**) are available only with filament-wound flanges.

Nom Pipe Size		Radius Type	Laying Length (L)		Flange Thickness At Face (t)		Flange Thickness At Hub (D)		Approx Wt Flange Type (m)		Approx Wt Flange Type (f/w)	
in.	mm		in.	mm	in.	mm	in.	mm	lb.	kg	lb.	kg
1	25	l/r	5.00**	127**	1.13	29	1.13	29	–	–	1	0.5
1 1/2	40	l/r	6.00**	152	1.38	35	1.38	35	–	–	1	0.5
2	50	s/r	4.50	114	1.00	25	2.00	51	5	2.3	4	1.8
		l/r	6.50	165	1.00	25	2.00	51	5	2.3	5	2.3
3	80	s/r	5.50	140	1.13	29	2.00	51	8	3.6	7	3.2
		l/r	7.75	197	1.13	29	2.00	51	9	4.1	8	3.6
4	100	s/r	6.50	165	1.25	32	2.00	51	11	5.0	10	4.5
		l/r	9.00	229	1.25	32	2.00	51	13	5.9	12	5.4
6	150	s/r	8.00	203	1.75	44	2.38	60	22	10.0	18	8.2
		l/r	11.50	292	1.75	44	2.38	60	26	11.8	22	10.0
8	200	s/r	9.00	229	2.00	51	2.63	67	35	15.9	29	13.2
		l/r	14.00	356	2.00	51	2.63	67	41	18.6	37	16.8
10	250	s/r	11.00	279	2.00	51	2.88	73	50	22.7	43	19.5
		l/r	16.50	419	2.00	51	2.88	73	57	25.9	54	24.5
12	300	s/r	12.00	305	2.13	54	3.13	80	82	37.2	77	34.9
		l/r	19.00	483	2.13	54	3.13	80	91	41.3	86	39.0
14	350	l/r	21.50**	546	2.81	71	3.81	97	–	–	150	68.0
16	400	l/r	24.00**	610	3.25	83	4.25	108	–	–	180	81.6

90° Combination Elbows

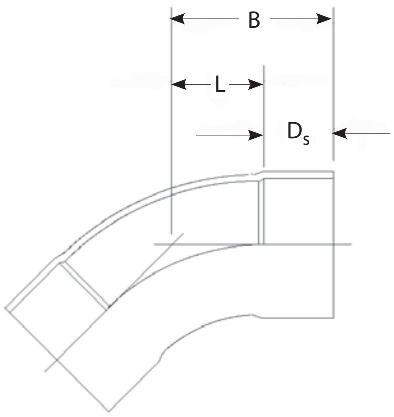
Only center-to-flange-face dimensions correspond to ANSI laying lengths. The fitting body is filament wound; flanges are available in molded (m) or filament-wound (f/w) variants. Dimensions marked with an asterisk (*) indicate molded flanges. Fittings marked with two asterisks (**) are available only with filament-wound flanges.



Nom Pipe Size		Radius Type	Laying Length (L1)		Flange Thickness At Face (t)		Flange Thickness At Hub (D)		Overall Length (B)		Laying Length (L2)		Socket Depth (Ds)		Approx Wt Flange Type (m)		Approx Wt Flange Type (f/w)	
in.	mm		in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	lb.	kg	lb.	kg
1	25	l/r	5.00	127	1.13**	29	1.13	29	3.62	92	2.56	65	1.06	27	–	–	2	0.9
1½	40	l/r	6.00	152	1.38**	35	1.38	35	4.44	113	3.19	81	1.25	32	–	–	3	1.4
2	50	s/r	4.50	114	1.00	25	2.00	51	6.56	167	4.75	121	1.81	46	4	1.8	3	1.4
		l/r	6.50	165	1.00	25	2.00	51	8.56	217	6.75	171	1.81	46	4	1.8	4	1.8
3	80	s/r	5.50	140	1.13	29	2.00	51	7.56	192	5.75	146	1.81	46	6	2.7	5	2.3
		l/r	7.75	197	1.13	29	2.00	51	9.81	249	8.00	203	1.81	46	6	2.7	6	2.7
4	100	s/r	6.50	165	1.25	32	2.00	51	8.56	217	6.75	171	1.81	46	8	3.6	8	3.6
		l/r	9.00	229	1.25	32	2.00	51	11.06	281	9.25	235	1.81	46	10	4.5	10	4.5
6	150	s/r	8.00	203	1.75	44	2.38	60	10.50	267	8.25	210	2.25	57	16	7.3	14	6.4
		l/r	11.50	292	1.75	44	2.38	60	14.00	356	11.75	298	2.25	57	20	9.1	18	8.2
8	200	s/r	9.00	229	2.00	51	2.63	67	11.75	298	9.25	235	2.50	64	26	11.8	23	10.4
		l/r	14.00	356	2.00	51	2.63	67	16.75	425	14.25	362	2.50	64	32	14.5	31	14.1
10	250	s/r	11.00	279	2.00	51	2.88	73	14.00	356	11.25	286	2.75	70	38	17.2	34	15.4
		l/r	16.50	419	2.00	51	2.88	73	19.50	495	16.75	425	2.75	70	45	20.4	45	20.4
12	300	s/r	12.00	305	2.13	54	3.13	80	15.25	387	12.25	311	3.00	76	61	27.7	61	27.7
		l/r	19.00	483	2.13	54	3.13	80	22.25	565	19.25	489	3.00	76	70	31.8	70	31.8
14	350	l/r	21.50	546	2.88**	73	3.75	95	17.62	448	14.12	359	3.50	89	–	–	85	38.6
16	400	l/r	24.00	610	3.25**	83	4.25	108	19.62	498	15.62	397	4.00	102	–	–	104	47.2

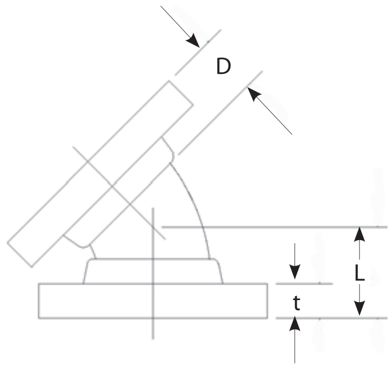
45° Elbows

Fittings are filament wound unless otherwise designated. Fittings marked with an asterisk (*) are molded.



Nom Pipe Size		Laying Length (L)		Overall Length (B)		Socket Depth (Ds)		Approx Wt	
in.	mm	in.	mm	in.	mm	in.	mm	lb.	kg
1	25	0.88	22	1.94	49	1.06	27	1	0.5
1½	40	1.12	28	2.37	60	1.25	32	1	0.5
2	50	1.38	35	3.20	81	1.82	46	1	0.5
		1.38*	35	3.20	81	1.82	46	1	0.5
3	80	2.00	51	3.82	97	1.82	46	2	0.9
		1.62*	41	3.43	87	1.82	46	2	0.9
4	100	2.50	64	4.32	110	1.82	46	3	1.4
		2.42*	61	4.23	107	1.82	46	3	1.4
6	150	3.75	95	6.00	152	2.25	57	5	2.3
		3.31*	84	5.56	141	2.25	57	8	3.6
8	200	5.00	127	7.50	191	2.50	64	9	4.1
10	250	6.25	159	9.00	229	2.75	70	16	7.3
12	300	7.50	191	10.50	267	3.00	76	26	11.8
14	350	4.69	119	8.19	208	3.50	89	38	17.2
16	400	5.38	137	9.38	238	4.00	102	45	20.4

45° Flanged Elbows

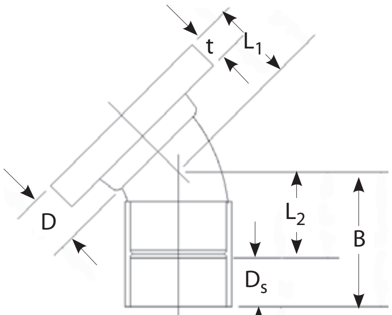


Flanges are filament wound unless otherwise designated. Fittings marked with an asterisk (*) have molded flanges. Laying lengths meet ANSI criteria.

Fittings with double asterisk (**) do not meet ANSI laying length.

Nom Pipe Size		Laying Length (L)		Flange Thickness At Face (t)		Flange Thickness At Hub (D)		Approx Wt (m)		Approx Wt (f/w)	
in.	mm	in.	mm	in.	mm	in.	mm	lb.	kg	lb.	kg
2	50	2.50	64	1.00	25	2.00	51	5	2.3	4	1.8
3	80	3.00	76	1.13	29	2.00	51	7	3.2	6	2.7
4	100	4.00	102	1.25	32	2.00	51	10	4.5	10	4.5
6	150	5.00	127	1.75	44	2.38	60	21	9.5	17	7.7
8	200	5.50	140	2.00	51	2.63	67	32	14.5	29	13.2
10	250	6.50	165	2.00	51	2.88	73	50	22.7	47	21.3
12	300	7.50	191	2.13	54	3.13	80	76	34.5	70	31.8
14	350	12.25**	311	2.81	71	3.81	97	–	–	59	26.8
16	400	13.94**	354	3.25	83	4.25	108	–	–	77	34.9

45° Combination Elbows



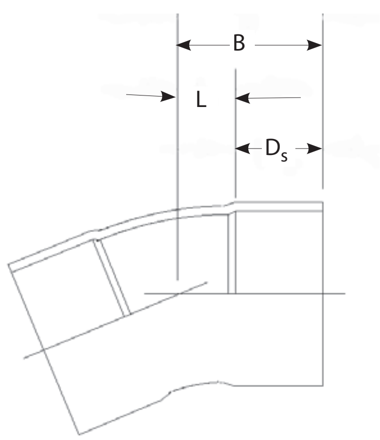
Flanges are available in molded (m) or filament-wound (f/w) construction. Dimensions marked with an asterisk (*) indicate molded flanges.

Fittings with double asterisk (**) do not meet ANSI laying length.

Nom Pipe Size		Laying Length (L_1)		Flange Thickness At Face (t)		Flange Thickness At Hub (D)		Overall Length (B)		Laying Length (L_2)		Socket Depth (D_S)		Approx Wt Flange Type (m)		Approx Wt Flange Type (f/w)	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	lb.	kg	lb.	kg
*2	50	2.50	64	1.00	25	2.00	51	4.56	116	2.75	70	1.82	46	3	1.4	*3	1.4
*3	80	3.00	76	1.13	29	2.00	51	5.06	129	3.25	83	1.82	46	5	2.3	*4	1.8
*4	100	4.00	102	1.25	32	2.00	51	6.06	154	4.25	108	1.82	46	7	3.2	7	3.2
*6	150	5.00	127	1.75	44	2.38	60	7.50	191	5.25	133	2.25	57	15	6.8	13	5.9
*8	200	5.50	140	2.00	51	2.63	67	8.25	210	5.75	146	2.50	64	23	10.4	23	10.4
10	250	6.50	165	2.00	51	2.88	73	9.50	241	6.75	171	2.75	70	38	17.2	38	17.2
12	300	7.50	191	2.13	54	3.13	80	10.75	273	7.75	197	3.00	76	55	24.9	54	24.5
14	350	12.25**	311	2.81	71	3.81	97	8.18	208	4.69	119	3.50	89	63	28.6	60	27.2
16	400	13.94**	354	3.25	83	4.25	108	9.38	238	5.38	137	4.00	102	69	31.3	66	29.9

22 1/2 ° Elbows

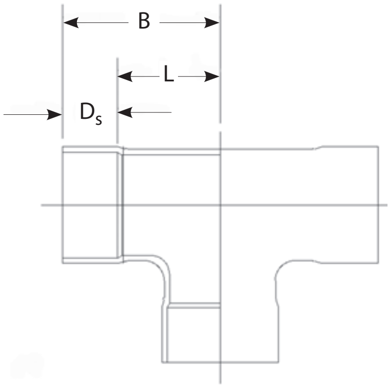
Fittings feature filament-wound Quick-Lock bell ends. Elbows with angles such as 11 1/4°, 30°, 60° and 75° and other special angles are available. Consult your representative.



Nom Pipe Size		Laying Length (L)		Overall Length (B)		Socket Depth (D_S)		Approx Wt	
in.	mm	in.	mm	in.	mm	in.	mm	lb.	kg
1	25	0.38	10	1.44	37	1.06	27	0.3	0.1
1 1/2	40	0.38	10	1.63	41	1.25	32	0.5	0.2
2	50	0.50	13	2.31	59	1.82	46	0.7	0.3
3	80	0.81	21	2.62	67	1.82	46	1.3	0.6
4	100	1.12	28	2.94	75	1.82	46	2.0	0.9
6	150	1.69	43	3.94	100	2.25	57	4.0	1.8
8	200	2.25	57	4.75	121	2.50	64	7.0	3.2
10	250	2.62	67	5.38	137	2.75	70	13.0	5.9
12	300	3.00	76	6.00	152	3.00	76	16.0	7.3
14	350	3.25	83	6.75	171	3.50	89	26.0	11.8
16	400	3.50	89	7.50	191	4.00	102	30.0	13.6

Tees

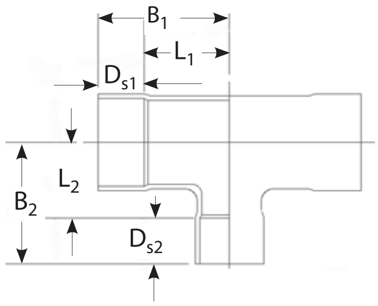
Fittings are filament wound unless otherwise noted. Molded fittings are indicated with an asterisk (*).



Nom Pipe Size in.	mm	Laying Length (L) in.	mm	Overall Length (B) in.	mm	Socket Depth (D_s) in.	mm	Approx Wt lb.	kg
1	25	1.06	27	2.12	54	1.06	27	1	0.5
1½	40	1.19	30	2.44	62	1.25	32	1	0.5
2	50	2.00*	51	3.81	97	1.82	46	3	1.4
		2.50	64	4.32	110	1.82	46	2	0.9
3	80	2.69*	68	4.50	114	1.82	46	5	2.3
		3.38	86	5.20	132	1.82	46	4	1.8
4	100	3.69*	94	5.50	140	1.82	46	7	3.2
		4.12	105	5.94	151	1.82	46	5	2.3
6	150	5.25*	133	7.50	191	2.25	57	14	6.4
		5.62	143	7.87	200	2.25	57	11	5.0
8	200	7.00	178	9.50	241	2.50	64	18	8.2
10	250	8.50	216	11.25	286	2.75	70	32	14.5
12	300	10.00	254	13.00	330	3.00	76	46	20.9
14	350	10.50	267	14.00	356	3.50	89	65	29.5
16	400	11.50	292	15.50	394	4.00	102	97	44.0

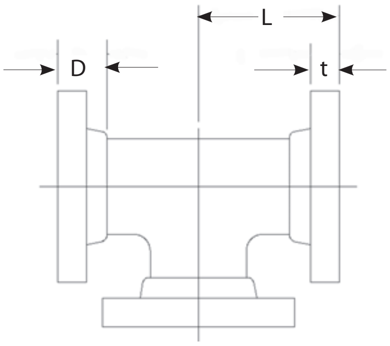
Reducing Tees

Fittings are filament wound



Nom Pipe Size in.	mm	Laying Length (L_1) in.	mm	Laying Length (L_2) in.	mm	Overall Length (B_1) in.	mm	Overall Length (B_2) in.	mm	Socket Depth (D_{s1}) in.	mm	Socket Depth (D_{s2}) in.	mm	Approx Wt lb.	kg
2x2x1	50x50x25	2.50	64	2.25	57	4.31	109	3.31	84	1.81	46	1.06	27	3	1.4
3x3x2	80x80x50	3.38	86	3.00	76	5.19	132	4.81	122	1.81	46	1.82	46	4	1.8
4x4x2	100x100x50	4.12	105	3.50	89	5.93	151	5.31	135	1.81	46	1.82	46	5	2.3
4x4x3	100x100x80	4.12	105	3.88	99	5.93	151	5.68	144	1.81	46	1.82	46	5	2.3
6x6x2	150x150x50	5.62	143	4.50	114	7.87	200	6.31	160	2.25	57	1.82	46	8	3.6
6x6x3	150x150x80	5.62	143	4.88	124	7.87	200	6.69	170	2.25	57	1.82	46	9	4.1
6x6x4	150x150x100	5.62	143	5.12	130	7.87	200	6.93	176	2.25	57	1.82	46	10	4.5
8x8x3	200x200x80	7.00	178	5.88	149	9.50	241	7.69	195	2.50	64	1.82	46	14	6.4
8x8x4	200x200x100	7.00	178	6.12	155	9.50	241	7.94	202	2.50	64	1.82	46	15	6.8
8x8x6	200x200x150	7.00	178	6.62	168	9.50	241	8.87	225	2.50	64	2.25	57	17	7.7
10x10x4	250x250x100	8.50	216	7.25	184	11.25	286	9.06	230	2.75	70	1.81	46	20	9.1
10x10x6	250x250x150	8.50	216	7.62	194	11.25	286	9.87	251	2.75	70	2.25	57	24	10.9
10x10x8	250x250x200	8.50	216	8.00	203	11.25	286	10.50	267	2.75	70	2.50	64	28	12.7
12x12x4	300x300x100	10.00	254	8.12	206	13.00	330	9.93	252	3.00	76	1.81	46	30	13.6
12x12x6	300x300x150	10.00	254	8.62	219	13.00	330	10.87	276	3.00	76	2.25	57	34	15.4
12x12x8	300x300x200	10.00	254	9.00	229	13.00	330	11.50	292	3.00	76	2.50	64	38	17.2
12x12x10	300x300x250	10.00	254	9.50	241	13.00	330	12.25	311	3.00	76	2.75	70	42	19.1
14x14x6	350x350x150	10.50	267	9.62	244	14.00	356	11.87	301	3.50	89	2.25	57	45	20.4
14x14x8	350x350x200	10.50	267	10.00	254	14.00	356	12.50	318	3.50	89	2.50	64	50	22.7
14x14x10	350x350x250	10.50	267	10.50	267	14.00	356	13.25	337	3.50	89	2.75	70	55	24.9
14x14x12	350x350x300	10.50	267	11.00	279	14.00	356	14.00	356	3.50	89	3.00	76	60	27.2
16x16x6	400x400x150	11.50	292	10.38	264	15.50	394	12.63	321	4.00	102	2.25	57	70	31.8
16x16x8	400x400x200	11.50	292	10.75	273	15.50	394	13.25	337	4.00	102	2.50	64	75	34.0
16x16x10	400x400x250	11.50	292	11.12	282	15.50	394	13.87	352	4.00	102	2.75	70	80	36.3
16x16x12	400x400x300	11.50	292	11.62	295	15.50	394	14.62	371	4.00	102	3.00	76	85	38.6
16x16x14	400x400x350	11.50	292	11.50	292	15.50	394	15.00	381	4.00	102	3.50	89	90	40.8

Flanged Tees

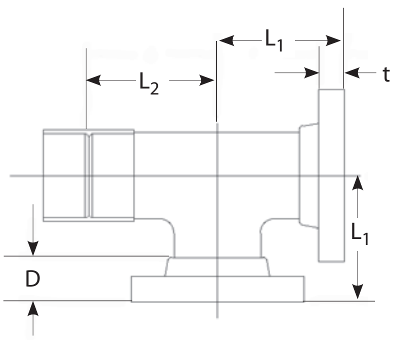


Flanges are filament wound unless otherwise noted. Molded flanges available in 2- through 12-inch sizes. Fittings noted with an asterisk (*) do not meet ANSI laying lengths. Flange thickness with double asterisk (**) represents molded flange dimension.

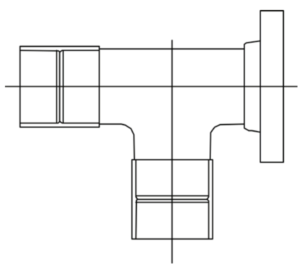
Nom Pipe Size		Laying Length (L)		Flange Thickness At Face (t)		Flange Thickness At Hub (D)		Approx Wt	
in.	mm	in.	mm	in.	mm	in.	mm	lb.	kg
1	25	3.50	89	1.13	29	1.13	29	2	0.9
1¹/₂	40	4.00	102	1.38	35	1.38	35	3	1.4
2	50	4.50	114	1.00	25	2.00	51	7	3.2
3	80	5.50	140 .	1.13	29	2.00	51	11	5.0
4	100	6.50	165	1.25	32	2.00	51	17	7.7
		6.50	165	1.56**	40	–	–	17	7.7
6	150	8.00	203	1.75	44	2.38	60	32	14.5
8	200	9.00	229	2.00	51	2.63	67	47	21.3
10	250	11.00	279	2.00	51	2.88	73	70	31.8
12	300	12.00	305	2.13	54	3.13	80	114	51.7
14	350	18.00*	457	2.81	71	3.81	97	220	99.8
16	400	20.00*	508	3.25	83	4.25	108	280	127.0

Combination Tees

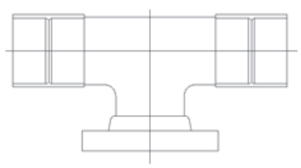
Flanges are filament wound unless otherwise noted. Molded flanges are available in 2- through 12-inch sizes. Any combination of flanged or Quick-Lock ends is available. Fittings noted with an asterisk (*) do not match ANSI laying length dimensions. Quick-Lock bell ends in 14- and 16-inch sizes are integrally wound.



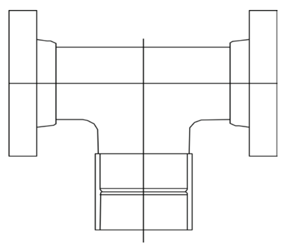
QL x FLG x FLG



QL x FLG x QL



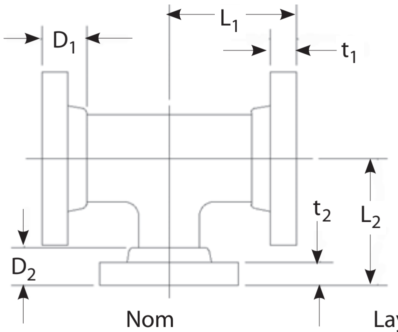
QL x QL x FLG



FLG x FLG x QL

Nom Pipe Size		Laying Length (L_1)		Laying Length (L_2)		Flange Thickness At Face (t)		Flange Thickness At Hub (D)		Approx Wt 1 cplg 2 flgs		Approx Wt 2 cplg 1 flg	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	lb.	kg	lb.	kg
1	25	3.50	89	1.06	27	1.13	29	1.13	29	3	1.4	3	1.4
1¹/₂	40	4.07	103	1.19	30	1.38	35	1.38	35	4	1.8	4	1.8
2	50	4.50	114	4.75	121	1.00	25	2.00	51	6	2.7	5	2.3
3	80	5.50	140	5.75	146	1.13	29	2.00	51	10	4.5	8	3.6
4	100	6.50	165	6.75	171	1.25	32	2.00	51	14	6.4	12	5.4
6	150	8.00	203	8.25	210	1.75	44	2.38	60	28	12.7	24	10.9
8	200	9.00	229	9.25	235	2.00	51	2.63	67	41	18.6	35	15.9
10	250	11.00	279	11.25	286	2.00	51	2.88	73	61	27.7	52	23.6
12	300	12.00	305	12.25	311	2.13	54	3.13	80	98	44.5	82	37.2
14	350	18.00*	457	10.50	267	2.81	71	3.81	97	130	59.0	120	54.4
16	400	20.00*	508	11.50	292	3.25	83	4.25	108	145	65.8	130	59.0

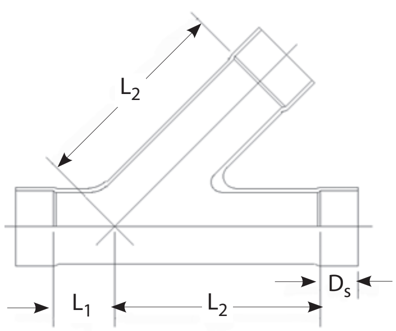
Flanged Reducing Tees



Flanges are filament wound unless otherwise noted. Molded flanges available in 2- through 12-inch sizes. Fittings with asterisk (*) do not meet ANSI laying lengths. Flange thicknesses with double asterisk (**) represent molded flange dimensions.

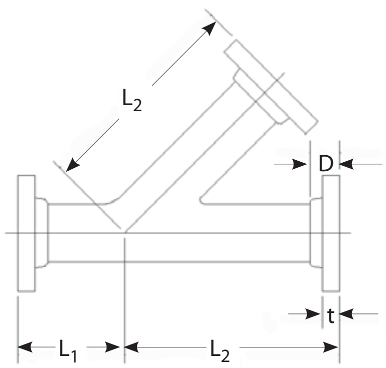
Nom Pipe Size		Laying Length (L_1)		Laying Length (L_2)		Flange Thickness At Face (t_1)		Flange Thickness At Hub (D_1)		Flange Thickness At Face (t_2)		Flange Thickness At Hub (D_2)		Approx Wt	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	lb.	kg
3x3x2	80x80x50	5.50	140	5.50	140	1.13	29	2.00	51	1.00	25	2.00	51	10	4.5
4x4x2	100x100x50	6.50	165	6.50	165	1.25	32	2.00	51	1.00	25	2.00	51	15	6.8
		6.50	165	6.50	165	1.56**	40	2.00	51	1.00	25	2.00	51	15	6.8
4x4x3	100x100x80	6.50	165	6.50	165	1.25	32	2.00	51	1.13	29	2.00	51	16	7.3
		6.50	165	6.50	165	1.56**	40	2.00	51	1.13	29	2.00	51	16	7.3
6x6x2	150x150x50	8.00	203	8.00	203	1.75	44	2.38	60	1.00	25	2.00	51	25	11.3
6x6x3	150x150x80	8.00	203	8.00	203	1.75	44	2.38	60	1.13	29	2.00	51	27	12.2
6x6x4	150x150x100	8.00	203	8.00	203	1.75	44	2.38	60	1.25	32	2.00	51	29	13.2
		8.00	203	8.00	203	1.75	44	2.38	60	1.56**	40	2.00	51	29	13.2
8x8x3	200x200x80	9.00	229	9.00	229	2.00	51	2.63	67	1.13	29	2.00	51	32	14.5
8x8x4	200x200x100	9.00	229	9.00	229	2.00	51	2.63	67	1.25	32	2.00	51	37	16.8
8x8x6	200x200x150	9.00	229	9.00	229	2.00	51	2.63	67	1.75	44	2.38	60	42	19.1
		9.00	229	9.00	229	2.00	51	2.63	67	1.56**	40	2.00	51	43	19.5
10x10x4	250x250x100	11.00	279	11.00	279	2.00	51	2.88	73	1.25	32	2.00	51	50	22.7
		11.00	279	11.00	279	2.00	51	2.88	73	1.56**	40	2.00	51	50	22.7
10x10x6	250x250x150	11.00	279	11.00	279	2.00	51	2.88	73	1.75	44	2.38	60	57	25.9
10x10x8	250x250x200	11.00	279	11.00	279	2.00	51	2.88	73	2.00	51	2.00	51	64	29.0
12x12x4	300x300x100	12.00	305	12.00	305	2.13	54	3.13	80	1.25	32	2.00	51	75	34.0
		12.00	305	12.00	305	2.13	54	3.13	80	1.56**	40	2.00	51	75	34.0
12x12x6	300x300x150	12.00	305	12.00	305	2.13	54	3.13	80	1.75	44	2.38	60	85	38.6
12x12x8	300x300x200	12.00	305	12.00	305	2.13	54	3.13	80	2.00	51	2.63	67	95	43.1
12x12x10	300x300x250	12.00	305	12.00	305	2.13	54	3.13	80	2.00	51	2.88	73	105	47.6
14x14x6	350x350x150	18.00*	457	14.39	366	2.81	71	3.81	97	1.75	44	2.38	60	155	70.3
14x14x8	350x350x200	18.00*	457	15.25	387	2.81	71	3.81	97	2.00	51	2.63	67	170	77.1
14x14x10	350x350x250	18.00*	457	16.25	413	2.81	71	3.81	97	2.00	51	2.88	73	185	83.9
14x14x12	350x350x300	18.00*	457	17.25	438	2.81	71	3.81	97	2.13	54	3.13	80	200	90.7
16x16x6	400x400x150	20.00*	508	15.12	384	3.25	83	4.25	108	1.75	44	2.38	60	200	90.7
16x16x8	400x400x200	20.00*	508	16.00	406	3.25	83	4.25	108	2.00	51	2.63	67	215	97.5
16x16x10	400x400x250	20.00*	508	16.88	429	3.25	83	4.25	108	2.00	51	2.88	73	230	104.3
16x16x12	400x400x300	20.00*	508	17.88	454	3.25	83	4.25	108	2.13	54	3.13	80	245	111.1
16x16x14	400x400x350	*20.00*	508	19.06	484	3.25	83	4.25	108	2.81	71	3.81	97	260	117.9

45° Laterals



Nom Pipe Size		Laying Length (L_1)		Laying Length (L_2)		Socket Depth (D_s)		Approx Wt	
in.	mm	in.	mm	in.	mm	in.	mm	lb.	kg
2	50	2.50	64	8.00	203	1.82	46	4	1.8
3	80	3.00	76	10.00	254	1.82	46	7	3.2
4	100	3.00	76	12.00	305	1.82	46	9	4.1
6	150	3.50	89	14.50	368	2.25	57	15	6.8
8	200	4.50	114	17.50	445	2.50	64	27	12.2
10	250	5.00	127	20.50	521	2.75	70	47	21.3
12	300	5.50	140	24.50	622	3.00	76	67	30.4
14	350	5.50	140	24.50	622	3.50	89	87	39.5
16	400	5.50	140	24.50	622	4.00	102	110	49.9

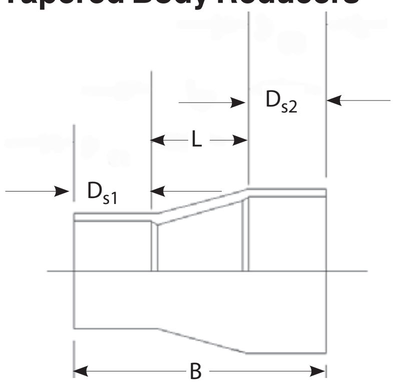
45° Flanged Laterals



Flanges are filament wound and meet ANSI B16.5 Cl 150 requirements.

Nom Pipe Size		Laying Length (L_1)		Laying Length (L_2)		Flange Thickness At Face (t)		Flange Thickness At Hub (D)		Approx Wt	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	lb.	kg
2	50	6.44	164	11.94	303	1.00	25	2.00	51	9	4.1
3	80	6.94	176	13.94	354	1.13	29	2.00	51	14	6.4
4	100	6.94	176	15.94	405	1.25	32	2.00	51	20	9.1
6	150	8.25	210	19.25	489	1.75	44	2.38	60	34	15.4
8	200	9.76	248	22.75	578	2.00	51	2.63	67	57	25.9
10	250	10.75	273	26.25	667	2.00	51	2.88	73	89	40.4
12	300	11.75	298	30.75	781	2.13	54	3.13	80	136	61.7
14	350	13.06	332	32.00	813	2.81	71	3.81	97	201	91.2
16	400	14.00	356	33.00	838	3.25	83	4.25	108	269	122.0

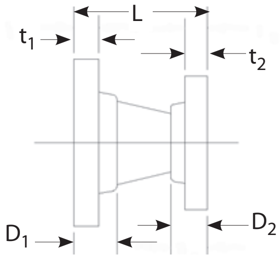
Tapered Body Reducers



Nom Pipe Size		Overall Length (B)		Laying Length (L)		Socket Depth (D_{s1})		Socket Depth (D_{s2})		Approx Wt	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	lb.	kg
1½x1	40x25	3.56	90	1.31	33	1.06	27	1.25	32	0.4	0.2
2x1	50x25	5.38	137	2.50	64	1.06	27	1.82	46	0.6	0.3
2x1½	20x40	4.32	110	1.25	32	1.25	32	1.82	46	1.0	0.5
3x2	80x50	5.75	146	2.12	54	1.82	46	1.82	46	1.4	0.6
4x2	100x50	6.62	168	3.00	76	1.82	46	1.82	46	2.0	0.9
4x3	100x80	6.50	165	2.88	73	1.82	46	1.82	46	2.0	0.9
6x3	150x80	7.88	200	3.81	97	1.82	46	2.25	57	4.0	1.8
6x4	150x100	7.75	197	3.69	94	1.82	46	2.25	57	4.0	1.8
8x4	200x100	9.75	248	5.44	138	1.82	46	2.50	64	7.0	3.2
8x6	200x150	8.63	219	3.88	99	2.25	57	2.50	64	7.0	3.2
10x6	250x150	9.62	244	4.62	117	2.25	57	2.75	70	9.0	4.1
10x8	250x200	9.37	238	4.12	105	2.50	64	2.75	70	8.0	3.6
12x8	300x200	11.38	289	5.88	149	2.50	64	3.00	76	14.0	6.4
12x10	300x250	11.12	282	5.38	137	2.75	70	3.00	76	13.0	5.9
14x10	350x250	13.50	343	7.25	184	2.75	70	3.50	89	36.0	16.3
14x12	350x300	13.50	343	7.00	178	3.00	76	3.50	89	37.0	16.8
16x12	400x300	13.50	343	6.50	165	3.00	76	4.00	102	54.0	24.5
16x14	400x350	13.50	343	6.00	152	3.50	89	4.00	102	57.0	25.9

Flanged Tapered Body Reducers

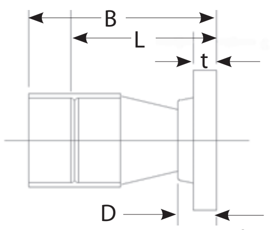
Flanges are filament wound. Flanges in 2-, 3- and 4-inch sizes are available only in heavy-duty (hubless) configuration. Molded flanges available in 2- through 12-inch sizes. Fittings with asterisk (*) meet ANSI laying lengths.



Nom Pipe Size		Laying Length (L)		Flange Thickness At Face (t_1)		Flange Thickness At Hub (D_1)		Flange Thickness At Face (t_2)		Flange Thickness At Hub (D_2)		Approx Wt	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	lb.	kg
1½x1	40x25	6.50	165	1.38	35	1.38	35	1.13	29	1.13	29	4	1.8
2x1	50x25	8.75	222	1.00	25	2.00	51	1.13	29	1.13	29	5	2.3
2x1½	20x40	8.00	203	1.00	25	2.00	51	1.38	35	1.38	35	6	2.7
3x2*	80x50	6.00	152	1.13	29	2.00	51	1.00	25	2.00	51	9	4.1
4x2*	100x50	7.00	178	1.25	32	2.00	51	1.00	25	2.00	51	10	4.5
4x3*	100x80	7.00	178	1.25	32	2.00	51	1.13	29	2.00	51	11	5.0
6x3*	150x80	9.00	229	1.75	44	2.38	60	1.13	29	2.00	51	15	6.8
6x4*	150x100	9.00	229	1.75	44	2.38	60	1.25	32	2.00	51	17	7.7
8x4*	200x100	11.00	279	2.00	51	2.63	67	1.25	32	2.00	51	21	9.5
8x6*	200x150	11.00	279	2.00	51	2.63	67	1.75	44	2.38	60	23	10.4
10x6*	250x150	12.00	305	2.00	51	2.88	73	1.75	44	2.38	60	28	12.7
10x8*	250x200	12.00	305	2.00	51	2.88	73	2.00	51	2.63	67	35	15.9
12x8*	300x200	14.00	356	2.13	54	3.13	80	2.00	51	2.63	67	45	20.4
12x10*	300x250	14.00	356	2.13	54	3.13	80	2.00	51	2.88	73	50	22.7
14x10*	350x250	16.00	406	2.81	71	3.81	97	2.00	51	2.88	73	73	33.1
14x12*	350x300	16.00	406	2.81	71	3.81	97	2.13	54	3.13	80	84	38.1
16x12*	400x300	18.00	457	3.25	83	4.25	108	2.13	54	3.13	80	100	45.4
16x14*	400x350	18.00	457	3.25	83	4.25	108	2.81	71	3.81	97	115	52.2

Combination Reducers (Flanged Small End)

Flanges are filament wound with tapered body. Molded flanges available in 2- through 12-inch sizes.

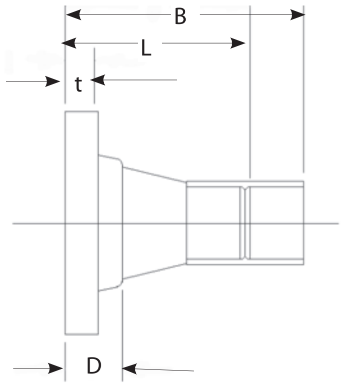


Nom Pipe Size		Laying Length* (L)		Overall Length (B)		Flange Thickness At Face (t)		Flange Thickness At Hub (D)		Approx Wt	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	lb.	kg
3x2	80x50	6.25	159	8.06	205	1.13	29	2.00	51	8	3.6
4x2	100x50	7.25	184	9.06	230	1.25	32	2.00	51	9	4.1
4x3	100x80	7.25	184	11.06	281	1.25	32	2.00	51	10	4.5
6x3	150x80	9.25	235	11.06	281	1.75	44	2.38	60	13	5.9
6x4	150x100	9.25	235	11.06	281	1.75	44	2.38	60	14	6.4
8x4	200x100	11.25	286	13.06	332	2.00	51	2.63	67	18	8.2
8x6	200x150	11.25	286	13.50	343	2.00	51	2.63	67	19	8.6
10x6	250x150	12.25	311	14.50	368	2.00	51	2.88	73	24	10.9
10x8	250x200	12.25	311	14.75	375	2.00	51	2.88	73	29	13.2
12x8	300x200	14.25	362	16.75	425	2.13	54	3.13	80	39	17.7
12x10	300x250	14.25	362	17.00	432	2.13	54	3.13	80	41	18.6
14x10	350x250	16.13	410	19.88	505	2.82	72	3.81	97	59	26.8
14x12	350x300	16.13	410	19.13	486	2.82	72	3.81	97	56	25.4
16x12	400x300	18.38	467	22.38	568	3.25	83	4.25	108	78	35.4
16x14	400x350	18.38	467	21.88	556	3.25	83	4.25	108	82	37.2

* Laying length is measured from contact surface to pipe stop in Quick Lock bell.

Combination Reducers (Flanged Large End)

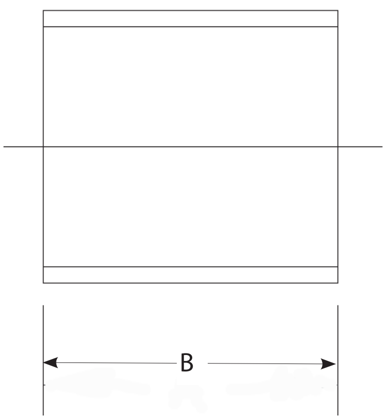
Standard flanges are filament wound. Molded flanges available in 2 through 12 inch sizes.



Nom Pipe Size		Laying Length* (L)		Overall Length (B)		Flange Thickness At Face (t)		Flange Thickness At Hub (D)		Approx Wt	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	lb.	kg
3x2	80x50	6.25	159	8.06	205	1.00	25	2.00	51	7	3.2
4x2	100x50	7.25	184	9.06	230	1.00	25	2.00	51	8	3.6
4x3	100x80	7.25	184	9.06	230	1.13	29	2.00	51	9	4.1
6x3	150x80	9.25	235	11.25	286	1.13	29	2.00	51	11	5.0
6x4	150x100	9.25	235	11.25	286	1.25	32	2.00	51	13	5.9
8x4	200x100	11.25	286	13.75	349	1.25	32	2.00	51	15	6.8
8x6	200x150	11.25	286	13.75	349	1.75	44	2.38	60	17	7.7
10x6	250x150	12.25	311	15.00	381	1.75	44	2.38	60	19	8.6
10x8	250x200	12.25	311	15.00	381	2.00	51	2.63	67	26	11.8
12x8	300x200	14.25	362	17.25	438	2.00	51	2.63	67	29	13.2
12x10	300x250	14.25	362	17.25	438	2.00	51	2.88	73	34	15.4
14x10	350x250	16.13	410	19.88	505	2.00	51	2.88	73	39	17.7
14x12	350x300	16.13	410	19.88	505	2.13	54	3.81	97	47	21.3
16x12	400x300	18.13	461	22.38	568	2.13	54	4.25	108	54	24.5
16x14	400x350	18.38	467	22.38	568	2.81	71	4.25	108	66	29.9

* Laying length is measured from contact surface to pipe stop in Quick Lock bell.

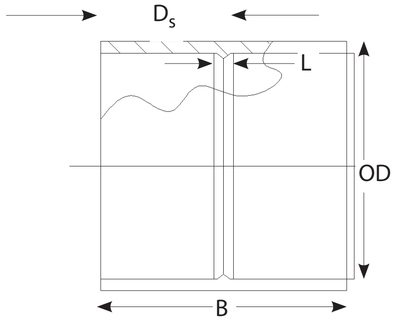
Pipe Nipples



Nom Pipe Size		Overall Length (B)		Approx Wt	
in.	mm	in.	mm	lb.	kg
1	25	2.25	57	0.1	0.0
1 1/2	40	2.62	67	0.2	0.1
2	50	3.75	95	0.2	0.1
3	80	3.75	95	0.3	0.1
4	100	3.75	95	0.5	0.2
6	150	4.62	117	0.9	0.4
8	200	5.12	130	1.4	0.6
10	250	5.62	143	1.9	0.9
12	300	6.12	155	2.4	1.1
14	350	7.25	184	6.7	3.0
16	400	8.25	210	9.7	4.4

Couplings and End Caps

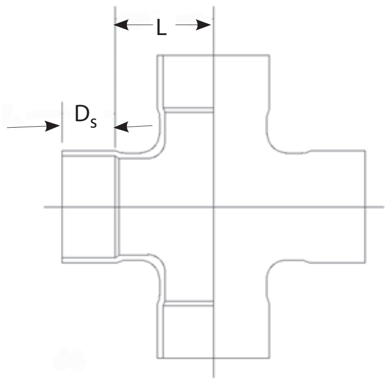
Couplings are filament wound. End caps consist of filament-wound couplings with molded plugs bonded in.



Nom Pipe Size		Overall Length (B)		Socket Depth (D_S)		Outside Dia (OD)		Pipe Stop (L)		Approx Wt Cplg		Approx Wt Cap	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	lb.	kg	lb.	kg
1	25	2.50	64	1.06	27	1.62	41	0.38	10	0.2	0.1	0.9	0.4
1½	40	2.88	73	1.25	32	2.31	59	0.38	10	0.3	0.1	1.0	0.5
2	50	4.00	102	1.81	46	2.81	71	0.38	10	0.6	0.3	1.2	0.5
3	80	4.00	102	1.81	46	3.94	100	0.38	10	0.9	0.4	2.2	1.0
4	100	4.00	102	1.81	46	5.06	129	0.38	10	1.4	0.6	3.4	1.5
6	150	4.88	124	2.25	57	7.19	183	0.38	10	2.4	1.1	8.4	3.8
8	200	5.38	137	2.50	64	9.25	235	0.38	10	4.0	1.8	14.0	6.4
10	250	5.88	149	2.75	70	11.38	289	0.38	10	5.0	2.3	22.0	10.0
12	300	6.38	162	3.00	76	13.38	340	0.38	10	7.0	3.2	22.0	10.0
14	350	7.75	197	3.50	89	14.69	373	0.75	19	12.0	5.4	–	–
16	400	8.75	222	4.00	102	16.62	422	0.75	19	14.0	6.4	–	–

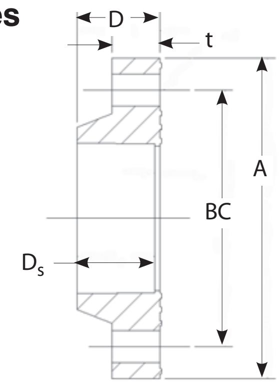
Crosses

Crosses are filament wound. Mitered crosses are available in 14- and 16-inch sizes. Contact FGS for dimensions and pressure ratings.



Nom Pipe Size		Laying Length (L)		Socket Depth (D_S)		Approx Wt	
in.	mm	in.	mm	in.	mm	lb.	kg
2	50	2.50	64	1.81	46	3	1.4
3	80	3.38	86	1.81	46	6	2.7
4	100	4.12	105	1.81	46	7	3.2
6	150	5.62	143	2.25	57	13	5.9
8	200	7.00	178	2.50	64	23	10.4
10	250	8.50	216	2.75	70	37	16.8
12	300	10.00	254	3.00	76	61	27.7

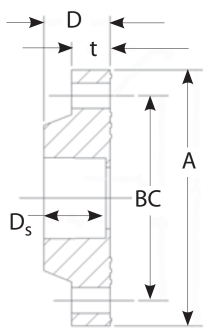
Flanges



Filament-wound and molded flanges correspond to ANSI B16.5 Cl. 150 classification. Sealing ring thicknesses for 1- and 1½-inch flanges are 0.035; for 2- through 8-inch flanges, 0.047; and for 10- through 16-inch flanges, 0.060, respectively. Molded flanges are indicated with an asterisk (*).See **Assembly Instructions for Bondstrand fiberglass flanges**, for recommendations on gasket selection, nut and washer dimensions, bolt lengths and torques, and tightening sequences.

Nom Pipe Size in.	mm	Flange Dia (A) in.	mm	Bolt Circle (BC) in.	mm	Laying Length (L) in.	mm	Flange Thickness At Hub (D) in.	mm	Flange Thickness At Face (t) in.	mm	Socket Depth (D_S) in.	mm	Hole Count	Hole Dia in.	mm	Bolt Dia in.	mm	Approx Wt lb.	kg
1	25	4.25	108	3.13	80	0.063	2	1.13	29	–	–	1.06	27	4	0.63	16	0.50	13	1	0.5
1½	40	5.00	127	3.88	99	0.125	3	1.38	35	–	–	1.25	32	4	0.63	16	0.50	13	2	0.9
2	50	6.00	152	4.75	121	0.188	5	2.00	51	1.00	25	1.82	46	4	0.75	19	0.63	16	2	0.9
		6.00*	152	4.75	121	0.188	5	2.00	51	1.00	25	1.82	46	4	0.75	19	0.63	16	2	0.9
3	80	7.50	191	6.00	152	0.188	5	2.00	51	1.13	29	1.82	46	4	0.75	19	0.63	16	3	1.4
		7.50*	191	6.00	152	0.188	5	2.00	51	1.13	29	1.82	46	4	0.75	19	0.63	16	3	1.4
4	100	9.00	229	7.50	191	0.188	5	2.00	51	1.25	32	1.82	46	8	0.75	19	0.63	16	4	1.8
		9.00*	229	7.50	191	0.188	5	2.00	51	1.56	40	1.82	46	8	0.75	19	0.63	16	4	1.8
6	150	11.00	279	9.50	241	0.125	3	2.38	60	1.75	44	2.25	57	8	0.88	22	0.75	19	7	3.2
		11.00*	279	9.50	241	0.125	3	2.38	60	1.75	44	2.25	57	8	0.88	22	0.75	19	7	3.2
8	200	13.50	343	11.75	298	0.125	3	2.63	67	2.00	51	2.50	64	8	0.88	22	0.75	19	10	4.5
		13.50*	343	11.75	298	0.125	3	2.63	67	2.00	51	2.50	64	8	0.88	22	0.75	19	12	5.4
10	250	16.00	406	14.25	362	0.125	3	2.88	73	2.00	51	2.75	70	12	1.00	25	0.88	22	14	6.4
		16.00*	406	14.25	362	0.125	3	2.88	73	2.00	51	2.75	70	12	1.00	25	0.88	22	16	7.3
12	300	19.00	483	17.00	432	0.125	3	3.13	80	2.13	54	3.00	76	12	1.00	25	0.88	22	22	10.0
		19.00*	483	17.00	432	0.125	3	3.13	80	2.13	54	3.00	76	12	1.00	25	0.88	22	27	12.2
14	350	21.00	533	18.75	476	0.312	8	3.81	97	2.81	71	3.50	89	12	1.12	28	1.00	25	37	16.8
16	400	23.50	597	21.25	540	0.250	6	4.25	108	3.25	83	4.00	102	16	1.12	28	1.00	25	53	24.0

Reducing Flanges

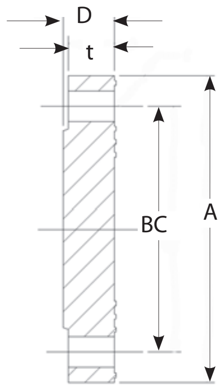


Reducing flanges are of molded construction. See assembly instructions for bolting and gasket recommendations. Use ½-inch drive to avoid wrench socket to flange hub interference while torquing bolts.

Nom Pipe Size in.	mm	Flange Dia (A) in.	mm	Bolt Circle (BC) in.	mm	Laying Length (L) in.	mm	Flange At Hub (D) in.	mm	Thickness At Face (t) in.	mm	Hole Dia (F) in.	mm	Hole Count	Socket Depth (D_S) in.	mm	Bolt Dia in.	mm	Approx Wt lb.	kg
2x1½	50x40	6.00	152	4.75	121	0.75	19	2.00	51	1.00	25	0.75	19	4	1.25	32	0.63	16	2	0.9
3x2	80x50	7.50	191	6.00	152	0.12	3	1.93	49	1.12	28	0.75	19	4	1.81	46	0.63	16	3	1.4
4x2	100x50	9.00	229	7.50	191	0.12	3	1.93	49	1.25	32	0.75	19	8	1.81	46	0.63	16	6	2.7
4x3	100x80	9.00	229	7.50	191	0.12	3	1.93	49	1.25	32	0.75	19	8	1.81	46	0.63	16	5	2.3
6x3	150x80	11.00	279	9.50	241	0.69	18	2.50	64	1.75	44	0.88	22	8	1.81	46	0.75	19	12	5.4
6x4	150x100	11.00	279	9.50	241	0.69	18	2.50	64	1.75	44	0.88	22	8	1.81	46	0.75	19	11	5.0
8x4	200x100	13.50	343	11.75	298	0.94	24	2.75	70	2.00	51	0.88	22	8	1.81	46	0.75	19	21	9.5
8x6	200x150	13.50	343	11.75	298	0.50	13	2.75	70	2.00	51	0.88	22	8	2.25	57	0.75	19	17	7.7
10x6	250x150	16.00	406	14.25	362	0.75	19	3.00	76	2.00	51	1.00	25	12	2.25	57	0.88	22	29	13.2
10x8	250x200	16.00	406	14.25	362	0.50	13	3.00	76	2.00	51	1.00	25	12	2.50	64	0.88	22	24	10.9
12x8	300x200	19.00	483	17.00	432	0.75	19	3.25	83	2.12	54	1.00	25	12	2.50	64	0.88	22	43	19.5
12x10	300x250	19.00	483	17.00	432	0.50	13	3.25	83	2.12	54	1.00	25	12	2.75	70	0.88	22	36	16.3

Blind Flanges

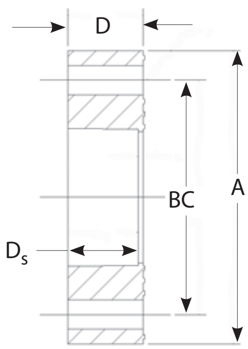
Blind flanges are molded.



Nom Pipe Size in.	Nom Pipe Size mm	Flange Dia (A) in.	Flange Dia (A) mm	Bolt Circle (BC) in.	Bolt Circle (BC) mm	Flange Thickness At Face (D) in.	Flange Thickness At Face (D) mm	Flange Thickness At Holes (t) in.	Flange Thickness At Holes (t) mm	Hole Count	Hole Dia (F) in.	Hole Dia (F) mm	Bolt Dia in.	Bolt Dia mm	Approx Wt lb.	Approx Wt kg
2	50	6.00	152	4.75	121	1.18	30	1.00	25	4	0.75	19	0.63	16	3	1.4
3	80	7.50	191	6.00	152	1.25	32	1.13	29	4	0.75	19	0.63	16	4	1.8
4	100	9.00	229	7.50	191	1.43	36	1.25	32	8	0.75	19	0.63	16	6	2.7
6	150	11.00	279	9.50	241	2.50	64	1.75	44	8	0.88	22	0.75	19	14	6.4
8	200	13.50	343	11.75	298	2.75	70	2.00	51	8	0.88	22	0.75	19	23	10.4
10	250	16.00	406	14.25	362	3.00	76	2.00	51	12	1.00	25	0.88	22	35	15.9
12	300	19.00	438	17.00	432	3.25	83	2.13	54	12	1.00	25	0.88	22	55	24.9

Heavy-Duty Flanges

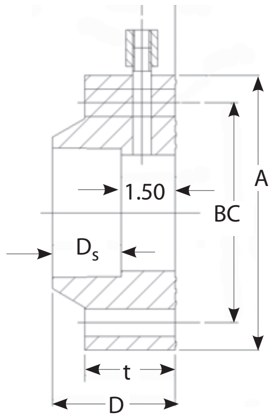
Heavy-duty (hubless) flanges are filament-wound.



Nom Pipe Size in.	Nom Pipe Size mm	Flange Dia (A) in.	Flange Dia (A) mm	Bolt Circle (BC) in.	Bolt Circle (BC) mm	Laying Length (L) in.	Laying Length (L) mm	Flange Thickness (D) in.	Flange Thickness (D) mm	Socket Depth (D_S) in.	Socket Depth (D_S) mm	Hole Count	Hole Dia (F) in.	Hole Dia (F) mm	Bolt Dia in.	Bolt Dia mm	Approx Wt lb.	Approx Wt kg
1	25	4.25	108	3.13	80	0.06	2	1.13	29	1.06	27	4	0.63	16	0.50	13	1	0.5
1½	40	5.00	127	3.88	99	0.13	3.	1.38	35	1.25	32	4	0.63	16	0.50	13	2	0.9
2	50	6.00	152	4.75	121	0.19	5	1.94	49	1.82	46	4	0.75	19	0.63	16	3	1.4
3	80	7.50	191	6.00	152	0.19	5	1.94	49	1.82	46	4	0.75	19	0.63	16	4	1.8
4	100	9.00	229	7.50	191	0.19	5	1.94	49	1.82	46	8	0.75	19	0.63	16	6	2.7
6	150	11.00	279	9.50	241	0.13	3	2.38	60	2.25	57	8	0.88	22	0.75	19	10	4.5
8	200	13.50	343	11.75	298	0.13	3	2.63	67	2.50	64	8	0.88	22	0.75	19	14	6.4
10	250	16.00	406	14.25	362	0.13	3	2.88	73	2.75	70	12	1.00	25	0.88	22	21	9.5
12	300	19.00	483	17.00	432	0.13	3	3.13	80	3.00	76	12	1.00	25	0.88	22	32	14.5
14	350	21.00	533	18.75	476	0.31	8	3.81	97	3.50	89	12	1.12	28	1.00	25	45	20.4
16	400	23.50	597	21.25	540	0.25	6	4.25	108	4.00	102	16	1.12	28	1.00	25	59	26.8

Orifice Flanges

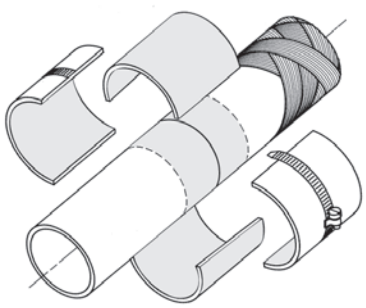
Orifice flanges are filament-wound.



Nom Pipe Size		Flange Dia (A)		Bolt Circle (BC)		Flange Thickness Maximum (D)		Flange Thickness Minimum (t)		Socket Depth (D_S)		Hole Count	Hole Dia		Bolt Dia		Approx Wt	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm		in.	mm	in.	mm	lb.	kg
2	50	6.00	152	4.75	121	3.38	86	2.38	60	1.82	46	4	0.75	19	0.63	16	3	1.4
3	80	7.50	191	6.00	152	3.38	86	2.50	64	1.82	46	4	0.75	19	0.63	16	5	2.3
4	100	9.00	229	7.50	191	3.38	86	2.63	67	1.82	46	8	0.75	19	0.63	16	7	3.2
6	150	11.00	279	9.50	241	3.75	95	2.94	75	2.25	57	8	0.88	22	0.75	19	11	5.0
8	200	13.50	343	11.75	298	4.00	102	3.19	81	2.50	64	8	0.88	22	0.75	19	17	7.7
10	250	16.00	406	14.25	362	4.25	108	3.25	83	2.75	70	12	1.00	25	0.88	22	24	10.9
12	300	19.00	483	17.00	432	4.50	114	3.50	89	3.00	76	12	1.00	25	0.88	22	36	16.3
14	350	21.00	533	18.75	476	5.00	127	4.00	102	3.50	89	12	1.12	28	1.00	25	49	22.2
16	400	23.50	597	21.25	540	5.50	140	4.50	114	4.00	102	16	1.12	28	1.00	25	57	25.9

Maintenance Couplings

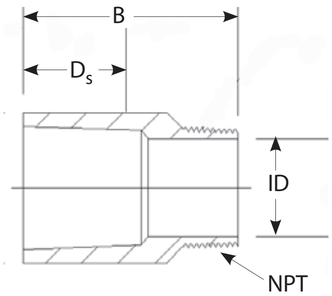
Bondstrand maintenance coupling kits include inner and outer sections, hose clamp(s), and instructions for assembly (**Bondstrand Installation Maintenance Coupling**). Adhesive must be ordered separately.



Nom Pipe Size		Overall Length		Pressure Rating		Adhesive Kits Required
in.	mm	in.	mm	psi.	N/m^2	6 oz.
1	25	2.50	64	150	1.03x10^6	1/2
1 1/2	40	3.00	76	150	1.03x10^6	1
2	50	4.00	102	150	1.03x10^6	1
3	80	4.00	102	150	1.03x10^6	1
4	100	4.00	102	150	1.03x10^6	2
6	150	4.88	124	150	1.03x10^6	2
8	200	5.38	137	150	1.03x10^6	3
10	250	5.88	149	150	1.03x10^6	4
12	300	6.38	162	150	1.03x10^6	4
14	350	7.38	187	150	1.03x10^6	6
16	400	8.38	213	150	1.03x10^6	8

Adapters (Threaded and Victaulic)

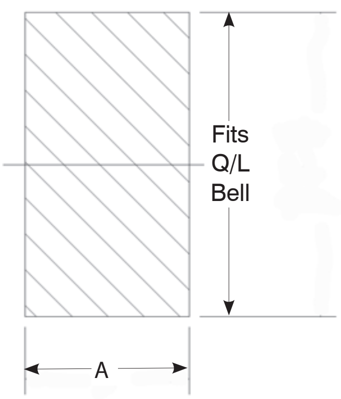
Adapters are available in Quick-Lock bell x NPT threaded male (M), and Quick-Lock bell x Victaulic male end (V) configurations. Sizes 1" (25 mm) and 1½" are filament wound; 2" through 6" are compression molded. Consult manufacturer for dimensions of QL bell x victaulic adapters.



Nom Pipe Size in.	mm	Overall Length (B) in.	mm	Socket Depth (D_S) in.	mm	Inside Dia (ID) in.	mm	Approx Wt lb.	kg
1	25	2.38	60	1.06	27	0.76	19	0.3	0.1
1½	40	2.81	71	1.25	32	1.43	36	0.4	0.2
2	50	3.57	91	1.81	46	1.89	48	0.6	0.3
3	80	4.36	111	1.81	46	2.80	71	1.2	0.5
4	100	4.63	118	1.81	46	3.89	99	1.6	0.7
6	150	4.67	119	2.25	57	5.90	150	2.6	1.2

Molded Plugs

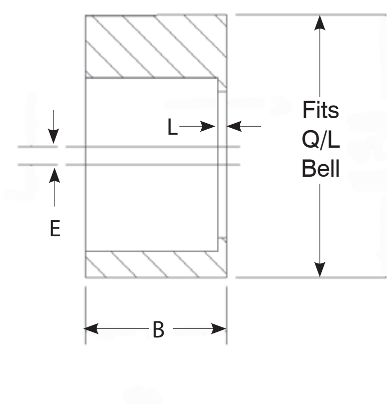
50 psi maximum



Nom Pipe Size in.	mm	Total Thickness (T) in.	mm	Approx Wt lb.	kg
2	50	1.94	49	0.6	0.3
3	80	1.94	49	1.3	0.6
4	100	1.94	49	2.0	0.9
6	150	2.38	60	6.0	2.7
8	200	2.63	67	10.0	4.5
10	250	2.88	73	17.0	7.7
12	300	3.13	80	27.0	12.2

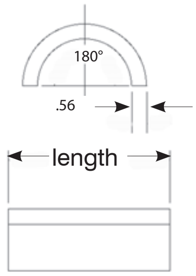
Molded Reducer Bushings

50 psi maximum



Nom Pipe Size in.	mm	Overall Length (B) in.	mm	Pipe Stop (L) in.	mm	Eccentricity (E) in.	mm	Approx Wt lb.	kg
3x2	80X50	1.94	49	0.13	3	0.25	6	0.7	0.3
4x2	100x50	1.94	49	0.13	3	0.75	19	1.5	0.7
4x3	100x80	1.94	49	0.13	3	0.13	3	0.8	0.4
6x3	150x80	2.38	60	0.56	14	1.25	32	4.1	1.9
6x4	150x100	2.38	60	0.56	14	0.63	16	3.1	1.4
8x4	200x100	2.63	67	0.81	21	1.63	41	8.0	3.6
8x6	200x150	2.63	67	0.38	10	0.63	16	5.0	2.3
10x6	250x150	2.88	73	0.63	16	1.63	41	12.0	5.4
10x8	250x200	2.88	73	0.38	10	0.63	16	7.0	3.2
12x8	300x200	3.13	80	0.63	16	1.63	41	15.0	6.8
12x10	300x250	3.13	80	0.38	10	0.63	16	8.0	3.6

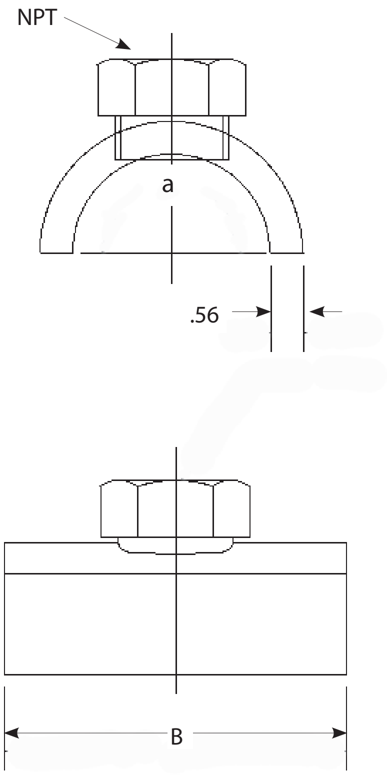
Blank Saddles



Blank saddles are filament wound and are used for pipe support and restraint. Thickness for all saddles is 0.56 inches. Available in same lengths as reducing saddles.

Nom Pipe Size		Approx Wt		Adhesive Kits Required	
in.	mm	lb./in.	kg/mm	(3 oz)	(6 oz)
1	25	0.1	0.05	1	
1 1/2	40	0.2	0.09	1	
2	50	0.2	0.09	1	
3	80	0.3	0.14	1	
4	100	0.4	0.18	1	
6	150	0.5	0.23	1	
8	200	0.6	0.27	1	
10	250	0.8	0.36		1 1/2
12	300	1.0	0.45		1 1/2
14	350	1.1	0.50		2
16	400	1.2	0.54		2

Reducing Saddles (Bushed Outlets)

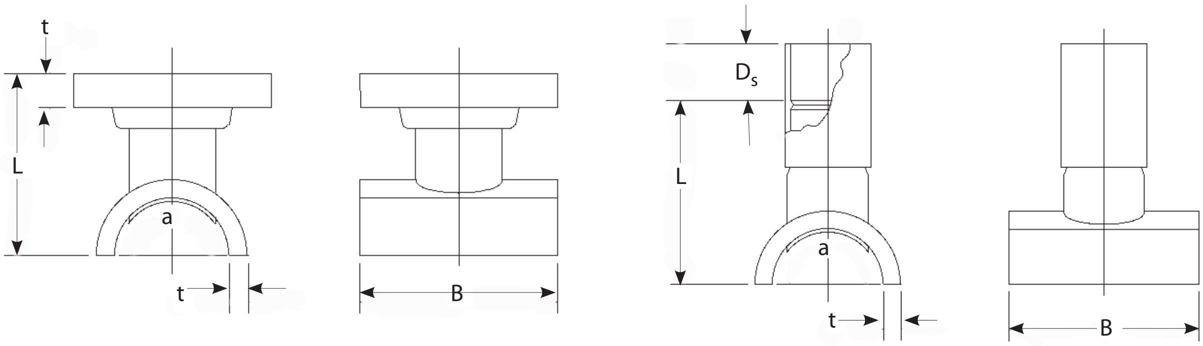


Standard reducing saddles come with 1 1/2-in NPT plastic bushing. All smaller bushings are 316 stainless steel. Other materials available on special order. Saddles are filament wound.

Nom Size Required		Outlet Nom Size		Length (B)		Saddle Girth (a)	Approx Wt		Adhesive Kits	
in.	mm	in.	mm	in.	mm	degrees	lb.	kg	3 oz.	6 oz.
2	50	1/4, 3/8, 1/2, 3/4	6, 9, 13, 19	4.00	102	180	1.0	0.5	1	
		1	25	6.00	152	180	2.0	0.9	1	
3	80	1/4	6	4.00	102	90	1.6	0.7	1	
		1/4, 3/8, 1/2, 3/4	6, 9, 13, 19	4.00	102	180	1.6	0.7	1	
		1, 1 1/4, 1 1/2	25, 30, 40	6.00	152	180	3.9	1.8	1	
4	100	1/4, 3/8	6, 9	4.00	102	90	2.0	0.9	1	
		1/4, 3/8, 1/2, 3/4	6, 9, 13, 19	4.00	102	180	2.0	0.9	1	
		1, 1 1/4, 1 1/2	25, 30, 40	6.00	152	180	4.0	1.8	1	
6	150	1/4, 3/8, 1/2	6, 9, 13	4.00	102	180	2.4	1.1	1	
		1/4, 3/8, 1/2, 3/4	6, 9, 13, 19	4.00	102	180	2.4	1.1	1	
		1, 1 1/4, 1 1/2	25, 30, 40	6.00	152	180	4.6	2.1		1
8	200	1/4, 3/8, 1/2, 3/4	6, 9, 13, 19	4.00	102	90	2.8	1.3	1	
		1, 1 1/4, 1 1/2	25, 30, 40	6.00	152	180	5.2	2.4		1
10	250	1/4, 3/8, 1/2	6, 9, 13	4.00	102	45	3.8	1.7		1
		3/4	19	4.00	102	90	3.8	1.7		1
		1, 1 1/4, 1 1/2	25, 30, 40	6.00	152	90	6.3	2.9		1
12	300	1/4, 3/8, 1/2, 3/4	6, 9, 13, 19	4.00	102	45	4.2	1.9		1
		1, 1 1/4, 1 1/2	25, 30, 40	6.00	152	90	7.4	3.4		1
14	350	1/4, 3/8, 1/2, 3/4	6, 9, 13, 19	4.00	102	45	4.2	1.9		2
		1, 1 1/4, 1 1/2	25, 30, 40	6.00	152	90	7.4	3.4		2
16	400	1/4, 3/8, 1/2, 3/4	6, 9, 13, 19	4.00	102	45	4.2	1.9		2
		1, 1 1/4, 1 1/2	25, 30, 40	6.00	152	45	7.4	3.4		2

Reducing Saddles with Flanged and Quick-Lock Outlets

Both filament-wound and molded flanges are available. Saddles are filament wound. See Quick-Lock coupling table for socket depth, D_S. See Quick-Lock flange table for flange thickness.



Nom Size in.	Nom Size mm	Outlet Nom Size in.	Outlet Nom Size mm	Laying Length (L) in.	Laying Length (L) mm	Nominal Thickness (t) in.	Nominal Thickness (t) mm	Length (B) in.	Length (B) mm	Saddle Girth (a) degrees	Approx Wt (Flg) lb.	Approx Wt (Flg) kg	Approx Wt (Q/L) lb.	Approx Wt (Q/L) kg	Adhesive Kits Required 3 oz.	Adhesive Kits Required 6 oz.
3	80	1,1½,2	25,40,50	5.25	133	0.56	14	6.00	152	180	4	1.8	3	1.4	1	-
4	100	1,1½,2	25,40,50	6.00	152	0.81	21	6.00	152	180	7	3.2	5	2.3	1	-
		3	80	6.00	152	0.81	21	9.50	241	180	7	3.2	5	2.3	1	-
6	150	1,1½,2	25,40,50	7.38	187	1.06	27	6.00	152	180	18	8.2	14	6.4		1
		3	80	7.38	187	1.06	27	9.50	241	180	18	8.2	14	6.4		1
		4	100	7.38	187	1.06	27	12.00	305	180	18	8.2	14	6.4		1
8	200	1,1½,2	25,40,50	8.13	207	1.31	33	6.00	152	90	14	6.4	11	5.0		1
		3	80	8.13	207	1.31	33	9.50	241	180	17	7.7	13	5.9		1
		4	100	8.63	219	1.31	33	12.00	305	180	22	10.0	16	7.3	1	1
		6	150	9.00	229	1.31	33	17.00	432	180	30	13.6	21	9.5	1	1
10	250	1,1½,2	25,40,50	9.13	232	1.31	33	6.00	152	90	17	7.7	14	6.4		2
		3	80	9.13	232	1.31	33	9.50	241	90	17	7.7	14	6.4		2
		4	100	9.63	245	1.31	33	12.00	305	180	31	14.1	27	12.2	1	2
		6	150	10.13	257	1.31	33	17.00	432	180	40	18.1	35	15.9		3
12	300	1,1½,2	25,40,50	10.38	264	1.31	33	6.00	152	90	27	12.2	23	10.4	1	2
		3	80	10.38	264	1.31	33	9.50	241	90	27	12.2	23	10.4	1	2
		4	100	10.38	264	1.31	33	12.00	305	90	27	12.2	23	10.4	1	2
		6	150	11.13	283	1.31	33	17.00	432	180	53	24.0	46	20.9		3
14	350	1,1½,2	25,40,50	11.00	279	1.31	33	6.00	152	90	37	16.8	35	15.9		3
		3	80	11.00	279	1.31	33	9.50	241	90	37	16.8	35	15.9		3
		4	100	11.00	279	1.31	33	12.00	305	90	37	16.8	35	15.9		3
		6	150	11.75	298	1.31	33	17.00	432	180	64	29.0	49	22.2		4
16	400	1,1½,2	25,40,50	12.00	305	1.31	33	6.00	152	90	53	24.0	41	18.6		2
		3	80	12.00	305	1.31	33	9.50	241	90	53	24.0	41	18.6		2
		4	100	12.00	305	1.31	33	12.00	305	90	53	24.0	41	18.6		2
		6	150	12.75	324	1.31	33	17.00	432	180	75	34.0	67	30.4		5

Fittings Pressure Ratings

Bondstrand Series 2000, 5000 and 7000 fittings

- 45° elbows, bell end
- 90° elbows, bell end
- 45° elbows, flanged
- 90° elbows, flanged
- Tees, bell end
- Tees, flanged

Nom Pipe Size		Filament-wound Quick-Lock		Filament-wound Flanged		Molded Quick-Lock		Molded Flanged	
in.	mm	psi	bar	psi	bar	psi	bar	psi	bar
1	25	300	21	300	21	–	–	–	–
1 1/2	40	300	21	300	21	–	–	–	–
2	50	375	26	375	26	300	21	300	21
		300*	21*	300*	21*	200*	14*	200*	14*
3	80	325	22	325	22	225	16	225	16
		275*	19*	275*	19*	150*	10*	150*	10*
4	100	300	21	300	21	175	12	175	12
		200*	14*	200*	14*	125*	9*	125*	9*
6	150	225	16	225	16	150	10	150	10
		175*	12*	175*	12*	100*	7*	100*	7*
8	200	225	16	225	16	–	–	–	–
		150*	10*	150*	10*	–	–	–	–
10	250	200	14	200	14	–	–	–	–
		150*	10*	150*	10*	–	–	–	–
12	300	175	12	150	10	–	–	–	–
		150*	10*	150*	10*	–	–	–	–
14	350	150	10	150	10	–	–	–	–
16	400	150	10	150	10	–	–	–	–

*Note: Pressure ratings for Series 5000 are lower than for other pipe series.

- Tapered body reducers
- Tapered body reducers, flanged
- Flanges
- Flanges, blind
- Saddles, bell end
- Crosses, bell end
- Crosses, flanged
- End caps
- Reducer bushings

Nom Pipe Size		Tapered body reducers Tapered body reducers, flanged Flanges		Saddles, bell end Saddles, flanged Blind Flanges		Crosses, bell end Crosses, flanged		End caps Reducer bushings	
in.	mm	psi	bar	psi	bar	psi	bar	psi	bar
1	25	600	41	150	10	–	–	50	3
1 1/2	40	550	38	150	10	–	–	50	3
2	50	450	31	150	10	150	10	50	3
3	80	350	24	150	10	150	10	50	3
4	100	350	24	150	10	150	10	50	3
6	150	250	17	150	10	100	7	50	3
8	200	225	16	150	10	100	7	50	3
10	250	175	12	150	10	100	7	50	3
12	300	150	10	150	10	100	7	50	3
14	350	150	10	150	10	–	–	50	3
16	400	150	10	150	10	–	–	50	3

Fittings Pressure Ratings (cont'd.)

Bondstrand Series 2000, 5000 and 7000 fittings

- Laterals, bell end
- Laterals, flanged
- Sleeve couplings
- Adapters, threaded
- Adapters, grooved

Nom pipe Size		Laterals, bell end Laterals, flanged		Sleeve couplings		Adapters, threaded Adapters, grooved	
in.	mm	psi	bar	psi	bar	psi	bar
1	25	–	–	450	31	–	–
1½	40	–	–	450	31	–	–
2	50	150	10	450	31	200	14
		150*	10*	450	31	150*	10*
3	80	150	10	425	29	200	14
		150*	10*	350*	24*	150*	10*
4	100	150	10	400	28	150	10
		150*	10*	350	24*	100*	7*
6	150	100	7	300	21	150	10
		100*	7*	250	17*	100*	7*
8	200	100	7	250	17	–	–
		100*	7*	225*	16*	–	–
10	250	100	7	200	14	–	–
		100*	7*	175*	12*	–	–
12	300	100	7	170	12	–	–
		100*	7*	150*	10*	–	–
14	350	–	–	165	11	–	–
		–	–	150*	10*	–	–
16	400	–	–	165	11	–	–
		–	–	150*	10*	–	–

*Note: Pressure ratings for Series 5000 are lower than for other pipe series.

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NOV Fiber Glass Systems

CI2050 supersedes FP 282B - February 2013

Fittings & Flanges for 32-50 Bar Pipe Series 2400

32 Bar Fittings
90° Elbows....2
45° Elbows....2
22½° Elbows....3
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Concentric Reducers....5
Couplings....6
Nipples....6
Heavy-Duty Flanges....7
Stub-end Flanges....8

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50 Bar Fittings
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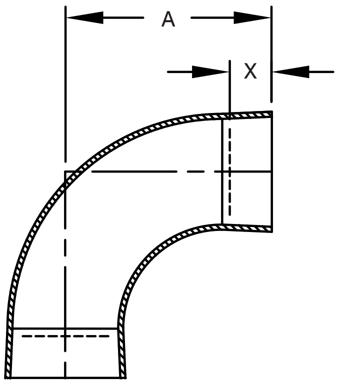
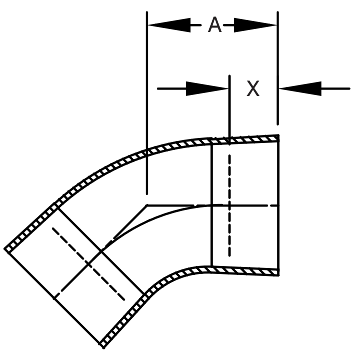
32 Bar Fittings

90° Elbows



Nominal Pipe Size		A	X	Wgt.
mm	in	mm	mm	kg
50	2	137	50	0.6
80	3	190	80	2.1
100	4	235	80	3.8
150	6	350	110	8.7
200	8	455	140	24.0
250	10	561	170	39.0
300	12	663	200	61.0
350	14	594	230	66.0
400	16	632	230	84.0
450	18	732	260	168.0
500	20	813	290	230.0
600	24	975	350	367.0

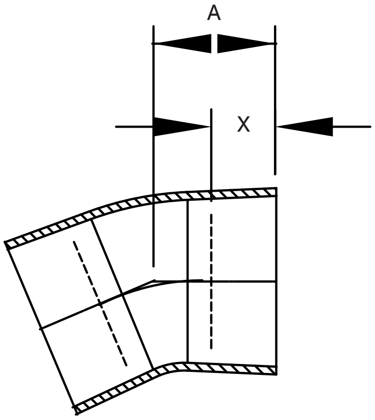
45° Elbows



Nominal Pipe Size		A	X	Wgt.
mm	in	mm	mm	kg
50	2	95	50	0.5
80	3	141	80	1.7
100	4	153	80	2.4
150	6	216	110	7.0
200	8	277	140	15.5
250	10	339	170	32.0
300	12	396	200	45.0
350	14	355	230	58.0
400	16	372	230	80.0
450	18	464	260	115.0
500	20	515	290	157.0
600	24	618	350	281.0

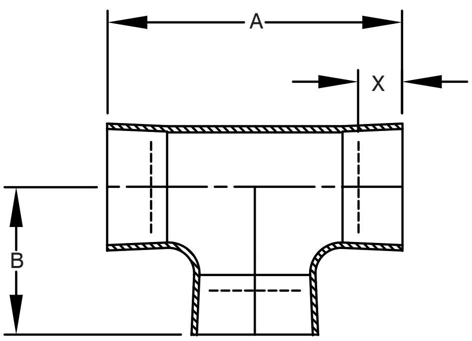
32 Bar Fittings

22½° Elbows



Nominal Pipe Size		A	X	Wgt.
mm	in	mm	mm	kg
50	2	79	50	0.4
80	3	117	80	1.5
100	4	123	80	2.0
150	6	170	110	5.9
200	8	216	140	10.5
250	10	238	170	19.1
300	12	277	200	32.0
350	14	301	230	43.0
400	16	315	230	57.0
450	18	366	260	78.0
500	20	406	290	107.0
600	24	486	350	185.0

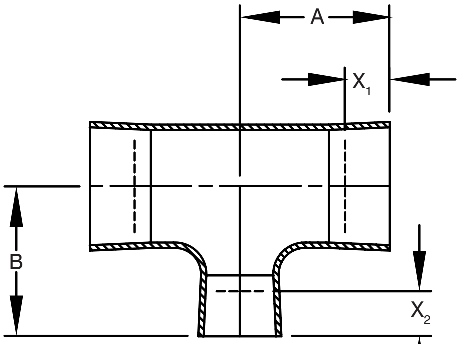
Tees



Nominal Pipe Size		A	B	X	Wgt.
mm	in	mm	mm	mm	kg
50	2	248	124	50	1.6
80	3	352	176	80	3.6
100	4	390	195	80	6.4
150	6	526	263	110	18.0
200	8	656	328	140	37.0
250	10	792	396	170	55.0
300	12	928	464	200	92.0
350	14	1004	502	230	106.0
400	16	1050	525	230	126.0
450	18	1198	599	260	293.0
500	20	1320	660	290	398.0
600	24	1568	784	350	682.0

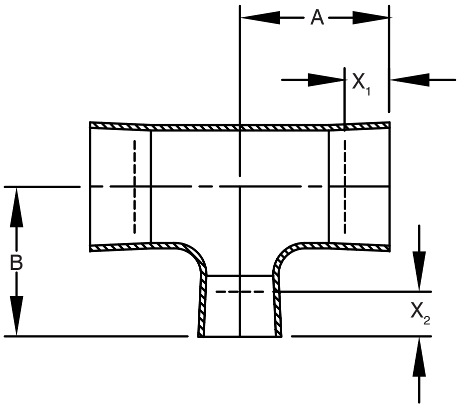
32 Bar Fittings

Reducing Tees



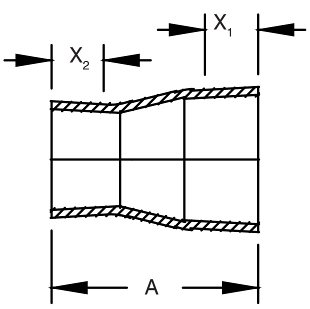
Nominal Pipe Size		A	X1	B	X2	Wgt
mm	in	mm	mm	mm	mm	kg
80x80x50	3x3x2	176	80	136	50	3.0
100x100x50	4x4x2	195	80	149	50	5.4
100x100x80	4x4x3	195	80	188	80	5.5
150x150x50	6x6x2	263	110	174	50	12.2
150x150x80	6x6x3	263	110	214	80	12.6
150x150x100	6x6x4	263	110	220	80	13.7
200x200x80	8x8x3	328	140	239	80	19.3
200x200x100	8x8x4	328	140	252	80	26.0
200x200x150	8x8x6	328	140	288	110	33.0
250x250x100	10x10x4	396	170	274	80	42.0
250x250x150	10x10x6	396	170	314	110	42.0
250x250x200	10x10x8	396	170	353	140	53.0
300x300x100	12x12x4	464	200	296	80	60.0
300x300x150	12x12x6	464	200	339	110	86.0
300x300x200	12x12x8	464	200	379	140	90.0
300x300x250	12x12x10	464	200	421	170	92.0
350x350x150	14x14x6	502	230	364	110	92.0
350x350x200	14x14x8	502	230	404	140	96.0
350x350x250	14x14x10	502	230	447	170	102.0
350x350x300	14x14x12	502	230	489	200	106.0
400x400x150	16x16x6	525	230	384	110	97.0
400x400x200	16x16x8	525	230	423	140	102.0
400x400x250	16x16x10	525	230	463	170	107.0
400x400x300	16x16x12	525	230	505	200	117.0
400x400x350	16x16x14	525	230	545	230	104.0
450x450x200	18x18x8	599	260	456	140	210.0
450x450x250	18x18x10	599	260	499	170	218.0
450x450x300	18x18x12	599	260	529	200	227.0
450x450x350	18x18x14	599	260	560	230	234.0
450x450x400	18x18x16	599	260	560	230	240.0
500x500x250	20x20x10	660	290	525	170	339.0
500x500x300	20x20x12	660	290	555	200	250.0
500x500x350	20x20x14	660	290	586	230	360.0
500x500x400	20x20x16	660	290	586	230	367.0
500x500x450	20x20x18	660	290	525	260	381.0
600x600x300	24x24x12	784	350	605	200	577.0

Reducing Tees cont



Nominal Pipe Size		A	X_1	B	X_2	Wgt
mm	in	mm	mm	mm	mm	kg
600x600x350	24x24x14	784	350	636	230	589.0
600x600x400	24x24x16	784	350	636	230	598.0
600x600x450	24x24x18	784	350	688	260	619.0
600x600x500	24x24x20	784	350	716	290	638.0

Concentric Reducers

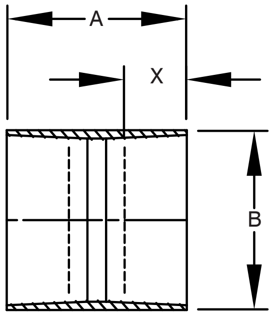


Nominal Pipe Size		A	X_1	X_2	Wgt.
mm	in	mm	mm	mm	kg
80x50	3x2	204	80	50	0.9
100x50	4x2	226	80	50	2.7
100x80	4x3	254	80	80	2.8
150x80	6x3	307	110	80	3.9
150x100	6x4	314	110	80	4.2
200x100	8x4	383	140	80	9.5
200x150	8x6	379	140	110	9.5
250x150	10x6	428	170	110	14.5
250x200	10x8	445	170	140	16.0
300x200	12x8	520	200	140	33.0
300x250	12x10	537	200	170	35.0
350x250	14x10	614	230	170	45.0
350x300	14x12	638	230	200	50.0
400x300	16x12	625	230	200	42.0
400x350	16x14	643	230	230	48.0
450x400	18x16	618	260	230	71.0
500x400	20x16	769	290	230	113.0
500x450	20x18	701	290	260	117.0
600x400	24x16	1066	350	230	156.0
600x450	24x18	998	350	260	155.0
600x500	24x20	907	350	290	164.0

Note: Eccentric Reducers are available on request

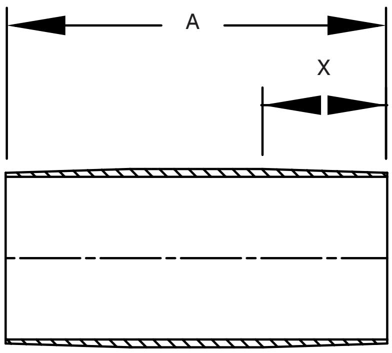
32 Bar Fittings

Couplings



Nominal Pipe Size		A	X	B	Wgt.
mm	in	mm	mm	mm	kg
50	2	170	50	70	0.4
80	3	230	80	100	0.9
100	4	230	80	124	1.2
150	6	290	110	180	2.2
200	8	350	140	238	5.0
250	10	410	170	296	7.9
300	12	470	200	350	11.6
350	14	530	230	381	13.2
400	16	530	230	435	17.4
450	18	590	260	472	17.8
500	20	650	290	524	23.0
600	24	770	350	630	41.0

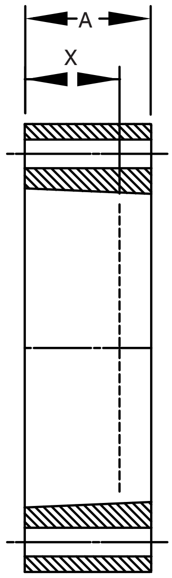
Nipples



Nominal Pipe Size		A	X	Wgt.
mm	in	mm	mm	kg
50	2	125	50	0.1
80	3	185	80	0.2
100	4	185	80	0.3
150	6	245	110	0.8
200	8	310	140	1.6
250	10	370	170	3.1
300	12	440	200	5.0
350	14	500	230	7.4
400	16	500	230	9.1
450	18	580	260	12.9
500	20	640	290	17.8
600	24	760	350	30.0

32 Bar Fittings

Heavy-Duty Flanges



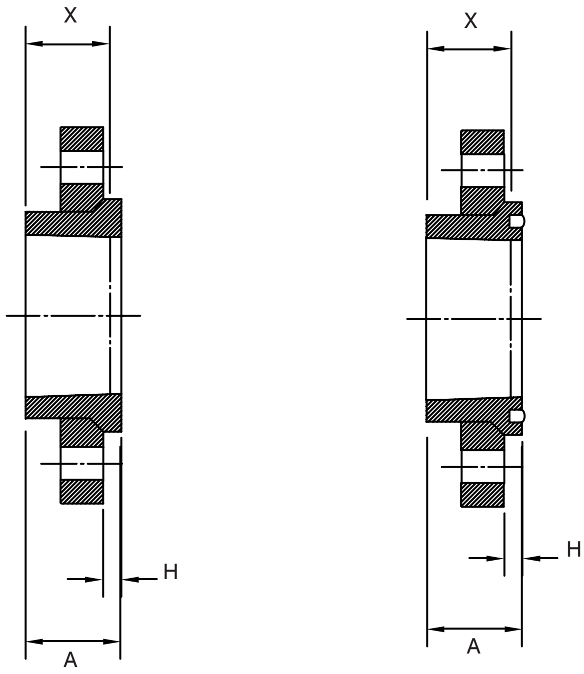
Nominal Pipe Size		A	X	Wgt.(1)
mm	in	mm	mm	kg
50	2	55	50	1.7
80	3	85	80	4.0
100	4	85	80	5.9
150	6	115	110	11.2
200	8	146	140	19.2
250	10	176	170	28.0

Notes:
(1)The weights shown are for ANSI B16.5 Class 300 drilled flanges. Weights for other drilling classes may be different. For more detailed information reference is made to the appropriate product data.

*Heavy Duty Flanges are standard available in drillings according to ANSI and ISO (DIN).
**Full-face elastomeric gaskets may be used, suitable for the service pressure, service temperature and fluid. Shore A durometer hardness of 60 ±5 is recommended and a thickness of 3 mm.
Compressed fiber gaskets, 3 mm thick, compatible with the pressure, temperature and medium, may also be used. The mechanical properties should be in accordance with DIN 3754 (IT 400) or equal.
***For maximum bolt torque refer to the appropriate Bondstrand literature. Please be aware that excessive torque may result in flange failure and, therefore a torque-wrench is required.

32 Bar Fittings

Stub-end Flanges (Van Stone)



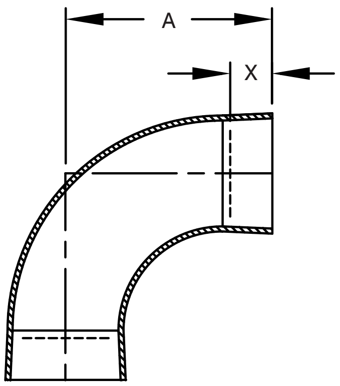
Nominal Pipe Size		A	X	H	Wgt. Stub End	Wgt. Steel Ring(1)
mm	in	mm	mm	mm	kg	kg
50	2	65	50	10	0.2	2.5
80	3	95	80	16	0.7	4.8
100	4	95	80	16	1.1	7.0
150	6	125	110	23	2.3	12.2
200	8	155	140	29	4.0	18.3
250	10	185	170	33	5.5	26.0
300	12	215	200	38	7.6	39.0
350	14	245	230	40	7.9	56.0
400	16	250	230	47	11.6	70.0
450	18	280	260	51	22.0	85.0
500	20	310	290	58	26.0	107.0
600	24	370	350	71	29.0	182.0

Notes:
(1)The weight shown is for ANSI B16.5 Class 300 drilled flanges. Weights for other drilling classes may be different. For more detailed information reference is made to the appropriate product data.

*Stub-End Flange Rings are standard available in drillings according to ANSI and ISO (DIN).
**Stub-End Flanges are available with and without O-ring groove in the face.
Suitable O-ring seals should be used, available on request.
***Make sure that the O-ring grooved stub-end is compatible with its counter flange, e.g. use a stub-end without groove or another flat surface flange as counter flange.
****Maximum bolt-torque for use with O-rings seals may be calculated based on pressure, size and number of bolts.

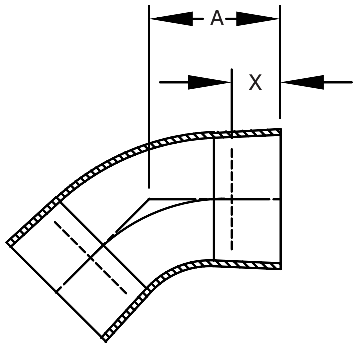
40 Bar Fittings

90° Elbows



Nominal Pipe Size		A	X	Wgt.
mm	in	mm	mm	kg
50	2	167	80	0.9
80	3	190	80	2.1
100	4	280	110	5.2
150	6	380	140	13.0
200	8	485	170	34.0
250	10	616	200	54.0
300	12	748	260	94.0
350	14	649	260	100.0
400	16	717	290	135.0
450	18	827	320	200.0
500	20	928	380	278.0

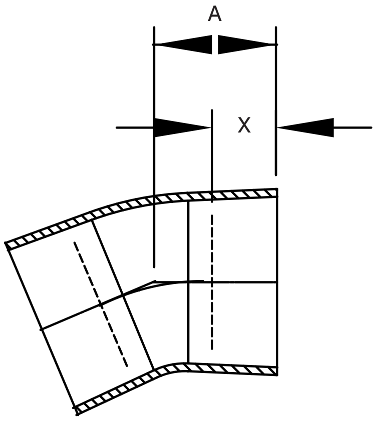
45° Elbows



Nominal Pipe Size		A	X	Wgt.
mm	in	mm	mm	kg
50	2	125	80	0.8
80	3	141	80	1.7
100	4	198	110	4.0
150	6	246	140	10.8
200	8	307	170	23.0
250	10	394	200	45.0
300	12	481	260	73.0
350	14	410	260	86.0
400	16	457	290	121.0
450	18	559	320	182.0
500	20	630	380	258.0

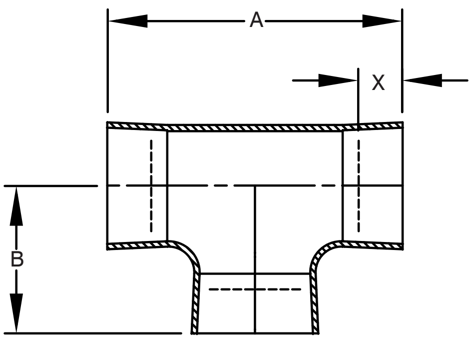
40 Bar Fittings

22½° Elbows



Nominal Pipe Size		A	X	Wgt.
mm	in	mm	mm	kg
50	2	109	80	0.7
80	3	117	80	1.5
100	4	168	110	3.5
150	6	200	140	9.2
200	8	246	170	16.1
250	10	293	200	30.0
300	12	362	260	54.0
350	14	356	260	64.0
400	16	400	290	87.0
450	18	461	320	126.0
500	20	521	380	181.0

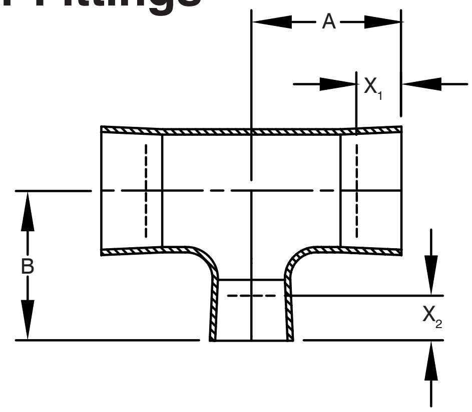
Tees



Nominal Pipe Size				X	Wgt.
mm	in	mm	mm	mm	kg
50	2	308	154	80	2.0
80	3	352	176	80	3.6
100	4	480	240	110	9.8
150	6	586	293	140	21.0
200	8	716	358	170	49.0
250	10	902	451	200	78.0
300	12	1098	549	260	136.0
350	14	1114	557	260	164.0
400	16	1220	610	290	219.0
450	18	1388	694	320	388.0
500	20	1550	775	380	623.0

40 Bar Fittings

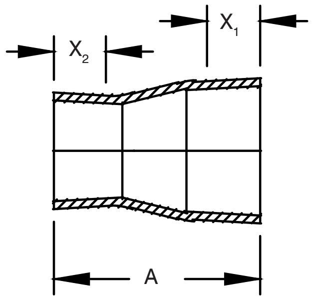
Reducing Tees



Nominal Pipe Size		A	X_1	B	X_2	Wgt.
mm	in	mm	mm	mm	mm	kg
80X80X50	3X3X2	176	80	166	80	3.5
100X100X50	4X4X2	240	110	179	80	8.5
100X100X80	4X4X3	240	110	188	80	8.7
150X150X50	6X6X2	293	140	204	80	18.3
150X150X80	6X6X3	293	140	214	80	19.1
150X150X100	6X6X4	293	140	265	110	21.0
200X200X80	8X8X3	358	170	239	80	39.0
200X200X100	8X8X4	358	170	297	110	41.0
200X200X150	8X8X6	358	170	318	140	44.0
250X250X100	10X10X4	451	200	319	110	62.0
250X250X150	10X10X6	451	200	344	140	66.0
250X250X200	10X10X8	451	200	383	170	70.0
300X300X100	12X12X4	549	260	341	110	107.0
300X300X150	12X12X6	549	260	369	140	111.0
300X300X200	12X12X8	549	260	409	170	116.0
300X300X250	12X12X10	549	260	476	200	125.0
350X350X150	14X14X6	557	260	394	140	134.0
350X350X200	14X14X8	557	260	434	170	140.0
350X350X250	14X14X10	557	260	502	200	150.0
350X350X300	14X14X12	557	260	574	260	163.0
400X400X150	16X16X6	610	290	414	140	176.0
400X400X200	16X16X8	610	290	453	170	182.0
400X400X250	16X16X10	610	290	518	200	193.0
400X400X300	16X16X12	610	290	590	260	206.0
400X400X350	16X16X14	610	290	600	260	137.0
450X450X200	18X18X8	694	320	486	170	317.0
450X450X250	18X18X10	694	320	554	200	3330.0
450X450X300	18X18X12	694	320	614	260	350.0
450X450X350	18X18X14	694	320	615	260	356.0
450X450X400	18X18X16	694	320	645	290	370.0
500X500X250	20X20X10	775	380	580	200	521.0
500X500X300	20X20X12	775	380	640	260	543.0
500X500X350	20X20X14	775	380	641	260	551.0
500X500X400	20X20X16	775	380	671	290	570.0
500X500X450	20X20X18	775	380	720	320	593.0

40 Bar Fittings

Concentric Reducers

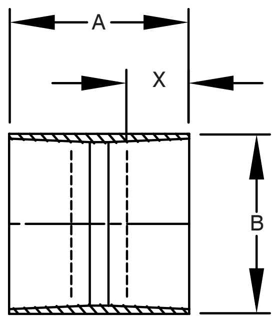


Nominal Pipe Size		A	X_1	X_2	Wgt.
mm	in	mm	mm	mm	kg
80X50	3X2	234	80	80	1.4
100X50	4X2	301	110	80	4.2
100X80	4X3	299	110	80	4.3
150X80	6X3	337	140	80	4.4
150X100	6X4	389	140	110	5.0
200X100	8X4	458	170	110	14.2
200X150	8X6	439	170	140	16.5
250X150	10X6	513	200	140	23.0
250X200	10X8	530	200	170	26.0
300X200	12X8	635	260	170	50.0
300X250	12X10	677	260	200	57.0
350X250	14X10	724	260	200	67.0
350X300	14X12	778	260	260	79.0
400X300	16X12	795	290	260	95.0
400X350	16X14	783	290	260	64.0
450X400	18X16	798	320	290	116.0
500X400	20X16	969	380	290	187.0
500X450	20X18	911	380	320	194.0
500X400	20X16	879	290	290	164.0
500X450	20X18	821	290	320	171.0

Note: Eccentric Reducers are available on request

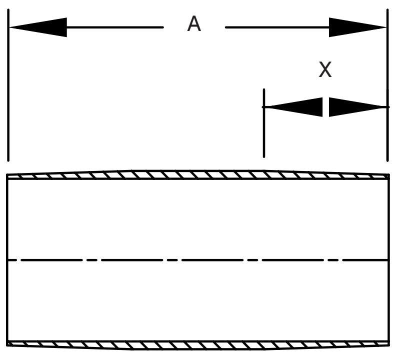
40 Bar Fittings

Couplings



Nominal Pipe Size		A	X	B	Wgt.
mm	in	mm	mm	mm	kg
50	2	230	80	70	0.5
80	3	230	80	100	0.9
100	4	290	110	124	1.3
150	6	350	140	188	3.7
200	8	410	170	238	5.3
250	10	470	200	296	7.9
300	12	590	260	350	12.0
350	14	590	260	390	18.5
400	16	650	290	445	26.0
450	18	710	320	480	24.0
500	20	830	380	544	40.0

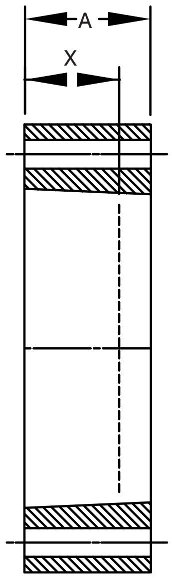
Nipples



Nominal Pipe Size		A	X	Wgt.
mm	in	mm	mm	kg
50	2	185	80	0.1
80	3	185	80	0.2
100	4	245	110	0.5
150	6	305	140	1.3
200	8	370	170	2.5
250	10	430	200	4.8
300	12	560	260	8.8
350	14	560	260	10.3
400	16	620	290	14.6
450	18	700	320	21.0
500	20	820	380	26.0

40 Bar Fittings

Heavy-Duty Flanges



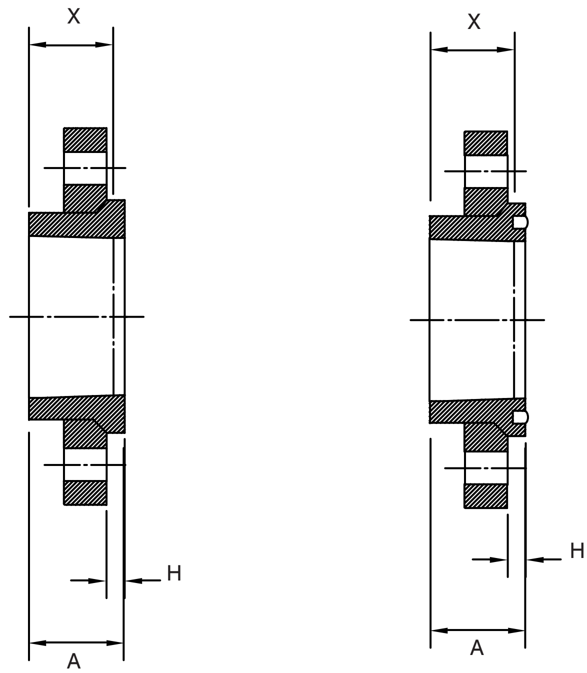
Nominal Pipe Size		A	X(1)	Wgt.(2)
mm	in	mm	mm	kg
50	2	55	**50**	1.7
80	3	85	80	4.0
100	4	115	110	7.9
150	6	145	140	14.1

Notes:
(1) Underlined insertion depth for subsequent flanges deviates from other fittings.
(2)The weights shown are for ANSI B16.5 Class 400 drilled flanges. Weights for other drilling classes may be different. For more detailed information reference is made to the appropriate product data.

*Heavy Duty Flanges are standard available in drillings according to ANSI and ISO (DIN).
**Compressed fibre gaskets, 3 mm thick, compatible with the pressure, temperature and medium, may be used. The mechanical properties should be in accordance with DIN 3754 (IT 400) or equal.

40 Bar Fittings

Stub-end Flanges (Van Stones)



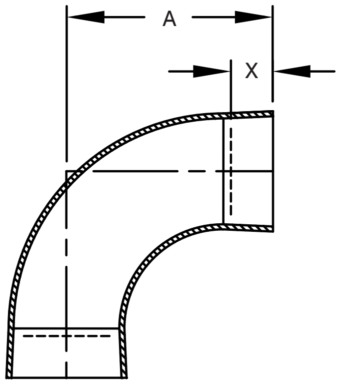
Nominal Pipe Size		A	X	H	Wgt. Stub Ring	Wgt. Steel Ring(1)
mm	in	mm	mm	mm	kg	kg
50	2	95	80	14	0.3	2.5
80	3	95	80	16	0.7	4.8
100	4	125	110	19	1.3	7.0
150	6	155	140	27	2.7	12.2
200	8	185	170	35	4.5	18.3
250	10	215	200	40	5.9	26.0
300	12	275	260	46	8.5	39.0
350	14	275	260	49	8.1	56.0
400	16	310	290	58	12.7	70.0
450	18	340	320	62	24	85.0
500	20	400	380	70	28	107.0

Notes:
(1)The weight shown is for ANSI B16.5 Class 400 drilled flanges. Weights for other drilling classes may be different. For more detailed information reference is made to the appropriate product data.

*Stub-End Flange Rings are standard available in drillings according to ANSI and ISO (DIN).
**Stub-End Flanges are available with and without O-ring groove in the face.
Suitable O-ring seals should be used, available on request.
***Make sure that the O-ring grooved stub-end is compatible with its counter flange, e.g. use a stub-end without groove or another flat surface flange as counter flange.
****Maximum bolt-torque for use with O-rings seals may be calculated based on pressure, size and number of bolts.

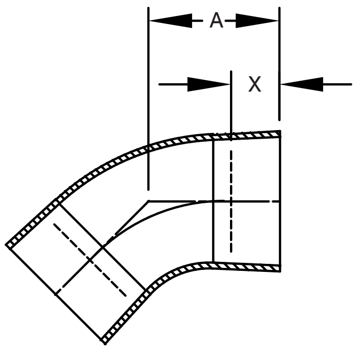
50 Bar Fittings

90° Elbow



Nominal Pipe Size		A	X	Wgt.
mm	in	mm	mm	kg
50	2	167	80	1.1
80	3	235	110	3.4
100	4	330	140	7.0
150	6	420	170	22.0
200	8	540	200	48.0
250	10	676	260	77.0
300	12	753	290	122.0

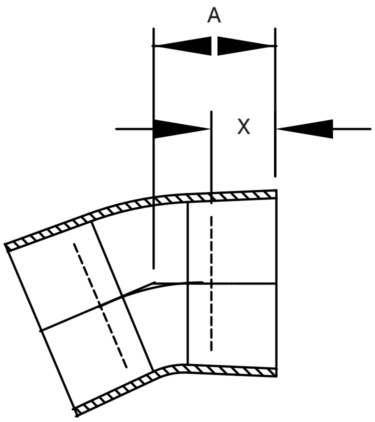
45° Elbows



Nominal Pipe Size		A	X	Wgt.
mm	in	mm	mm	kg
50	2	125	80	1.0
80	3	186	110	2.9
100	4	248	140	6.3
150	6	286	170	16.7
200	8	362	200	35.0
250	10	454	260	70.0
300	12	486	290	97.0

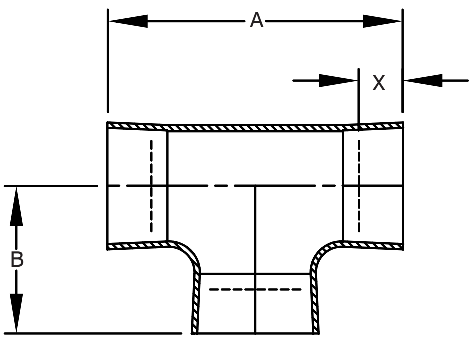
50 Bar Fittings

22½° Elbows



Nominal Pipe Size		A	X	Wgt.
mm	in	mm	mm	mm
50	2	109	80	0.8
80	3	162	110	2.5
100	4	218	140	5.5
150	6	240	170	14.1
200	8	301	200	24.0
250	10	353	260	48.0
300	12	367	290	74.0

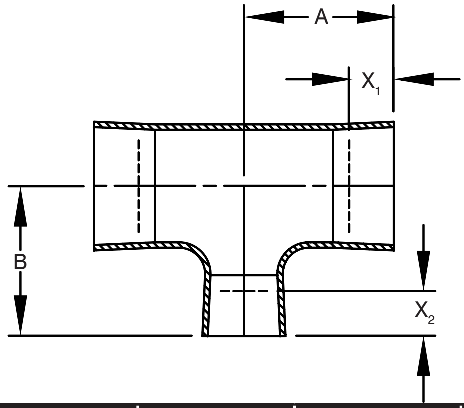
Tees



Nominal Pipe Size		A	B	X	Wgt.
mm	in	mm	mm	mm	kg
50	2	308	154	80	2.3
80	3	442	221	110	7.3
100	4	580	290	140	16.4
150	6	666	333	170	28.0
200	8	826	413	200	58.0
250	10	1022	511	260	114.0
300	12	1108	554	290	174.0

50 Bar Fittings

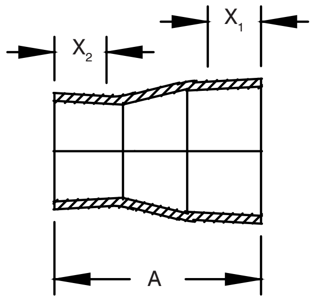
Reducing Tees



Nominal Pipe Size		A	X_1	B	X_2	Wgt.
mm	in	mm	mm	mm	mm	kg
80x80x50	3x3x2	221	110	166	80	6.2
100x100x50	4x4x2	290	140	179	80	12.6
100x100x80	4x4x3	290	140	233	110	13.3
150x150x50	6x6x2	333	170	204	80	21.0
150x150x80	6x6x3	333	170	259	110	23.0
150x150x100	6x6x4	333	170	315	140	25.0
200x200x80	8x8x3	413	200	284	110	46.0
200x200x100	8x8x4	413	200	347	140	49.0
200x200x150	8x8x6	413	200	358	170	52.0
250x250x100	10x10x4	511	260	369	140	92.0
250x250x150	10x10x6	511	260	384	170	96.0
250x250x200	10x10x8	511	260	438	200	103.0
300x300x100	12x12x4	554	290	391	140	138.0
300x300x150	12x12x6	554	290	409	170	144.0
300x300x200	12x12x8	554	290	464	200	153.0
300x300x250	12x12x10	554	290	536	260	165.0

50 Bar Fittings

Concentric Reducers

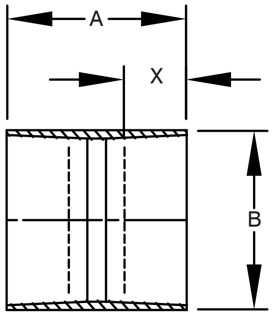


Nominal Pipe Size		A	X_1	X_2	Wgt
mm	in	mm	mm	mm	mm
80x50	3x2	279	110	80	2.0
100x50	4x2	351	140	80	6.2
100x80	4x3	394	140	110	6.9
150x80	6x3	422	170	110	6.8
150x100	6x4	479	170	140	8.0
200x100	8x4	563	200	140	21.0
200x150	8x6	534	200	170	25.0
250x150	10x6	613	260	170	35.0
250x200	10x8	645	260	200	41.0
300x200	12x8	695	290	200	70.0
300x250	12x10	742	290	260	82.0

Note: Eccentric Reducers are available on request.

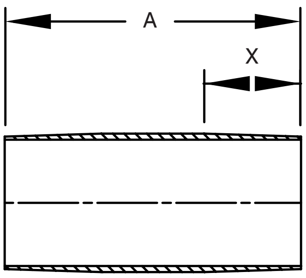
50 Bar Fittings

Couplings



Nominal Pipe Size		A	X	B	Wgt.
mm	in	mm	mm	mm	kg
50	2	230	80	70	0.5
80	3	290	110	100	1.0
100	4	350	140	128	1.8
150	6	410	170	188	3.9
200	8	470	200	242	6.4
250	10	590	260	302	11.1
300	12	650	290	380	31.0

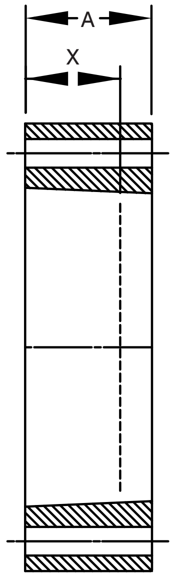
Nipples



Nominal Pipe Size		A	X	Wgt.
mm	in	mm	mm	kg
50	2	25	80	0.1
80	3	25	110	0.4
100	4	25	140	0.8
150	6	25	170	2.0
200	8	30	200	3.8
250	10	30	260	7.7
300	12	40	290	11.8

50 Bar Fittings

Heavy-Duty Flanges



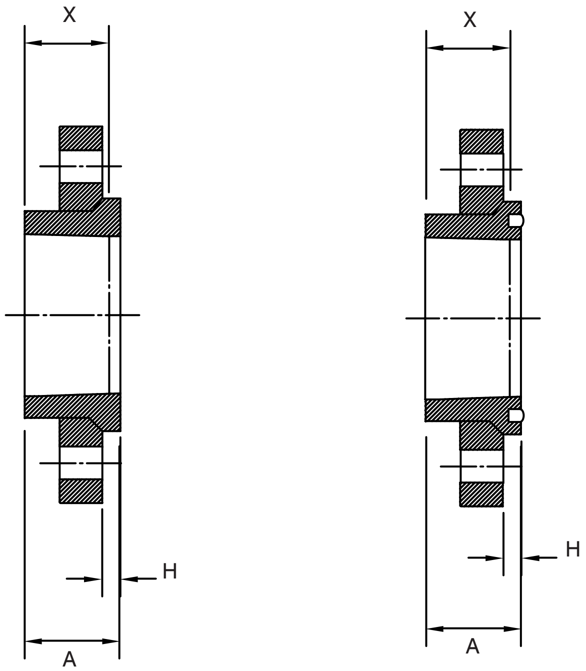
Nominal Pipe Size		A	X	Wgt(1)
mm	in	mm	mm	kg
50	2	85	80	2.6
80	3	115	110	5.4
100	4	145	140	9.8
150	6	175	170	16.5

Notes:
(1)The weights shown are for ANSI B16.5 Class 400 drilled flanges. Weights for other drilling classes may be different. For more detailed information reference is made to the appropriate product data.

*Heavy Duty Flanges are standard available in drillings according to ANSI and ISO (DIN).
**Compressed fibre gaskets, 3 mm thick, compatible with the pressure, temperature and medium, may be used. The mechanical properties should be in accordance with DIN 3754 (IT 400) or equal.
***For maximum bolt torque refer to the appropriate Bondstrand literature. Please be aware that excessive torque may result in flange failure and, therefore a torque-wrench is required.

50 Bar Fittings

Stub-end Flanges
(Van Stone)



Nominal Pipe Size		A	X	H	Wgt. Stub End	Wgt. Steel Ring(1)
mm	in	mm	mm	mm	kg	kg
50	2	95	80	14	0.3	2.8
80	3	125	110	19	0.8	5.3
100	4	155	140	22	1.6	8.4
150	6	185	170	34	3.0	13.3
200	8	215	200	43	4.8	21.0
250	10	275	260	48	6.7	29.0
300	12	305	290	56	8.6	42.0

Notes:
(1)The weight shown is for ANSI B16.5 Class 400 drilled flanges. Weights for other drilling classes may be different. For more detailed information reference is made to the appropriate product data.

*Stub-End Flange Rings are standard available in drillings according to ANSI and ISO (DIN).
**Stub-End Flanges are available with and without O-ring groove in the face.
Suitable O-ring seals should be used, available on request.
***Make sure that the O-ring grooved stub-end is compatible with its counter flange, e.g. use a stub-end without groove or another flat surface flange as counter flange.
****Maximum bolt-torque for use with O-rings seals may be calculated based on pressure, size and number of bolts.

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NOV Fiber Glass Systems

CI2450 - June 2013

Fittings Dimensions in 2" through 16"

(For Bondstrand™ pipe systems 3000, 3200, 3300, 3000A, 3200A and 3300A)

Units: All dimensions are in U.S. Customary units (inches). Diametric dimensions are maximums. Insertion depths (X) are typical. All weights (lbs.) are approximate and assume bell-end configurations.

Tolerances: Tolerance for center line to face dimensions on fittings with flange-end configurations is ±1/2 inch. Tolerance for center line to face dimensions on fittings with bell-end configurations is ±1/2 inch. Tolerance for angular dimensions is ±1°.

Standard end configurations: Bell end is standard configurations. All other end configurations, including size reductions, are made to order.

Taper angle: Taper angle on all bell x spigot end configurations is 1 3/4° for 2 through 6 inch nominal and 2° for sizes 8 through 16 inch pipe sizes.

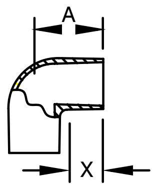
Manufacturing methods: The fiberglass-reinforced epoxy resin fittings shown in this publication are manufactured by the methods as indicated - Filament winding, Compression molding, Centrifugal casting and Contact molding.

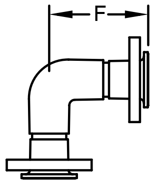
Pressure ratings: See the appropriate Bondstrand Product Data sheet for pressure ratings.

Individual system components may not have the same ratings as the pipe. Refer to the detailed product information for the specific components to determine the pressure rating for the system as a whole.

Flange rings: Bolt hole patterns are drilled in accordance with ANSI B16.5, Cl. 150.

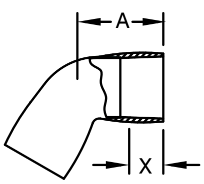
90° Elbows

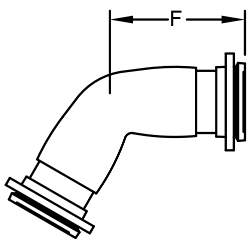




Nominal Pipe Size		Bell A	Flange F	Bell X	BxB Wgt.
in	mm	in	in	in	lbs.
2	50	3.82	7.00	2.1	1.0
3	80	4.42	9.20	2.3	1.5
4	100	5.50	10.40	3.2	3.0
6	150	7.50	13.60	4.0	8.5
8	200	13.00	22.30	4.0	18.0
10	250	15.50	25.50	4.3	24.0
12	300	17.80	27.30	4.3	40.0
14	350	20.80	30.50	5.8	85.0
16	400	23.00	35.00	6.2	161.0

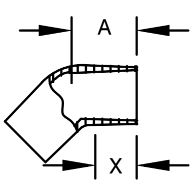
60° Elbows

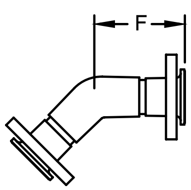




Nominal Pipe Size		Bell A	Flange F	Bell X	BxB Wgt.
in	mm	in	in	in	lbs.
8	200	9.80	18.80	4.0	25.0
10	250	11.00	21.00	4.3	33.0
12	300	12.50	22.00	4.3	50.0
14	350	14.80	24.50	5.8	100.0
16	400	16.30	28.30	6.2	161.0

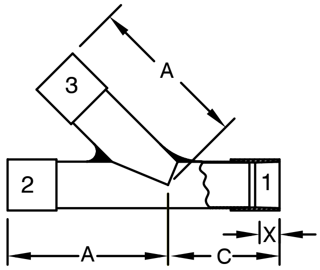
45° Elbows

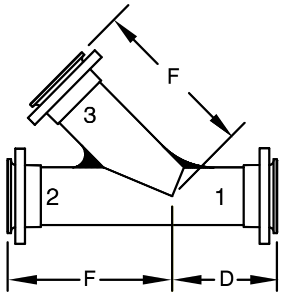




Nominal Pipe Size		Bell A	Flange F	Bell X	BxB Wgt.
in	mm	in	in	in	lbs.
2	50	3.18	6.40	2.1	0.9
3	80	3.43	8.10	2.3	1.5
4	100	4.23	9.10	3.2	2.5
6	150	5.56	11.50	4.0	7.0
8	200	8.30	17.50	4.0	15.0
10	250	9.30	19.30	4.3	28.0
12	300	10.50	20.00	4.3	36.0
14	350	12.50	22.30	5.8	50.0
16	400	13.80	25.80	6.2	106.0

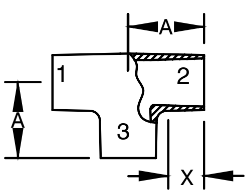
45° Laterals

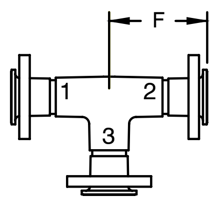




Nominal Pipe Size		Bell	Bell	Flange	Flange	Bell	BxB Wgt.
		A	C	D	F	X	
in	mm	in	in	in	in	in	lbs.
2	50	12.31	9.81	7.62	10.12	1.8	1.7
3	80	14.16	10.66	8.26	11.76	2.1	3.5
4	100	16.44	11.94	9.48	13.98	2.4	5.4
6	150	22.95	15.95	12.27	19.27	2.7	15.8
8	200	26.00	16.00	13.00	20.50	4.0	80.0
10	250	30.00	16.00	14.00	24.50	4.3	110.0
12	300	32.50	18.50	16.00	26.00	4.3	134.0
14	350	37.50	19.50	16.50	30.00	5.8	204.0
16	400	40.50	22.50	16.50	32.50	6.2	254.0

Tees*

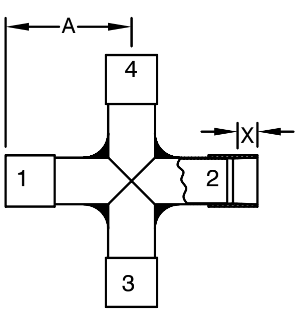


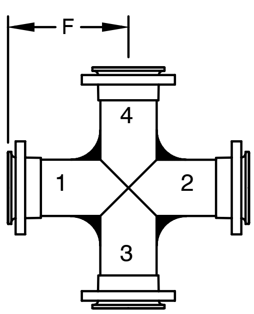


Nominal Pipe Size		Bell	Flange	Bell	BxB Wgt.
		A	F	X	
in	mm	in	in	in	lbs.
2	50	3.82	7.00	1.8	1.3
3	80	4.50	9.13	2.0	2.5
4	100	5.50	10.38	2.5	4.0
6	150	7.50	13.62	3.6	12.0
8	200	11.75	21.05	4.0	29.5
10	250	13.06	23.06	4.3	40.5
12	300	15.50	25.00	4.3	55.0
14	350	19.00	28.70	5.8	116.5
16	400	20.25	32.25	6.2	157.0

The length of the reducing branch is equal to the length of the branch of the run diameter with the appropriate end configuration. Specify end configuration in the sequence: run(1), run(2), branch(3).

Crosses

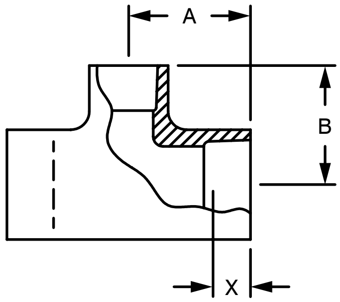




Nominal Pipe Size		Bell	Flange	Bell	BxB Wgt.
		A	F	X	
in	mm	in	in	in	lbs.
2	50	10.81	8.62	1.8	2.1
3	80	11.91	9.51	2.1	4.4
4	100	13.44	10.98	2.4	6.8
6	150	17.95	14.27	2.7	19.8
8	200	13.00	22.30	4.0	89.0
10	250	15.50	25.50	4.3	122.0
12	300	17.80	27.30	4.3	149.0
14	350	20.80	30.50	5.8	226.0
16	400	23.00	35.00	6.2	282.0

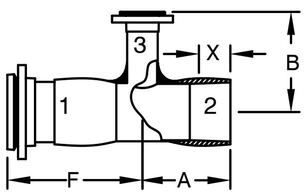
The length of the reducing branch is equal to the length of the branch of the run diameter with the appropriate end configuration. Specify end configuration in the sequence: run(1), run(2), branch(3), branch(4).

FW Reducing Tee



Run Nominal Pipe Size		"B" Branch Lenght for Bell				Bell	Bell
		8	10	12	14	A	X
in	mm	in	in	in	in	in	in
10	250	12.81	--	--	--	13.06	4.3
12	300	13.79	14.05	--	--	15.50	4.3
14	350	--	14.90	16.35	--	19.00	5.8
16	400	--	--	17.36	20.01	20.25	6.2

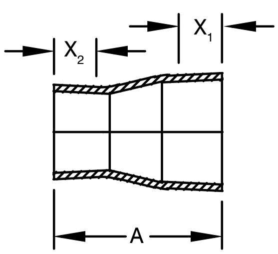
Reducing Tees*

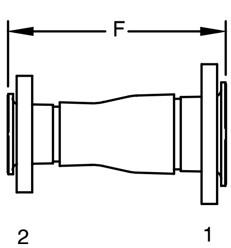


Run Nominal Pipe Size		"B" Branch length for bell or Flange								Bell	Flange	Bell
		2	3	4	6	8	10	12	14	A	F	X
in	mm	in	in	in	in	in	in	in	in	in	in	in
8	200	13.0	13.5	14.8	18.8	--	--	--	--	13.0	22.3	4.0
10	250	14.3	14.8	16.0	20.0	21.5	--	--	--	15.5	25.5	4.3
12	300	15.3	15.8	17.0	21.0	22.5	25.5	--	--	17.8	27.3	4.3
14	350	16.0	16.5	17.8	21.8	23.3	26.3	28.3	--	20.8	30.5	5.8
16	400	17.0	17.5	18.8	22.8	24.3	27.3	29.3	31.3	23.0	35.0	6.2

*Specify end configurations (bell or flanges) in sequence: run(1), run(2), branch(3).

FW Concentric Reducers*

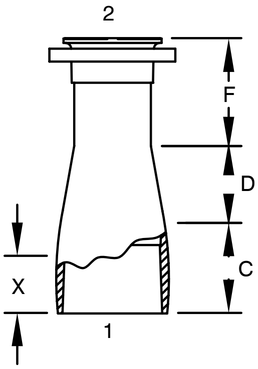




Nominal Pipe Size		Bell	Flange	Bell	Bell	BxB Wgt.
		A	F	X_1	X_2	
in	mm	in	in	in	in	lbs.
3x2	80x50	7.05	13.65	2.4	2.2	1.5
4x3	100x80	7.35	14.05	2.8	2.4	2.6
6x4	150x100	9.80	17.60	3.0	2.8	4.9
8x6	200x150	14.18	29.34	4.0	2.7	--
10x8	250x200	15.62	34.92	4.3	4.0	--
12x10	300x250	17.25	36.75	4.3	4.3	--
14x12	350x300	21.06	40.26	5.8	4.3	--
16x14	400x350	24.88	46.58	6.2	5.8	--

*Specify end configurations (bell or flange) in the sequence: major diameter(1), minor diameter(2).

FW Concentric Reducers



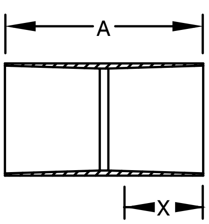
Nominal Pipe Size		Bell	Flange	Bell
		C	F	X
in	mm	in	in	in
2	50	4.30	12.50	1.80
3	80	5.00	12.50	2.13
4	100	5.80	14.50	2.44
6	150	8.00	14.50	2.69
8	200	9.00	14.50	4.0
10	250	9.00	15.50	4.3
12	300	9.60	15.50	4.3
14	350	10.50	17.00	5.8
16	400	11.30	19.50	6.2

NOTE: The overall length is determined by adding the two end configurations and the cone length "D".

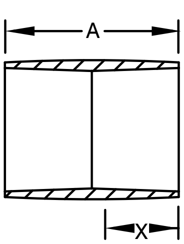
Cone length "D"										
Major Nominal Pipe Size		Minor Nominal Pipe Size								
		2	3	4	6	8	10	12	14	Wgt.
in	mm	in	in	in	in	in	in	in	in	lbs.
8	200	17.60	14.00	11.20	5.30	--	--	--	--	30
10	250	23.20	20.50	17.20	11.30	6.00	--	--	--	44
12	300	28.50	25.40	23.60	16.60	11.30	5.20	--	--	65
14	350	33.40	30.20	27.40	21.50	16.20	11.00	4.80	--	86
16	400	39.10	36.00	33.10	27.20	21.80	15.90	10.60	5.70	110

SLEEVE Couplings

2"-6"

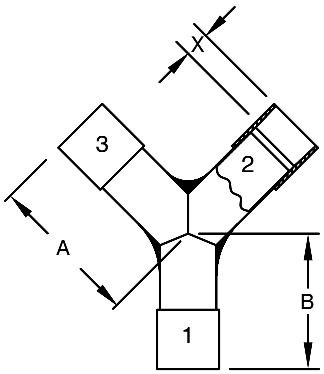


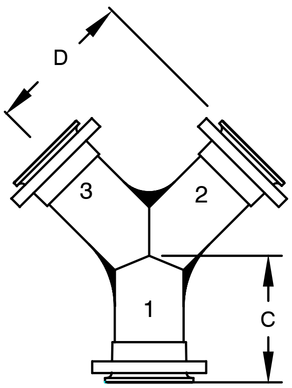
8"-16"



Nominal Pipe Size		Bell	Bell	Wgt.
		A	X	
in	mm	in	in	lbs.
2	50	4.87	2.1	0.7
3	80	5.12	2.2	1.3
4	100	5.50	2.4	1.9
6	150	7.00	3.1	4.1
8	200	12.00	4.0	12.0
10	250	12.00	4.3	18.0
12	300	13.25	4.3	23.0
14	350	15.00	5.8	28.0
16	400	16.50	6.2	37.0

True Wyes

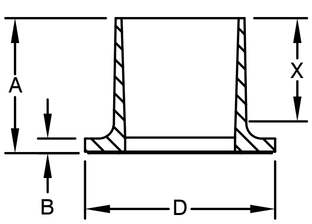




Nominal Pipe Size		Bell A	Bell B	Flange C	Flange D	Bell X	Wgt.
in	mm	in	in	in	in	in	lbs.
2	50	10.81	9.81	7.62	8.62	2.1	1.7
3	80	11.91	10.66	8.26	9.51	2.2	3.5
4	100	13.44	11.94	9.48	10.98	2.4	5.4
6	150	17.95	15.95	12.27	14.27	3.1	15.8
8	200	22.00	22.00	16.00	16.00	4.0	98.0
10	250	26.50	26.00	20.00	20.00	4.3	122.0
12	300	30.50	30.50	24.00	24.00	4.3	157.0
14	350	35.50	35.50	28.00	28.00	5.8	238.0
16	400	40.00	40.00	32.00	32.00	6.2	297.0

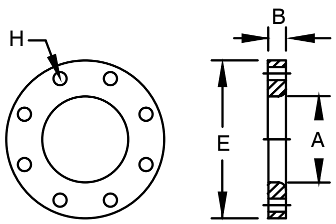
Specify end configuration in the sequence: run(1), branch(2), branch(3).

Stub Ends



Nominal Pipe Size		Pressure Rating	A	B	D	X	Wgt.
in	mm	psi	in	in	in	in	lbs.
2	50	250	2.75	0.27	3.91	2.1	0.5
3	80	200	2.88	0.28	5.16	2.4	0.7
4	100	150	2.88	0.28	6.66	2.4	1.0
6	150	150	3.88	0.39	8.53	3.3	2.4
8	200	300	4.00	0.80	10.90	3.8	6.5
10	250	300	5.00	1.30	13.00	4.8	9.0
12	300	300	5.00	1.50	15.60	4.8	13.0
14	350	200	6.00	1.60	17.40	5.8	19.0
16	400	200	6.00	1.60	19.80	5.8	26.0

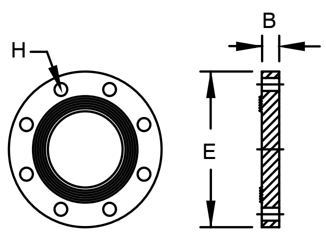
Flange Rings



Nominal Pipe Size		A	B	E	Bolt Hole Size	Wgt.
in	mm	in	in	in	in	lbs.
2	50	2.78	0.82	6.00	3/4 - 4 holes	1.1
3	80	3.90	1.10	7.50	3/4 - 4 holes	2.1
4	100	4.90	1.10	9.00	3/4 - 8 holes	2.9
6	150	7.26	1.25	11.00	7/8 - 8 holes	3.8
8	200	10.00	1.30	13.50	7/8 - 8 holes	5.0
10	250	12.20	1.30	16.00	1 - 12 holes	7.0
12	300	14.30	1.50	19.00	1 - 12 holes	12.0
14	350	16.30	1.60	21.00	1 1/8 12 holes	14.5
16	400	18.60	1.90	23.50	1 1/8-16 holes	19.0

3000A/3200A Blind Flanges

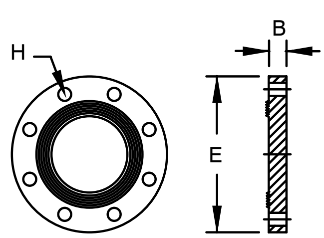
ANSI B16.5, 150 Bolt Hole configuration



Nominal Pipe Size		B	E	H	Bolt-Holes	Wgt.
in	mm	in	in	in	#	lbs.
2	50	0.75	6.00	0.75	4	0.9
3	80	1.00	7.50	0.75	4	1.9
4	100	1.00	9.00	0.75	8	2.7
6	150	1.13	11.00	0.88	8	4.7
8	200	1.80	13.50	0.90	8	11.5
10	250	2.00	16.00	1.00	12	15.9
12	300	2.40	19.00	1.00	12	25.1
14	350	2.60	21.00	1.10	12	36.2
16	400	2.80	23.50	1.10	16	49.8

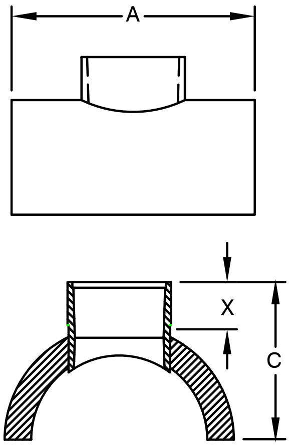
3300A Blind Flanges

ANSI B16.5, 150 Blot Hole configuration



Nominal Pipe Size		B	E	H	Bolt-Holes	Wgt.
in	mm	in	in	in	#	lbs.
2	50	0.75	6.00	0.75	4	0.9
3	80	1.00	7.50	0.75	4	1.9
4	100	1.00	9.00	0.75	8	2.7
6	150	1.13	11.00	0.88	8	4.7
8	200	2.00	13.50	0.90	8	17.7
10	250	2.40	16.00	1.00	12	29.5
12	300	2.70	19.00	1.00	12	47.2
14	350	3.00	21.00	1.10	12	64.4
16	400	3.10	23.50	1.10	16	85.5

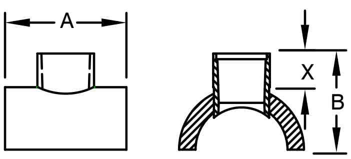
3000A Saddles



Minor Nominal Pipe Size		Bell	Major NPS Dimension C					Bell
		A	8	10	12	14	16	X
in	mm	in	in	in	in	in	in	in
2	50	10.00	7.80	8.90	9.90	10.80	11.80	1.80
3	80	11.00	8.40	9.50	10.50	11.40	12.40	2.13
4	100	12.00	8.40	9.50	10.50	11.40	12.40	2.44
6	150	14.00	8.80	9.90	10.90	11.80	12.80	2.69
8	200	16.00	--	10.90	11.90	12.80	13.80	5.0
10	250	20.00	--	--	11.90	12.80	13.80	5.0
12	300	24.00	--	--	--	--	14.20	5.5

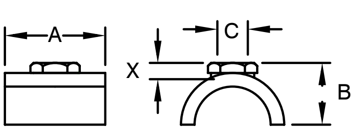
Saddles are available in the sizes shown above. The standard branch end configuration is bell. The taper angle on 2”-6” NPS bells is 1.75° and 2° for 8”-12”

Bonded Branch Saddles



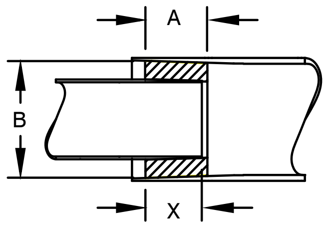
Nominal Pipe Size		A	B	X	Wgt.
in	mm	in	in	in	lbs.
3x2	80x50	6.00	4.00	1.80	1.2
4x2	100x50	6.00	4.50	1.80	1.4
4x3	100x80	6.00	5.25	2.13	1.4
6x2	150x50	7.75	5.56	1.80	3.0
6x3	150x80	7.75	6.31	2.13	3.0
6x4	150x100	7.75	7.63	2.44	3.0

Threaded Branch Saddles



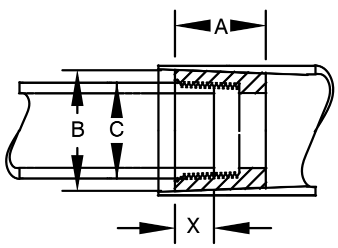
Nominal Pipe Size		A	B	C	X	Wgt.
in	mm	in	in	in	in	lbs.
2x1/2	50x12	4.00	2.00	1/2 x 14	0.50	1.0
3x1/2	80x12	4.00	2.62	1/2 x 14	0.50	1.6
4x1/2	100x12	4.00	3.12	1/2 x 14	0.50	2.0
6x1/2	150x12	4.00	4.18	1/2 x 14	0.50	2.4

Bonded Reducer Bushings



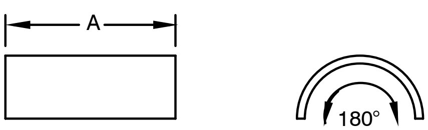
Nominal Pipe Size		A	B	X	Wgt.
in	mm	in	in	in	lbs.
3x2	80x50	1.88	3.51	1.75	0.7
4x3	100x80	1.96	4.51	1.75	0.9
6x4	150x100	2.86	6.65	2.20	4.1

Threaded Reducer Bushings



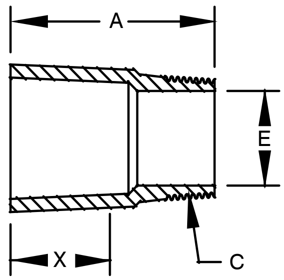
Nominal Pipe Size		A	B	C	X	Wgt.
in	mm	in	in	in	in	lbs.
2x1/2	50x12	1.80	2.40	1/2 x 14	0.50	0.9
2x3/4	50x19	1.80	2.40	3/4 x 14	0.50	0.8
2x1	50x25	1.80	2.40	1 x 11 1/2	0.70	0.8
2x1 1/4	50x32	1.80	2.40	1 1/4 x 11 1/2	0.70	0.6
2x1 1/2	50x40	1.80	2.40	1 1/2 x 11 1/2	0.70	0.3

Wear Saddles



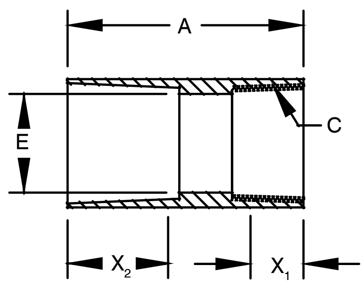
Nominal Pipe Size		A	Wgt.
in	mm	in	lbs.
2	50	6.00	0.12
3	80	6.00	0.17
4	100	6.00	0.25
6	150	6.00	0.48
8	200	6.00	0.78
10	250	6.00	1.13
12	300	6.00	1.53
14	350	6.00	1.88
16	400	6.00	2.35

Adapters: Bell x NPT Male



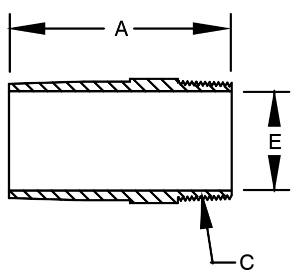
Nominal Pipe Size		A	C	E	X	Wgt.
in	mm	in	in	in	in	lbs.
2	50	4.16	2 x 11 1/2	1.90	2.00	0.4
3	80	5.00	3 x 8	2.80	2.05	0.7
4	100	5.19	4 x 8	3.90	2.05	0.9
6	150	6.00	6 x 8	5.90	3.20	2.1

Adapters: Bell x NPT Female



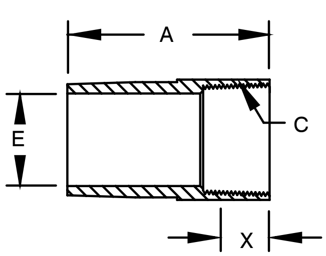
Nominal Pipe Size		A	C	E	X_1	X_2	Wgt.
in	mm	in	in	in	in	in	lbs.
2	50	4.75	2 x 11 1/2	2.00	0.70	1.85	0.4
3	80	5.38	3 x 8	3.00	1.00	2.00	0.7
4	100	5.38	4 x 8	4.00	1.10	2.25	0.9
6	150	6.75	6 x 8	6.00	1.20	3.20	2.1

Adapters: Spigot x NPT Male



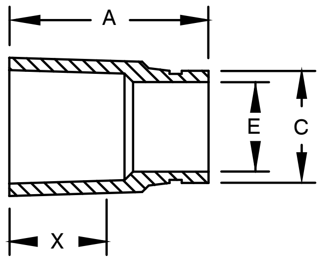
Nominal Pipe Size		A	C	E	Wgt.
in	mm	in	in	in	lbs.
2	50	5.65	2 x 11 1/2	2.00	0.5
3	80	6.90	3 x 8	3.00	1.3
4	100	7.55	4 x 8	4.00	1.7
6	150	10.15	6 x 8	6.00	4.2

Adapters: Spigot x NPT Female



Nominal Pipe Size		A	C	E	X	Wgt.
in	mm	in	in	in	in	lbs.
2	50	5.65	2 x 11 1/2	2.00	0.70	0.5
3	80	6.90	3 x 8	3.00	1.00	1.3
4	100	7.55	4 x 8	4.00	1.20	1.7
6	150	10.15	6 x 8	6.00	1.00	4.2

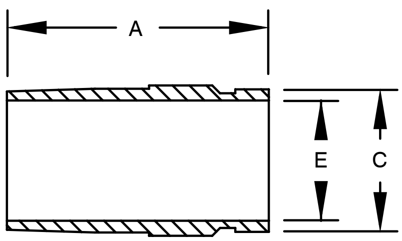
Adapters: Bell x Grooved End*



Nominal Pipe Size		A	C	E	X	Wgt.
in	mm	in	in	in	in	lbs.
2	50	4.16	2.38	1.90	2.00	0.5
3	80	5.00	3.50	2.80	2.05	1.1
4	100	5.20	4.50	3.90	2.05	1.3
6	150	6.00	6.63	5.90	3.20	3.2
8	200	6.63	8.63	7.64	5.00	7.5
10	250	8.00	10.75	10.0	5.00	9.6
12	300	8.75	12.75	12.0	5.50	12.5

*Compatible with Victaulic coupling style 77 Standard or HP-70ES.

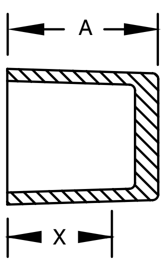
Adapters: Spigot x Grooved End*



Nominal Pipe Size		A	C	E	Wgt.
in	mm	in	in	in	lbs.
2	50	4.38	2.38	2.00	0.5
3	80	5.50	3.50	3.00	1.3
4	100	6.00	4.50	4.00	1.7
6	150	8.00	6.63	6.00	4.2
8	200	6.75	8.63	8.00	3.7
10	250	6.75	10.75	10.00	5.6
12	300	8.25	12.75	12.00	7.6

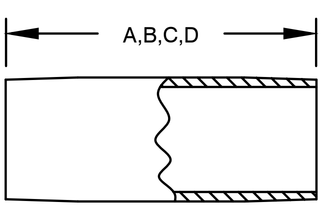
*Compatible with Victaulic coupling style 77 Standard or HP-70ES.

End Caps



Nominal Pipe Size		A	X	Wgt.
in	mm	in	in	lbs.
2	50	3.25	2.00	0.6
3	80	3.38	2.25	1.0
4	100	3.38	2.25	1.4
6	150	4.63	3.30	4.5

Nipples



Nominal Pipe Size		A	B	C	D	Wgt.
in	mm	in	in	in	in	lbs/ft
2	50	6.00	8.00	10.00	12.00	0.5
3	80	--	8.00	10.00	12.00	0.7
4	100	--	--	10.00	12.00	1.0
6	150	--	--	--	12.00	2.1

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NOV Fiber Glass Systems

CI3050ENG - September 2015

Secondary Containment Pipe and Two-Piece Fittings

(Red Thread™, Green Thread™, Z-Core™, Centricast Plus™ RB-2530 or CL-2030 and Centricast™ RB-1520 or CL-1520)

CHEMICAL & INDUSTRIAL

Product

NOV Fiber Glass Systems offers secondary containment piping systems with two-piece fittings that meet EPA requirements and help protect the environment by containing possible fluid leaks in case of damage to the system. Both vinyl ester and epoxy resin systems are available to match your application.

Secondary containment piping systems are available in 3”-16” sizes. The primary and secondary containment piping is manufactured by either filament winding or the centrifugal casting process. Refer to Brochure CI1000 for more details.

The secondary containment system is designed for use with Red Thread, Green Thread, Z-CORE™, Centricast Plus RB-2530 or CL-2030, and Centricast RB-1520 or CL-1520 primary (product) pipe. Primary piping can be centered in the containment piping by using centralizers and anchors as needed.

The secondary containment piping system consists of the next larger pipe size (as a minimum) and special two-piece fittings. The size of the containment pipe may be dictated by the leak detection method used. Standard fittings are manufactured with epoxy vinyl ester resin. Fittings are manufactured by either the compression molding process, or the contact molding process.

The specific primary, or product, piping should be selected to meet your particular temperature, chemical, and pressure requirements. Depending on size and type of product, the pipe can withstand pressures to 450 psig and temperatures to 275˚ F. Refer to Brochure CI1000 and associated Product Data bulletins for your primary pipe selection. The containment systems can be pressure tested and continuously monitored.

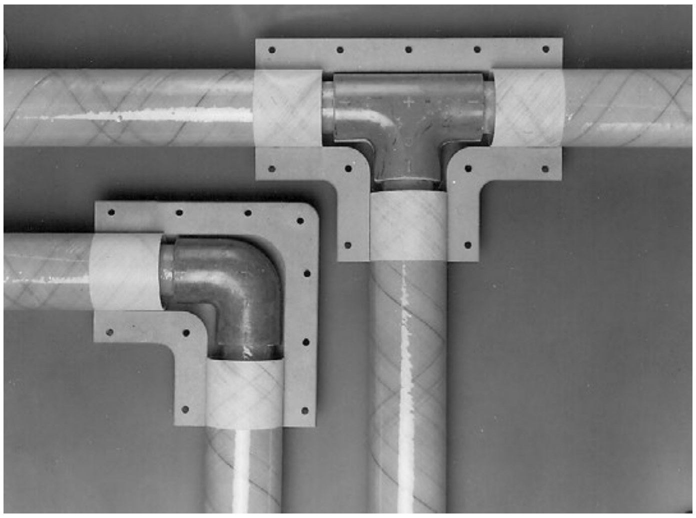
Refer to Matched Taper Joint, Socket Joint, and Clam Shell Installation Manuals..

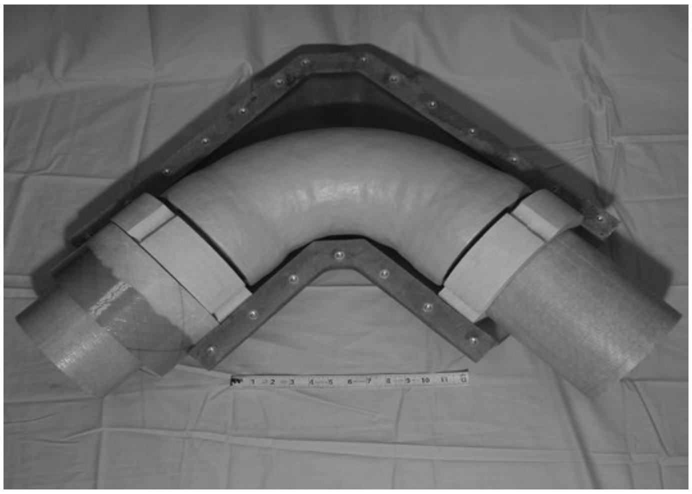
Years of experience have proven that fiberglass pipe from NOV Fiber Glass Systems will outlast pipe made of traditional materials. The service life of fiberglass pipe is far greater than that of pipe made from protected steel, copper, black iron, and even stainless steel.

The advantages of lightweight fiberglass piping are even greater when installing secondary containment systems. Very little equipment is required, and the ease of installation results in material handling and installation cost savings.

Fittings

A complete range of primary fittings is manufactured with the same temperature and pressure capabilities as the pipe. For containment systems, easy to use two-piece fittings constructed of epoxy vinyl ester resin and fiberglass are available.





Standard Secondary Containment Piping Systems

Primary Pipe Size	Minimum Containment Pipe Size for Red Thread & Green Thread Primary Pipe	Minimum Containment Pipe Size for Centricast RB & CL and Z-Core Primary Pipe
in	**mm**	**in**
1	--	3
1½	--	3
2	3[1]	3[1]
3	4[1]	4[1]
4	6[1]	6[1]
6	8	8
8	10	10[2]
10	12	12
12	14	14
14	16	16

[1] When using 2”, 3”, or 4” sweep fittings, use containment pipe and fittings that are two diameter sizes larger than the primary. Contact the factory for recommendations.

[2] When using 8” 90º elbows, 12” containment 90º elbows may be needed. Contact factory for recommendations.

NOTE: When using 3” 90˚ elbows, 6” containment 90˚ elbow may be needed. Contact the factory for recommendations.

NOTE: Primary couplings must be installed inside of secondary containment coupling fittings.

Installation

Refer to installation manuals for instructions.

NOTE: It is highly recommended that assembly training be conducted by a factory representative prior to installation start up.

When connecting containment pipe and fittings, plain ends of the containment pipe are machined or thoroughly sanded to accept the two-piece containment fitting. Containment pipe must be positioned over the primary piping before assembly and bonding of the primary pipe system. The size of the containment fittings may dictate the minimum center line dimensions for the primary piping.

Upon completion of a successful primary pipe test procedure, the two-piece secondary containment fittings may be installed. They are installed using threaded inserts embedded in the fittings and the hex-head bolts supplied by NOV Fiber Glass Systems. A system-matching adhesive must be applied to all bonding surfaces just prior to being joined by the bolts. The secondary containment system must be given time for the adhesive to properly cure before testing the annular space.

The testing of secondary containment piping systems is recommended to ensure the integrity of the pipe, fittings and joints of all types. The introduction of the test fluid during testing should be controlled to prevent sudden pressure surges (Water Hammer). Water Hammer can produce pressures that greatly exceed recommended system test pressure.

WARNING: These procedures must be followed to avoid serious personal injury or property damage. Failure to do so will result in loss of warranty. Buyer, installer or any employee, agent or representative thereof assumes the risk of any damage or injury to person or property.

Testing with air or gas can be extremely dangerous. Review safety precautions before starting the test and follow all testing procedures.

Air Testing

Hydrostatic test should be used instead of air or compressed gas if possible. When air or compressed gas is used for testing, tremendous amounts of energy can be stored in the system. If a failure occurs, the energy may be released catastrophically, which can result in property damage and personal injury. In cases where system contamination or fluid weight prevents the use of hydrostatic test, air test may be used with extreme caution. To reduce the risk of air testing, use the use the table below to determine maximum pressure. When pressurizing the system with air or compressed gas, the area surrounding the piping must be cleared of personnel to prevent injury. Hold air pressure for one hour, then reduce the pressure to one half the original. Personnel can then enter the area to perform soap test of all joints. Again, extreme caution must be exercised during air testing to prevent property damage or personnel injury. If air or compressed gas testing is used, NOV Fiber Glass Systems will not be responsible for any resulting injury to personnel or damage to property, including the piping system. Air or compressed gas testing is done entirely at the discretion and risk of management at the job site.

Maximum Allowable Air Test Pressure

Containment Pipe Size	3"-8"	10"	12"-16"
Pressure, psig	15	10	5

Anchors

Anchors are available to control pipe movement due to thermal expansion/contractions or fluid flow transients. Secondary containment anchors bond directly to the primary pipe and to the inside of the secondary containment fittings to eliminate relative movement between the two piping systems. The secondary piping can be anchored externally by the methods in Manual No. ENG1000 as required.

Custom Design

NOV Fiber Glass Systems can help you in solving secondary containment piping design problems. NOV Fiber Glass Systems also has experience in designing and installing double-wall secondary containment systems 16" diameter and larger. Contact NOV Fiber Glass Systems for additional information.

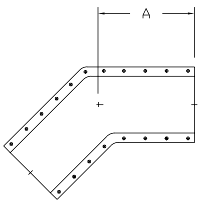
Dimensional Data for Containment Fittings

Containment[2] Size		A		B		C		D[1]		E		F		H		I		W	
in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm
3	80	6	152	7	178	14	356	--	--	11	298	7	178	2	51	7	178	1½	38
4	100	7½	191	8	203	14	356	6	152	13	333	7	181	2	51	8	203	1½	38
6	150	8	203	9	229	16	406	8	279	15	387	8	203	2	51	9	229	1½	38
8	200	11	279	13	330	20	508	12	305	23¼	591	13	330	2½	64	14	356	1½	44
10	250	18	457	21½	546	24	610	15	381	32½	826	19	483	4³⁄₁₆	106	21½	546	1¾	44
12	300	21½	546	26	660	26¼	667	17	432	37½	953	22½	572	4³⁄₁₆	106	26	660	1¾	44
14	350	22½	572	27	686	28	711	29	737	43½	1,105	28½	724	5	127	27	686	1¾	44
16	400	22½	572	29	737	32	813	31½	800	47½	1,207	32	813	5	127	29	737	1¾	44

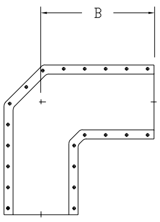
[1] The overall length is based on the largest size.

[2] Sizes 3"-6" are compression molded and 8"-16" are contact molded.

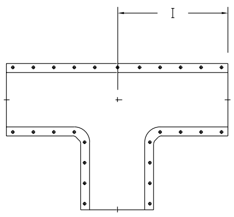
View of Fitting Illustrations



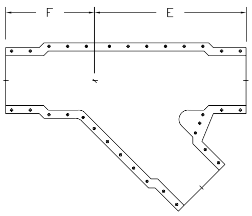
45° Elbow



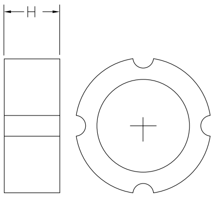
90° Elbow



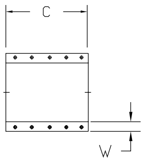
Tee



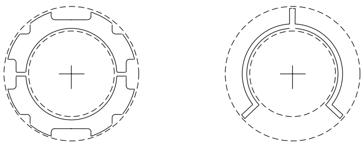
45° Lateral

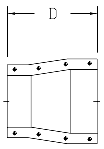


Anchor Assembly

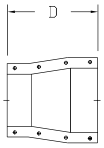


Coupling


Centralizers



Concentric Reducer



Termination Fitting (Vented/Non Vented)

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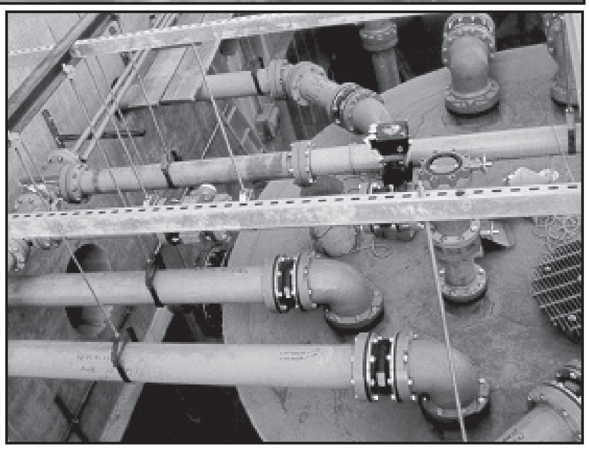
Phone: 210 477 7500
Fax: 210 477 7560

CI1352ENG April 2016

Engineering & Piping Design Guide

Fiberglass Reinforced Piping Systems



www.fgspipe.com

NOV Fiber Glass Systems

INTRODUCTION

NOV Fiber Glass Systems' fiberglass reinforced epoxy and vinyl ester resin piping systems possess excellent corrosion resistance and a combination of mechanical and physical properties that offer many advantages over traditional piping systems. We are recognized worldwide as a leading supplier of piping systems for a wide range of chemical and industrial applications.

This manual is provided as a reference resource for some of the specific properties of our piping systems. It is not intended to be a substitute for sound engineering practices as normally employed by professional design engineers.

NOV Fiber Glass Systems has an international network of distributors and trained field personnel to advise on proper installation techniques. It is recommended they be consulted for assistance when installing the piping system. This not only enhances the integrity of the piping system, but also increases the efficiency and economy of the installation.

Additional information regarding installation techniques is provided in the following installation manuals:

Manual No. F6000	*Pipe Installation Handbook for Tapered Bell & Spigot Joints*
Manual No. F6080	*Pipe Installation Handbook for Straight Socket Joints and Butt & Wrap Joints*
Manual No. F6300	*Pipe Installation Handbook for Marine-Offshore Piping*

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SAFETY

This safety alert symbol indicates an important safety message. When you see this symbol, be alert to the possibility of personal injury.

PIPING SYSTEMS

Epoxy Resin Systems:

- Z-Core® (High Performance Resin)
- Centricast Plus® RB-2530
  - Centricast ® RB-1520
- Green Thread®
- Marine-Offshore
  - Green Thread 175
  - Green Thread 175 Conductive
  - Green Thread 250
  - Green Thread 250 Conductive
  - Green Thread 250 Fire Resistant
- Red Thread® II
  - Red Thread II JP
- Silver Streak® (FGD Piping)
- Ceram Core® (Ceramic-lined Piping)
- F-Chem® (Custom Piping)
- HIGH PRESSURE Line Pipe and Downhole Tubing*

Vinyl Ester Systems:

- Centricast Plus CL-2030
  - Centricast CL-1520
- F-Chem (Custom Piping)

* Available from NOV Fiber Glass Systems,
San Antonio, Texas
Phone: (210) 434-5043 · FAX: (210) 434-7543
Web site: http://www.fgspipe.com

NOV Fiber Glass Systems has developed a computer program specifically for our fiberglass products. This software program called *Success By Design* is available on our web site at http://www.fgspipe.com.

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PIPING SYSTEM SELECTION

When selecting a piping system for a particular application, it is important to consider the corrosive characteristics of the media to which the pipe and fittings will be exposed, the normal and potential upset temperatures and pressures of the system, as well as other environmental factors associated with the project. Fiberglass reinforced plastic (FRP) piping systems provide excellent corrosion resistance, combined with high temperature and pressure capabilities, all at a relatively low installed cost. NOV Fiber Glass Systems engineers, using epoxy, vinyl ester, and polyester resins, have developed a comprehensive array of piping systems designed to meet the most demanding application requirements. Piping systems are available with liners of varying type and thickness, with molded, fabricated, or filament wound fittings, ranging in size from 1" to 72"(25 to 1800 mm) in diameter.

TYPICAL APPLICATIONS

Fiberglass piping is used in most industries requiring corrosion resistant pipe. FRP piping is used in vent and liquid applications that operate from -70°F to 300°F (-57°C to 149°C). NOV Fiber Glass Systems piping systems use high grade resins that are resistant to acids, caustics or solvents. Abrasion resistant materials can be used in the piping inner surface liner to enhance wear resistance to slurries. Table 1.0 is a brief list of the many applications and industries where fiberglass piping has been used successfully. See Bulletin No. E5615 for a complete chemical resistance guide.

Our piping systems can be installed in accordance with the ASME B 31.3 piping code. Second party listings from regulatory authorities such as Factory Mutual, NSF, UL/ULC, and marine registrars are in place on several of these piping systems.

TABLE 1.0 Typical Fiberglass Pipe Applications by Industry

Applications	INDUSTRY								
	Chemical Process	Petro Chemical	Marine Offshore	Pharma-ceutical	Food Processing	Power Plants	Pulp and Paper	Waste Water Treatment	Mining and Metal Refining
Aeration								X	
Brine Slurry	X								
Bottom Ash						X			
Chemical Feed	X	X			X	X	X	X	X
Column Piping			X						
Condensate Return	X	X	X	X	X	X	X		
Conduit		X			X	X	X		
Cooling Water	X	X		X	X	X			
Disposal Wells	X	X	X					X	X
DownholeTubing & Casing		X	X					X	
Effluent Drains	X	X	X	X	X	X	X	X	X
Fire Mains		X	X			X	X		X
Flue Gas Desulfurization						X			
Guttering & Downspouts	X				X	X	X		
Oily Water		X	X						X
Scrubber Headers	X	X				X			
Seawater		X	X			X			
Slurry	X					X			
Vents	X	X	X	X	X		X	X	X
Water	X	X	X	X	X	X	X		X
Waste Treatment	X		X	X	X	X	X	X	X
Buried Gasoline		X							

SECTION 1. Flow Properties

The smooth interior surface of fiberglass pipe, combined with inside diameters larger than steel or thermoplastic pipe of the same nominal diameter, yield significant flow advantages. This section provides design techniques for exploiting the flow capacity of fiberglass pipe.

PRELIMINARY PIPE SIZING

The determination of the pipe size required to transport a given amount of fluid is the first step in designing a piping system.

Minimum recommended pipe diameters.

Clear fluids

Eq. 1 $$d := \frac{0.73 \cdot \sqrt{\frac{Q}{Sg}}}{\rho^{0.33}}$$

Corrosive or erosive fluids

Eq. 2 $$d := \frac{1.03 \cdot \sqrt{\frac{Q}{Sg}}}{\rho^{0.33}}$$

Where:

d = Pipe inner diameter, inch

Q = Flow rate, gal/min (gpm)

Sg = Fluid specific gravity, dimensionless

p = Fluid density, lb/ft^3

Recommended maximum fluid velocities

Clear fluids

Eq. 3 $$V := \frac{48}{\rho^{0.33}}$$

Corrosive or erosive fluids

Eq. 4 $$V := \frac{24}{\rho^{0.33}}$$

Where:

V = velocity, ft/sec

p = fluid density, lb/ft^3

Typical fiberglass piping systems are operated at flow velocities between 3 & 12 ft/sec.

DETAILED PIPE SIZING

A. Liquid Flow

Fluid flow characteristics are very sensitive to the absolute roughness of the pipe inner surface. The absolute roughness of NOV Fiber Glass Systems piping is (0.00021 inches) 1.7 x 10^{-5} feet[1]. This is less than 1/8 the average value for (non-corroded) new steel of (0.0018 inch) 15 x 10^{-5} feet[2]. For ambient temperature water, the equivalent Manning value (n) is 0.009 and the Hazen-Williams coefficient is 150.

The most commonly used pipe head loss formula is the Darcy-Weisbach equation.

Eq. 5 $$Hf := f \cdot \frac{L}{D} \cdot \frac{V^2}{2g}$$

Where:

Hf = Pipe friction loss, ft(m)

f = Friction factor

L = Length of pipe run, ft (m)

D = Inner diameter, ft (m)

V = Fluid velocity, ft/sec (m/sec)

g = Acceleration of gravity, 32.2 ft/s^2 (9.81 m/s^2)

The friction factor is dependent on the flow conditions, pipe diameter and pipe smoothness. The flow conditions are determined by the value of the Reynolds Number. There are four flow zones defined by the Reynolds Number; they are laminar, critical, transitional and turbulent.

For laminar flow (Reynolds Number below 2,000), the friction factor is calculated by Eq. 6

Eq. 6 $$f := \frac{64}{Nr}$$

Where Nr is the dimensionless Reynolds Number

Eq. 7 $$Nr := \frac{D \cdot V}{\nu}$$

Where:

D = Pipe inner diameter, ft (m)

V = Fluid velocity, ft/sec (m/sec)

v = Fluid kinematic viscosity, ft^2/sec (m^2/sec)

Nr = Reynolds Number

f = Friction Factor

---

[1] Based on testing at Oklahoma State University in Stillwater, OK.

[2] Cameron Hydraulic Data, Ingersoll-Rand, Seventeenth Edition, 1988.

For turbulent flow (Reynolds Number greater than 4,000), the friction factor is calculated by the Colebrook Equation.

Eq. 8 $$\frac{1}{\sqrt{f}} = -2\cdot\log\left(\frac{e}{3.7\cdot D} + \frac{2.51}{Nr\cdot\sqrt{f}}\right)$$

Where:

D = Pipe inner diameter, inch (mm)

e = Absolute roughness, inch (mm)

Nr = Reynolds Number, unit less

f = Friction Factor, unit less

The flow with Reynolds numbers between 2,000 and 4,000 is considered the critical zone. Flow is neither fully laminar or turbulent, although it is often assumed to be laminar for calculation purposes. Flow with Reynolds numbers between 4,000 and 10,000 is called the transitional zone where use of the Colebrook equation is considered more appropriate.

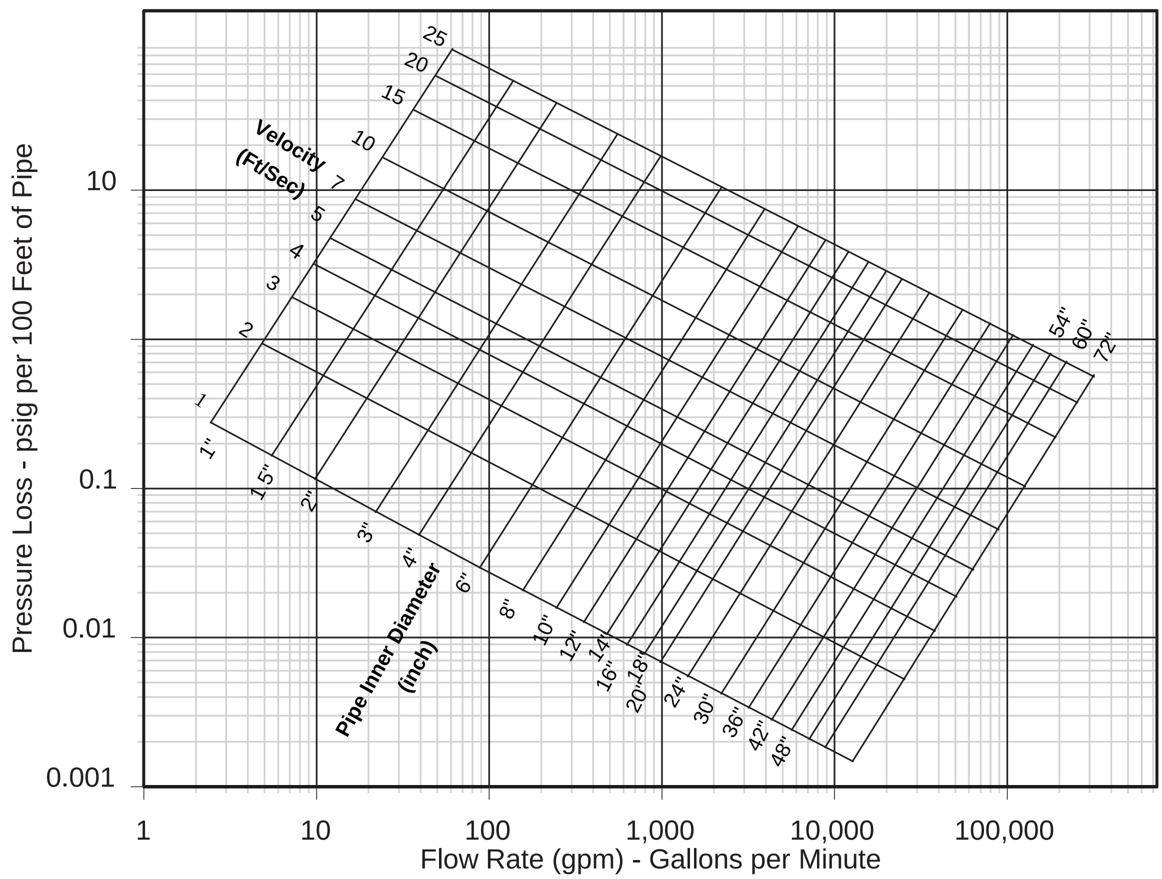
These equations are quickly solved using a computer program, *Success By Design,* developed by NOV Fiber Glass Systems specifically for our fiberglass products.

A demonstration of the Darcy-Weisbach and Colebrook equations for fiberglass pipe is shown in Figure 1.0.

Figure 1.0

Fiberglass Pipe Pressure Loss Curves for Water

Basis: Specific Gravity of 1.0 and Viscosity of 1.0 cps



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B. Loss in Pipe Fittings

The head loss through a fitting is proportional to the fluid velocity squared (V^2). Equation 9 relates the head loss in fittings to the fluid velocity by incorporating a fitting loss factor obtained from experimental test data.

Eq. 9 $$hf := \frac{k \cdot V^2}{2 \cdot g}$$

Where:

hf = Fitting head loss, ft (m)

k = Flow resistance coefficient

V = fluid velocity, ft/sec

g = acceleration of gravity, 32.2 ft/s^2

Typical values of k are given in Table 1.1.

The most common method for determining the contribution to the overall piping system of the fittings head loss is to convert the fitting head loss into an equivalent pipe length. As an example, use 60°F water as the working fluid in a 3-inch diameter piping system with an internal flow of 10 ft/sec. The equivalent pipe length for a short radius 90° elbow would be 6.9 feet for Red Thread II and 5.9 feet for Centricast Plus CL-2030 . The two piping systems have different inner diameters that contribute to the differences in equivalent footage. Therefore, for best accuracy it is recommended that our computer software *Success By Design* be used to determine fittings equivalent piping footage.

Typical liquid properties are presented in Table 1.2.

TABLE 1.1 Flow Resistance coefficients for Fittings

Fitting/Size (In.)	1	1½	2	3	4	6	8-10	12-16	18-24
Short Radius 90º Elbow	0.75	0.66	0.57	0.54	0.51	0.45	0.42	0.39	0.36
Sweep Radius 90º Elbow	0.37	0.34	0.30	0.29	0.27	0.24	0.22	0.21	0.19
Short Radius 45º Elbow	0.37	0.34	0.30	0.29	0.27	0.24	0.22	0.21	0.19
Sweep Radius 45º Elbow	0.20	0.18	0.16	0.15	0.14	0.13	0.12	0.11	0.10
Tee Side Run	1.38	1.26	1.14	1.08	1.02	0.90	0.84	0.78	0.72
Tee Thru Branch	0.46	0.42	0.38	0.36	0.34	0.30	0.28	0.26	0.24

TABLE 1.2 Typical Liquid Properties

Type of Liquid	Specific Gravity at 60ºF	Viscosity at 60ºF Centipoise
10% Salt Water	1.07	1.40
Brine, 25% NaCl	1.19	2.20
Brine, 25% $CaCl_2$	1.23	2.45
30º API Crude Oil	0.87	13.00
Average Fuel Oils	0.93	8.90
Kerosene	0.83	1.82
Auto Gasoline	0.72	1.20
Aviation Gasoline	0.70	0.46
50% Sodium Hydroxide (NaOH)	1.53	95.00
Mil 5624 Jet Fuels:		
JP3	0.75	0.79
JP5	0.84	2.14
JP8	0.80	1.40
Acids:	*At 68ºF*	*At 68ºF*
60% Sulfuric (H_2SO_4)	1.50	6.40
98% Sulfuric (H_2SO_4)	1.83	24.50
85% Phosphoric (H_2PO_4)	1.69	12.00
37.5% Hydrochloric (HCl)	1.46	1.94

C. Open Channel Flow

One of the most widely used, formulas for open-channel flow is that of Robert Manning. This formula in Equation 10 is useful in predicting the flow in open "gravity feed" fiberglass sewer lines. Our *Success By Design* software is recommended to perform these calculations.

Eq. 10 $$Q := \frac{k}{n}\cdot A\cdot Rh^{0.666}\cdot S^{0.5}$$

Where:

Q = Flow rate in ft^3/sec (m^3/sec)

A = Flow cross sectional area, ft^2 (m^2)

Rh = Hydraulic radius, ft (m)

S = Hydraulic slope, dimensionless

S = H/L

H = elevation change over the pipe length "L", ft (m)

L = Length measured along the pipe, ft (m)

k = 1.49 (US Customary units, ft. & sec.)

k = 1.0 for flow in m^3/sec. Use meter for A, Rh, & D.

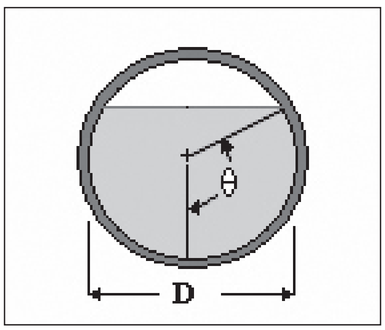
n = 0.009 Manning's constant for fiberglass

Eq. 11 $$Rh := \frac{D}{4}\cdot\left(1-\frac{\sin(2\cdot\theta)}{2\cdot\theta}\right)$$

Where:

D = Pipe inner diameter, ft (m)

Θ = Wet contact angle, radians



D. Gas Flow

NOV Fiber Glass Systems piping systems can be used in pressurized gas service when the pipe is buried at least three feet deep.

In above ground applications, they can be used provided the pressure does not exceed the values shown below and further that the pipe is properly safeguarded when conveying a hazardous gas.

Pipe Diameter	1"	1½"	2"	3"	4"	6"	8"	10"	12"	14"	16"
psig	25	25	25	25	25	25	14	9	6	5	4

Consult your local representative for safeguard procedures.

Since the inside diameter of the pipe is smoother and larger than steel pipe of corresponding nominal diameters, less frictional resistance is developed under turbulent flow conditions, resulting in greater flow capacities. There are two basic equations used to calculate pressure loss for flow of gases. To determine which equation is required, the transition flow rate must be determined from Equations 12, 13 and 14. If the desired flow rate is greater than the value calculated from equation 14, then the equations for fully turbulent or rough pipe flow must be used. If the desired flow rate is less than the value calculated from equation 14, then the equation for partially turbulent or smooth pipe flow must be used.

Equations for transition flow rate:

Eq. 12 $$KT := \left(\frac{0.4692\cdot T_b}{P_b\cdot\sqrt{G\cdot T\cdot Z}}\right)^2$$

Eq. 13 $$KS := \left(\frac{0.6643\cdot T_b}{P_b\cdot T^{0.5556}\cdot Z^{0.5556}\cdot G^{0.4444}\cdot \mu^{0.1111}}\right)^{1.8}$$

Eq. 14 $$QT := \left(\frac{KT}{KS}\right)^5\cdot D\cdot\left(\log\left(\frac{3.7\cdot D}{K}\right)\right)^{10}$$

Where *QT* = Transition Flow Rate

For fully turbulent or rough pipe flow:[1]

Eq. 15 $$Q := \frac{0.4692\cdot T_b}{P_b}\cdot\left[\frac{\left(P_i^2-P_o^2\right)\cdot D^5}{G\cdot T\cdot Z\cdot L}\right]^{0.5}\cdot\log\left(\frac{3.7\cdot D}{K}\right)$$

(1) IGT Distribution Equations from American Gas Association Plastic Pipe Handbook for Gas Service.

or

Eq. 16 $$P_o := \left[P_i^2 - \left[\frac{G \cdot T \cdot Z \cdot L}{D^5} \cdot \left(\frac{Q \cdot P_b}{0.4692 \cdot T_b \cdot \log\left(\frac{3.7 \cdot D}{K}\right)}\right)^2\right]\right]^{0.5}$$

For partially turbulent or smooth pipe flow(1)

Eq. 17 $$Q := \frac{0.6643 \cdot T_b}{P_b} \cdot \left(\frac{P_i^2 - P_o^2}{T \cdot Z \cdot L}\right)^{0.5556} \cdot \frac{D^{2.6667}}{G^{0.4444} \cdot \mu^{0.1111}}$$

Where:

Eq. 18 $$P_o := \left[P_i^2 - L \cdot T \cdot Z \cdot \left(\frac{Q \cdot P_b \cdot G^{0.4444} \cdot \mu^{0.1111}}{0.6643 \cdot T_b \cdot D^{2.6667}}\right)^{1.8}\right]^{0.5}$$

D = Inside Diameter (in.)
G = Specific Gravity (S.G. of air = 1.0)
L = Length of Pipe Section (ft.)
P_b = Base Pressure (psia)
P_i = Inlet Pressure (psia)
P_o = Outlet Pressure (psia)
Q = Flow Rate (MSCFH - thousand standard cubic ft. per hr.)
T_b = Base Temperature (°R)
T = Temperature of Gas (°R)
Z = Compressibility Factor
m = Viscosity (lb./ft. sec.)
K = Absolute Roughness of Pipe = 0.00021 (in.) for Fiber Glass Systems pipe
R = Rankine (°F + 460°)
m = (lb./ft. sec.) = *m* (centipoise) ÷ 1488
psia (Absolute) = psig (Gauge) + 14.7

You can perform computer calculations using the *Success By Design* program to solve gas flow problems for: pipe size, Q, P_i, or P_o if the other variables are known.

TABLE 1.3 Typical Gas Properties

Type of Gas	Specific Gravity at 60°F(1)	Viscosity at 60°F lb./ft. sec.
Air	1.02	0.0000120
Carbon Dioxide	1.56	0.0000098
Carbon Monoxide	0.99	0.0000116
Chlorine	2.51	0.0000087
Ethane	1.06	0.0000060
Methane	0.57	0.0000071
Natural Gas	0.64	0.0000071
Nitrogen	0.99	0.0000116
Nitrous Oxide	1.56	0.0000096
Oxygen	1.13	0.0000132
Sulfur Dioxide	2.27	0.0000083

(1) All Specific Gravity based on air = 1.0 at 70° F.

SECTION 2. Above Ground System Design - Supports, Anchors and Guides

PIPING SUPPORT DESIGN

Above ground piping systems may be designed as restrained or unrestrained. Selection of the design method is dependent on variables such as operating temperature, flow rates, pressures and piping layout. System designs combining the two methods often lead to the most structurally efficient and economical piping layout.

Unrestrained System Design

The unrestrained system is often referred to as a “simple supported" design. It makes use of the inherent flexibility of fiberglass pipe to safely absorb deflections and bending stresses. Simple pipe hangers or steel beams are used to provide vertical support to the pipe. These simple supports allow the piping system to expand and contract freely resulting in small axial stresses in the piping system. Long straight runs often employ changes-in-direction to safely absorb movement due to thermal expansion and contractions, flow rate changes, and internal pressure.

Experience has shown the use of too many simple pipe hangers in succession can result in an unstable line when control valves operate and during pump start-up and shutdown. To avoid this condition the designer should incorporate guides periodically in the line to add lateral stability. In most cases, the placement of lateral guides at intervals of every second or third support location will provide adequate stability. Axial stability in long pipe runs may be improved by the proper placement of a “Pipe Hanger with Axial Guide" as shown in Figure 2.6. The project piping engineer must determine the guide requirements for system stability.

Restrained System Design

The restrained system is often referred to as an “anchored and guided design". The low modulus of elasticity for fiberglass piping translates to significantly smaller thermal forces when compared to steel. Anchors are employed to restrain axial movement and provide vertical support in horizontal pipelines. Anchors used to restrain thermal expansion create compressive forces in the pipeline. These forces must be controlled by the use of pipe guides to prevent the pipe from buckling. In cases where axial loads created by anchoring a pipe run are excessively high, the use of expansion loops or expansion joints must be employed. When using anchors, the effect of system contraction should be considered. See the thermal analysis section for more thorough information on handling thermal loads.

FIBERGLASS PIPING SYSTEM “SUPPORT" TERMINOLOGY

Fiberglass piping engineers use three basic structural components to design a piping system. They are the support, anchor and guide.

Support

Pipe supports hold the pipe in position and when properly spaced prevent excessive deflections due to the weight of the pipe, fluid, external insulation and other loads.

Anchor

Pipe anchors restrain axial movement and applied forces. These forces may result from thermal loads, water hammer, vibrating equipment, or externally applied mechanical loads.

Guide

Pipe guides prevent lateral (side-to-side) movement of the pipe. Guides are required to prevent the pipe from buckling under compressive loading. For example: When anchors are used to control thermal expansion, guides are always required.

A. Support Design

The hanger support in Figure 2.0 must have sufficient contact areas to distribute the load. The preferred circumferential load bearing contact is 180°. Refer to Table 2.0 for minimum width requirements. When less than 180° of circumference contact and/or larger diameters are encountered, support saddles as shown in Figure 2.1 are recommended.

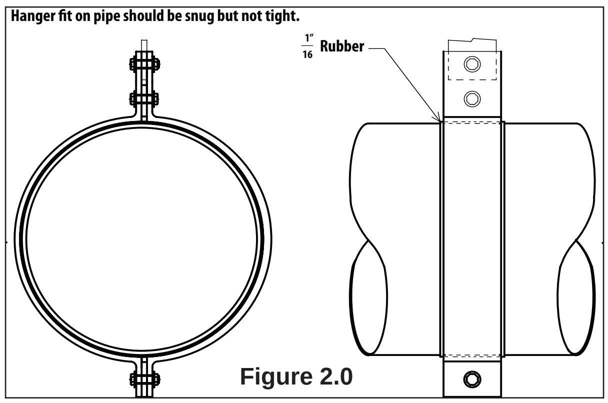


Figure 2.0

TABLE 2.0 Minimum Support Width*

Pipe Size (In.)	Class I (In.)	Class II (In.)
1	7/8	7/8
1 1/2	7/8	7/8
2	7/8	1
3	1 1/4	1 1/2
4	1 1/4	1 1/2
6	1 1/2	2
8	1 3/4	3
10	1 3/4	4
12	2	4
14	2	6

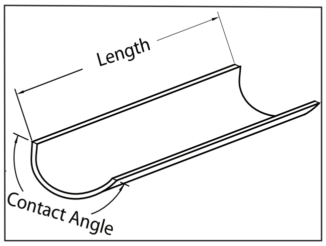
*Note: Valid for Sg < 1.25

Class I Products: Centricast Plus CL-2030, Centricast Plus RB-2530, Z-Core. Minimum recommended support saddle contact angle is 110°

Class II Products: Red Thread II, Green Thread, Silver Streak, F-Chem, Centricast CL-1520, Centricast RB-1520. Recommended support saddle contact angle is 180°

Support saddles are recommended for 16-24 inch diameter pipe. The pipe surface bearing stress should not exceed 50 lb/in^2 for support designs.

Figure 2.1



Support Saddle

TABLE 2.1 Saddle Length

Pipe Size (In.)	Class I (In.)	Class II (In.)
1	3	2
1½	3	2
2	4	4
3	4	4
4	4	4
6	4	6
8	6	8
10	9	10
12	9	12
14	9	14
16-24	-	(1)(2)

(1) Use the pipe diameter as minimum saddle length.
(2) Refer to F-Chem product bulletin for sizes greater than 24-inch diameter.

Typical supports requiring support saddles are shown in Figures 2.2 & 2.3. The support saddles should be bonded to the pipe or held in place by flexible clamps. If clamped to filament wound pipe a 1/16" rubber pad should be placed between the pipe and the saddle. Saddle lengths should accommodate pipe movements to prevent them from sliding off the supports.

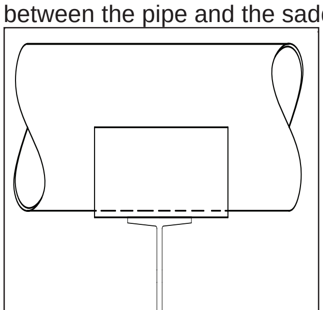


Figure 2.2

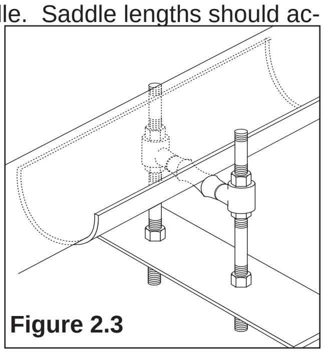


Figure 2.3

B. Guide Design

Typical Guide Usage

1. Between anchors to prevent buckling of pipeline at elevated temperatures.
2. Near entry points of expansion joints and loops to ensure proper functionality.
3. To provide system stability.

Properly designed and installed guides prevent the pipe from sliding off support beams and allow the pipe to freely move in the axial direction. Guides should be used with 180° support saddles to reduce wear and abrasion of the pipe walls.

Figure 2.4

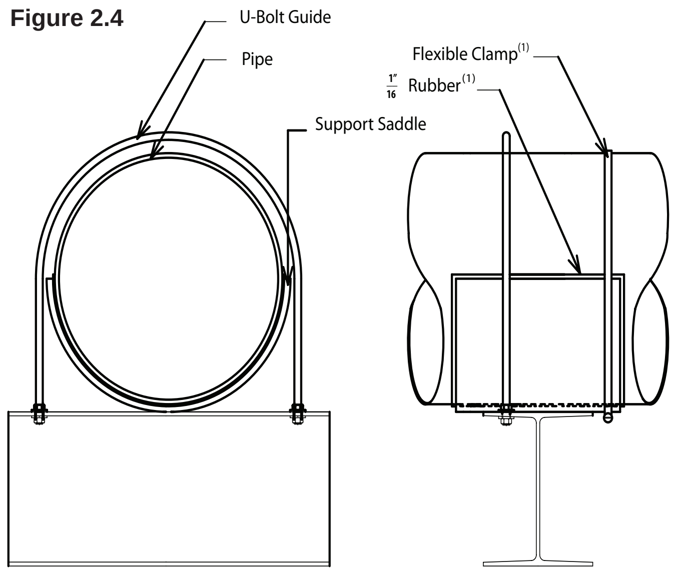


Figure 2.4 shows a common method of guiding fiberglass pipe. A clearance of 1/16 to 1/8-inch is recommended between the guide and the support saddle. A 180° support “wear" saddle is recommended to prevent point contact between the U-bolt and pipe. The U-bolt should not be tightened down onto the pipe. It should be tightened to the structural support member using two nuts and appropriate washers. A 1/8-inch clearance is recommended between the U-bolt and the top of the pipe.

Eight-inch diameter and larger pipe are generally allowed more clearance than smaller sizes. The determination of acceptable clearance for these sizes is dependent on the piping system and should be determined by the project piping engineer.

Another design practice is to use U-straps made from flat rolled steel instead of U-bolts. Flat U-straps are less apt than U-bolts to “point" load the pipe wall. U-strap use is most common when guiding pipe sizes greater than 6-inches diameter.

Pipe Hanger with Lateral Guide

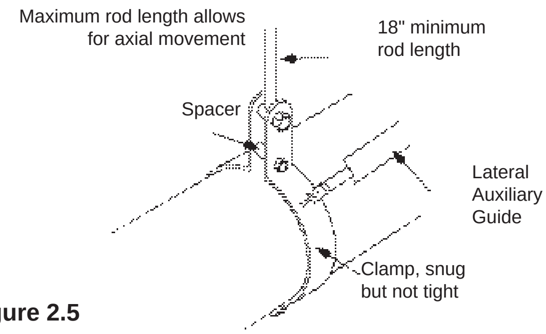


Figure 2.5

When U-bolts are used in vertical piping, then two 180° wear saddles should be used to protect the pipe around its entire circumference. It is appropriate to gently snug the U-bolt if a 1/8-inch thick rubber pad is positioned between the U-bolt and the saddle. If significant thermal cycles are expected, then the U-bolts should be installed with sufficient clearance to allow the pipe to expand and contract freely. See the “Vertical Riser Clamps" section for additional options in supporting vertical piping.

Figure 2.5 shows a more sophisticated pipe hanger and guide arrangement. It may be used without wear saddles as long as the tie rod allows free axial movement. The hanger must meet the width requirements in Table 2.0. If a clamp width does not meet the requirements in Table 2.0 or the pipe sizes are greater than 14-inch diameter, then support saddles should be used. See Table 2.1 for support saddle sizing recommendations.

Lateral loading on guides is generally negligible under normal operating conditions in unrestrained piping systems. In restrained piping systems, guides provide the stability required to prevent buckling of pipelines under compressive loads. If the guides are located properly in the pipeline, the loads required to prevent straight pipe runs from buckling will be very small.

Pipe Hanger with Axial Guide

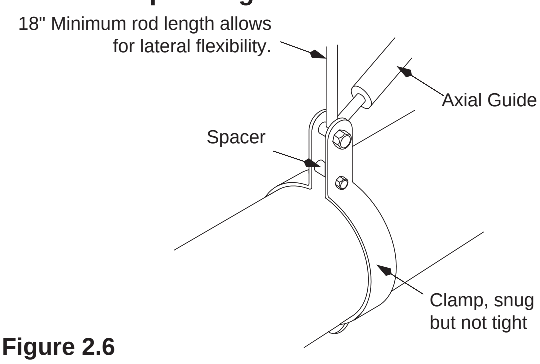


Figure 2.6

Upset conditions can result in significant lateral loads on the guides and should be considered during the design phase by a qualified piping engineer. Water hammer and thermal expansion or contraction may cause lateral loading on guides near changes in direction. Therefore, it is always prudent to protect the pipe from point contact with guides near changes in directions and side runs.

Figure 2.6 shows a pipe hanger with an axial guide using a double bolt pipe clamp arrangement. This support provides limited axial stability to unrestrained piping systems.

Pipe lines supported by long swinging hangers may experience instability during rapid changes in fluid flow. Stability of such lines benefit from the use of pipe guides as shown in Figures 2.5 and 2.6. The support widths for guided pipe hangers should meet the recommendations in Tables 2.0 & 2.1.

Vertical Riser Clamps

Riser clamps as shown in Figure 2.7 may act as simple supports, as well as guides, depending upon how they are attached to the substructure. The clamp should be snug but not so tight as to damage the pipe wall. The use of an anchor sleeve bonded onto the pipe is required to transfer the load from the pipe to the riser clamp. See the “Anchor Designs" section for detailed information concerning the anchor sleeve or FRP buildup.

Riser Clamp

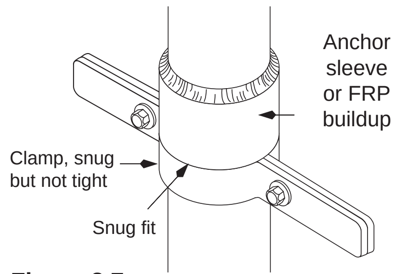


Figure 2.7

It is important to note that this type of clamp only provides upward vertical support. Certain design layouts and operating conditions could lift the pipe off the riser clamp. This would result in a completely different load distribution on the piping system. A pipe designer needs to consider whether the column will be under tension, or in a state of compression. Additional guides may be required to prevent unwanted movement or deflection.

A qualified piping engineer should be consulted to ensure an adequate design.

Riser clamps designed to provide lateral support should incorporate support saddles to distribute the lateral loads.

C. Anchor Design

Anchor Usage

1. To protect piping at “changes-in-directions" from excessive bending stresses.
2. To protect major branch connections from primary pipeline induced shears and bending moments. Particular consideration should be given to saddle and lateral fitting side runs.
3. Installed where fiberglass piping is connected to steel piping and interface conditions are unavailable.
4. To protect a piping system from undesirable movement caused by water hammer or seismic events.

5. To protect sensitive in-line equipment.
6. To absorb axial thrust at in-line reducer fittings when fluid velocities exceed 7.5 ft/sec.
7. To provide stability in long straight runs of piping.

Restrains pipe movement in all directions

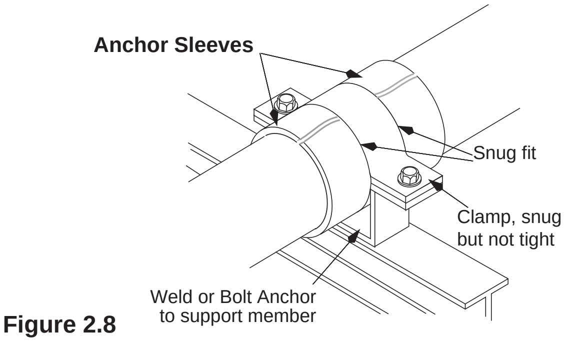


Figure 2.8

To be effective, an anchor must be attached to a substructure capable of supporting the applied forces. In practice, pumps, tanks, and other rigidly fixed equipment function as anchors for fiberglass piping systems.

Anchors as previously described are used to provide axial restraint to piping systems. In most cases an anchor provides bidirectional lateral support to the pipe thus acting like both a support and guide. Furthermore, anchors can be designed to provide partial or complete rotational restraint. But, this is not normally the case in practice. Figures 2.8 through 2.11 show typical methods of anchoring fiberglass piping systems.

Restrains pipe movement in all directions

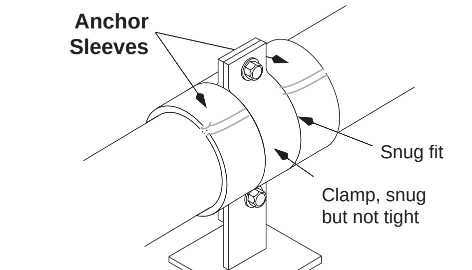


Figure 2.9

Restrains pipe movement in all directions

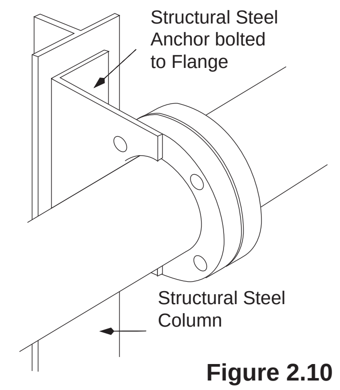


Figure 2.10

Restrains pipe movement in all directions and directly supports heavy fittings

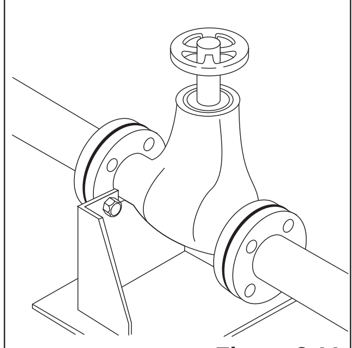


Figure 2.11

The anchor in Figure 2.9 will provide considerably less lateral stiffness than the anchor in Figure 2.8. The effect of lateral stiffness on the overall system stability should always be considered when selecting an anchor design.

The anchor widths should meet the recommendations for support designs in Table 2.0.

The reactions generated at anchors when restraining large thermal loads can be significant and should be calculated by a qualified piping engineer. The anchor brackets and substructure design should be designed with sufficient stiffness and strength to withstand these loads combined with any other system loads. Other system loads may include water hammer,seismic, static weight of pipe, fluid and any external loads such as insulation, wind, ice, and snow.

Anchor Sleeves

An anchor sleeve as shown in Figure 2.12 is necessary to transfer axial load from a pipe body to an anchor bracket. Pairs of anchor sleeves are bonded to the outer surface of a pipe to provide a shear load path around the complete circumference of the pipe body. To restrain pipe motion in two directions, two pairs of anchor sleeves are required. They must be bonded on both sides of an anchor bracket to completely restrain a pipe axially. There are design conditions where only one set of anchor sleeves is required. The piping engineer should make this determination and size the sleeves appropriately for the design loads. Lengths equal to the pipe diameter are generally satisfactory for most load conditions

Anchor Sleeve

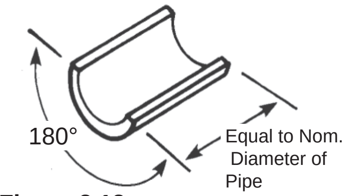


Figure 2.12

During installation the anchor sleeve end faces must be aligned to mate precisely against the anchor brackets when engaged. If only one of the two halves of an anchor sleeve contacts the anchor bracket, the loading will be off center or eccentric. Eccentric loading will increase the shear stress on the contacted anchor sleeve. It may also cause the pipe to rotate at the anchor resulting in unwanted deflections in the pipe. Refer to Figures 2.8 & 2.9 for typical configurations.

It is important to understand how the load is transferred from the pipe to the anchor brackets. First the axial load is sheared from the pipe wall into the anchor sleeves through the adhesive bond. The load is then transferred from the anchor sleeve by direct contact bearing stress between the end of the anchor sleeve and the anchor bracket which ultimately transfers it to the substructure.

Under no circumstances is the anchor to be tightened down on the pipe surface and used as a friction clamp to transfer load. The pipe should be free to slide until the anchor sleeves contact the anchor bracket to transfer the load. Piping engineers often take advantage of this anchoring procedure by allowing the pipe to slide a small amount before contacting the anchor. This effectively reduces restrained thermal loads.

Split repair couplings, split fiberglass pipe sections or hand lay ups of fiberglass and resin are commonly used as anchor sleeves. Contact your fiberglass distributor to determine the most appropriate choice for Fiber Glass Systems' wide variety of piping products.

D. Piping Support Span Design

A support span is the distance between two pipe supports. Proper support span lengths ensure the pipe deflections and bending stresses are within safe working limits. For static weight loads, it is standard practice to limit the maximum span deflection in horizontal pipe lines to ½" and the bending stresses to $^{1}/_{8}$" of the ultimate allowable bending stress. NOV Fiber Glass Systems applies these design limits to the engineering analysis used to determine the allowable support spans.

Span Analysis Methodology

The maximum allowable piping support spans are determined using the “Three Moment Equations" for uniformly loaded continuous beams. The equations may be modified to represent various end conditions, load types and even support settlements. Refer to Appendix A for the fundamental equations. NOV Fiber Glass Systems uses these equations to calculate the bending moments in piping spans. The pipe bending stresses and deflections are then evaluated for compliance with the aforementioned design criteria.

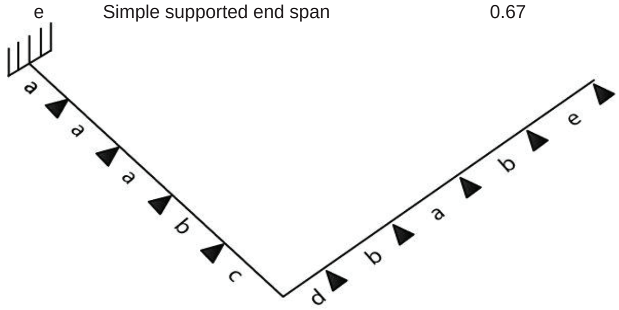
To avoid lengthy engineering calculations, our individual product bulletins contain recommended piping support span lengths. These span lengths are easily modified to match fluid specific gravity, operating temperatures and end conditions. Figures 2.13 and 2.14 provide span adjustment factors for various end conditions found in most horizontal piping system layouts. Tables for fluid specific gravity and temperature adjustment factors are product unique. Please refer to the product data bulletins for detailed design information.

Success By Design software quickly calculates support spans for uniformly loaded piping systems and takes into consideration product type, temperature, specific gravity, uniform external loads, and end conditions as shown in Figures 2.13 and 2.14.

Complex piping system designs and load conditions may require detailed flexibility and stress analysis using finite element modeling. The project design engineer must determine the degree of engineering analysis required for the system at hand.

Figure 2.13 Piping Span Adjustment Factors With Unsupported Fitting at Change in Direction

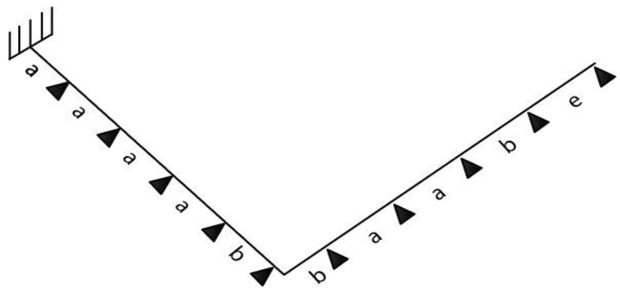
	Span Type	Factor
a	Continuous interior or fixed end spans	1.00
b	Second span from simple supported end or unsupported fitting	0.80
c + d	Sum of unsupported spans at fitting	≤ 0.75*
e	Simple supported end span	0.67



*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).

Figure 2.14 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



Support Design Summary

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 loading to minimize bending stresses on pipe and fittings.
7. Provide adequate axial and lateral restraint to ensure line stability during rapid changes in flow.

SECTION 3. Temperature Effects on Fiberglass Pipe

SYSTEM DESIGN

The properly designed piping system provides safe and efficient long-term performance under varying thermal environments. The system design dictates how a piping system will react to changes in operating temperatures.

The unrestrained piping system undergoes expansion and contraction in proportion to changes in the pipe wall mean temperature. Fiberglass piping systems that operate at or near the installation temperature are normally unrestrained designs, where the most important design consideration is the basic support span spacing. Since few piping systems operate under these conditions, some provisions must be made for thermal expansion and contraction.

The simplest unrestrained piping systems use directional changes to provide flexibility to compensate for thermal movements. When directional changes are unavailable or provide insufficient flexibility, the use of expansion loops or expansion joints should be designed into the system to prevent overstressing the piping system. These systems are considered unrestrained even though partial anchoring and guiding of the pipe is required for proper expansion joint, expansion loop performance and system stability.

The fully restrained “anchored" piping system eliminates axial thermal movement. Pipe and fittings generally benefit from reduced bending stresses at directional changes. Restrained systems develop internal loads required to maintain equilibrium at the anchors due to temperature changes. When the pipe is in compression, these internal loads require guided supports to keep the pipe straight preventing Euler buckling. Thus, the commonly referred to name of restrained systems is “anchored and guided". Anchored and guided systems have anchors at the ends of straight runs that protect fittings from thermal movement and stresses.

Anchors at directional changes (elbows and tees) transmit loads to the support substructure. Special attention should be given to these loads by the piping engineer to ensure an adequate substructure design. When multiple anchors are used to break up long straight runs, the loads between them and the substructure are generally small. The axial restraining loads are simply balanced between the two opposing sides of the pipeline at the anchor.

THERMAL PROPERTIES & CHARACTERISTICS

The reaction of fiberglass piping to changes in temperature depends on two basic material properties, the thermal “coefficient of expansion"(a) and the axial moduli of elasticity. The composite nature of fiberglass piping results in two distinctive axial moduli of elasticity. They are the axial compression and axial tensile moduli. Systems installed at ambient temperature and operated at higher temperatures will generate internal compression piping stress when anchored. Although this is the most common engineering design condition, the piping engineer should not overlook the opposite thermal condition that generates tensile stresses.

The thermal properties of fiberglass pipe distinguish it from steel in important ways. The coefficient of expansion is roughly twice that of steel. This translates to twice the thermal movement of steel in unrestrained systems. The axial compression modulus of elasticity of fiberglass pipe varies from 3% to 10% that of steel. When restraining thermal movements in fiberglass piping the anchor loads would be 1/5 or less than the loads created by a same size and wall thickness in steel piping system.

Thermoplastic pipe coefficients of expansion are typically more than four times that of fiberglass. The elastic modulus of thermoplastic piping is considerably smaller than the moduli of fiberglass and steel. The modulus of elasticity of thermoplastic pipe decreases rapidly as the temperatures increases above 100°F. This results in very short support spans at elevated temperatures. A restrained thermoplastic piping systems operating at elevated temperatures is very susceptible to buckling thus requiring extensive guiding.

It is important to properly determine the temperature gradient. The gradient should be based on the pipeline temperature at the time that the system is tied down or anchored. If the operating temperature is above this temperature, then the gradient is positive and conversely if it is less than this temperature, then the gradient is negative. Many piping systems will see both positive and negative temperature gradients that must be considered during the system design.

Success By Design software performs thermal analysis on fiberglass piping systems based on the methods discussed in this section. The benefits of using *Success By Design* are not only ease of use, but increased analysis accuracy. The software evaluates the fiberglass material properties at the actual operating temperatures, eliminating the conservatism built into charts and tables designed to cover worst case scenarios for all designs.

FUNDAMENTAL THERMAL ANALYSIS FORMULAS

A. Thermal Expansion and Contraction

The calculation of thermal expansion or contraction in straight pipelines is easily accomplished using the following equation.

Eq. 19 $$\delta := \alpha \cdot L \cdot \left(T_o - T_i\right)$$

Where:
d = Length change, in (m)
a = Thermal coefficient of expansion, in/in/°F (m/m/°C)
L = Pipe length, in (m)
To = Operating temperature, °F (°C)
Ti = Installation temperature, °F (°C)
Final tie-in or completion temperature.
(To - Ti) is the temperature gradient

B. Anchor Restraint Load

The calculation of the restrained load in a pipeline between two anchors is easily accomplished using the following equation.

Eq. 20 $$Fr := \alpha \cdot A \cdot E \cdot \left(T_o - T_i\right)$$

Where:
Fr = Restraining load, lb (N)
a = Thermal coefficient of expansion, in/in/°F (m/m/°C)
A = Reinforced pipe wall cross sectional area, in^2 (m^2)
To = Operating temperature, °F (°C)
Ti = Installation temperature, °F (°C)
Final tie-in or completion temperature.
(To - Ti) Temperature gradient
E = Axial modulus of elasticity, lb/in^2 (N/m^2)
The compression modulus should be used with a positive temperature change (To>Ti) and the tensile modulus with a negative temperature change (To<Ti).

The reactions on the external support structure at internally spaced anchors in long straight runs are negligible because the in-line forces balance. However, the anchors at the end of straight runs will transmit the full load to the support structure.

C. Guide Spacing

The Guide spacing calculations are derived from Euler's critical elastic buckling equation for a slender column with pivot ends.

Eq. 21 $$Lg := \sqrt{\frac{\pi^2 \cdot E \cdot I}{Fr}}$$

Where:
Lg = Guide spacing, in (m)
Fr = Restraining force, lb (N)
E = Bending modulus of elasticity, lb/in^2 (N/m^2)
I = Pipe area moment of inertia, in^4 (m^4)

FLEXIBILITY ANALYSIS AND DESIGN

There are four basic methods of controlling thermal expansion and contraction in above ground piping systems. They are:

1. Anchoring and Guiding
2. Directional Changes
3. Expansion Loops
4. Mechanical Expansion Joints

The use of anchors and guides as discussed earlier simply restrain thermal growth. Directional changes, expansion loops and mechanical expansion joints use component flexibility to safely absorb thermal movements.

A. Directional Change Design

The flexibility analysis of a directional change is based on a guided cantilever beam model. The cantilever must be of sufficient length to ensure the pipe will not be overstressed while absorbing the thermal movement. This is accomplished by satisfying the following equations.

Eq. 22 Based on pipe allowable bending stress

$$L := \sqrt{\frac{K \cdot \delta \cdot E \cdot OD}{\sigma}}$$

Where:

K = 3, Guided cantilever beam coefficient
L = Length of cantilever leg, in (m)
E = Pipe beam bending modulus of elasticity, lb/in^2(N/m^2)
OD = Pipe outer diameter, in (m)
δ = Total deflection to be absorbed, in (m)
σ = Pipe allowable bending stress, lb/in^2(N/m^2)

Eq. 23 Based on fitting allowable bending moment

$$L := \sqrt{\frac{K \cdot E \cdot I \cdot \delta}{M}}$$

Where:
K = 6, Guided cantilever beam coefficient
L = Length of cantilever leg, in(m)
E = Pipe beam bending modulus of elasticity, lb/in^2(N/m^2)
I = Pipe reinforced area moment of inertia, in^4(m^4)
d = Total deflection to be absorbed, in(m)
M = Fitting allowable bending moment, in-lb (N-m)

Minor out of plane rotation of the elbow should be allowed to minimize bending moments on the elbow.

The use of the guided cantilever beam equation results in conservative leg lengths.

Horizontal Directional Change

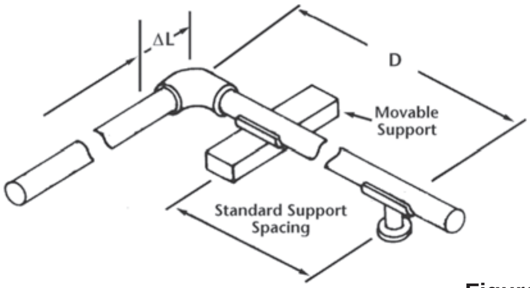


Figure 3.0

See Figure 3.0 for a typical horizontal directional change layout.

B. Expansion Loop Design

The flexibility of an expansion loop is modeled using two equal length guided cantilever beams. Each cantilever absorbs half of the thermal expansion or contraction. The cantilevers must be of sufficient length to ensure the pipe and fittings will not be overstressed. Determination of the minimum required lengths is accomplished by satisfying equation 22 with K= 1.5 and equation 23 with K=3. These equations should be used with the total deflection ($d=d_1+d_2$) to be absorbed by both expansion loop legs.

See Figure 3.1 for a typical expansion loop layout.

The pipe should be guided into the expansion loop as shown in Figure 3.1. The positioning of two guides on each side of the expansion loop is required to maintain proper alignment. The recommended guide spacing is four and fourteen nominal pipe diameters from the elbow for the first and second guides respectively.
To achieve the required flexibility 90°elbows should be used in directional changes and expansion loops. The substitution of 45° elbows will result in an unsatisfactory design.

C. Expansion Joint Design

Mechanical expansion joint use requires the engineer to determine the complete range of thermal movement expected in the system. This is accomplished by calculating the maximum thermal expansion and thermal contraction for the operating conditions. The mechanical expansion joint must be capable of absorbing the full range of thermal movement with an appropriate margin of safety. During installation the set position must be determined to ensure the expansion joint will accommodate the entire range of movement. This is accomplished using the following equation.

Eq. 24 $$SetPoint := R \cdot Travel$$

Where:
Set Point = Installed position of mechanical expansion joint “Distance from the joint being fully compressed", in(m)
Travel = Mechanical expansion joint maximum movement, in(m)

Eq. 25 $$R := \frac{T_i - T_{min}}{T_{max} - T_{min}}$$

R = Thermal ratio
Ti = Installation tie-in temperature, F°(C°)
Tmin = Minimum operating temperature, F°(C°)
Tmax = Maximum operating temperature, F°(C°)
Tmin ≤ Ti

Example Problem:

Determine the “Travel" and “Set Point" for the following conditions.

Ti = 75°F, Tmin = 45°F, Tmax = 145°F, R = 0.3
Pipe total thermal movement is 6 inches
Design factor 1.5

Expansion Joint

Typical guides and supports require pads a shown when there is point contact. Supports can be snug or loose fitting around the pipe. Guides must be loose.

First guide, 4 diameters distance from expansion joint. Second guide, 14 diameters distance from expansion joint.

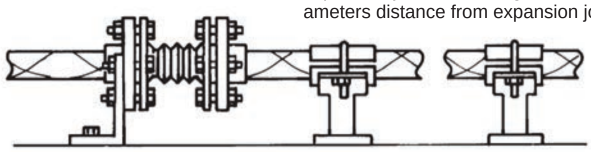
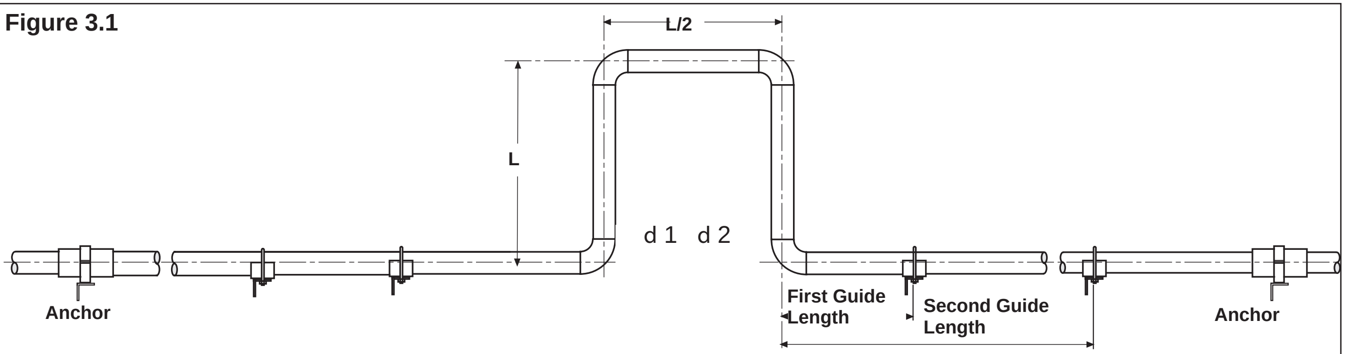


Figure 3.2

Figure 3.1



Expansion joint "Travel" required is 9 inches (6 x 1.5). The "Set Point" should be 0.3 x 9 = 2.7 inches (compression). This set point allows for 1.5 times the thermal growth or contraction for the given operating conditions. See Figure 3.2 for a typical expansion joint layout.

The proper selection of an expansion joint design depends on the available activation loads generated by the piping system. Equation 20 should be used to determine the fully restrained activation load capability of the piping system. If a mechanical expansion joint requires an activation force higher than the fully restrained activation load then the expansion joint will not function. The expansion joint activation force in practice should not exceed ¼ of the load in a fully restrained piping system. Mechanical expansion joints requiring higher activation forces may not provide sufficient flexibility to warrant its use.

D. Heat Tracing

Heat tracing is the practice of heating a piping system to prevent freezing or cooling of a process line. Steam tracing and electrical heat tapes are typical methods of heat tracing fiberglass piping. The maximum heat tracing temperature is governed by one of three criteria:

(1) The mean wall temperature must not exceed the maximum temperature rating of the pipe,

Eq. 26 $$\frac{T_{in} + T_{ra}}{2} \le T_{pr}$$

(2) The maximum tracing element temperature must not exceed 100°F(55.6C°) above the temperature rating of the pipe

Eq. 27 $$T_{ra} \le T_{pr} + 100$$

(3) The maximum recommended temperature for the service chemical must not be exceeded at the surface of the pipe inner wall.

Eq. 28 $$T_{in} \le T_{cr}$$

For stagnant flow, the temperature of the fluid and inner surface of the pipe can be assumed to equal the trace temperature. This assumption is valid if the heat trace element provides sufficient energy to overcome heat losses to the environment. For the stagnant or no flow condition, equation 29 is used to determine the maximum allowable heat trace temperature.

Eq. 29 $$T_{ra} \le T_{cr}$$

For Eq. 26-29:

T_{in} = Pipe inner surface temperature, °F(°C)

T_{ra} = Heat trace element temperature, °F(°C)

T_{pr} = Pipe temperature rating, °F(°C)

T_{cr} = Chemical resistance temperature rating of pipe, °F(°C)

Determination of the pipe inner wall temperature under active flow conditions depends on flow rate, specific heat of the fluid, temperature of fluid entering pipe, conduction through the pipe wall, external environmental heat losses and the heating element capacity. The complexity of this analysis is beyond the scope of this manual. Therefore, prudent engineering practices should be employed to determine the safe heat tracing temperatures under these conditions.

These criteria are most easily explained by the following examples:

Example: What is the maximum heat tracing temperature allowed to maintain a 5% caustic solution at 95°F inside Red Thread II pipe rated to 210°F?

The three governing criteria must be considered in order to determine the maximum tracing element temperature.

Step I: Solving for criterion (1) equation 26 is applied.

$$T_{ra} \le 2 \cdot T_{pr} - T_{in}$$

$$T_{ra} \le 2 \cdot 210 - 95$$

$$T_{ra} \le 325$$

Rearranging and solving for the maximum trace temperature, Tra we get 325°F.

Step II: Solving for criterion (2) equation 27 is applied.

$$T_{ra} \le T_{pr} + 100$$

$$T_{ra} \le 210 + 100$$

$$T_{ra} \le 310$$

Rearranging and solving for the maximum trace temperature, Tra we get 310°F.

Step III: Solving for criterion (3) equation 29 the stagnant flow condition is applied.

$$T_{ra} := T_{cr}$$

Therefore the maximum allowable heat trace temperature equals the maximum chemical resistance temperature for the piping. Referencing *Chemical Resistance Guide*, Bulletin No. E5615, Red Thread II pipe is rated to 100°F in 5% caustic. Therefore the maximum heat trace temperature is 100°F.

However, if the fluid were flowing into the pipeline at temperatures below 100°F, then the heat trace temperature would be higher than 100°F. A thorough heat transfer analysis would be required to determine the appropriate heat trace temperature for this condition.

The maximum heat trace temperature for stagnant flow is 100°F, the lowest temperature calculated using the three criteria.

E. Thermal Conductivity

The thermal conductivity of fiberglass piping is approximately 1/100 that of steel, making it a poor conductor of heat compared to steel. However, the use of insulation to prevent heat loss or gain is recommended when there are economic consequences due to heat loss or gain. Typical fiberglass thermal conductivity values vary from 0.07-0.29 BTU/(Ft.)(Hr.)(°F).

F. Thermal Expansion in Buried Pipe

Soil restraint inherently restrains movement of buried fiberglass pipelines because these pipes develop relatively small forces during a temperature change. Special precautions (thrust blocks, guides, expansion joints, etc.) for handling thermal expansion are not necessary if the pipe is buried at least two to three feet and the bedding material is of a soil type capable of restraining the line. Sand, loam, clay, silt, crushed rock and gravel are suitable bedding for restraining a pipeline; however, special precautions must be taken to properly anchor the pipe in swamps, bogs, etc. where bedding might easily shift and yield to even the low forces developed in fiberglass pipe.

G. Pipe Torque Due to Thermal Expansion

Torsion shear stresses in piping systems containing multiple elevation and directional changes normally do not have to be considered in pipe analysis. The allowable bending moments are lower than the allowable torsional moments in a pipe. Therefore, bending moments in a pipe leg reacted by torsion in a connecting pipe will be limited by the bending moment capability of the pipe not the torsional load. Computer modeling is recommended for this sophisticated level of piping system analysis.

SECTION 4. Pipe Burial

INTRODUCTION

The guidelines in this section pertain to the design and burial of fiberglass pipe. The structural design process assumes the pipe will receive adequate support in typically encountered soil conditions. Recommendations for trenching, selecting, placing and compacting backfill will be discussed.

The successful installation depends on all components working together to form a sound support system. Therefore, once a pipe is selected, it is of utmost importance to carefully review the native soil conditions, select the backfill material and closely monitor the trenching and installation process. Properly positioned and compacted bedding and backfill reduces pipe deformations maximizing long-term performance of a buried pipeline.

Detailed design and installation data for buried fiberglass piping systems may be found in AWWA M45, *Manual of Water Supply Practices, Fiberglass Pipe Design, First Edition*. Contact NOV Fiber Glass Systems applications engineer for detailed burial calculations.

PIPE FLEXIBILITY

The response of fiberglass pipe to burial loads is highly dependent on the flexibility of the pipe walls. The best measure of pipe flexibility can be found using the “pipe stiffness" value as defined and determined by ASTM D2412 tests.

Pipe with pipe stiffness values greater than 72 psi typically resist native backfill loads with minimal pipe deformation. The pipe stiffness of small diameter fiberglass pipe, 1 to 8 inch diameters, typically meets or exceeds 72 psi. Two to three feet of native backfill cover with a soil modulus greater than or equal to 1,000 psi is generally sufficient to protect this category of pipe from HS-20 vehicular and dead weight soil loads.

Pipe that is buried under concrete or asphalt roadways that support vehicular loads requires less cover. Design data and burial depth recommendation for specific piping can be found in our product bulletins and installation handbooks. Manual No. B2160 contains special installation instructions for UL Listed Red Thread IIA piping commonly used under pavements.

Pipe with pipe stiffness values less than 72 psi, are considered flexible and are more susceptible to the effects of poor compaction or soil conditions. Because of this, larger diameter piping requires detailed attention during the design and installation of buried pipelines.

BURIAL ANALYSIS

Pipe burial depth calculations are based on Spangler’s deflection equation and Von Mise’s buckling equation as outlined in AWWA M45. Application of these methods is based on the assumption that the design values used for bedding, backfill and compaction levels will be achieved with good field practice and appropriate equipment. If these assumptions are not met, the deflections can be higher or lower than predicted by calculation.

A. Soil Types

A soil’s ability to support pipe depends on the type of soil, degree of compaction and condition of the soil, i.e. density and moisture content. A stable soil is capable of providing sufficient long-term bearing resistance to support a buried pipe. Unstable soils such as peat, organic soil, and highly expansive clays exhibit a significant change in volume with a change in moisture content. Special trenching and backfill requirements are necessary when the native soil is unstable. Some guidelines to aid the engineer in determining the stability at a particular site follow:

1. For cohesive soils or granular-cohesive soils, if the unconfined compressive strength per ASTM D2166 exceeds 1,500 lb/ft^2, the soil will generally be stable.

2. For cohesive soils, if the shear strength of the soil per ASTM D2573 is in excess of 750 lb/ft^2, the soil will generally be stable.

3. For sand, if the standard penetration “Blow" value, N, is above 10, the soil will generally be stable.

Soils types are grouped into “stiffness categories" (SC). They are designated SC1 through SC5. SC1 indicates a soil that provides the highest soil stiffness at any given Proctor density. An SC1 classified soil requires the least amount of compaction to achieve the desired soil stiffness. The higher numbered soil classifications (SC2-SC4) become, the more compaction is required to obtain specific soil stiffness at a given Proctor density. The SC5 soils are unstable and should not be used as backfill or bedding. Decaying organic waste and frozen materials fall in the SC5 category. Lists of recommended backfill materials are shown in Table 4.0.

TABLE 4.0　　Recommended Bedding and Backfill Materials

Stiffness Category[1]	Pipe Zone Backfill Material [2,5]	Degree of Compaction[3] %
SC1	Crushed rock[4] with ≤15% sand, maximum 25% passing the 3/8" sieve and maximum 5% fines	As Dumped (No compaction required)
SC2	Coarse-grained soils with ≤ 12% fines	75-85
SC3	Coarse-grained soils with >12% fines	85-95
SC3	Fine-grained soils with >12% fines	85-95
SC4	Fine-grain soils with medium to no plasticity with <30% coarse-grained particles	>95

1 AWWA M45 soil stiffness categories

2 Maximum particle size of ¾ inch for all types.

3 Compaction to achieve a soil modulus of 1,000 psi.

4 Pea gravel is a suitable alternative.

5 A permeable fabric trench liner may be required where significant ground water flow is anticipated.

B. Soil Modulus

The soil modulus is a common variable that is very important to fiberglass piping burial analysis regardless of the soil type. Extensive research and engineering analysis has shown that a soil modulus of 1,000 psi provides very good support to fiberglass pipe. Table 4.0 shows the degree of compaction based on the Proctor density to obtain a soil modulus of 1,000 psi. It is worth noting that for all stiffness categories this soil modulus may be obtained, although with varying compaction requirements.

Although a modulus of 1,000 psi is preferred, values as low as 750 psi will provide sufficient support to fiberglass pipe if it is properly engineered and installed.

TRENCH EXCAVATION AND PREPARATION

A. Trench Size

The purpose of the trench is to provide working space to easily install the pipeline. The trench depth must account for the bedding thickness, pipe height and backfill cover. Trench widths must accommodate workers and their tools, as well as allow for side bedding and backfill. The trench widths listed in Table 4.1 are satisfactory for most installations.

B. Trench Construction

1. Solid rock conditions

If solid rock is encountered during trench construction, the depth and width of the trench must be sufficient to allow a minimum of 6-inches of bedding between the rock and pipe surface.

2. Granular or loose soils

These types of soils are characterized by relatively high displacement under load, and soft to medium soft consistencies. The walls of trenches in this type of soil usually have to be sheeted or shored, or the trench made wide enough to place a substantial amount of bedding material in order to prevent excessive deformation in the pipe sides (see figures 4.0 & 4.1). In some cases, additional depth or supplementary trench foundation material may be required.

TABLE 4.1　　Trench Widths

Pipe Size (In.)	Minimum Width (In.)	Maximum Width* (In.)
2	18	26
3	18	27
4	18	28
6	20	30
8	23	32
10	25	34
12	28	36
14	31	38
16	33	40
18	36	42
20	39	44
24	44	48
30	52	56
36	60	64
42	66	70
48	72	80
54	78	86
60	84	96
72	96	108
84	108	120

* Trench widths may be wider depending on soil conditions.

Trench for Soft and Medium Consistency Soils

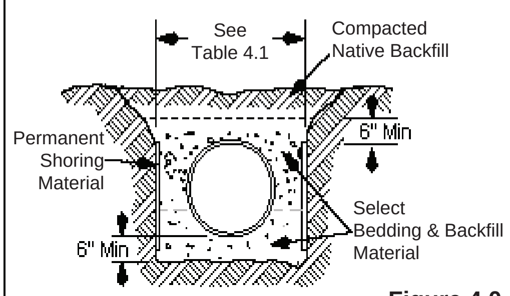


Figure 4.0

Trench for Granular Type Soils

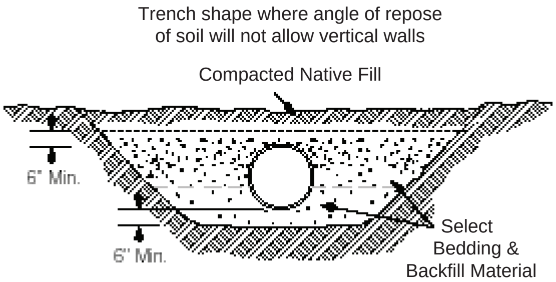


Figure 4.1

3. Unstable soils

Unstable soils require special precautions to develop a stable environment for fiberglass pipe. See Figure 4.2 for a recommended trenching procedure. SC1 bedding and backfill material should be used with a permeable, fabric liner to prevent migration of fill into the native soil. Due to the unpredictable nature of unstable soils a soils engineer should be consulted for project specific design recommendations.

Wide Trench for Very Soft or Unstable Soils

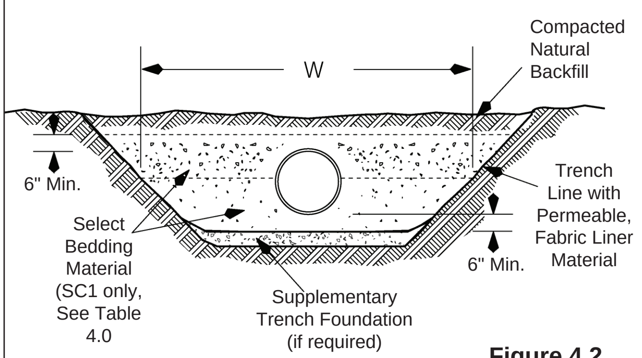


Figure 4.2

C. Maximum Burial Depth

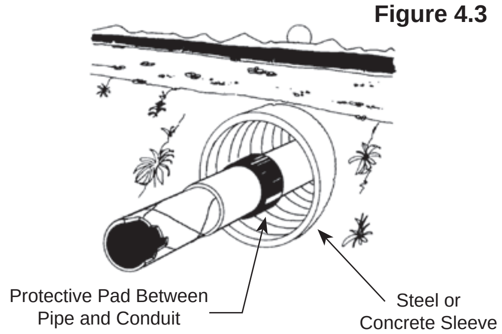
Surface loads do not usually affect the maximum burial depths. The maximum burial depth ultimately depends on the soil backfill modulus. When burying pipe in stable soil with a backfill modulus of 1,000 psi, the maximum allowable depth of cover is normally 15-20 feet. When burying pipe in soil with a backfill modulus of 700 psi, the maximum allowable cover is seven feet. Although the above maximum burial depths are typical, NOV Fiber Glass Systems will design custom products suitable for your application. Reference NOV Fiber Glass System's product bulletins for specific product recommendations.

D. Roadway Crossing

Pipe passing under unpaved roadways should be protected from vehicular loads and roadbed settlement. Burial depths under stable roadbeds should be determined per AWWA M45 for vehicular traffic. If the roadbed is unstable or burial-depths are shallow then steel or concrete sleeves are required see Figure 4.3.

Typical Roadway Crossing

Figure 4.3



BEDDING AND BACKFILL

A. Trench bottom

The trench bottom is the foundation of the pipe support system. Select bedding material is required for flexible fiberglass pipelines. The bedding should be shaped to conform to the bottom of pipe. Proper placement and compaction of the bedding is required to ensure continuous pipe support. See Figures 4.4, 4.5 & 4.6 for examples of standard bedding practices.

Proper Bedding

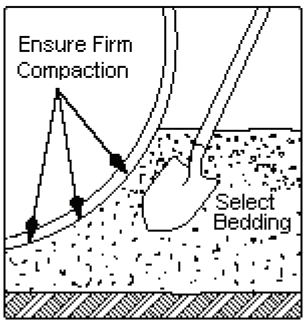


Figure 4.4

Improper Bedding

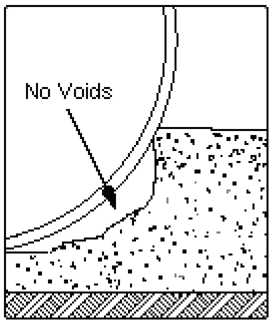


Figure 4.5

Bedding and Backfill for Firm or Hard Native Soil

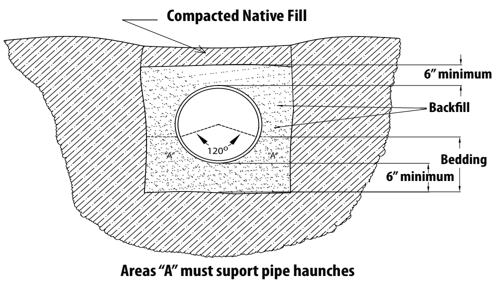


Figure 4.6

B. Backfill materials

Backfill material at the sides of the pipe is to be added in lifts, not to exceed 6-inches at a time, mechanically compacted to the required density and continued to 6-inches above the top of the pipe. The degree of compaction is dependent upon the type of fill material used. Water flooding for compaction is not recommended, nor is compacting the fill material while it is highly saturated with water.

Proper compaction of the backfill material is required for pipeline stability and longevity. Sand, pea gravel or crushed rocks are the recommended SC1 backfill materials requiring minimal compaction if per Table 4.0.

If excavated native material meets the requirements listed in Table 4.0, it may be used for bedding and backfill. Soils containing large amounts of organic material or frozen materials should not be used. If there is any question as to the suitability of the native soil, a soil engineer should be consulted.

C. Backfill cover

The cover layers above the backfill should be applied in lifts of 6 inches. Native soil may be used, provided it is not unstable type SC5 soil. This includes soils loaded with organic material or frozen earth and ice. Each lift should be compacted to a Proctor Density to achieve a 1,000-psi modulus per Table 4.0. Lifts applied 18 inches or more above the top of the pipe may be applied in 12-inch layers provided there are not chunks of soil larger than 12 inches. Again, each layer is to be compacted to the required density. Lift heights should never exceed the capacity of the compaction equipment.

Heavy machinery should not be allowed to cross over trenches unless completely covered and compacted.

D. High water table

Areas with permanent high water tables are usually coincident with very poor soil conditions. In most of these areas, it will be necessary to use crushed rock or pea gravel as the bedding and backfill material. In addition, permeable fabric trench liner should be used to prevent migration of the fill material into the native soil. In extreme cases such as soft clay and other plastic soils, it will be necessary to use "Class A" bedding. (See Figure 4.7). Also, if the depth of the pipe and the depth of cover is less than one diameter, tie downs or concrete encasement is recommended in sufficient quantity to prevent flotation.

Areas prone to flooding or poor draining soil should be treated similar to high water table areas.

Class "A" Bedding

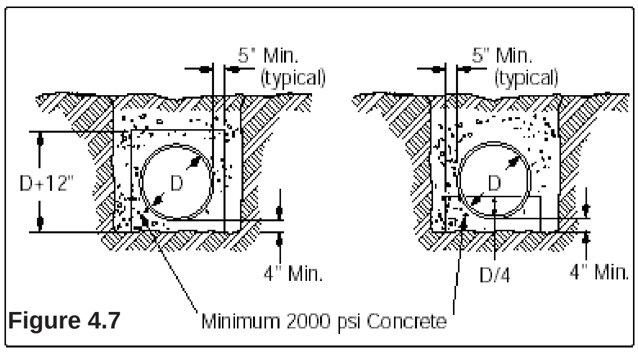


Figure 4.7

SECTION 5. Other Considerations

A. ABRASIVE FLUIDS

NOV Fiber Glass Systems piping systems are used to convey abrasive fluids that may also be corrosive. Since fiberglass pipe does not depend upon a protective oxide film for corrosion resistance, it is not subject to the combination of corrosion and abrasion that occurs with metals.

The effects of abrasive fluids on any piping system are difficult to predict without test spools or case history information. Particle size, density, hardness, shape, fluid velocity, percent solids, and system configuration are some of the variables that affect abrasion rates. Standard fiberglass piping with a resin-rich liner can generally handle particle sizes less than 100 mesh (150 micron) at flow rates up to 8 ft./sec. The abrasion resistance can be improved by adding fillers such as fine silica, silicon carbide, or ceramic to the abrasion barrier (such as with Silver Streak, F-Chem, and Ceram Core products). Wear resistance of fiberglass fittings can be improved by using long-radius fittings.

Since each abrasive service application is different and peculiar to its industry, please consult your local representative for a recommendation.

B. LOW TEMPERATURE APPLICATIONS

Fiberglass pipe is manufactured with thermosetting resin systems that do not become brittle at low temperatures, as do thermoplastic materials. NOV Fiber Glass Systems pipe and fittings can be used for low temperature applications such as liquid gases (refer to Chemical Resistance Guide for compatibility with liquid gases). Tensile tests performed at -75°F(-59.4°C) actually show an increase in strength and modulus. Typical low temperature applications are the conveyance of fuel, oil, and other petroleum production applications in Alaska.

C. PIPE PASSING THROUGH WALLS OR CONCRETE STRUCTURES

The design of wall penetrations must consider the possible effects of wall settlement and the resulting reactions on the pipe body. Wall penetrations below grade must also be sealed to prevent water seepage. Typically fiberglass pipe is sealed into the wall opening with epoxy grout material such as if manufactured by ITW Devcon Corporation, Danvers, MA. Fiberglass piping systems should be designed with sufficient flexibility near wall penetrations to minimize reactions to slight wall movements. To prevent leakage around the grout, it is common to embed a steel sleeve with a water-stop during the wall construction (Figure 5.0).

Pipe Passing through Concrete Wall

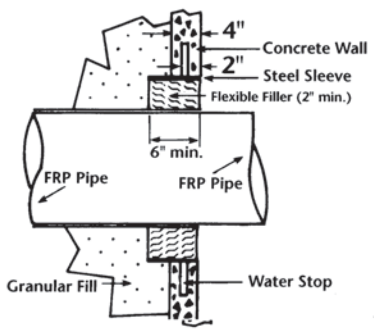


Figure 5.0

The use of flexible seals between the pipe and wall penetration is a standard practice used to protect fiberglass pipe from abrasion and minimize effects of wall movements. A segmented rubber seal such as Link-Seal® manufactured by Thunderline/Link-Seal, 19500 Victor Parkway, Suite 275, Livonia, MI 48152 is commonly used with fiberglass pipe.

If the pipe is not sealed into the wall, it must be protected from surface abrasion. A heavy gage sheet metal sleeve will provide sufficient protection.

D. PIPE BENDING

Pipe is often bent during transportation, handling and during installation to match trenching contours, etc. As long as the minimum bending radius is not exceeded, these practices will not harm the pipe. Minimum bending radius values are unique to product type and diameter. Therefore, NOV Fiber Glass System piping bulletins must be referred to for accurate data.

Bending of pipe with in-line saddles, tees, or laterals should be avoided. Bending moments in the pipe will create undesirable stresses on the bonded joints and fittings.

® Link-Seal is registered trademark of Thunderline/Link-Seal

E. STATIC ELECTRICITY

The generation of static electricity is not a problem in most industrial applications. The effects of static electricity usually become a design problem only if a dry, electrically non-conductive gas or liquid is piped at high velocity through an ungrounded system.

The generation of static electricity under fluid flow conditions is primarily related to the flow rate, ionic content of the fluid, material turbulence, and surface area at the interface of the fluid and the pipe. The rate of electrostatic generation in a pipe increases with increasing length of pipe to a maximum limiting value. This maximum limiting value is related to fluid velocity and is greater for high velocities. Highly refined hydrocarbons, such as jet fuels, accumulate charges more rapidly than more conductive hydrocarbons, such as gasoline. However, the rate of charge buildup in buried piping systems handling jet fuels at a maximum flow velocity of 5 ft/sec is such that special grounding is not necessary.

Static charges are generated at approximately the same rate in fiberglass piping and metallic pipe. The difference in the two systems is that the charge can be more easily drained from a metal line than from a fiberglass line. Under the operating conditions encountered in most industrial applications, any static charge generated is readily drained away from the pipe at hangers or by other contact with the ground, and any small charge in the fluid is drained away at metallic valves and/or instrumentation lines.

NOV Fiber Glass Systems manufactures an electrically conductive piping system that should be employed when static electricity is a critical design parameter.

⚠ Occasionally in piping a dry gas at high velocity, a charge may build up on an ungrounded valve. If this charge is not drained off by humid air, it can shock personnel who come in contact with the valve. This situation can be easily remedied by grounding the valve.

⚠ Bulk fuel-loading facilities, because of high fluid velocities, present a problem to both metallic and fiberglass pipe. Filters and other high surface area devices are prolific generators of static electricity at these facilities. Special grounding procedures may be necessary under these conditions.

F. STEAM CLEANING

Short duration steam cleaning of epoxy fiberglass pipe is acceptable provided the following recommendations are adhered to:

- The piping system must be open-ended to prevent pressure buildup.
- The maximum steam pressure does not exceed 15 psig corresponding to a steam saturation temperature of approximately 250°F. Contact a factory representative for specific product design information.
- The piping system design must consider the effects of the steam cleaning temperatures. In most cases the support spans will be reduced 15-35%.
- Contact the factory before steam cleaning vinyl ester or polyester pipe.

G. THRUST BLOCKS

Thrust blocks are not required for NOV Fiber Glass System's adhesive bonded piping systems. Large diameter F-Chem O-ring pipe is not restrained and may require the use of thrust blocks. Consult the factory for specific recommendations.

H. VACUUM SERVICE

Vacuum service may be a system design condition, or it may occur as the result of an inadvertent condition. Sudden pump shut off, valve closures, slug flow and system drain down are examples of flow conditions that result in vacuum. They should always be considered during the design phase. Regardless of the source, vacuum conditions result when the external atmospheric pressure exceeds the internal pressure. The pipe wall must be capable of resisting this external pressure without buckling. Consult our product bulletins for specific external pressure (vacuum) ratings. Large diameter pipe through 72-inches manufactured specifically for vacuum conditions are available upon request.

I. VALVES

When using valves with fiberglass piping products, consideration must be given to the corrosion resistance of the valve with respect to the fluid being conveyed and the external environment. Heavy valves should be independently supported to reduce bending stresses on adjacent pipe. Flanged valves mated to molded fiberglass flanges must have a full flat face to prevent overstressing the flanges. To ensure a good seal, use a $^1/_8$-inch thick full-face, 60-70 durometer gasket between the valve sealing surface and the fiberglass flange for up to 14-inch diameter pipe. Use ¼-inch thick gaskets on larger sizes. If the valves do not have full flat faces consult installation manuals for additional recommendations.

J. VIBRATION

Low amplitude vibrations such as those produced by well-anchored centrifugal pumps will have little effect on fiberglass piping. Such vibrations will be dampened and absorbed by the relatively low modulus pipe. However, care must be taken to protect the exterior of the pipe from surfaces that might abrade and wear through the pipe wall over a long period of time. This can be accomplished by using support "wear" saddles at the supports or padding the supports with 1/8-inch rubber gasket material. See Section 2 for recommended support designs.

High amplitude vibration from pumps or other equipment must be isolated from the piping system by flexible connectors.

K. FLUID HAMMER

A moving column of fluid has momentum proportional to its mass and velocity. When flow is abruptly stopped, the fluid momentum is converted into an impulse or high-pressure surge. The higher the liquid velocity and longer the pipe line, the larger the impulse.

These impulse loads can be of sufficient magnitude to damage pipe, fittings and valves.

Accurate determination of impulse loads is very complex and typically requires computer modeling of the piping system. However, the Talbot equation, given in ***Appendix A***, may be used to calculate theoretical impulses assuming an instantaneous change in velocity. Although, it is physically impossible to close a valve instantaneously, Talbot's equation is often employed to calculate worst case conditions.

In the real world quick reacting valves, reverse flow into check valves and sudden variations in pump flow rates will cause water hammer surges. Engineers typically incorporate slow operating valves, surge tanks and soft-starting pumps into piping systems to minimize fluid hammer. Piping systems that experience surge conditions should be restrained to prevent excessive movement.

If the system operating pressure plus the peak surge pressure exceeds the system pressure rating, then a higher pressure class piping system should be employed.

L. ULTRAVIOLET (U.V.) RADIATION AND WEATHERING

Fiberglass pipe undergoes changes in appearance when exposed to sunlight. This is a surface phenomenon caused by U.V. degradation of the resin. The degradation depends upon the accumulated exposure and the intensity of the sunlight. Long-term surface degradation may expose the outer layer of glass fibers; this condition is called "fiber-blooming". These exposed glass fibers will block and reflect a significant portion of ultraviolet radiation resulting in a slower rate of degradation. This minimizes future damage to the remaining pipe wall. Because NOV Fiber Glass Systems pipe bodies are designed with significant safety factors, minor fiber blooming does not prevent the pipe from safely performing at its published pressure rating. If service conditions are such that exposed fibers will be abraded with time, it is highly recommended that surface be protected. Painting the pipe with a good quality acrylic or solvent-based paint is useful in blocking UV radiation.

M. FUNGAL, BACTERIAL, AND RODENT RESISTANCE

Some plastics (thermoplastics) are subject to fungal, bacterial, and/or rodent attack, but fiberglass pipe offers no nourishment or attraction to these annoyances. Under stagnant conditions, some marine growths will attach to fiberglass surfaces, but they do not attack or bore into the pipe and are usually easily removed. **Note regarding zebra mussels:** It was recently reported that a utility compared zebra mussel growth in similar metal and fiberglass intake lines at the same location. Only two liters of zebra mussels were removed from the fiberglass line, while two dumpster loads of mussels were removed from a metal line.

N. FLANGE CONNECTIONS

Our flanges are designed to meet ANSI B16.5 Class 150 bolt hole standards. Alternate bolt hole standards are available. Flanges are designed for 1/8 inch thick gaskets made from materials with a 60-70 durometer Shore A hardness. The use of flat washers under nuts and bolt heads is required. Refer to the appropriate product specific fittings bulletin for recommended bolt torque values.

Raised Face Flange Connections

Special mating requirements exist when connecting flat-face compression molded fiberglass flanges to raised-face metallic flanges or valves having partial liner facings. The addition of a metallic spacer ring placed between the raised face and the outer edge of the flange to form a full flat-face on the mating flange is recommended. The purpose of the spacer ring is to fill the gap outside the raised-face to prevent bolt loads from bending and breaking the fiberglass flange. An alternative to the spacer ring is the use of metallic back-up rings behind molded fiberglass flanges. Filament wound flanges may be connected directly to raised-face flanges without the use of spacer rings. Refer to installation manual for backing ring sizes.

Lug and Wafer Valves

Lined lug and wafer valves that use integral seals, require a ¼-inch steel spacer plate with an inner diameter equal to Schedule 40 steel or as required by the valve manufacturer. The spacer plate outer diameter should match the fiberglass flange outer diameter.

Unlined lug and wafer valves without integral seals may be directly connected to fiberglass filament flanges without back up rings or to molded flanges with metal back-up rings. Refer to installation manual for backing ring sizes.

SECTION 6. Specifications and Approvals

A. COMPLIANCE WITH NATIONAL SPECIFICATIONS

American Petroleum Institute

API Specification 15LR

Red Thread II Pipe & Fittings, 2"-24 Cyclic Design

American Society for Testing & Materials (ASTM)

ASTM D2310 (See Table 6.0 & 6.2)

“Standard Classification for Machine Made ‘Fiberglass’ (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe"

Classifications of Pipe at 73.4°F are:

TABLE 6.0 ASTM D2310 Classification

Pipe	Size	ASTM D2310 Classification
Red Thread II	2”-3” 4”-24”	RTRP-11AF RTRP-11AH
Green Thread	1”-16”	RTRP-11FY
Z-Core	1”-8”	RTRP-21CO
Silver Streak	2”-48”	RTRP-11FY
Ceram Core	6”-16”	RTRP-11CF
F-Chem	1”-72”	RTRT-12EU
Centricast RB-1520 RB-2530 CL-1520 CL-2030	 1 1/2”-14” 1”-14” 1 1/2”-14” 1”-14”	 RTRP-21CW RTRP-21CW RTRP-22BT RTRP-22BS

ASTM D2996

“Standard Specification for Filament-Wound ‘Fiberglass’ (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe"

Designation Codes are available in product bulletins.

ASTM D2997

“Standard Specification for Centrifugally Cast ` ‘Fiberglass’ (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe"

Designation Codes are available in product bulletins.

ASTM D4024 (See Table 6.1)

“Standard Specification for Machine Made ‘Fiberglass’ (Glass-Fiber-Reinforced Thermosetting-Resin) Flanges"

Designation Codes at 73.4°F, by flange size, are available in product bulletins.

ASTM D5685

“Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe Fittings Designation Codes are available in technical application bulletins.

B. APPROVALS, LISTINGS, AND COMPLIANCE WITH REGULATIONS

American Water Works Association

Red Thread II pipe, Green Thread pipe, and F-Chem pipe can be made in compliance with AWWA M45 for use as pressure pipes for water distribution (including services) and transmission systems for both above and below ground installations. When ordering, specify AWWA M45.

ASME/ANSI B31.3

“Process Piping"

Red Thread II and Green Thread pipe that are manufactured in compliance with ASTM D2996, and Centricast pipe manufactured in compliance with D2997, can be installed in compliance with ASME/ANSI B31.3.

Factory Mutual

Pipe and fittings, sizes 4"-16", are available with Factory Mutual approval for underground fire protection piping systems; pressure ratings to 200 psig. *When ordering, specify Factory Mutual Products.*

Food and Drug Administration

The resins and curing agents used in the manufacture of Red Thread II Pipe and Fittings and Green Thread Pipe and Fittings are defined as acceptable with the U.S. Food, Drug, and Cosmetic Act as listed under 21 CFR Part 177 Subpart C Section 177.2280 and 21 CFR Part 175 Subpart C Section 175.300.

Military Specifications

MIL-P-29206 or MIL-P-29206A—Red Thread II JP and Green Thread JP pipe and fittings, sizes 2"-12", are certified to be in compliance with MIL-P-29206 or MIL-P-29206A, Military Specification: “Pipe and Pipe Fittings, Glass Fiber Reinforced Plastic for Liquid Petroleum Lines."

NSF International
(National Sanitation Foundation)

ANSI/NSF Standard No. 61 (Drinking Water System Components—Health Effects) Listing: Note: Standard No. 61 was developed by a consortium and with support from the U.S. Environmental Protection Agency under cooperative agreement No. CR-812144:

- 2"-24" Red Thread II Pipe and Fittings
- 1"-36" Green Thread Pipe and Fittings
- 3033 and 8000 Series (Epoxy Adhesive)
- F-Chem Pipe (1)
- F-Chem Fittings (1)

(1) Piping greater than 14" diameter using NSF Listed resin system.

Underwriters Laboratories Inc. (UL) and Underwriters' Laboratories of Canada (ULC)
Red Thread II pipe and compatible primary fittings, along with secondary containment pipe and fittings, and adhesives are listed for use in conveying petroleum products, alcohols, and alcohol-gasoline mixtures including ethanol, methanol and MTBE underground (UL). The primary pipe sizes are 2", 3" and 4"; the secondary containment pipe and fittings sizes are 3", 4", and 6".

These products are listed for use in conveying petroleum products, gasoline mixtures and up to 100% ethanol underground (ULC).

TABLE 6.1 Table for Use in Classifying Fiberglass Flanges to ASTM D4024

	Type	Grade	Class	Pressure Rating Designation*	Property Designation
Filament Wound (FW)	1				
Compression Molded	2				
Resin-Transfer Molded	3				
Centrifugally Cast	4				
Epoxy Resin		1			
Polyester Resin		2			
Furan Resin		3			
Integrally-Molded (mfg. on pipe/fitting)			1		
Taper to Taper Adhesive Joint			2		
Straight to Taper Adhesive Joint			3		
Straight Adhesive Joint			4		
*Gauge Pressure (psig) 50				A	
(Flanges must withstand a pressure 100				B	
of 4 times the rating without damage 150				C	
to the flange) 200				D	
250				E	
300				F	
400				G	
500				H	

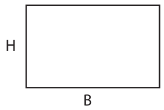
PROPERTY	0	1	2	3	4	5	6	7	8
Burst Pressure (psig)	(unspecified)	200	400	600	800	1000	1200	1600	2000
Sealing Test Pressure (psig)		75	150	225	300	375	450	600	750
Bolt Torque Limit (ft.•lbs.)		20	30	50	75	100	125	150	200

TABLE 6.2 Classifying Fiberglass Pipe

		ASTM D2310					ASTM D2996				ASTM D2997			
		Type	Grade	Class	Hoop Stress HDB D2992	Test-End Closures D2992	Short Term Burst D1599	Longit. Tensile Strength D2105	Tensile Modulus x 10^6 D2105	Stiffness Factor @ 5% Defl D2412	Short Term Burst D1599	Longit. Tensile Strength D2105	Tensile Modulus x 10^6 D2105	Pipe Stiffness 5% Defl D2412
Filament Wound (FW)		1												
Centrifugally Cast (CC)		2												
Glass Fiber Reinforced Epoxy Resin			1											
Glass Fiber Reinforced Polyester Resin			2											
Glass Fiber Reinforced Phenolic Resin			3											
Glass Fiber Reinforced Furan Resin			7											
No Liner				A										
Polyester Resin Liner (Non-Reinforced)				B										
Epoxy Resin Liner (Non-Reinforced)				C										
Phenolic Resin Liner (Non-Reinforced)				D										
Polyester Resin Liner (Reinforced)				E										
Epoxy Resin Liner (Reinforced)				F										
Phenolic Resin Liner (Reinforced)				G										
Thermoplastic Resin Liner (Specify)				H										
Furan Resin Liner (Reinforced)				I										
Cyclic Values	2500				A									
(Determined by D2992 Procedure A)	3150				B									
	4000				C									
	5000				D									
	6300				E									
	8000				F									
	10000				G									
	12500				H									
Static Values	5000				Q									
(Determined by D2992 Procedure B)	6300				R									
	8000				S									
	10000				T									
	12500				U									
	16000				W									
	20000				X									
	25000				Y									
	31500				Z									
Free End						1								
Restrained End						2								
Number in Last Four Positions	0						(Unspecified)							
	1						10000	8000	1	40	4000	2000	0.6	9
	2						30000	15000	2	200	12000	8000	1.3	18
	3						40000	25000	3	1000	22000	16000	1.5	36
	4						50000	35000	4	1500	30000	22000	1.9	72
	5						60000	45000	5	2000	40000	30000	2.5	144
	6						70000	55000	6	2500	50000	40000	3.0	288
Examples:														
2"-8" Green Thread Pipe	RTRP 11FY1-3112	FW	Epoxy	Epoxy-Re	25000	Free End	40000	10300	1.8	200				
10"-12" CL-2030	RTRP-22BS-4444	CC	Polyester	Poly-Re	8000	-					30000	22000	2.1	73

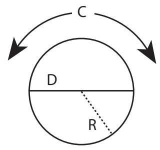
APPENDIX A

Geometric Properties: A = Area; A1 = Surface area of solids; V = Volume; C = Circumference



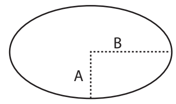
Rectangle

$A = HB$



Circle

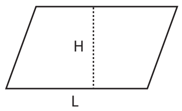
$A = \pi R^2$
$C = \pi D$
$R = D / 2$



Ellipse

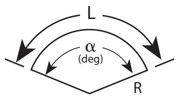
$A = \pi AB$

$C = 2\pi \sqrt{\frac{A^2 + B^2}{2}}$



Parallelogram

$A = HL$



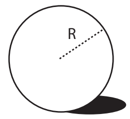
Sector of Circle

$A = \pi R^2 \frac{\alpha}{360}$

$L = \pi R \frac{\alpha}{180}$

$\alpha = 57.296 \frac{L}{R}$

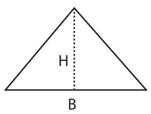
$R = 57.296 \frac{L}{\alpha}$



Sphere

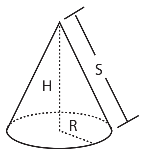
$A = 4\pi R^2$

$V = \frac{4\pi R^3}{3}$



Triangle

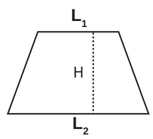
$A = \frac{BH}{2}$



Cone

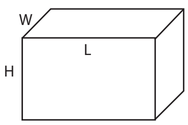
$A = \pi R(S + R)$

$V = \frac{\pi}{3} R^2 H$



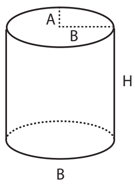
Trapezoid

$A = H \frac{L_1 + L_2}{2}$



Rectanglular Solid

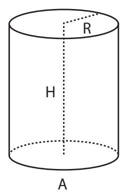
$A1 = 2 (WL + LH + HW)$
$V = WLH$



Elliptical Tanks

$A1 = 2\pi \left(AB + H\sqrt{\frac{A^2 + B^2}{2}} \right)$

$V = \pi ABH$



Cylinder

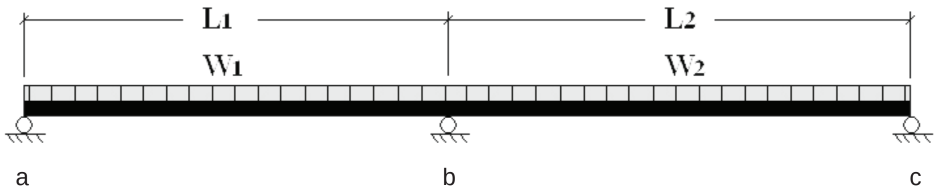
$A1 = 2\pi R(H + R)$
$V = \pi HR^2$

For Above Containers:

Capacity in gallons = $\frac{V}{231}$ when V is in cubic inches   Capacity in gallons = 7.48 x V when V is in cubic feet

SUPPORT SPANS

“Three Moment Equation" for a uniformly loaded continuous beam.

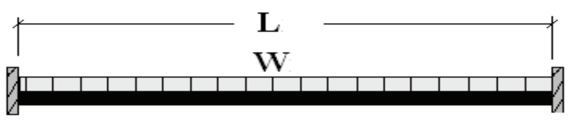


$$\frac{M_a \cdot L_1}{E_1 \cdot I_1} + 2 \cdot M_b \cdot \left(\frac{L_1}{E_1 \cdot I_1} + \frac{L_2}{E_2 \cdot I_2} \right) + \frac{M_c \cdot L_2}{E_2 \cdot I_2} + \frac{W_1 \cdot L_1^{3}}{4 \cdot E_1 \cdot I_1} + \frac{W_2 \cdot L_2^{3}}{4 \cdot E_2 \cdot I_2} = 0$$

Where:

Ma = Internal moment at support A, in-lb(N-m)
Mb = Internal moment at support B, in-lb(N-m)
Mc = Internal moment at support C, in-lb(N-m)
L_n = Span "n" length, in(m)
I_n = Span "n" area moment of inertia, $in^4(m^4)$
W_n = Span "n" uniformly distributed load, lb/in(N/m)
E_n = Span "n" modulus of elasticity, $lb/in^2(N/m^2)$
n = 1,2

“Fixed-Fixed Beam Equation" for a uniformly loaded beam.



Maximum Deflection, in(m)

$$\delta max := \frac{W \cdot L^4}{384 \cdot E \cdot I}$$

Maximum Moment, in-lb (n-m)

$$Mmax := \frac{W \cdot L^2}{12}$$

Where:

W = Uniformly distributed load, lb/in(N/m)
L = Span length in(m)
I = Area moment of inertia, $in^4(m^4)$
E = Modulus of elasticity, $lb/in^2(N/m^2)$

WATER HAMMER

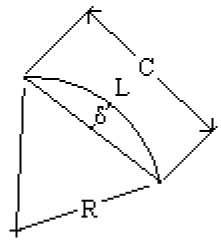
$$P := \rho \cdot \left[Ev \cdot t \cdot \frac{E}{\rho \cdot (t \cdot E + D \cdot Ev)} \right]^{0.5} \cdot \delta V$$

Talbot Equation for calculating the surge pressure due to an instantaneous change in flow velocity.

Where:

P = Pressure surge, lb/in^2 (N/m^2)
r = Mass density, lb/in^3 (kg/m^3)
En = Volume modulus compressibility of fluid, lb/in^2 (N/m^2)
E = Hoop modulus of elasticity of pipe wall, lb/in^2 (N/m^2)
t = Pipe wall thickness, in (m)
D = Pipe inner diameter, in (m)
dV = Change in velocity, ft/sec (m/sec)

GEOMETRIC RELATIONSHIPS FOR MINIMUM BENDING RADIUS



$$\delta = R \cdot \left(1 - \cos\left(\frac{L}{2 \cdot R}\right)\right)$$

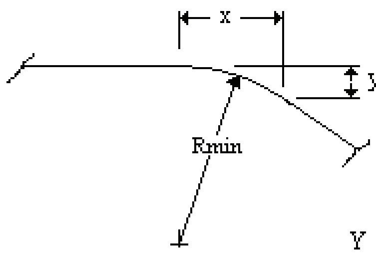
$$C = 2 \cdot R \cdot \sin\left(\frac{L}{2 \cdot R}\right)$$

Where:

- L = pipe length, ft(m)
- R = minimum bend radius, ft(m)
- δ = maximum offset deflection, ft(m)
- C = chord length, ft(m)

(trigonometric functions based on radians)

MINIMUM BENDING RADIUS OFFSET FORMULA



$$Y = R \cdot \left(1 - \cos\left(\operatorname{asin}\left(\frac{X}{R}\right)\right)\right)$$

Where:

- X = Run, ft(m)
- Y = Offset, ft(m) n)
- R = minimum bend radius, ft(m)

(trigonometric function based on radians)

Table A.1 Water Pressure to Feet of Head

Pressure Lb/In^2	Head Feet	Pressure Lb/In^2	Head Feet
1	2.31	100	230.90
2	4.62	110	253.98
3	6.93	120	277.07
4	9.24	130	300.16
5	11.54	140	323.25
6	13.85	150	346.34
7	16.16	160	369.43
8	18.47	170	392.52
9	20.78	180	415.61
10	23.09	200	461.78
15	34.63	250	577.24
20	46.18	300	692.69
25	57.72	350	808.13
30	69.27	400	922.58
40	92.36	500	1154.48
50	115.45	600	1385.39
60	138.54	700	1616.30
70	161.63	800	1847.20
80	184.72	900	2078.10
90	207.81	1000	2309.00

Note: One pound of pressure per square inch of water equals 2.309 feet of water at 62°F. Therefore, to find the feet head of water for any pressure not given in the table above, multiply the pressure pounds per square inch by 2.309.

Table A.2 Feet of Head of Water to psi

Head Feet	Pressure Lb/In^2	Head Feet	Pressure Lb/In^2
1	0.43	100	43.31
2	0.87	110	47.64
3	1.30	120	51.97
4	1.73	130	56.30
5	2.17	140	60.63
6	2.60	150	64.96
7	3.03	160	69.29
8	3.46	170	73.63
9	3.90	180	77.96
10	4.33	200	86.62
15	6.50	250	108.27
20	8.66	300	129.93
25	10.83	350	151.58
30	12.99	400	173.24
40	17.32	500	216.55
50	21.65	600	259.85
60	25.99	700	303.16
70	30.32	800	346.47
80	34.65	900	389.78
90	38.98	1000	433.00

Note: One foot of water at 62°F equals 0.433 pound pressure per square inch. To find the pressure per square inch for any feet head not given in the table above, multiply the feet head by 0.433.

Table A.3 Dry Saturated Steam Pressure

ABS Press., Lb/In^2	Temp °F	ABS Press., Lb/In^2	Temp °F
0.491	79.03	30	250.33
0.736	91.72	35	259.28
0.982	101.14	40	267.25
1.227	108.71	45	274.44
1.473	115.06	50	281.01
1.964	125.43	55	287.07
2.455	133.76	60	292.71
5.000	162.24	65	297.97
10.000	193.21	70	302.92
14.696	212.00	75	307.60
15.000	213.03	80	312.03
16.000	216.32	85	316.25
18.000	222.41	90	320.27
20.000	227.96	100	327.81
25.000	240.07	110	334.77

Table A.4 Specific Gravity of Gases
(At 60°F and 29.92 Hg)

Dry Air (1 ft^3 at 60°F. and 29.92" Hg. weighs 0.07638 Lb)		1.000
Acetylene	C_2H_2	0.91
Ethane	C_2H_6	1.05
Methane	CH_4	0.554
Ammonia	NH_3	0.596
Carbon-dioxide	CO_2	1.53
Carbon-monoxide	CO	0.967
Butane	C_4H_{10}	2.067
Butane	C_4H_8	1.93
Chlorine	Cl_2	2.486
Helium	He	0.138
Hydrogen	H_2	0.0696
Nitrogen	N_2	0.9718
Oxygen	O_2	1.1053

Table A.5 Specific Gravity of Liquids

Liquid	Temp °F	Specific Gravity
Water (1 ft^3 weighs 62.41 lb.)	50	1.00
Brine (Sodium Chloride 25%)	32	1.20
Pennsylvania Crude Oil	80	0.85
Fuel Oil No. 1 and 2	85	0.95
Gasoline	80	0.74
Kerosene	85	0.82
Lubricating Oil SAE 10-20-30	115	0.94

Table A.6 Weight of Water

1 cu. ft. at 50°F	weighs 62.41 lb.
1 gal. at 50°F	weighs 8.34 lb.
1 cu. ft. of ice	weighs 57.2 lb.
1 cu. ft. at 39.2°F	weighs 62.43 lb.

Water is at its greatest density at 39.2°F

Table A.7 Conversion Factors

Pressure

1 in. of mercury	= 345.34 kg/m^2
	= 0.0345 kg/cm^2
	= 0.0334 bar
	= 0.491 lb/in^2
1 lb. per sq. in.	= 2.036 in head of mercury
	= 2.309 ft head of water
	= 0.0703 kg/cm^2
	= 0.0690 bar
	= 6894.76 pascals
1 pascal	= 1.0 newton/m^2
	= 9.8692 x 10^{-6} atmospheres
	= 1.4504 x 10^{-4} lb/in^2
	= 4.0148 x 10^{-3} in. head of water
	= 7.5001 x 10^{-4} cm. head of mercury
	= 1.0200 x 10^{-5} kg/m^2
	= 1.0 x 10^{-5} bar
1 atmosphere	= 101,325 pascals
	= 1,013 milibars
	= 14.696 lbs/in^2

Temperature

° C.	= (°F-32) x 5/9

Weight of Liquid

1 gal. (U.S.)	= 8.34 lb. x Sg
1 cu. ft.	= 62.4 lb. x Sg
1 lb.	= 0.12 U.S. gal/Sg.
	= 0.016 ft^3/ Sg

Flow

1 gpm	= 0.134 ft^3/min
	= 500 lb/hr. x Sg
500 lb/hr.	= 1 gpm/Sg
1 ft^3/min	= 448.8 gal/hr

Work

1 Btu (mean)	= 778 ft lb
	= 0.293 watt hr
	= 1/180 of heat required to change temp of 1 lb water from 32°F to 212°F
1 hp-hr	= 2545 Btu
	= 0.746 kwhr
1 kwhr	= 3413 Btu
	= 1.34 hp hr

Power

1 Btu per hr.	= 0.293 watt
	= 12.96 ft lb/min
	= 0.00039 hp
1 ton refrigeration (U.S.)	= 288,000 Btu/24 hr
	= 12,000 Btu/hr
	= 200 Btu/min
	= 83.33 lb ice melted per hr from and at 32°F
	= 2000 lb. ice melted per 24 hr. from and at 32°F
1 hp	= 550 ft lb/s
	= 746 watt
	= 2545 Btu/hr
1 boiler hp	= 33,480 Btu/hr
	= 9.8 kw
1 kw.	= 3413 Btu/hr

Mass

1 lb. (avoir.)	= 16 oz. (avoir.)
	= 7000 grain
1 ton (short)	= 2000 lb
1 ton (long)	= 2240 lb

Volume

1 gal. (U.S.)	= 128 f. oz. (U.S.)
	= 231 in^3
	= 0.833 gal (British)
1 cu. ft.	= 7.48 gal (U.S.)

NOTES

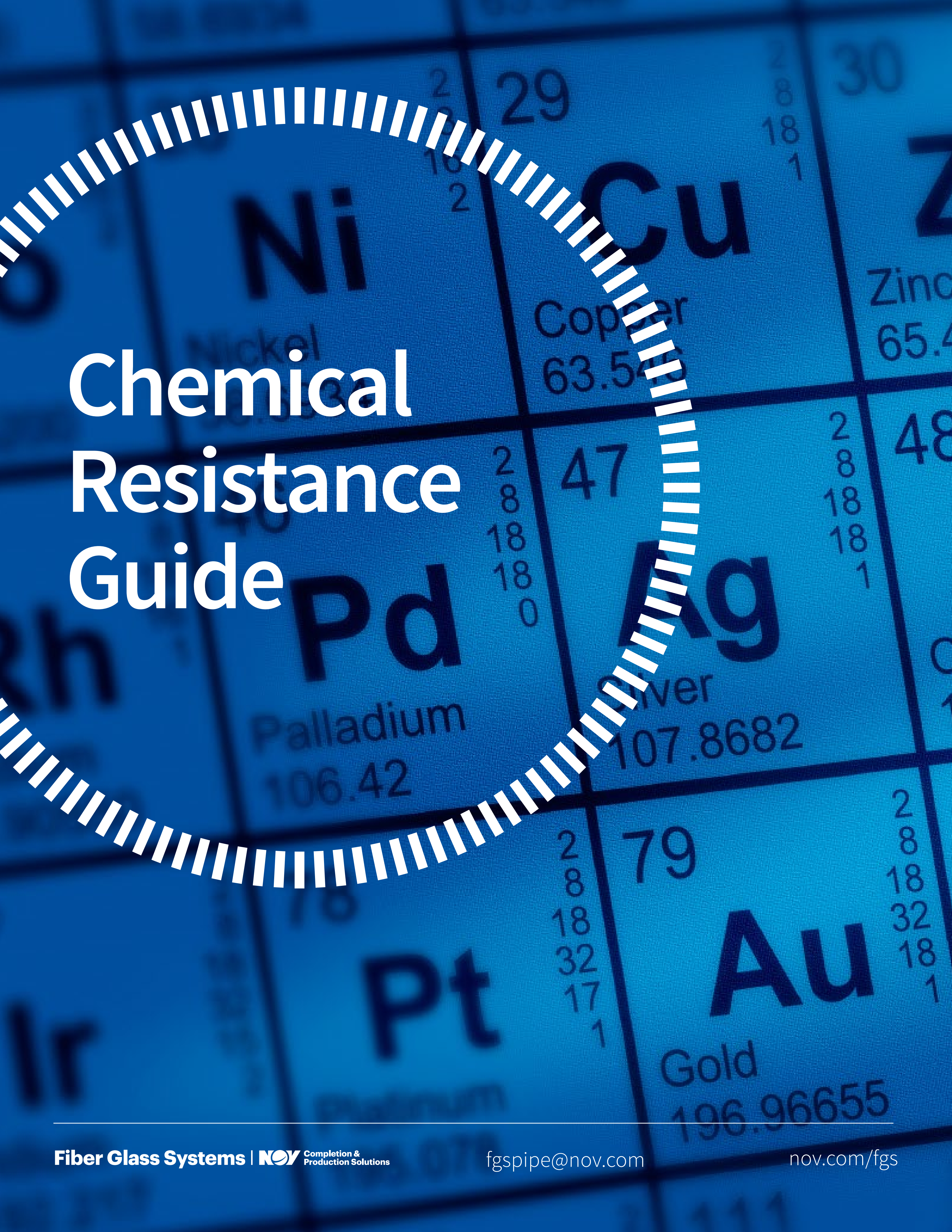
2700 West 65th Street
Little Rock, Arkansas 72209
Phone: 1 (501) 568-4010

25 S. Main Street
Sand Springs, Oklahoma 74063
1 (918) 245-6651

NOV Fiber Glass Systems

ENG 1000 March 2011

Chemical Resistance Guide



Introduction

This guide is intended for use only as a reference in evaluating NOV Fiber Glass Systems piping systems. It should be used for a general indication of chemical resistance. NOV Fiber Glass Systems data indicates that the pipe and fittings listed are suitable for the services as recommended. However, due to varying conditions encountered in usage from plant to plant, the data should be considered as a recommendation and not as a guarantee. NOV Fiber Glass Systems offers a limited warranty of its products, which is in the Terms and Conditions of Sale. This data does not take into account chemical mixtures, thermal-mechanical or associated loading or stress combinations. Accordingly, the end-user of the fiberglass products assumes the responsibility and risk for proper evaluation, selection, use, and performance of the products in its particular application.

Basis of Chemical Resistance Recommendations

The information contained in this literature is based on corrosion resistance testing, field experience, published information, and NOV Fiber Glass Systems engineering judgment. Corrosion resistance testing includes the pipe, fittings and adhesive used in NOV Fiber Glass Systems piping systems. There are many successful installations that form the basis of the field experience and engineering judgment recommendations. NOV Fiber Glass Systems products must be installed and used in accordance with proven practice and common sense. Corrosion barrier and total wall thickness may affect service life in aggressive chemical or abrasive applications.

Unlisted Applications and Combinations of Chemicals

NOV Fiber Glass Systems piping is being used in many applications containing other chemicals, solvents, and combinations of chemicals not listed in this literature. These applications should be reviewed with the factory for evaluations of the chemicals, their concentrations, temperatures, frequency of use, and other factors that may determine our suitability to provide economic service life. Extra care should be taken when there are combinations of chemicals as some combinations may be more aggressive than their constituent parts. Trace amounts of some chemicals can affect the piping service life.

Process Drains and Combined Waste Systems

Due to the inherent chemical resistance of NOV Fiber Glass Systems piping systems, they are widely used in aggessive process drains and combined waste systems. For these systems and other intermittent conditions, the products may be used outside of the ratings published in this chemical guide. Please contact Applications Engineering for specific recommendations.

General Notes

NR = Not Recommended, except for very low concentrations. Contact NOV Fiber Glass Systems Application Engineering for further evaluation.

NT = Not Tested. Contact NOV Fiber Glass Systems Application Engineering for further evaluation.

When no concentration is shown, recommendations apply to any concentration to 100% or to saturation.

Spills or Upset Conditions

Flush the system immediately if spills or upsets exposes the piping to chemicals that have not been recommended.

Solvent Applications

Solvents may separate from the fluid stream in piping with static or low flow rates. The solvents will be concentrated and may damage piping not recommended for 100% concentrations. Flush the piping system immediately after shutdown to prevent solvent damage. Vent lines carrying solvent vapors can also have high concentrations of liquid solvent due to condensation. The condensation can affect the service life of systems not recommended for full concentrations.

Mixing Chemicals in the Piping System

Careful consideration should be given to the by-products of mixing chemicals. By-products of chemical reactions may aggressively corrode a piping system.

Abrasive Fluid

Piping is used successfully in many abrasive slurry applications. Products made especially for abrasive applications are available. Products selection is dependent on particle size, percent solids, particle hardness, flow rates and continuous or intermittent usage.

Regulations & Standards

Local, state, or federal regulations, or industry standards may govern the use of our products in particular applications and should be reviewed by the customer to assure compliance.

Trademarks

Bondstrand™, Red Thread™, Green Thread™ and Centricast™ piping systems and Key-Lock™ joints are trademark names of NOV Fiber Glass Systems.

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
1,1,2,2-Tetrachloroethane		NR	NR	NR	NR	120	49	150	66	NT	NT	NT	NT	NT	NT
1,1,1-Trichloroethane		120	49	120	49	125(2)	52(2)	175	79	120	49	80	27	NR	NR
2-Butoxyethoxyethanol		NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	80	27	NT	NT
2-Chlorophenol		NT	NT	NT	NT	NT	NT	100	38	NR	NR	NR	NR	NT	NT
Acetaldehyde		120	49	80	27	120	49	100	38	75	24	NR	NR	NR	NR
Acetamide		NR	NR	NR	NR	NR	NR	100	38	NR	NR	NR	NR	NT	NT
Acetic acid	≤ 10%	150	66	150	66	200	93	200	93	150(2)	66(2)	175	79	210	99
Acetic acid	10 ≤ 20%	150	66	150	66	200	93	200	93	150	66	175	79	210	99
Acetic acid	20 ≤ 50%	NT	NT	NT	NT	150	66	120	49	100	38	175	79	180	82
Acetic acid	50 ≤ 75%	NT	NT	NT	NT	75	24	75	24	75	24	150	66	110	43
Acetic acid	> 75%	NR	NR	NR	NR	75	24	75	24	75	24	100	38	NT	NT
Acetic acid, "glacial"		NT	NT	NT	NT	75	24	75	24	75	24	NR	NR	NT	NT
Acetic anhydride		NR	NR	NR	NR	NR	NR	100	38	NR	NR	NR	NR	NR	NR
Acetone	≤ 1%	150	66	150	66	150	66	200	93	150	66	150	66	NR	NR
Acetone	1 ≤ 10%	150	66	150	66	150	66	200	93	150	66	150	66	NR	NR
Acetone	> 10%	100	38	100	38	120	49	200	93	125	52	NR	NR	NR	NR
Acetonitrile		NT	NT	NT	NT	NT	NT	120	49	NR	NR	NR	NR	NR	NR
Acetophenone		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NR	NR
Acetyl chloride		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Acrylic acid	≤ 25%	NT	NT	NT	NT	120	49	120	49	NT	NT	100	38	NT	NT
Acrylic acid	25 ≤ 95%	NT	NT	NT	NT	100	38	100	38	NT	NT	75	24	NT	NT
Acrylonitrile		NT	NT	NT	NT	NT	NT	100	38	NT	NT	NT	NT	NR	NR
Air "wet or dry"		210	99	210	99	250	121	300	149	300	149	200	93	200	93
Allyl alcohol		NT	NT	NT	NT	NT	NT	150	66	100	38	75	24	NT	NT
Allyl chloride		100	38	100	38	120	49	NT	NT	NT	NT	NT	NT	NR	NR
Aluminum acetate	≤ 10%	NT	NT	NT	NT	NT	NT	275	135	250	121	150	66	150	66
Aluminum chloride (4)	Sat'd	210	99	210	99	225	107	275	135	250	121	200	93	200	93
Aluminum chlorohydroxide	≤ 50%	NT	NT	NT	NT	NT	NT	150	66	150	66	NT	NT	NR	NR
Aluminum fluoride	Sat'd	NR	NR	NR	NR	NR	NR	200	93	200	93	175	79	NT	NT

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Aluminum hydroxide	Sat'd	NR	NR	NR	NR	190	88	250	121	250	121	175	79	150	66
Aluminum nitrate		150	66	150	66	205	96	250	121	250	121	175	79	180	82
Aluminum potassium sulfate "alum"	Sat'd	210	99	210	99	225	107	275	135	250	121	200	93	200	93
Aluminum sulfate	Sat'd	210	99	210	99	225	107	275	135	250	121	200	93	200	93
Ammonia gas, "dry, anhydrous" [3]		150	66	150	66	225	107	275	135	150[2]	66[2]	100	38	100	38
Ammonia gas, "wet"		NT	NT	NT	NT	NT	NT	NT	NT	150[2]	66[2]	100	38	NT	NT
Ammonia, liquid		NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NR	NR	NT	NT
Ammonium acetate	≤ 65%	NT	NT	NT	NT	NT	NT	275	135	75	24	75	24	NT	NT
Ammonium bicarbonate	≤ 50%	180	82	180	82	220	104	200	93	180	82	150	66	150	66
Ammonium bicarbonate	Sat'd	150	66	150	66	180	82	225	107	225	107	125	52	NT	NT
Ammonium bisulfate	Sat'd	NT	NT	NT	NT	NT	NT	275	135	175	79	150	66	NT	NT
Ammonium bisulfate, "black liquor"		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	150	66	NT	NT
Ammonium bisulfate, "cook liquor"		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	150	66	NT	NT
Ammonium carbonate	≤ 50%	150	66	150	66	180	82	225	107	200	93	150	66	100	38
Ammonium carbonate	Sat'd	150	66	150	66	205	96	225	107	200	93	150	66	NT	NT
Ammonium chloride	≤ 25%	150	66	150	66	205	96	225	107	200	93	200	93	NT	NT
Ammonium chloride	Sat'd	150	66	150	66	205	96	225	107	200	93	200	93	200	93
Ammonium citrate	Sat'd	200	93	200	93	225	107	275	135	175	79	125	52	NT	NT
Ammonium fluoride	≤ 25%	NR	NR	NR	NR	75	24	150	66	150	66	125	52	NT	NT
Ammonium fluoride	Sat'd	NR	NR	NR	NR	75	24	100	38	100	38	125	52	NT	NT
Ammonium hydroxide	≤ 5%	120	49	120	49	150	66	200	93	150	66	150	66	150	66
Ammonium hydroxide	5 ≤ 10%	120	49	120	49	150	66	200	93	150	66	150	66	150	66
Ammonium hydroxide	10 ≤ 20%	120	49	120	49	125	52	200	93	150	66	150	66	150	66
Ammonium hydroxide	20 ≤ 29%	120	49	120	49	125	52	200	93	100	38	100	38	100	38
Ammonium hydroxide	Sat'd	120	49	120	49	125	52	175	79	NT	NT	NT	NT	NT	NT
Ammonium lauryl sulfate	≤ 30%	NT	NT	NT	NT	NT	NT	NT	NT	150	66	120	49	NT	NT
Ammonium molybdate		NT	NT	NT	NT	NT	NT	NT	NT	100	38	150	66	NT	NT
Ammonium nitrate	≤ 25%	210	99	200	93	225	107	275	135	250	121	200	93	200	93
Ammonium nitrate	Sat'd	210	99	200	93	225	107	210	99	250	121	175	79	200	93

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Ammonium pentaborate	≤ 12%	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	120	49	NT	NT
Ammonium persulfate	Sat'd	NR	NR	NR	NR	100	38	100	38	100	38	180	82	180	82
Ammonium phosphate	≤ 65%	150	66	150	66	200	93	225	107	180	82	200	93	150	66
Ammonium phosphate	Sat'd	150	66	150	66	200	93	225	107	180	82	150	66	150	66
Ammonium sulfate	Sat'd	200	93	200	93	225	107	275	135	250	121	200	93	200	93
Ammonium sulfide, "bisulfide"	Sat'd	NT	NT	NT	NT	NT	NT	100	38	100	38	120	49	NT	NT
Ammonium sulfite		NT	NT	NT	NT	NT	NT	150	66	NR	NR	NR	NR	NT	NT
Ammonium thiocyanate	≤ 20%	100	38	100	38	150	66	NT	NT	150	66	190	88	100	38
Ammonium thiocyanate	Sat'd	100	38	100	38	150	66	NT	NT	150	66	100	38	100	38
Ammonium thioglycolate	≤ 8%	NT	NT	NT	NT	NT	NT	NT	NT	100	38	90	32	NT	NT
Ammonium thiosulfate	Sat'd	100	38	100	38	150	66	NT	NT	100	38	90	32	100	38
Amyl acetate		75	24	75	24	120	49	150	66	NR	NR	NR	NR	NR	NR
Amyl alcohol		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	100	38	100	38
Amyl chloride		NR	NR	NR	NR	NR	NR	100	38	NR	NR	100	38	NR	NR
Aniline		NT	NT	NT	NT	NT	NT	150	66	75	24	NR	NR	NR	NR
Aniline hydrochloride		NT	NT	NT	NT	NT	NT	100	38	NR	NR	180	82	NT	NT
Aniline sulfate	Sat'd	NR	NR	NR	NR	NR	NR	100	38	NR	NR	200	93	NT	NT
Antimony pentachloride		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	90	32
Antimony trichloride		NR	NR	NR	NR	NR	NR	150	66	150	66	200	93	200	93
Aqua regia		NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Arsenic acid		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	100	38	180	82
Arsenious acid		NR	NR	NR	NR	NR	NR	100	38	NT	NT	NT	NT	NT	NT
Barium acetate	Sat'd	150	66	150	66	180	82	275	135	180	82	180	82	150	66
Barium bromide		NT	NT	NT	NT	NT	NT	NT	NT	100	38	200	93	NT	NT
Barium carbonate	Sat'd	210	99	200	93	225	107	275	135	250	121	200	93	200	93
Barium chloride	Sat'd	210	99	210	99	225	107	275	135	250	121	200	93	200	93
Barium cyanide		NT	NT	NT	NT	NT	NT	NT	NT	200	93	150	66	NT	NT
Barium hydroxide	≤ 10%	180	82	180	82	200	93	225	107	210	99	200	93	150	66
Barium hydroxide	>10%	NT	NT	NT	NT	NT	NT	225	107	200	93	150	66	NT	NT

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Barium nitrate		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	150	66
Barium sulfate	Sat'd	NT	NT	NT	NT	NT	NT	275	135	250	121	200	93	200	93
Barium sulfide	Sat'd	210	99	210	99	225	107	275	135	250	121	200	93	NT	NT
Beer		210	99	200	93	225	107	250	121	200	93	200	93	150	66
Benzaldehyde		NR	NR	NR	NR	NR	NR	200	93	NT	NT	NT	NT	NR	NR
Benzene hydrochloric acid, "wet"		NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NT	NT
Benzene in kerosene	≤ 5%	NT	NT	NT	NT	NT	NT	NT	NT	200	93	200	93	NT	NT
Benzene sulfonic acid	≤ 50%	NT	NT	NT	NT	NT	NT	100	38	100	38	125	52	200	93
Benzene sulfonic acid	50 ≤ 75%	NT	NT	NT	NT	NT	NT	100	38	NR	NR	100	38	200	93
Benzene sulfonic acid	> 75%	NT	NT	NT	NT	NT	NT	75	24	NR	NR	100	38	200	93
Benzene		120[(2)]	49[(2)]	120[(2)]	49[(2)]	150[(2)]	66[(2)]	180[(2)]	82[(2)]	125	52	NR	NR	NR	NR
Benzoic acid	Sat'd	100	38	100	38	150	66	200	93	200	93	200	93	200	93
Benzyl alcohol		NT	NT	NT	NT	NT	NT	150	66	NR	NR	NR	NR	NT	NT
Benzyl chloride		NT	NT	NT	NT	NT	NT	150	66	NR	NR	NR	NR	NT	NT
Benzyltrimethylammonium chloride	≤ 60%	NT	NT	NT	NT	NT	NT	NT	NT	150	66	100	38	NT	NT
Biodiesel		210	99	210	99	225	107	275	135	250	121	180	82	NT	NT
Black liquor, "pulp mill"		150	66	125	52	225	107	230	110	180	82	180	82	180	82
Borax		200	93	200	93	225	107	275	135	250	121	200	93	200	93
Boric acid		200	93	200	93	225	107	250	121	200	93	200	93	200	93
Brass plating solution		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	150	66	NT	NT
Brine "< 20% salts"		210	99	190	88	225	107	275	135	250	121	200	93	200	93
Bromic acid		NT	NT	NT	NT	NT	NT	NT	NT	150	66	NR	NR	NT	NT
Brominated phosphate ester		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT
Bromine, "dry gas"		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	100	38	NR	NR
Bromine, "liquid"		NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Bromine, "wet gas"		NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Bromine water	≤ 1%	200	93	NT	NT	200	93	75	24	100	38	100	38	NT	NT
Bromine water	≤ 5%	NT	NT	NT	NT	NT	NT	75	24	100	38	100	38	NT	NT
Bromoform		NR	NR	NR	NR	NR	NR	185	85	NT	NT	NT	NT	NT	NT

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Brown stock		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	100	38	NT	NT
Butadiene, "gas"		NR	NR	NR	NR	NR	NR	200	93	100	38	100	38	100	38
Butane		75	24	75	24	75	24	100	38	180	82	100	38	100	38
Butanol		See Butyl alcohol													
Butyl acetate		75	24	75	24	150	66	175	79	100	38	NR	NR	NR	NR
Butyl acrylate		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT
Butyl alcohol	< 10%	120	49	120	49	150	66	200	93	120	49	120	49	100	38
Butyl alcohol	> 10%	120	49	120	49	150	66	200	93	NT	NT	NT	NT	100	38
Butyl benzoate	≤ 70%	NT	NT	NT	NT	NT	NT	200	93	NR	NR	NR	NR	NT	NT
Butyl benzyl phthalate [4]		NT	NT	NT	NT	NT	NT	125	52	125	52	100	38	NT	NT
Butyl carbitol diethylene glycol		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	80	27	NT	NT
Butyl cellosolve		150	66	150	66	150	66	175	79	150	66	100	38	NR	NR
Butyl phthalate		NT	NT	NT	NT	NT	NT	125	52	NT	NT	NT	NT	NT	NT
Butylene glycol		150	66	150	66	150	66	250	121	200	93	150	66	NT	NT
Butyraldehyde		NT	NT	NT	NT	NT	NT	150	66	150	66	NR	NR	NR	NR
Butyric acid	< 25%	150	66	150	66	200	93	100	38	150	66	175	79	180	82
Butyric acid	25 ≤ 50%	150	66	150	66	200	93	100	38	150	66	150	66	160	71
Cadmium chloride	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	220	104	180	82	NT	NT
Cadmium cyanide plating solution		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	150	66	NT	NT
Calcium bisulfate		NT	NT	NT	NT	NT	NT	250	121	250	121	180	82	200	93
Calcium bisulfite	Sat'd	NR	NR	NR	NR	NR	NR	100	38	200	93	180	82	180	82
Calcium bromide		NT	NT	NT	NT	NT	NT	NT	NT	210	99	200	93	NT	NT
Calcium carbonate	Sat'd	150	66	150	66	205	96	275	135	250	121	150	66	180	82
Calcium chlorate	Sat'd	180	82	125	52	180	82	200	93	200	93	200	93	200	93
Calcium chloride	Sat'd	210	99	210	99	225	107	275	135	250	121	200	93	200	93
Calcium hydroxide	≤ 15%	NR	NR	NR	NR	150	66	225	107	200	93	150	66	180	82
Calcium hydroxide	15 ≤ 50%	NR	NR	NR	NR	150	66	NT	NT	200	93	150	66	180	82
Calcium hydroxide	> 50%	NR	NR	NR	NR	150	66	NT	NT	200	93	175	79	180	82
Calcium hypochlorite	≤ 10%	NT	NT	NT	NT	NT	NT	NT	NT	100	38	160[1][8]	71[1][8]	160	71

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Calcium hypochlorite	Sat'd	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	160 (1)(8)	71 (1)(8)	160	71
Calcium nitrate	Sat'd	150	66	150	66	205	96	275	135	250	121	200	93	200	93
Calcium phosphate		NT	NT	NT	NT	NT	NT	250	121	250	121	180	82	200	93
Calcium sulfate	Sat'd	200	93	200	93	225	107	275	135	250	121	200	93	200	93
Calcium sulfite	Sat'd	NT	NT	NT	NT	NT	NT	100	38	225	107	180	82	NT	NT
Cane sugar liquor	Sat'd	200	93	200	93	225	107	250	121	225	107	180	82	NT	NT
Capric acid		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	80	27	NT	NT
Caprylic acid	Sat'd	NT	NT	NT	NT	NT	NT	225	107	NR	NR	150	66	NT	NT
Carbo wax		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	150	66	NT	NT
Carbolic acid		See Phenol													
Carbon dioxide, "dry gas"	(1)	210	99	210	99	225	107	275	135	250	121	200	93	200	93
Carbon dioxide, "wet acidic"	(1)	150	66	150	66	150	66	200	93	150	66	150	66	160	71
Carbon disulfide		120	49	120	49	120	49	150	66	(1)	(1)	NR	NR	NR	NR
Carbon monoxide		NT	NT	NT	NT	NT	NT	250	121	250	121	200	93	200	93
Carbon tetrachloride		150	66	125	52	150	66	175	79	100	38	125	52	NR	NR
Carbonic acid		150	66	150	66	150	66	200	93	150	66	150	66	160	71
Carboxyethyl cellulose	≤ 10%	NT	NT	NT	NT	NT	NT	NT	NT	75	24	150	66	NT	NT
Carboxymethyl cellulose	≤ 10%	NT	NT	NT	NT	NT	NT	NT	NT	75	24	150	66	NT	NT
Cascade detergent in solution		NT	NT	NT	NT	NT	NT	NT	NT	100	38	180	82	NT	NT
Castor oil		210	99	210	99	225	107	250	121	200	93	160	71	75	24
Cellosolve		NT	NT	NT	NT	NT	NT	150	66	NR	NR	NR	NR	NT	NT
Chlorinated water		See Water, chlorinated													
Chlorinated wax		NT	NT	NT	NT	NT	NT	150	66	75	24	125	52	NT	NT
Chlorine dioxide	≤ 15%	NT	NT	NT	NT	150	66	150	66	75	24	150	66	NT	NT
Chlorine dioxide	> 15%	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT	NT	NT
Chlorine gas, "dry" (3)		NR	NR	NR	NR	NR	NR	NR	NR	125	52	200	93	200	93
Chlorine gas, "wet" (3)(1)		NR	NR	NR	NR	NR	NR	NR	NR	100	38	200	93	200	93
Chlorine liquid		NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NR	NR	NT	NT
Chlorine saturated brine (5)		NT	NT	NT	NT	NT	NT	75	24	NR	NR	NT	NT	NT	NT

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Chloroacetic acid	≤ 10%	100	38	100	38	120	49	150	66	100	38	100	38	100	38
Chloroacetic acid	10 ≤ 25%	NT	NT	NT	NT	NT	NT	100	38	100	38	100	38	100	38
Chloroacetic acid	25 ≤ 50%	NT	NT	NT	NT	NT	NT	100	38	NR	NR	75	24	100	38
Chloroacetic acid, "glacial"		NT	NT	NT	NT	NT	NT	100	38	NR	NR	NR	NR	NT	NT
Chlorobenzene		200(2)	93(2)	200(2)	93(2)	200(2)	93(2)	200	93	NT	NT	NR	NR	NR	NR
Chloroform		NR	NR	NR	NR	NR	NR	185	85	100(1)	38(1)	NR	NR	NR	NR
Chloromethane		See Methyl chloride													
Chloropicrin		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Chlorosulfonic acid		NR	NR	NR	NR	NR	NR	75	24	NR	NR	NR	NR	NR	NR
Chrome alum		NT	NT	NT	NT	NT	NT	200	93	200	93	180	82	200	93
Chromic acid	≤ 5%	NR	NR	NR	NR	120	49	75	24	120	49	100	38	100	38
Chromic acid	5 ≤ 10%	NR	NR	NR	NR	120	49	75	24	100	38	100	38	100	38
Chromic acid	10 ≤ 15%	NR	NR	NR	NR	NR	NR	75	24	75	24	100	38	100	38
Chromic acid	15 ≤ 20%	NR	NR	NR	NR	NR	NR	NR	NR	75	24	100	38	100	38
Chromic acid	> 20%	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Chromic flouride		NT	NT	NT	NT	NT	NT	NT	NT	75	24	75	24	NT	NT
Chromium plate		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	100	38	NT	NT
Chromium sulfate	Sat'd	NT	NT	NT	NT	NT	NT	100	38	125	52	180	82	NT	NT
Cinnamaldehde	≤ 50%	NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT
Cinnamic acid	≤ 50%	NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	100	38	NT	NT
Cinnamyl alcohol	≤ 50%	NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT
Citric acid	≤ 15%	210	99	210	99	225	107	225	107	150	66	150	66	200	93
Citric acid	Sat'd	210	99	210	99	225	107	225	107	200	93	180	82	200	93
Cobalt chloride		NT	NT	NT	NT	NT	NT	NT	NT	200	93	180	82	NT	NT
Coca-Cola, "syrup"		100	38	100	38	150	66	NR	NR	NT	NT	NR	NR	NT	NT
Coconut oil		200	93	200	93	225	107	275	135	100	38	180	82	NT	NT
Copper acetate		NT	NT	NT	NT	NT	NT	200	93	NT	NT	NT	NT	160	71
Copper brite plating, "caustic-cyanide"		NT	NT	NT	NT	NT	NT	100	38	NR	NR	NR	NR	NT	NT
Copper carbonate		NT	NT	NT	NT	NT	NT	200	93	NT	NT	NT	NT	NT	NT
Copper chloride	Sat'd	150	66	150	66	205	96	225	107	250	121	200	93	200	93

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Copper cyanide	Sat'd	150	66	150	66	205	96	225	107	140	60	200	93	200	93
Copper fluoride	Sat'd	NT	NT	NT	NT	200	93	225	107	250	121	175	79	NT	NT
Copper matte dipping bath		NT	NT	NT	NT	NT	NT	200	93	NR	NR	NR	NR	NT	NT
Copper nitrate	Sat'd	150	66	150	66	200	93	210	99	200	93	200	93	200	93
Copper pickling bath, "ferric sulfate"	≤ 10%	NR	NR	NR	NR	NT	NT	150	66	NR	NR	200	93	NT	NT
Copper plating solution, "cyanide based"		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	150	66	NT	NT
Copper plating solution, fluoroborate		NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NR	NR	NT	NT
Copper sulfate	Sat'd	150	66	150	66	200	93	250	121	200	93	200	93	210	99
Corn oil		200	93	200	93	225	107	275	135	200	93	200	93	NT	NT
Corn starch, slurry		200	93	200	93	225	107	275	135	NT	NT	NT	NT	NT	NT
Corn sugar/syrup		200	93	200	93	225	107	250	121	220	104	180	82	NT	NT
Cottonseed oil		200	93	200	93	225	107	275	135	200	93	210	99	NT	NT
Cresol	≤ 5%	75	24	75	24	120	49	200	93	NT	NT	NT	NT	NT	NT
Cresol	5 ≤ 10%	NR	NR	NR	NR	75	24	200	93	NT	NT	NT	NT	NT	NT
Cresol	> 10%	NR	NR	NR	NR	NT	NT	200	93	NT	NT	NT	NT	NT	NT
Cresylic acid		NR	NR	NR	NR	NR	NR	100	38	NR	NR	NT	NT	NR	NR
Crude oil, "sweet or sour"		210	99	210	99	225	107	275	135	250	121	200	93	200	93
Cupric chloride	≤ 50%	NT	NT	NT	NT	NT	NT	200	93	NT	NT	NT	NT	NT	NT
Cupric fluoride		150	66	150	66	200	93	250	121	200	93	180	82	200	93
Cupric nitrate		180	82	180	82	220	104	250	121	220	104	180	82	200	93
Cupric sulfate		180	82	180	82	220	104	250	121	220	104	180	82	200	93
Cyclohexane		NT	NT	NT	NT	NT	NT	175	79	NR	NR	110	43	120	49
Cyclohexanol		NT	NT	NT	NT	NT	NT	200	93	NT	NT	NT	NT	NR	NR
Cyclohexanone		NT	NT	NT	NT	NT	NT	125	52	NT	NT	NT	NT	NT	NT
Decanoic acid		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	80	27	NT	NT
Detergents, "sulfonated"		NT	NT	NT	NT	NT	NT	275	135	200	93	150	66	NT	NT
Diacetone alcohol		NT	NT	NT	NT	NT	NT	NT	NT	150	66	NR	NR	NR	NR
Diallyl phthalate		NT	NT	NT	NT	NT	NT	150	66	NR	NR	150	66	150	66
Di-ammonium phosphate	≤ 65%	NT	NT	NT	NT	NT	NT	275	135	150	66	150	66	NT	NT

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Dibromophenol		NT	NT	NT	NT	NT	NT	100	38	NR	NR	NR	NR	NT	NT
Dibutyl carbitol		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	75	24	NT	NT
Dibutyl ether		NT	NT	NT	NT	NT	NT	125	52	NR	NR	75	24	NT	NT
Dibutyl phthalate		120	49	120	49	180	82	200	93	200	93	175	79	180	82
Dibutyl sebacate		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT
Dicalcium phosphate		NT	NT	NT	NT	NT	NT	150	66	150	66	120	49	120	49
Dichloroacetaldehyde		NT	NT	NT	NT	NT	NT	100	38	NR	NR	NR	NR	NR	NR
Dichloroacetic acid		NT	NT	NT	NT	NT	NT	100	38	NR	NR	NR	NR	NT	NT
Dichlorobenzene		150	66	150	66	180	82	180	82	NT	NT	NT	NT	NR	NR
Dichloroethane		NT	NT	NT	NT	NT	NT	185	85	NR	NR	NR	NR	NT	NT
Dichloroethylene		NT	NT	NT	NT	NT	NT	185	85	75	24	NR	NR	NR	NR
Dichloromethane (methylene chloride)		See Methylene chloride													
Dichloromonomethane		NT	NT	NT	NT	NT	NT	125	52	NT	NT	NT	NT	NT	NT
Dichloropropane		NT	NT	NT	NT	NT	NT	185	85	NT	NT	NT	NT	NT	NT
Dichloropropionic acid		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT
Diesel fuel/bio-diesel		210	99	210	99	225	107	275	135	250	121	180	82	150	66
Diethanolamine		NT	NT	NT	NT	NT	NT	150	66	NR	NR	NR	NR	NR	NR
Diethyl benzene		NT	NT	NT	NT	NT	NT	185	85	NT	NT	NT	NT	NT	NT
Diethyl carbonate		NT	NT	NT	NT	NT	NT	100	38	NR	NR	NR	NR	NT	NT
Diethyl ether		NT	NT	NT	NT	NT	NT	100	38	NR	NR	NR	NR	NR	NR
Diethyl ketone		NT	NT	NT	NT	NT	NT	150	66	NR	NR	NR	NR	NR	NR
Diethyl sulfate		NT	NT	NT	NT	NT	NT	100	38	NR	NR	NR	NR	NT	NT
Diethylamine		NR	NR	NR	NR	NR	NR	100	38	NR	NR	NR	NR	NT	NT
Diethylene glycol		210	99	150	66	225	107	275	135	200	93	150	66	180	82
Diethylene triamine	≤ 10%	NR	NR	NR	NR	NR	NR	120	49	NT	NT	NT	NT	NT	NT
Diethylhexyl phosphoric acid, "20% kerosene"		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	150	66	NT	NT
Diisobutyl phthalate		NT	NT	NT	NT	NT	NT	175	79	NR	NR	100	38	NT	NT
Diisobutylene		NT	NT	NT	NT	NT	NT	225	107	NR	NR	80	27	NT	NT
Diisopropanolamine (DIPA)		NT	NT	NT	NT	NT	NT	120	49	NR	NR	110	43	NT	NT

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Dimethyl formamide		NR	NR	NR	NR	NR	NR	100	38	NR	NR	NR	NR	NR	NR
Dimethyl morpholine		NR	NR	NR	NR	NR	NR	100	38	NR	NR	NR	NR	NT	NT
Dimethyl phthalate		150	66	100	38	150	66	175	79	NR	NR	125	52	100	38
Dimethylamine		NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dioctyl phthalate (DOP)		150	66	150	66	150	66	175	79	NR	NR	125	52	NT	NT
Dioxane		NR	NR	NR	NR	75	24	125	52	NT	NT	NT	NT	NT	NT
Diphenyl ether		NT	NT	NT	NT	NT	NT	120	49	NT	NT	NR	NR	NR	NR
Diphenyl oxide		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT
Dipotassium phosphate	≤ 50%	NT	NT	NT	NT	NT	NT	NT	NT	150	66	100	38	NT	NT
Dipropylene glycol		150	66	150	66	200	93	275	135	200	93	150	66	150	66
Disodium methyl arsenate		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	100	38	100	38
Disodium phoshate	≤ 75%	NT	NT	NT	NT	NT	NT	150	66	150	66	100	38	NT	NT
Distillery stillage		NT	NT	NT	NT	NT	NT	175	79	NT	NT	NT	NT	NT	NT
Distillery syrup		NT	NT	NT	NT	NT	NT	175	79	NT	NT	NT	NT	NT	NT
Divinyl benzene		100(2)	38(2)	100(2)	38(2)	100(2)	38(2)	175	79	NT	NT	NT	NT	NT	NT
Dodecanol		See Dodecyl alcohol													
Dodecene		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	100	38	NT	NT
Dodecyl alcohol		NT	NT	NT	NT	NT	NT	225	107	NR	NR	125	52	NT	NT
Dodecyl benzene sulfonic acid		NT	NT	NT	NT	NT	NT	NT	NT	75	24	100	38	NT	NT
Dow Latex 2144		NT	NT	NT	NT	NT	NT	275	135	NT	NT	NT	NT	NT	NT
Dow Latex 560		NT	NT	NT	NT	NT	NT	275	135	NT	NT	NT	NT	NT	NT
Dow Latex 700		NT	NT	NT	NT	NT	NT	275	135	NT	NT	NT	NT	NT	NT
Dowanol EE		75	24	75	24	75	24	100	38	NT	NT	NT	NT	NT	NT
Dowanol EM		75	24	75	24	75	24	100	38	NT	NT	NT	NT	NT	NT
Dowfax 9N9-Surfactant		NT	NT	NT	NT	NT	NT	100	38	NT	NT	NT	NT	NT	NT
Electrosol	≤ 5%	NT	NT	NT	NT	NT	NT	225	107	100	38	75	24	NT	NT
Epichlorohydrin		NT	NT	NT	NT	NT	NT	100	38	NT	NT	NT	NT	NT	NT
Epoxidized soybean oil		NT	NT	NT	NT	NT	NT	275	135	NR	NR	150	66	NT	NT
Esters, "fatty acids"		NT	NT	NT	NT	NT	NT	275	135	100	38	150	66	NT	NT

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2"-6" 2400 Conductive		Bondstrand 3000A 8"-16"		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Ethanol		See Ethyl alcohol													
Ethyl acetate		75	24	75	24	120	49	150	66	NT	NT	NT	NT	NR	NR
Ethyl acrylate		120	49	100	38	120	49	150	66	NT	NT	NT	NT	NR	NR
Ethyl alcohol	≤ 10%	NT	NT	NT	NT	NT	NT	200	93	NT	NT	120(1)	49(1)	100	38
Ethyl alcohol	> 10%	120	49	120	49	120	49	175	79	125	52	80(1)	27(1)	NR	NR
Ethyl amines		NR	NR	NR	NR	NR	NR	NT	NT	NR	NR	NR	NR	NT	NT
Ethyl benzene		120	49	120	49	150	66	185	85	NT	NT	NT	NT	NR	NR
Ethyl bromide		NT	NT	NT	NT	NT	NT	100	38	NT	NT	NT	NT	NT	NT
Ethyl cellosolve		NT	NT	NT	NT	NT	NT	NT	NT	100	38	NR	NR	NR	NR
Ethyl chloride		NT	NT	NT	NT	NT	NT	100	38	75	24	NR	NR	NR	NR
Ethyl ether		120(2)	49(2)	120(2)	49(2)	120(2)	49(2)	120	49	NT	NT	NT	NT	NR	NR
Ethyl sulfate		NT	NT	NT	NT	NT	NT	100	38	NT	NT	NT	NT	NT	NT
Ethyl tert-butyl ether (ETBE)		NT	NT	NT	NT	NT	NT	150	66	NT	NT	NR	NR	NR	NR
Ethylene chlorohydrin		100	38	100	38	150	66	150	66	150	66	100	38	100	38
Ethylene diamine		NR	NR	NR	NR	NR	NR	100	38	NR	NR	NR	NR	NR	NR
Ethylene dichloride		NT	NT	NT	NT	NT	NT	185	85	NR	NR	NR	NR	NR	NR
Ethylene glycol	≤ 50% (in water)	210	99	210	99	225	107	275	135	200	93	200	93	200	93
Ethylene glycol	> 50%	210	99	210	99	225	107	275	135	200	93	200	93	200	93
Ethylenediaminetetraacetic acid		NT	NT	NT	NT	NT	NT	NT	NT	75	24	100	38	NT	NT
Eucalyptus oil		NT	NT	NT	NT	NT	NT	NT	NT	150	66	140	60	NT	NT
Fatty acids	Sat'd	210	99	210	99	225	107	275	135	200	93	200	93	200	93
Ferric acetate	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	150	66	160	71	180	82
Ferric chloride	≤ 20%	170	77	170	77	220	104	275	135	250	121	200	93	200	93
Ferric chloride	20 ≤ 60%	150	66	150	66	205	96	275	135	250	121	200	93	200	93
Ferric chloride	Sat'd	150	66	150	66	205	96	275	135	250	121	200	93	NT	NT
Ferric nitrate	Sat'd	150	66	150	66	205	96	275	135	250	121	200	93	200	93
Ferric sulfate	Sat'd	210	99	210	99	225	107	275	135	200	93	200	93	200	93
Ferrous chloride	Sat'd	210	99	210	99	225	107	275	135	250	121	200	93	200	93
Ferrous chloride 5% HCL		NT	NT	NT	NT	NT	NT	NT	NT	210	99	175	79	NT	NT
Ferrous nitrate	Sat'd	NT	NT	NT	NT	NT	NT	275	135	200	93	200	93	200	93

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Ferrous sulfate	Sat'd	210	99	210	99	225	107	275	135	200	93	200	93	200	93
Fertilizer (8-8-8)		NT	NT	NT	NT	NT	NT	275	135	NR	NR	120	49	NT	NT
Fertilizer-urea ammonium nitrate		NT	NT	NT	NT	NT	NT	275	135	75	24	120	49	NT	NT
Fire fighting foam, "ATC"	3 or 6%	NR	NR	NR	NR	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR
Fire fighting foam, "AFFF"	3 or 6%	NR	NR	NR	NR	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR
Flue gas, "dry" (1)		210	99	210	99	250	121	300	149	300	149	200	93	200	93
Flue gas, "wet"		200	93	200	93	235	113	275	135	250	121	180	82	180	82
Fluoboric acid	Sat'd	NR	NR	NR	NR	NR	NR	75	24	NT	NT	150	66	200	93
Fluorine gas, "dry"		NT	NT	NT	NT	NT	NT	NT	NT	75	24	75	24	NT	NT
Fluorine gas, "wet"		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	150	66	NT	NT
Fluorobenzene (phenyl fluoride)		NT	NT	NT	NT	NT	NT	180	82	NT	NT	NT	NT	NT	NT
Fluoroboric acid		NT	NT	NT	NT	NT	NT	NT	NT	180	82	150	66	NT	NT
Fluosilicic acid	≤ 10%	NR	NR	NR	NR	100(2)	38(2)	125	52	NR	NR	80	27	NT	NT
Fluosilicic acid	10 ≤ 25%	NR	NR	NR	NR	100(2)	38(2)	125	52	NR	NR	100	38	NT	NT
Fluosilicic acid	25 ≤ 37%	NT	NT	NT	NT	NT	NT	150	66	NR	NR	NR	NR	NT	NT
Formaldehyde	≤ 37%	75	24	75	24	120(2)	49(2)	150	66	75	24	75	24	150	66
Formaldehyde	37 ≤ 40%	NT	NT	NT	NT	NT	NT	150	66	75	24	75	24	150	66
Formaldehyde	Sat'd	NT	NT	NT	NT	NT	NT	150	66	NR	NR	NR	NR	NT	NT
Formic acid	≤ 10%	NR	NR	NR	NR	NR	NR	120	49	140	60	100	38	180	82
Formic acid	10 ≤ 25%	NR	NR	NR	NR	NR	NR	120	49	100	38	100	38	120	49
Formic acid	25 ≤ 88%	NR	NR	NR	NR	NR	NR	120	49	NT	NT	NT	NT	NT	NT
Formic acid		NR	NR	NR	NR	NR	NR	100	38	NT	NT	NT	NT	NT	NT
Freon 11		75	24	75	24	75	24	75	24	150	66	75	24	NT	NT
Freon 12 or 22 (gas or liquid)		NR	NR	NR	NR	75	24	75	24	150	66	75	24	NT	NT
Fuel oil		210	99	210	99	225	107	275	135	175	79	200	93	180	82
Fumaric acid	≤ 25%	NT	NT	NT	NT	NT	NT	NT	NT	100	38	100	38	NT	NT
Furfural	≤ 5%	NR	NR	NR	NR	NR	NR	150	66	NR	NR	NR	NR	NT	NT
Furfural	5 ≤ 10%	NR	NR	NR	NR	NR	NR	125	52	NR	NR	NR	NR	NT	NT
Furfural	> 10%	NR	NR	NR	NR	NR	NR	100	38	NR	NR	NR	NR	NT	NT
Gallic acid	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	125	52	NT	NT

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Gas, natural		210	99	210	99	225	107	275	135	200	93	200	93	NT	NT
Gasoline		210	99	210	99	225	107	250	121	150	66	NR	NR	150	66
Gasoline/ethanol mixtures		210	99	210	99	225	107	250	121	225	107	NR	NR	NT	NT
Germanium tetrachloride		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Gluconic acid	≤ 50%	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	100	38	100	38
Glucose		210	99	210	99	225	107	275	135	200	93	200	93	200	93
Glutaric acid	≤ 50%	NT	NT	NT	NT	NT	NT	150	66	75	24	100	38	NT	NT
Gluteraldehyde	≤ 50%	NT	NT	NT	NT	NT	NT	150	66	NR	NR	75	24	NT	NT
Glycerine		NT	NT	NT	NT	NT	NT	275	135	250	121	200	93	200	93
Glycerine (aq.)		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	180	82	200	93
Glycol ethylene		210	99	210	99	225	107	275	135	200	93	200	93	NT	NT
Glycolic acid	≤ 10%	NR	NR	NR	NR	NR	NR	100	38	NR	NR	75	24	NT	NT
Glycolic acid	10 ≤ 70%	NR	NR	NR	NR	NR	NR	100	38	NR	NR	75	24	NT	NT
Glyconic acid, (gluconic)	≤ 50%	NT	NT	NT	NT	NT	NT	120	49	NT	NT	NT	NT	NT	NT
Glyoxal	≤ 40%	NT	NT	NT	NT	NT	NT	125	52	NR	NR	100	38	NT	NT
Glyoxal	Sat'd	NT	NT	NT	NT	NT	NT	120	49	NR	NR	NR	NR	NT	NT
Gold plating solultion		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Green liquor		100	38	100	38	205[2]	96[2]	225	107	NT	NT	NT	NT	NR	NR
Heptane		200	93	175	79	200	93	225	107	150	66	150	66	180	82
Hexamethylenetetramine	≤ 40%	NT	NT	NT	NT	NT	NT	NT	NT	100	38	75	24	NT	NT
Hexane		150[2]	66[2]	150[2]	66[2]	150[2]	66[2]	175	79	125	52	150	66	120	49
Hexylene glycol		NT	NT	NT	NT	NT	NT	250	121	150	66	150	66	NT	NT
HF, 2.5% and HCl, 1.5%		NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NT	NT	NT	NT
Hot stack gases		NT	NT	NT	NT	NT	NT	275	135	NT	NT	NT	NT	NT	NT
Hydrated lime (calcium hydroxide)		150	66	150	66	200	93	225	107	200	93	175	79	NT	NT
Hydraulic fluid	≤ 60%	200	93	200	93	225	107	250	121	200	93	100	38	180	82
Hydraulic fluid	> 60%	200	93	200	93	225	107	250	121	225	107	170	77	180	82
Hydraulic oils		210	99	210	99	225	107	275	135	250	121	200	93	200	93
Hydrazine		NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NR	NR	NR	NR
Hydriodic acid	≤ 40%	NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Hydrobromic acid	≤ 18%	NR	NR	NR	NR	75[6]	24[6]	150	66	150	66	100	38	200	93
Hydrobromic acid	18 ≤ 48%	NR	NR	NR	NR	75[6]	24[6]	100	38	100	38	100	38	160	71
Hydrobromic acid	48 ≤ 62%	NR	NR	NR	NR	75[6]	24[6]	100	38	100	38	NR	NR	NT	NT
Hydrochloric acid	≤ 1%	75	24	75	24	205[6]	96[6]	200	93	200	93	175	79	200	93
Hydrochloric acid	1 ≤ 10%	NT	NT	NT	NT	205[6]	96[6]	200	93	200	93	200	93	200	93
Hydrochloric acid [9]	10 ≤ 20%	NT	NT	NT	NT	150	66	200	93	200[1]	93[1]	175	79	200	93
Hydrochloric acid [9]	20 ≤ 36%	NR	NR	NR	NR	100	38	150	66	140[1]	60[1]	150	66	150	66
Hydrochloric acid (36.5% Muriatic) [9]	37%	NR	NR	NR	NR	75	24	150	66	140	60	150	66	150	66
Hydrocyanic acid	≤ 10%	NR	NR	NR	NR	NR	NR	100	38	120	49	150	66	NT	NT
Hydrocyanic acid (Prussic)	Sat'd	NR	NR	NR	NR	NR	NR	100	38	NT	NT	NT	NT	NT	NT
Hydrofluoric acid	≤ 1%	NR	NR	NR	NR	NR	NR	75	24	NR	NR	150	66	150	66
Hydrofluoric acid	1 ≤ 5%	NR	NR	NR	NR	NR	NR	75	24	NR	NR	150	66	120	49
Hydrofluoric acid	5 ≤ 10%	NR	NR	NR	NR	NR	NR	75	24	NR	NR	150	66	100	38
Hydrofluoric acid	10 ≤ 20%	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	100	38	NR	NR
Hydrofluoric acid	> 20%	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Hydrofluosilicic acid		See Fluosilicic acid													
Hydrogen bromide, gas (wet)		NR	NR	NR	NR	NR	NR	NR	NR	NT	NT	NT	NT	NT	NT
Hydrogen chloride, gas (dry) [3]		150	66	150	66	150	66	150	66	NT	NT	NT	NT	150	66
Hydrogen chloride, gas (wet)		NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NT	NT	150	66
Hydrogen fluoride, vapor		NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	180	82	NT	NT
Hydrogen peroxide	0 ≤ 10%	NR	NR	NR	NR	NR	NR	75	24	75	24	NR	NR	150	66
Hydrogen peroxide	10 ≤ 30%	NR	NR	NR	NR	NR	NR	75	24	NR	NR	NR	NR	100	38
Hydrogen sulfide (dry) [3]		150	66	150	66	150	66	150	66	250	121	175	79	180	82
Hydrogen sulfide (wet)	Sat'd	150	66	150	66	150	66	150	66	250	121	175	79	180	82
Hydrosulfite bleach		NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	150	66	NT	NT
Hydroxyacetic acid		See Glycolic acid													
Hypochlorous acid	≤ 10%	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NT	NT
Hypochlorous acid	10 ≤ 20%	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NT	NT
Hypophosphorous acid	≤ 50%	NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	120	49	NT	NT

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Iodine, vapor	Sat'd	120	49	80	27	150	66	200	93	NR	NR	100	38	100	38
Isobutanol		See Isobutyl alcohol													
Isobutyl alcohol	≤ 10%	120	49	120	49	120	49	150	66	100	38	100	38	80	27
Isobutyric acid	≤ 50%	NT	NT	NT	NT	NT	NT	NT	NT	75	24	100	38	NT	NT
Isocaproic acid		NT	NT	NT	NT	NT	NT	NT	NT	100	38	75	24	NT	NT
Isononyl alcohol		NT	NT	NT	NT	NT	NT	NT	NT	125	52	115	46	NT	NT
Isooctyl adipate		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT
Isooctyl alcohol		NT	NT	NT	NT	NT	NT	NT	NT	125	52	75	24	NT	NT
Isophthalic acid (liquor)		NT	NT	NT	NT	NT	NT	200	93	NT	NT	180	82	NT	NT
Isopropanol		See Isopropyl alcohol													
Isopropyl alcohol	≤ 10%	120	49	120	49	120	49	175	79	150	66	NT	NT	80	27
Isopropyl alcohol	> 10%	120	49	120	49	120	49	150	66	120	49	NT	NT	80	27
Isopropyl ether		NT	NT	NT	NT	NT	NT	150	66	NT	NT	NT	NT	NT	NT
Isopropyl myristate		NT	NT	NT	NT	NT	NT	NT	NT	200	93	75	24	NT	NT
Isopropyl palmitate		NT	NT	NT	NT	NT	NT	275	135	200	93	200	93	NT	NT
Itaconic acid	≤ 25%	NT	NT	NT	NT	NT	NT	NT	NT	200	93	120	49	NT	NT
Jet fuel (JP-A, JP-8 …)		150	66	150	66	225	107	275	135	250	121	175	79	180	82
Kerosene		210	99	210	99	225	107	275	135	250	121	175	79	175	79
Ketones (general)		100	38	100	38	120	49	150	66	NT	NT	NT	NT	NT	NT
Lactic acid		200	93	200	93	225	107	275	135	200	93	150	66	200	93
Lasso herbicide		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT
Latex		NT	NT	NT	NT	NT	NT	275	135	200	93	120	49	120	49
Lauric acid	Sat'd	200	93	200	93	225	107	275	135	200	93	150	66	200	93
Lauroyl chloride		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	120	49	NT	NT
Lauryl alcohol		NT	NT	NT	NT	NT	NT	NT	NT	250	121	150	66	200	93
Lauryl chloride		NT	NT	NT	NT	NT	NT	200	93	100	38	200	93	NT	NT
Lead acetate	Sat'd	150	66	150	66	200	93	275	135	250	121	200	93	200	93
Lead nitrate	Sat'd	NT	NT	NT	NT	NT	NT	225	107	NT	NT	NT	NT	200	93
Lead plating solution		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2"-6" 2400 Conductive		Bondstrand 3000A 8"-16"		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Levulinic acid		NT	NT	NT	NT	NT	NT	250	121	200	93	200	93	200	93
Lime		180	82	180	82	200	93	225	107	200	93	180	82	180	82
Lime slurry (abrasive media)	[1]	180	82	180	82	200	93	275	135	225	107	170	77	180	82
Linseed oil		200	93	200	93	225	107	275	135	225	107	200	93	200	93
Lithium bromide	Sat'd	NT	NT	NT	NT	NT	NT	275	135	100	38	200	93	NT	NT
Lithium carbonate	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	140	60	100	38	NT	NT
Lithium chloride	Sat'd	NT	NT	NT	NT	NT	NT	275	135	210	99	200	93	200	93
Lithium hydroxide	Sat'd	NT	NT	NT	NT	NT	NT	225	107	NT	NT	NT	NT	120	49
Lithium sulfate	Sat'd	NT	NT	NT	NT	NT	NT	275	135	100	38	200	93	NT	NT
Lube oil		200	93	200	93	225	107	250	121	220	104	180	82	180	82
Magnesium bisulfate	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	200	93	150	66	NT	NT
Magnesium bisulfite	Sat'd	NT	NT	NT	NT	NT	NT	225	107	100	38	150	66	NT	NT
Magnesium carbonate	Sat'd	150	66	150	66	200	93	275	135	250	121	175	79	200	93
Magnesium chloride	Sat'd	210	99	210	99	225	107	275	135	225	107	200	93	200	93
Magnesium fluosilicate		NT	NT	NT	NT	NT	NT	NT	NT	225	107	100	38	NT	NT
Magnesium hydroxide	Sat'd	120	49	120	49	205	96	275	135	250	121	150	66	150	66
Magnesium nitrate	Sat'd	210	99	210	99	225	107	275	135	250	121	200	93	160	71
Magnesium phosphate		NT	NT	NT	NT	NT	NT	NT	NT	250	121	150	66	NT	NT
Magnesium sulfate	Sat'd	210	99	210	99	225	107	275	135	250	121	200	93	200	93
Maleic acid		NT	NT	NT	NT	NT	NT	175	79	150	66	200	93	200	93
Maleic anhydride		150	66	150	66	150	66	175	79	NT	NT	NT	NT	120	49
Manganese chloride	Sat'd	NT	NT	NT	NT	NT	NT	250	121	225	107	180	82	NT	NT
Manganese sulfate		NT	NT	NT	NT	NT	NT	NT	NT	225	107	200	93	NT	NT
Mercaptoacetic acid		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT
Mercuric chloride	Sat'd	210	99	210	99	225	107	275	135	150	66	200	93	200	93
Mercurous chloride	Sat'd	NT	NT	NT	NT	NT	NT	275	135	150	66	200	93	200	93
Mercury		NT	NT	NT	NT	NT	NT	NT	NT	250	121	200	93	200	93
Methacrylic acid		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NR	NR
Methane		210	99	210	99	235	113	275	135	150	66	140	60	200	93
Methanesulfonic acid		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Methanol		See Methyl alcohol													
Methyl acetate		75	24	75	24	120	49	150	66	NT	NT	NT	NT	NT	NT
Methyl alcohol	≤ 80%	120	49	100	38	150	66	175	79	100	38	NR	NR	NR	NR
Methyl alcohol	> 80%	100	38	100	38	120	49	150	66	NT	NT	NT	NT	NR	NR
Methyl amine		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT
Methyl chloride		NR	NR	NR	NR	NR	NR	75	24	NR	NR	NR	NR	NT	NT
Methyl ester		75	24	75	24	120	49	100	38	NT	NT	NT	NT	NT	NT
Methyl ethyl ketone	≤ 5%	120	49	75	24	150	66	175	79	100	38	NR	NR	NR	NR
Methyl ethyl ketone	> 5%	100	38	80	27	150	66	175	79	NT	NT	NR	NR	NR	NR
Methyl isobutyl alcohol		150	66	170	77	180	82	200	93	180	82	120	49	120	49
Methyl isobutyl carbitol		NT	NT	NT	NT	NT	NT	150	66	100	38	NR	NR	NR	NR
Methyl isobutyl ketone		120	49	120	49	150	66	175	79	150	66	NR	NR	NR	NR
Methyl methacrylate		NT	NT	75	24	100	38	100	38	NT	NT	NR	NR	NR	NR
Methyl propyl ketone		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Methyl styrene		120	49	120	49	150	66	175	79	NT	NT	NT	NT	NT	NT
Methyl tert-butyl ether (MTBE)		100	38	100	38	120	49	120	49	100	38	NR	NR	NR	NR
Methylene chloride	[1]	NR	NR	NR	NR	NR	NR	100	38	NR	NR	NR	NR	NR	NR
Mineral oil		210	99	210	99	225	107	275	135	250	121	200	93	200	93
Mineral spirits		NT	NT	NT	NT	NT	NT	275	135	NT	NT	NT	NT	NT	NT
Monochloro acetic acid		NR	NR	NR	NR	NR	NR	100	38	NR	NR	NR	NR	NT	NT
Monochlorobenzene, "MCB"		75[2]	75[2]	75[2]	24[2]	100[2]	38[2]	200	93	NT	NT	NT	NT	NT	NT
Monoethanolamine		NT	NT	NT	NT	NT	NT	150	66	NR	NR	NR	NR	NT	NT
Motor oil		210	99	210	99	225	107	275	135	250	121	200	93	200	93
Muriatic acid		See Hydrochloric acid													
Myristic acid		NT	NT	NT	NT	NT	NT	250	121	150	66	175	79	NT	NT
Naphtha		210	99	210	99	225	107	275	135	200	93	175	79	180	82
Naphthalene		200	93	200	93	200	93	225	107	150	66	100	38	200	93
Natural gas		210	99	210	99	235	113	275	135	150	66	140	60	200	93
n-dibutyl amine		NT	NT	NT	NT	NT	NT	100	38	NT	NT	NT	NT	NT	NT

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Nickel chloride	Sat'd	210	99	210	99	225	107	275	135	250	121	200	93	200	93
Nickel nitrate	Sat'd	210	99	210	99	225	107	275	135	200	93	200	93	200	93
Nickel plating		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Nickel sulfate	Sat'd	210	99	210	99	225	107	275	135	225	107	200	93	200	93
n-Isopropyl acetate		NT	NT	NT	NT	NT	NT	150	66	NT	NT	NR	NR	NR	NR
Nitric acid [7]	≤ 1%	75	24	75	24	120[6]	49[6]	150	66	120	49	150	66	150	66
Nitric acid	1 ≤ 5%	75	24	75	24	100[6]	38[6]	150	66	120	49	150	66	150	66
Nitric acid	5 ≤ 10%	75	24	75	24	100[6]	38[6]	120	49	120	49	125	52	120	49
Nitric acid	10 ≤ 20%	NR	NR	NR	NR	75[6]	24[6]	75	24	NR	NR	NR	NR	120	49
Nitric acid	20 ≤ 25%	NR	NR	NR	NR	75[6]	24[6]	75	24	NR	NR	NR	NR	100	38
Nitric acid	> 25%	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Nitrilotriacetic acid, "NTA"		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Nitrobenzene		NT	NT	NT	NT	NT	NT	200	93	NR	NR	NR	NR	NT	NT
Nitrogen solutions		NT	NT	NT	NT	NT	NT	150	66	NT	NT	100	38	100	38
n-lauryl alcohol		See Lauryl alcohol													
Oakite rust stripper		NT	NT	NT	NT	NT	NT	150	66	150	66	100	38	NT	NT
Octanoic acid	Sat'd	See Caprylic acid													
Oil sweet crude		See Crude oil (sweet or sour)													
Oil, lubricating		See Lube oil													
Oil, sour crude		See Crude oil (sweet or sour)													
Oleic acid		200	93	200	93	225	107	275	135	200	93	100	38	200	93
Oleum		See Sulfuric acid, fuming													
Olive oil		210	99	210	99	225	107	275	135	200	93	200	93	200	93
Orange juice		200	93	200	93	225	107	275	135	250	121	180	82	180	82
Ortho benzoyl benzoic acid		NT	NT	NT	NT	NT	NT	100	38	200	93	200	93	NT	NT
Ortho-dichloro benzene, "ODB"	≤ 10%	120	49	120	49	150	66	200	93	NT	NT	NT	NT	NT	NT
Oxalic acid	Sat'd	NT	NT	NT	NT	NT	NT	225	107	200	93	200	93	NT	NT
Ozone	≤ 35 ppm	NR	NR	NT	NT	150	66	[1]	[1]	[1]	[1]	[1]	[1]	NT	NT
Ozone	35 ≤ 300 ppm	NR	NR	NT	NT	NR	NR	[1]	[1]	[1]	[1]	[1]	[1]	NT	NT
Palmitic acid		NT	NT	NT	NT	NT	NT	NT	NT	150	66	100	38	200	93

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Perchloric acid	≤ 10%	NT	NT	NT	NT	NT	NT	NT	NT	75	24	150	66	NT	NT
Perchloric acid	10 ≤ 30%	NT	NT	NT	NT	NT	NT	NT	NT	75	24	75	24	NT	NT
Perchloroethylene		150	66	100	38	150(2)	66(2)	150	66	120	49	75	24	NR	NR
Petroleum ether		NT	NT	NT	NT	NT	NT	125	52	NT	NT	NR	NR	NR	NR
Phenol	≤ 1%	100	38	100	38	150(6)	66(6)	175	79	150	66	NR	NR	NR	NR
Phenol	1 ≤ 5%	100	38	100	38	150(6)	66(6)	175	79	NR	NR	NR	NR	NR	NR
Phenol	5 ≤ 88%	NR	NR	NR	NR	NR	NR	100(1)	38(1)	NR	NR	NR	NR	NR	NR
Phenol sulfonic acid	1 ≤ 5%	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	200	93	NT	NT
Phosphoric acid (7)	≤ 2%	150	66	100	38	225(6)	107(6)	200	93	100	38	200	93	200	93
Phosphoric acid	2 ≤ 25%	150	66	75	24	150(6)	66(6)	150	66	100	38	200	93	200	93
Phosphoric acid	25 ≤ 50%	150	66	75	24	150(6)	66(6)	75	24	75	24	200	93	200	93
Phosphoric acid	50 ≤ 85%	NT	NT	NT	NT	75(6)	24(6)	NR	NR	NR	NR	175	79	200	93
Phosphorus oxychloride		NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Phosphorus pentoxide	≤ 54%	NT	NT	NT	NT	NT	NT	NT	NT	100	38	200	93	NT	NT
Phosphorus trichloride		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT
Phthalic acid		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	200	93	NT	NT
Phthalic anhydride		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	150	66	200	93
Pickling acid (5% H2SO4, 0.25% coal, coal tar inhibitor, water)		NT	NT	NT	NT	NT	NT	150	66	100	38	200	93	200	93
Picric acid, alcoholic	≤ 10%	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	100	38
Picric acid	Sat'd	NT	NT	NT	NT	NT	NT	100	38	NT	NT	NT	NT	100	38
Pine oil		NT	NT	NT	NT	NT	NT	NT	NT	200	93	NR	NR	150	66
Plating solution (17% NiSO4, 5% NiCl2, 30% H3BO3, water)		120	49	120	49	200	93	220	104	200	93	180	82	180	82
Polyethylene glycol (E-200)		120	49	120	49	150	66	180	82	150	66	150	66	150	66
Polyethylene glycol (P-400)		150	66	150	66	150	66	180	82	150	66	150	66	150	66
Polyethyleneimine, 10%		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	100	38	NT	NT
Polyvinyl acetate adhesives		NT	NT	NT	NT	NT	NT	NT	NT	150	66	120	49	NT	NT
Polyvinyl acetate emulsion		100	38	100	38	150	66	150	66	150	66	100	38	100	38
Polyvinyl acetate latex, "PVCa"		210	99	210	99	225	107	250	121	150	66	100	38	NT	NT
Polyvinyl alcohol, "PVA"		150	66	150	66	150	66	175	79	100	38	100	38	NT	NT

Chemical Substance	Concentration	**Red Thread HP** **Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive**		**Bondstrand 3000A 8”-16”**		**Green Thread HP** **Bondstrand 2000 2000M 2400 4000**		**Centricast Z-Core**		**Centricast RB-1520 RB-2530**		**Centricast CL-1520 CL-2030**		**Bondstrand 5000 5000M**	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Polyvinyl chloride latex w/ 35 parts DOP		NR	NR	NR	NR	NR	NR	NT	NT	NR	NR	120	49	NT	NT
Potash		See Potassium hydroxide													
Potassium alum sulfate	Sat'd	NT	NT	NT	NT	NT	NT	275	135	120	49	200	93	NT	NT
Potassium bicarbonate	≤ 50%	150	66	150	66	200	93	225	107	225	107	150	66	150	66
Potassium bicarbonate	> 50%	NT	NT	NT	NT	NT	NT	NT	NT	225	107	100	38	150	66
Potassium bromide	Sat'd	210	99	200	93	225	107	275	135	200	93	100	38	200	93
Potassium carbonate	≤ 14%	200	93	100	38	205	96	275	135	250	121	150	66	150	66
Potassium carbonate	14 ≤ 50%	150	66	100	38	205	96	275	135	250	121	150	66	150	66
Potassium carbonate	> 50%	150	66	100	38	205	96	275	135	250	121	150	66	150	66
Potassium chloride	Sat'd	210	99	210	99	225	107	275	135	250	121	200	93	200	93
Potassium cyanide	≤ 5%	210	99	210	99	225	107	275	135	NT	NT	NT	NT	180	82
Potassium dichromate	≤ 10%	150	66	150	66	200	93	250	121	250	121	200	93	210	99
Potassium dichromate	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	250	121	200	93	210	99
Potassium ferricyanide	Sat'd	200	93	200	93	225	107	275	135	250	121	200	93	200	93
Potassium ferrocyanide	Sat'd	200	93	200	93	225	107	275	135	225	107	200	93	200	93
Potassium fluoride	≤ 30%	NT	NT	NT	NT	NT	NT	150	66	NT	NT	NT	NT	150	66
Potassium gold cyanide	≤ 12%	NT	NT	NT	NT	NT	NT	NT	NT	225	107	100	38	NT	NT
Potassium hydroxide	≤ 25%	100	38	100	38	150	66	240	116	200	93	125	52	120	49
Potassium hydroxide	25 ≤ 50%	100	38	100	38	150	66	240	116	200	93	125	52	100	38
Potassium hydroxide	50 ≤ 75%	100	38	100	38	150	66	225	107	NT	NT	NT	NT	100	38
Potassium hypochlorite		NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	[1][8]	[1][8]	NT	NT
Potassium iodide		NT	NT	NT	NT	NT	NT	NT	NT	225	107	120	49	NT	NT
Potassium nitrate	Sat'd	200	93	200	93	225	107	275	135	250	121	200	93	200	93
Potassium permanganate		NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	100	38	100	38
Potassium persulfate	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	225	107	200	93	180	82
Potassium phosphate		NT	NT	NT	NT	NT	NT	200	93	180	82	100	38	100	38
Potassium pyrophosphate	≤ 60%	NT	NT	NT	NT	NT	NT	NT	NT	225	107	135	57	NT	NT
Potassium sulfate	Sat'd	210	99	210	99	225	107	275	135	225	107	200	93	180	82
Propane		75[2]	24[2]	75[2]	24[2]	75[2]	24[2]	100	38	150	66	200	93	100	38

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Propionic acid	≤ 20%	NT	NT	NT	NT	NT	NT	120	49	100	38	150	66	NT	NT
Propionic acid	20 ≤ 50%	NT	NT	NT	NT	NT	NT	120	49	100	38	NR	NR	NT	NT
Propionic acid	> 50%	NT	NT	NT	NT	NT	NT	100	38	100	38	NR	NR	NT	NT
Propylene glycol		210	99	210	99	225	107	275	135	200	93	200	93	200	93
Prussic acid		See Hydrocyanic acid													
Pyridine		NT	NT	NT	NT	NT	NT	125	52	NT	NT	NT	NT	NT	NT
Quatenary ammonium salts		NT	NT	NT	NT	NT	NT	150	66	120	49	100	38	100	38
Rayon spin bath		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT
Red liquor		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	100	38	NT	NT
Salicylic acid	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	125	52	125	52	NT	NT
Sebacic acid	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Selenious acid	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	200	93	NT	NT
Silicic acid		NT	NT	NT	NT	NT	NT	NT	NT	200	93	125	52	NT	NT
Silver nitrate	Sat'd	150	66	150	66	225	107	275	135	250	121	200	93	200	93
Silver plating solution		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Soaps		200	93	200	93	225	107	275	135	250	121	200	93	NT	NT
Sodium acetate	Sat'd	150	66	150	66	205	96	225	107	250	121	200	93	200	93
Sodium alkyl aryl sulfonates		NT	NT	NT	NT	NT	NT	225	107	125	52	150	66	NT	NT
Sodium aluminate	Sat'd	150	66	150	66	205	96	225	107	200	93	120	49	NT	NT
Sodium aluminum sulfate		NT	NT	NT	NT	NT	NT	275	135	250	121	180	82	200	93
Sodium benzoate	Sat'd	180	82	180	82	200	93	250	121	250	121	150	66	180	82
Sodium bicarbonate	≤ 10%	180	82	180	82	225	107	275	135	250	121	150	66	180	82
Sodium bicarbonate	10 ≤ 20%	180	82	180	82	225	107	275	135	250	121	150	66	150	66
Sodium bicarbonate	Sat'd	180	82	180	82	205	96	275	135	250	121	150	66	NT	NT
Sodium bifluoride	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Sodium bisulfate	Sat'd	150	66	150	66	205	96	225	107	250	121	200	93	200	93
Sodium bisulfite	Sat'd	200	93	200	93	205	96	250	121	250	121	200	93	200	93
Sodium borate	Sat'd	NT	NT	NT	NT	NT	NT	250	121	225	107	200	93	NT	NT
Sodium bromate	≤ 10%	NT	NT	NT	NT	NT	NT	125	52	125	52	140	60	NT	NT
Sodium bromide	Sat'd	210	99	210	99	225	107	275	135	200	93	200	93	200	93

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Sodium carbonate	≤ 10%	200	93	200	93	205	96	225	107	250	121	150	66	180	82
Sodium carbonate	10 ≤ 25%	200	93	200	93	205	96	225	107	250	121	NT	NT	160	71
Sodium carbonate	25 ≤ 50%	200	93	200	93	205	96	225	107	250	121	NT	NT	160	71
Sodium chlorate	≤ 50%	210	99	200	93	225	107	200	93	225	107	200	93	180	82
Sodium chlorate	Sat'd	180	82	180	82	180	82	200	93	225	107	200	93	NT	NT
Sodium chloride	Sat'd	205	96	205	96	225	107	275	135	250	121	200	93	200	93
Sodium chlorite	≤ 25%	NT	NT	NT	NT	NT	NT	NT	NT	125	52	100	38	NT	NT
Sodium chlorite	Sat'd	NR	NR	NR	NR	NR	NR	NT	NT	NT	NT	NT	NT	NT	NT
Sodium chloroacetate		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	100	38	NT	NT
Sodium chromate	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	150	66	200	93	NT	NT
Sodium cyanide	< 6%	NT	NT	NT	NT	NT	NT	250	121	250	121	200	93	200	93
Sodium cyanide	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	250	121	200	93	200	93
Sodium dichromate	≤ 10%	180	82	180	82	200	93	NT	NT	250	121	200	93	200	93
Sodium dichromate	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	250	121	200	93	NT	NT
Sodium diphosphate		NT	NT	NT	NT	NT	NT	NT	NT	210	99	200	93	NT	NT
Sodium dodecylbenzenesulfonate		NT	NT	NT	NT	NT	NT	NT	NT	175	79	160	71	NT	NT
Sodium ferricyanide	Sat'd	200	93	200	93	225	107	275	135	250	121	200	93	200	93
Sodium ferrocyanide	Sat'd	200	93	200	93	225	107	275	135	250	121	200	93	200	93
Sodium fluoride	Sat'd	150	66	150	66	150	66	200	93	200	93	150	66	NT	NT
Sodium fluorosilicate	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	150	66	120	49	NT	NT
Sodium hexametaphosphate	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	150	66	100	38	NT	NT
Sodium hydrosulfide	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	100	38	100	38
Sodium hydroxide [7]	≤ 1%[1]	100[6]	38[6]	100[6]	38[6]	150[6]	66[6]	200	93	200	93	180	82	100	38
Sodium hydroxide	2 ≤ 30%	NR	NR	NR	NR	150[6]	66[6]	200[2]	93[2]	200	93	150	66	100	38
Sodium hydroxide	30 ≤ 50%	NR	NR	NR	NR	150[6]	66[6]	240	116	200	93	200	93	150	66
Sodium hydroxide	Sat'd	NR	NR	NR	NR	150	66	240	116	200	93	NT	NT	NT	NT
Sodium hypochlorite	≤ 5.25%	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR[1][8]	NR[1][8]	140[1][8]	60[1][8]
Sodium hypochlorite (stable)	10 ≤ 18%	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Sodium lauryl sulfate	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	200	93	160	71	NT	NT

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2"-6" 2400 Conductive		Bondstrand 3000A 8"-16"		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Sodium metabisulfite (sodium bisulfite)		150	66	150	66	205	96	250	121	250	121	200	93	NT	NT
Sodium monophosphate	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	210	99	200	93	NT	NT
Sodium nitrate	Sat'd	200	93	200	93	225	107	275	135	250	121	200	93	200	93
Sodium nitrite	Sat'd	200	93	200	93	225	107	275	135	NT	NT	NT	NT	200	93
Sodium oxalate	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	210	99	200	93	NT	NT
Sodium permanganate	≤ 60%	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	100	38	100	38
Sodium peroxide		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT
Sodium persulfate	≤ 20%	NR	NR	NR	NR	75	24	NT	NT	NT	NT	NT	NT	NT	NT
Sodium phosphate	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	200	93	200	93	NT	NT
Sodium silicate	Sat'd	NT	NT	NT	NT	200	93	225	107	150	66	200	93	200	93
Sodium sulfahydrate (NaHS)	≤ 45%	NT	NT	NT	NT	140	60	NT	NT	NT	NT	NT	NT	NT	NT
Sodium sulfate, "soda ash"	Sat'd	200	93	200	93	225	107	275	135	250	121	200	93	NT	NT
Sodium sulfide	≤ 15%	210	99	200	93	225	107	250	121	150	66	200	93	150	66
Sodium sulfide	15% ≤ Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	200	93	200	93	NT	NT
Sodium sulfite	Sat'd	200	93	200	93	205	96	NT	NT	200	93	200	93	200	93
Sodium tartate		NT	NT	NT	NT	NT	NT	NT	NT	225	107	200	93	NT	NT
Sodium tetraborate	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	200	93	150	66	NT	NT
Sodium thiocyanate	≤ 57%	NT	NT	NT	NT	200	93	225	107	175	79	150	66	200	93
Sodium thiosulfate	Sat'd	NT	NT	NT	NT	150	66	200	93	150	66	150	66	200	93
Sodium tripolyphosphate	Sat'd	NT	NT	NT	NT	NT	NT	225	107	200	93	200	93	NT	NT
Sodium xylene sulfonate	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	125	52	175	79	NT	NT
Sorbitol solutions		NT	NT	NT	NT	NT	NT	225	107	200	93	160	71	NT	NT
Sour crude oil		See Crude oil (sweet or sour)													
Soybean fatty acid		NT	NT	NT	NT	NT	NT	275	135	NT	NT	NT	NT	NT	NT
Soybean oil (soya oil)		NT	NT	NT	NT	NT	NT	275	135	225	107	200	93	NT	NT
Stannic chloride	Sat'd	150	66	150	66	205	96	225	107	200	93	200	93	200	93
Stannic sulfate		200	93	200	93	225	107	250	121	225	107	180	82	200	93
Stannous chloride	Sat'd	150	66	150	66	205	96	225	107	140	60	200	93	200	93
Steam condensate		See (water, steam condensate)													

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Stearic acid		200	93	200	93	225	107	275	135	150	66	200	93	200	93
Strontium chloride		NT	NT	NT	NT	NT	NT	225	107	200	93	200	93	200	93
Styrene		75	24	75	24	75	24	185	85	NT	NT	NT	NT	100	38
Succinonitrile		NT	NT	NT	NT	NT	NT	120	49	NR	NR	70	21	NT	NT
Sugar solutions		NT	NT	NT	NT	NT	NT	275	135	250	121	180	82	180	82
Sugar, beet or cane liquor	Sat'd	NT	NT	NT	NT	NT	NT	275	135	200	93	100	38	NT	NT
Sugar, sucrose	Sat'd	NT	NT	NT	NT	NT	NT	275	135	225	107	200	93	NT	NT
Sulfamic acid	0 ≤ 10%	100	38	100	38	150	66	150	66	125	52	200	93	180	82
Sulfamic acid	10 ≤ 25%	100	38	100	38	150	66	150	66	125	52	150	66	180	82
Sulfamic acid	> 25%	NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	150	66	NT	NT
Sulfanilic acid	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Sulfate liquor		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	200	93	NT	NT
Sulfated detergents	Sat'd	NT	NT	NT	NT	NT	NT	225	107	200	93	200	93	150	66
Sulfite liquor		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	200	93	200	93
Sulfur chloride		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	200	93	NR	NR
Sulfur dioxide, gas (dry) [3]		150	66	150	66	150	66	150	66	150	66	200	93	200	93
Sulfur dioxide, gas (wet) [3]		NT	NT	NT	NT	NT	NT	NT	NT	150	66	200	93	NT	NT
Sulfur trioxide		75	24	75	24	100	38	180	82	NR	NR	160	71	160	71
Sulfur trioxide, air, dry		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	200	93	160	71
Sulfuric acid	≤ 2%	75	24	75	24	180[6]	82[6]	200	93	200	93	180	82	200	93
Sulfuric acid	2 ≤ 5%	NT	NT	NT	NT	180[6]	82[6]	200	93	200	93	180	82	200	93
Sulfuric acid	5 ≤ 10%	NT	NT	NT	NT	100[6]	38[6]	200	93	200	93	180	82	200	93
Sulfuric acid	10 ≤ 20%	NT	NT	NT	NT	100[6]	38[6]	150	66	150	66	180	82	200	93
Sulfuric acid	20 ≤ 25%	NT	NT	NT	NT	100[6]	38[6]	150	66	100	38	180	82	180	82
Sulfuric acid	25 ≤ 50%	NR	NR	NR	NR	100[6]	38[6]	150	66	100	38	160	71	180	82
Sulfuric acid	50 ≤ 70%	NR	NR	NR	NR	70[6]	21[6]	150	66	NR	NR	160	71	120	49
Sulfuric acid	70 ≤ 98%	NR	NR	NR	NR	NR	NR	120	49	NR	NR	NR	NR	NR	NR
Sulfuric acid	> 98%	NR	NR	NR	NR	NR	NR	100	38	NR	NR	NR	NR	NR	NR
Sulfuric acid, fuming, oleum		NR	NR	NR	NR	NR	NR	100	38	NR	NR	NR	NR	NT	NT
Sulfurous acid	≤ 6%	NT	NT	NT	NT	NT	NT	75	24	[1]	[1]	120	49	100	38

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2"-6" 2400 Conductive		Bondstrand 3000A 8"-16"		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Sulfurous acid	6 ≤ 10%	NT	NT	NT	NT	NT	NT	75	24	NT	NT	100	38	100	38
Superphosphoric acid		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Tall oil		NT	NT	NT	NT	NT	NT	225	107	150	66	210	99	200	93
Tannic acid	≤ 15%	210	99	210	99	225	107	275	135	200	93	200	93	200	93
Tannic acid	Sat'd	210	99	210	99	225	107	250	121	200	93	200	93	200	93
Tartaric acid	Sat'd	210	99	210	99	225	107	275	135	250	121	200	93	NT	NT
Terephthalic acid	≤ 25%	NT	NT	NT	NT	NT	NT	NT	NT	100	38	NR	NR	NT	NT
Tert-amyl methyl ether (TAME)		NT	NT	NT	NT	NT	NT	125	52	NT	NT	NR	NR	NR	NR
Tetrachloroethane 1, 1, 2, 2		See 1,1,2,2-Tetrachloroethane													
Tetrachloroethylene		NT	NT	NT	NT	NT	NT	175	79	NT	NT	NT	NT	NR	NR
Tetraethyl lead		NT	NT	NT	NT	NT	NT	NT	NT	100	38	NR	NR	100	38
Tetrahydrofuran - THF		NT	NT	NT	NT	NT	NT	100	38	NT	NT	NT	NT	NT	NT
Tetrapotassium pyrophosphate	≤ 60%	NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	150	66	NT	NT
Tetrasodium ethylene-diamine	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Tetrasodium ethylenediaminetetraacetic A		NT	NT	NT	NT	NT	NT	NT	NT	150	66	150	66	NT	NT
Thioglycolic acid	≤ 10%	NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT
Thionyl chloride, vents		NT	NT	NT	NT	NT	NT	120	49	NT	NT	NT	NT	NT	NT
Thionyl chloride		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT
Tin(II) chloride		See Stannous chloride													
Tin plating (1)		NR	NR	NR	NR	NR	NR	NT	NT	NR	NR	200	93	NT	NT
Titanium chloride		NT	NT	NT	NT	NT	NT	NT	NT	175	79	175	79	NT	NT
Titanium dioxide		NT	NT	NT	NT	NT	NT	NT	NT	200	93	175	79	NT	NT
Tobias acid (1)		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	200	93	NT	NT
Toluene		200	93	125	52	200	93	200	93	150	66	NR	NR	NR	NR
Toluene sulfonic acid		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	80	27	NT	NT
Tomato catsup		210	99	210	99	225	107	250	121	250	121	200	93	200	93
Tomato puree		210	99	210	99	225	107	250	121	250	121	200	93	200	93
Transformer oil		210	99	210	99	225	107	275	135	250	121	200	93	200	93
Transformer oil (chloro-phenyl types)		NT	NT	NT	NT	NT	NT	100	38	NT	NT	NT	NT	NT	NT

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Transformer oil (mineral oil type)		210	99	210	99	225	107	275	135	225	107	200	93	200	93
Tributyl phosphate		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	150	66	NT	NT
Trichloroacetic acid	≤ 50%	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Trichloroethane 1,1,1		See 1,1,1-Trichloroethane													
Trichloroethylene		120	49	100	38	120	49	150	66	150	66	NR	NR	NR	NR
Trichloromonofluoromethane		NT	NT	NT	NT	NT	NT	120	49	NT	NT	NT	NT	NT	NT
Trichloronitromethane		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Trichlorophenol		NT	NT	NT	NT	NT	NT	100	38	NR	NR	NR	NR	NT	NT
Trichlorophenoxyacetic acid		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NR	NT	NT
Tricresyl phosphate		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	150	66	NT	NT
Tridecylbenzene sulfonate		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Triethanolamine		150	66	150	66	150(2)	66(2)	150	66	100	38	100	38	NR	NR
Triethylamine		NR	NR	NR	NR	100	38	100	38	100	38	NR	NR	NR	NR
Triethylene glycol		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	100	38	NT	NT
Trimethylene chlorobromide		NT	NT	NT	NT	NT	NT	150	66	NT	NT	NT	NT	NT	NT
Triphenyl phosphite		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	120	49	120	49
Tripropylene glycol		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	150	66	NT	NT
Trisodium phosphate	≤ 25%	150	66	150	66	200	93	225	107	200	93	200	93	210	99
Trisodium phosphate		100	38	100	38	200	93	225	107	150	66	200	93	210	99
Tung oil		NT	NT	NT	NT	NT	NT	NT	NT	200	93	100	38	NT	NT
Turpentine		100	38	100	38	100	38	150	66	75	24	100	38	NR	NR
Tween surfactant		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	125	52	NT	NT
Urea formaldehyde resin		NT	NT	NT	NT	NT	NT	NT	NT	150	66	120	49	NT	NT
Urea	≤ 50%	200	93	150	66	200	93	225	107	150	66	150	66	150	66
Urea	> 50%	200	93	150	66	200	93	225	107	150	66	125	52	150	66
Vegetable oils		NT	NT	NT	NT	NT	NT	275	135	225	107	210	99	NT	NT
Vinegar, 300 grain,"acetic acid"		NR	NR	NR	NR	120	49	120	49	100	38	100	38	200	93
Vinyl ester resin, 45% styrene		NT	NT	NT	NT	NT	NT	150	66	NT	NT	NT	NT	NT	NT
Vinyl acetate		NR	NR	NR	NR	NR	NR	120	49	75	24	NR	NR	NR	NR

Chemical Substance	Concentration	Red Thread HP Bondstrand 7000 7000M 3000A 2”-6” 2400 Conductive		Bondstrand 3000A 8”-16”		Green Thread HP Bondstrand 2000 2000M 2400 4000		Centricast Z-Core		Centricast RB-1520 RB-2530		Centricast CL-1520 CL-2030		Bondstrand 5000 5000M	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Vinyltoluene		80	27	80	27	80	27	200	93	NT	NT	NT	NT	NT	NT
Water, brine		210	99	210	99	225	107	275	135	212	100	175	79	200	93
Water, chlorinated	0 ≤ 200 ppm	100	38	100	38	125	52	275	135	200	93	200	93	150	66
Water, chlorinated	200 ≤ 2000 ppm	NR	NR	NT	NT	NT	NT	150	66	100	38	150	66	110	43
Water, chlorinated	2000 ≤ 3500 ppm	NR	NR	NR	NR	NR	NR	125	52	NR	NR	150	66	110	43
Water, chlorinated	Sat'd	NR	NR	NR	NR	NR	NR	75	24	NR	NR	150	66	150	66
Water, chlorinated brine		NT	NT	NT	NT	NT	NT	150	66	120	49	150	66	150	66
Water, deionized		200	93	200	93	205	96	275	135	212	100	175	79	180	82
Water, demineralized		200	93	200	93	205	96	275	135	250	121	200	93	200	93
Water, distilled		200	93	200	93	205	96	275	135	212	100	175	79	200	93
Water, fresh		200	93	200	93	225	107	275	135	212	100	175	79	200	93
Water, hard		200	93	200	93	225	107	275	135	212	100	175	79	200	93
Water, pH 2-13		210	99	210	99	225	107	275	135	212	100	175	79	200	93
Water, reverse osmosis		200	93	200	93	225	107	275	135	212	100	175	79	200	93
Water, salt		210	99	210	99	225	107	275	135	250	121	175	79	200	93
Water, sea		210	99	210	99	225	107	275	135	250	121	175	79	200	93
Water, steam condensate		(1)	(1)	(1)	(1)	225(1)	107(1)	250	121	NR	NR	NR	NR	200	93
White liquor (pulp mill)		NT	NT	NT	NT	NT	NT	275	135	NT	NT	NT	NT	150	66
Xylene		200	93	125	52	205	96	200	93	125	52	NR	NR	NR	NR
Zinc acetate		NT	NT	NT	NT	NT	NT	200	93	180	82	180	82	180	82
Zinc bromide		NT	NT	NT	NT	NT	NT	NT	NT	250	121	200	93	NT	NT
Zinc chlorate	Sat'd	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Zinc chloride	≤ 50%	200	93	200	93	225	107	250	121	250	121	200	93	NT	NT
Zinc chloride	> 50%	200	93	200	93	225	107	250	121	225	107	180	82	200	93
Zinc electrolyte		NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	150	66	NT	NT
Zinc nitrate	Sat'd	200	93	200	93	200	93	250	121	(1)	(1)	200	93	NT	NT
Zinc phosphate		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	180	82	200	93
Zinc plating solution (1)		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Zinc sulfate	Sat'd	70	21	70	21	70	21	275	135	250	121	200	93	200	93

Footnotes

1. Contact NOV Fiber Glass Systems Application Engineering for further review and recommendations.

2. Based on limited service and test data, could be serviceable at higher temperatures. Contact NOV Fiber Glass Systems Application Engineering for consideration of higher temperature service.

3. Avoid service conditions where dry gasses such as chlorine or sulfur dioxide may condense to liquids inside fiberglass piping systems. Furthermore, liquid chlorine and sulfur dioxide should not be confused with solutions mixed with water.

4. Pneumatic conveyance of dry chemicals is not recommended. Contact NOV Fiber Glass Systems Application Engineering for further review.

5. These recommendations represent chemical compound saturation concentrations at atmospheric pressure. Higher concentrations or super saturation caused by higher pressure in a closed system may increase corrosion. Contact NOV Fiber Glass Systems Application Engineering for further review.

6. All grooved adapters, Bondstrand Key-Lock connections and 8" and larger Green Thread reducer bushings are not recommended for this service. Furthermore, exposed glass fibers at machined surfaces and/or threads must be covered with a protective coating of adhesive during installation. An adhesive may be used in place of thread locking compound in these services.

7. For very low caustic and acidic concentrations in water use the recommendations under "Water, pH 2-13".

8. Requires the use of RP-106 adhesive.

9. Not recommended for service temperatures above the chemical compounds boiling point at the operating pressure.

ENG1030ENG July 2016

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Red Thread™ HP, Green Thread™ HP, and Silver Streak™

Pipe Installation Handbook

Matched Tapered
Bell & Spigot Joints

Fiber Glass Systems

NOV Completion & Production Solutions

nov.com/fgs

Matched Tapered Bell & Spigot Joints

This fabrication manual is offered to assist you in the proper fabrication and installation procedures when assembling your NOV Fiber Glass Systems piping system.

If you do not find the answer to your questions in the manual, feel free to contact us or your local distributor.

Our products must be installed and used in accordance with sound, proven practice and common sense.

The information supplied by NOV Fiber Glass Systems in its literature must be considered as an expression of guidelines based on field experience rather than a warranty for which the company assumes responsibility. We offer a limited warranty of its products in the Terms and Conditions of Sale. The information contained in the literature and catalogs furnished cannot ensure, of itself, a successful installation and is offered to customers subject to these limitations and explanations.

Installing fiberglass pipe is easier than installing carbon steel, stainless steel, and lined steel due to its light weight. Learning the proper methods to prepare and make-up bell & spigot joints can help ensure the reliability and long-term performance of your piping system.

We offer the TQI Plus (ASME B31.3) Fabrication and Assembly certification program. Qualified Field Service Representatives train fabrication and assembly crews, conduct and supervise fabrication work, and inspect work in progress.

For complete information concerning these training seminars, contact your local distributor or NOV Fiber Glass Systems.

SAFETY

The safety alert symbol indicates an important safety message. When you see this symbol, be alert to the possiblity of personal injury

CAUTION

As this pipe may carry hazardous material and/or operate at a hazardous pressure level, you must follow instructions in this manual to avoid serious personal injury or property damage. In any event, improper installation can cause injury or damage.
In addition, installers should read and follow all cautions and warnings on adhesive kits, heat packs, propane torches, etc. to avoid personal injury. Also, observe general safety practices with all saws, tools, etc. to avoid personal injury. Wear protective clothing when necessary. Make sure work surfaces are clean and stable and that work areas are properly ventilated.

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Section 1

Pipe Products

Pipe Grades
Fittings
Adhesives
Fabrication Accessories
Joining Systems

Description of pipe products

The performance characteristics of a fiberglass pipe system depend on several important elements including the resin and curing agent, as well as the manufacturing process and type and thickness of the pipe's corrosion barrier.

NOV Fiber Glass Systems' piping systems are manufactured using epoxy, vinyl ester, or isophthalic polyester resin systems. All are heat cured for optimum chemical resistance and physical properties. Match your temperature, pressure and chemical resistance requirements to the piping system.

Pipe Grades

Red Thread HP

Epoxy pipe grade that provides long service life, lightweight and corrosion resistance. Used for light chemical services in salts, solvents and pH 2 to 13 solutions up to 210°F and pressures to 25 bar (362 psig). Available in 2"-42" pipe sizes. T.A.B. (Threaded and Bonded bell & spigot) is the primary joining method for 2"-6" diameter pipe. Matched tapered bell & spigot joining method is used for 8"-42" pipe.

Green Thread HP

Epoxy pipe with 15-20 mil resin-rich liner that provides excellent chemical resistance to dilute acids and caustics. Rated for temperatures up to 230°F (110°C) and pressures to 40 bar (580 psi). Matched tapered bell & spigot connection is provided on all 1"-42" pipe sizes.

Silver Streak

Custom filament wound pipe is specially designed for abrasive and corrosive services found in flue gas desulfurization. It is a proprietary blend of epoxy resin and abrasion-resistant additives. Rated for temperatures to 225°F and 225 psig. Available in 2"-24" pipe sizes.

Fittings

All fittings are black in color. Green Thread fittings may be used with Red Thread and Green Thread pipe. Be sure to use the correct grade of pipe and fittings for your service. Consult Fittings & Accessories Bulletins for pressure rating limits on various fittings. The lowest rated fitting determines the system pressure rating.

Most compression-molded fittings have a center line dot or cross which will assist you in making measurements.

Photo 1
Fittings

Adhesives

Our adhesives are formulated for specific use with the companion pipe grades. Use only the recommended adhesive with each pipe grade - do not mix systems! Standard adhesives are a two-component system (Parts A and B) which must be mixed prior to use. Detailed instructions for adhesives are provided with each kit. Read these instructions thoroughly and follow the recommended procedures. The cure time and pot-life of the adhesive is dependent on temperature. Refer to the adhesive instructions. Ambient temperatures above 100°F require extra care by the fabricator to assure sufficient working time of the adhesive. Refer to Adverse Weather Recommendations on page 23.

Adhesive Selection

Standard adhesive kits are designed to be used with specific piping systems as shown in Table 2.

Adhesive Working Life

Working life or pot life is the time it takes for the adhesive to harden in the mixing can. Refer to Table 1 below.

Table 1

Adhesive Estimated Pot Life

Pipe Resin Systems	Adhesive	Pot Life @ 70°F (min.)	Pot Life @ 90°F (min.)
Epoxy	2000	20	12
Epoxy	8000	15	8

NOTE:

Pot life is the time available for fabrication. Times may vary depending upon temperature, humidity, quantity mixed, etc.

Table 2

Adhesive Selection (refer to Bulletin ADH4000 for more information)

Use with these Piping Systems	Max. Temp.	Kit #	Number of Bonds per Kit															
			1	1½	2	3	4	6	8	10	12	14	16	18	20	24	30	36”-42”
Red Thread HP Green Thread HP Silver Streak	230°F (110°C)	8014	45	27	21	15	8	5	3	2	1			1/2				
		8024	20	12	9	6	4	2	1									
		8069						8	4	3	2	2	1		1/2	1/2		
		8036															1/2	1/2

Ambient temperature, adhesive working life and number of crewmen should be considered when ordering adhesive.

For long runs of 8” and larger pipe, one kit per joint is recommended

Fabrication Accessories

Heat Collars and Heat Blankets

We offer high temperature heat collars and silicone heat blankets for use in curing of adhesive joints. The blankets and collars have a pre-set thermostat which controls the temperature of the unit. See page 60 for heat collar cure times for adhesive joint fabrications.

Photo 2
Heat Collar

Photo 3
Heat Blanket

Heat Gun

High wattage electric heat guns are also available to heat adhesive joints. The heat guns are 1600 watt capacity.

Photo 4
Heat Gun

Heat Packs

A heat pack unit consisting of ties and reactants in a plastic bag attached to foil paper is also available. Heat packs will cure joints within one hour.

Tapering Tools

Matched tapered joints require various tools for making the tapered spigot in the field (RT, GT, SS). Refer to Table 6 on page 40 for selection of proper tapering tool.

Come-Along

Specifically designed hydraulic come-alongs are available for 8"-42" piping systems (RT, GT, SS). Especially useful for long straight runs of pipe.

Photo 5
Come-Along

Ratchet-Type Cable Come-Along

Kit consists of two manual cable puller come-alongs and one strap clamp kit. It is a mechanical aid used to join larger diameter piping. The come-along is most useful for 8"-16" pipe sizes to aid in the alignment and landing of the spigot end into the bell.

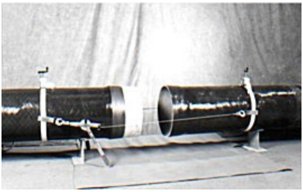


Photo 6
Ratchet-Type Cable Come-Along

Strap Clamp Kit

We offer Strap Clamp Kits that can be used in conjunction with come-alongs for bonding 8"-16" fittings. Strap clamp kits consist of two strap clamps and four D belts.

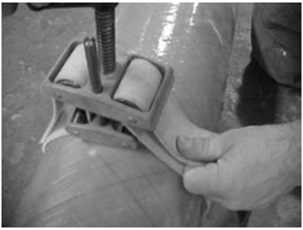


Photo 7
Strap Clamp Kit

Joining Systems

Bell and Spigot Joint

The adhesive bonded, tapered bell and spigot joint is a primary joining method for the following products:

1"-42" Green Thread piping and pipe to fittings

2"-42" Red Thread piping and pipe to fittings

2"-24" Silver Streak pipe to fittings

Pipe is supplied with one end tapered (the spigot) and the other end belled (integral bell or factory bonded coupling) to accept a tapered spigot. The joint is made by applying adhesive which, when cured, is compatible with the piping systems for joint strength and corrosion resistance.

T.A.B. (Threaded and Bonded) Joint

The T.A.B. joint is the primary joining method for the following product:

2"-6" Red Thread piping and pipe to couplings.

The joining system combines both threads and adhesives on the bonding surfaces. The mechanical locking action of these promotes positive makeup which prevents back out during adhesive curing. Standard tapered bell fittings are used with this system.

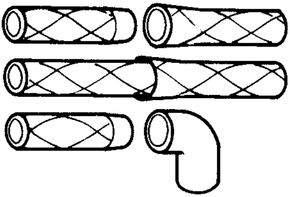


Figure 1
Bell and Spigot Joint

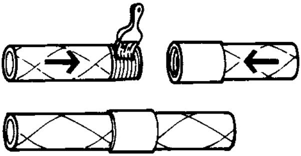


Figure 2
T.A.B. (Threaded and Bonded) Joint

Section 2

Site Considerations

Storage and Handling
Tools, Equipment and Supplies
Suggested Crew Setup and Assembly
Recommendations for Fabrication in Adverse Weather Conditions
Buried Recommendations
Anchors, Guides and Supports

Site Considerations

Storage and Handling

Pipe and Fittings

Fiberglass reinforced pipe, fittings, and adhesives require special storage and handling. Care should be taken in transporting, unloading, handling, and storing products to prevent impact and other damage.

When transporting pipe, the spacers under and between the pipe joints must be of sufficient width to avoid point loading, which could produce cracking or buckling damage. A minimum of four spacers should be used for supporting 14" and larger 40' long pipe joints. More spacers should be used for smaller pipe or if pipe is stacked over eight feet high.

Due to its light weight, lifting equipment is usually not required for 1" - 6" pipe. When lifting equipment is required, use nylon slings or chokers. Do not allow chains or cables to contact the pipe during transport or handling. If a pipe or fabrication is more than 20 feet long, use at least two support points.

For storage, a board (2" x 4" minimum) should be placed under each layer of pipe approximately every ten feet. The intent is to support the pipe and distribute the load evenly. The pipe should also be braced on either side of the pipe rack to prevent unnecessary pipe movement. Avoid placing pipe on sharp edges, narrow supports, or other objects that could cause damage to the pipe wall. When storing pipe directly on the ground, select a flat area free of rocks and other debris that could damage the pipe. Stack pipe a maximum of 8'. Our pipe is furnished factory packaged in compact, easy-to-handle bundles complete with protective end caps. Leave these caps in place until installation time to protect the pipe ends as well as to prevent dirt or other material from getting into the pipe. Fittings are packaged in cardboard boxes and should be stored in a dry area. If fittings are removed from the boxes, protect machined bells and spigots from exposure to direct sunlight.

If the protection on the pipe ends are damaged or removed, cover immediately with corrugated cardboard and/or heavy duty black plastic.

The pipe can be damaged when joints or bundles of pipe are dropped during handling or shipping. Severe localized impact blows may result in damage to the fiberglass reinforced structure in the pipe wall. **Before installation, inspect the pipe's outer surface for any damage.**

Do not use damaged pipe unless inspected and approved by a NOV Fiber Glass Systems' representative. If impact damage occurs, the damaged areas may be recognized by a star type fracture on the pipe. Pipe that has been damaged should have a length cut away approximately one foot either side of the impacted site.

NOTE:

Do not allow the bell end of the pipe to support any pipe weight.

Do not allow deformation of the pipe due to supports or straps.

Adhesive

Refer to adhesive instructions included in each kit for storage life recommendations.

Safety Data Sheets (SDS) are available at nov.com/fgs.

Tools, Equipment and Supplies

Requirements for Installation

For maximum efficiency, the following tools and equipment are recommended prior to any installation:

- Pipe Stands, Jacks, Chain Vise, Come-along & strap clamp kit
- Hand Tools
    - Level, Marking Pen, Tape Measure, Pipe Wrap
    - Hacksaw (22-28 teeth/inch)
    - Tapering tool (See pages 38-40)
    - Shop hammer, 3 lbs, and a 2x4 block of wood (for 1"-6" RT, GT, SS)

- Power Tools
  - Power tapering tools (See pages 38-40)
  - Circular power saw with a grit edge abrasive blade aluminum oxide, carbide or diamond
  - Jigsaw with carbide abrasive blade or fine-tooth metal cutting blade
  - Heat gun, heat blanket or collar
  - T.A.B. wrenches (for 2"-6" T.A.B. joint piping systems)
- Expendables
  - Clean, Dry, Lint-Free Shop Cloths
  - Sandpaper Disc/Emery Cloth (80-120 grit for RT, GT, SS)
  - Impermeable gloves
  - Chemical splash goggles

NOTE: You must use the proper tool for tapering each size and type of pipe (see pages 38-40).

Equipment for Cool Weather (Below 70°F) pipe assembly:

- Heat source
  - Portable torch with spreader tip, or
  - Portable electric heat lamp, or
  - Industrial hot air gun
- A means of maintaining adhesive kits at 70°-80°F:
  - A box with a 25 watt light bulb, or
  - Inside of a warm vehicle with the heat running.
- Heat assisted curing
  - Electric heating collars or blankets
  - Chemical heat packs

WARNING: Be sure there are no flammable material or gas present when using any type of heating device.

Additional equipment for 8"-42" pipe assembly (RT, GT, SS):

- Manual or hydraulic come-alongs for 8" - 16"
- Hydraulic come-alongs for 18"- 42"
- Strap clamp kit for 8" - 16"
- Strap Clamp kit and manual come alongs 8" - 16" /HP 32 - HP 40 systems
- Sledge hammer, 10-16 lbs., and a 4 x 4 block of wood

Additional equipment for applying saddles:

- Power sander with 24-60 grit sanding disc
- Hose clamps.

Table 2.1

Suggested labor times for Bell x Spigot Piping Systems

Pipe Size	Setup[1]	Scribe & Cutting Hand/power	Hand Tapering	Power Tapering	Joint Makeup [7,8]
in	min	min/jt	min/jt	min/jt	min
1	3	1.33/1.25	1	0.25[2]	1
1½	3	1.33/1.25	1.5	0.25[2]	1
2	3	1.50/1.25	2	0.25	1.5
3	3	2.0/1.33	3	0.25	2
4	4	5.0/2.5	4	0.25	3
6	5	7.0/3.0	5	2.5[2,3]	4
8	7	4.5/3.5	22	8.0[4,5,9]	5
10	7	NA/5.0	35	10.0[5, 9]	6
12	8	NA/5.0	40	12.0[5, 9]	8
14	9	NA/5.0	NA	12.0[5,9]	10
16	10	NA/6.0	NA	12.0[5,9]	14
18	12	NA/8.0	NA	25.0[6,9]	14
20	12	NA/8.0	NA	28.0[6,9]	20
24	15	NA/12.0	NA	30.0[6,9]	30
30	18	NA/15.0	NA	60.0[9,11]	36
36	24	NA/20.0	NA	70.0[9,11]	40
42	30	NA/24.0	NA	90.0[9,11]	45

Suggested Labor Times for Bell x Spigot Piping Systems

(1) These numbers are based on installations using experienced crews in typical installation conditions. They do not include extreme weather conditions, time used for gathering supplies and tools, break time, manpower issues, etc. Assume 6 hours of productive labor for every 8 hours worked. Adjustment factors should be applied to these base units to compensate for prevailing production and job conditions. Because of all the variables involved, NOV Fiber Glass Systems is not responsible for any differential between these numbers and actual results.

(2) 2000 series Power Tools

(3) 2"-6" Hand Tapering Tool

(4) Individual Tapering Tool

(5) 8"-16" Taper/Scarf Tool

(6) 18"-24" Taper Tool

(7) Each joint makeup calculation includes cleaning, sanding, applying adhesive and proper engagement. Allow three minutes for mixing adhesive.

(8) The units (time) listed above are based on using experienced crews on fitting intensive runs. For straight run pipe, contact your local representative.

(9) Time doubles for HP 25 products.

(10) Includes set up for hydraulic or manual come-along and setting pipe stand levels.

(11) Use the 30"- 42" taper tool.

Suggested Crew Setup and Assembly

Manpower requirements change depending on whether the installation is simple, consisting of long, straight runs, or complex. It also depends on pipe size, installation temperature, and other similar influences. Following are some general guidelines that are applicable to most installations. If you have any questions, please contact an NOV Fiber Glass Systems representative for information.

Suggested Crew Size for 1”-6” straight long pipe runs

A three-worker crew is the minimum recommended crew size. A four-worker crew is sometimes more efficient, even when installing 1" - 6" diameter pipe.

Man #	Crew Description
1	**Clean/prep/align** Removes end caps, sands and cleans joint and aligns pipe for bonding.
2	**Adhesive mixer/bonder** Mixes adhesive and applies to bell and spigot.
3	**Assembly man** Helps make up joint and checks for lock up.
4	**Pre-heat/prep/supplies** *(optional through 4"; recommended on 6")* Pre-heats joints and helps keep pipe aligned. Also applies heat collars during cool weather. (All help in moving supplies and equipment from joint to joint.)

Suggested Crew Size for 8"-42" straight long pipe runs

A six or seven crew members is recommended.

Man #	Crew Description
1	**Clean/prep/align** Removes end caps, sands and cleans joint and aligns pipe for bonding.
2	**Adhesive mixer/bonder** Mixes adhesive and applies to bell and spigot. Marks insertion depth and determines when joint is locked up. Assists with come-along.
3	**Adhesive mixer/bonder** Helps #2 with adhesive and assists with come-along.
4	**Pre-heat/alignment man** Pre-heats joints, helps align joints and assists with come-along.
5	**Alignment man** Sets level of pipe and aligns joint for proper insertion; directs tractor driver.
6	**Truck driver/Supply man** (optional) Drives supply truck and assists with all aspects of installation. Also coordinates heat collars during cool weather and ice chest during hot weather.
7	**Tractor Operator** Operates side boom tractor, track hoe or backhoe. (All help in moving supplies and equipment from joint to joint.)

In more complex pipe assemblies, the crew size will depend on the amount of tapering and prefabrication needed. In most cases, a three-worker crew is the minimum for any size piping installation. In some instances (small jobs with only a few joints) only one or two crewmen will be required.

Recommendations for Fabrication in Adverse Weather Conditions

The piping can be installed in adverse weather conditions when the necessary precautions are taken.

Actual work will often be more quickly completed in high temperature conditions. Low temperatures can increase the work time 20%-35% over normal shop conditions. A similar increase is common for high moisture conditions.

Hot Weather Installation Tips

Hot weather conditions, temperatures above 90°F, will greatly reduce the working time of the adhesive. The following steps are recommended when fabricating in hot weather conditions:

1. Avoid direct sunlight on the joining surfaces.
2. Store adhesive in a cool area.
3. Keep mixed adhesive in an ice chest with sealed bag of ice or ice pack.

Cold Weather Installation Tips

Adhesive cure time is directly related to the temperature. Colder temperatures result in longer cure times.

CAUTION: Overheating the adhesive could result in pre-mature exotherm.

The following steps should be used when fabricating in colder temperatures:

1. Adhesive kits should be placed in a warm room for six to twelve hours before application in order to reach temperatures of 80°F -100°F. This will make mixing much easier and speed cure times. Or use a box with a 25 watt light bulb to warm adhesive kits.
2. When possible, piping should be bonded indoors into sub-assemblies. The warmer conditions of these areas will allow faster cure times.
3. Pre-warm bonding surfaces to 80°F - 100°F when temperature falls below 70°F.

4. A heat gun, collar or blanket may be used to obtain a faster cure time. Apply a layer of fiberglass insulation or a welding blanket around the heat collars or blankets when installation temperatures are below 50°F.

Extreme Moisture

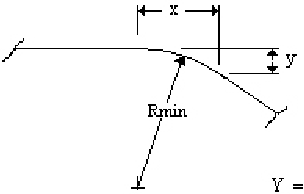
Adhesive Joints - If fittings or pipe have moisture on the bonding surface, wipe them dry prior to sanding and if within safety guidelines use some type of heat to complete drying.

- Sand pipe or fittings immediately before applying the adhesive to bond the joint. Sand surfaces until a fresh, dry surface is present, then remove dust with a clean dry cloth, and apply adhesive.
- Cure per the previous recommendations for normal, extreme heat or extreme cold temperatures.

Buried Installations

These are general guidelines only. For more details see Engineering and Piping Design Guide.

Minimum Bending Radius Layout



$$Y = R\cdot\left(1 - \cos\left(\operatorname{asin}\left(\frac{X}{R}\right)\right)\right)$$

Where:

X = Run, ft(m)

Y = Offset, ft(m) n)

R = minimum bend radius, ft(m)

(trigonometric function based on radians)

Offset Bending Allowance for Green & Red Thread HP 16/HP 25 Pipe (contact Applications Engineering for 30" - 42")

Pipe Size	**X Straight Run**		**Y Offset for HP 16**		**Y Offset for HP 25**	
in	**ft**	**m**	**ft**	**m**	**ft**	**m**
2	20	6.1	2	0.6	2	0.6
	40	12.2	10	3.0	8	2.4
3	40	12.2	6	1.8	5	1.5
	60	18.3	16	4.9	12	3.7
4	40	12.2	5	1.5	4	1.2
	80	24.4	23	7.0	17	5.2
6	40	12.2	3	0.9	3	0.9
	80	24.4	15	4.6	11	3.4
	120	36.6	34	10.4	26	7.9
	160	48.8	67	20.4	49	14.9
8	80	24.4	11	3.4	9	2.7
	120	36.6	25	7.6	20	6.1
	160	48.8	47	14.3	36	11.0
	200	61.0	78	23.8	58	17.7
10	80	24.4	9	2.7	7	2.1
	120	36.6	20	6.1	16	4.9
	160	48.8	36	11.0	28	8.5
	200	61.0	59	18.0	45	13.7
12	80	24.4	7	2.1	6	1.8
	120	36.6	17	5.2	13	4.0
	160	48.8	32	9.8	24	7.3
	200	61.0	51	15.5	38	11.6
14	80	24.4	6	1.8	5	1.5
	120	36.6	15	4.6	12	3.7
	160	48.8	28	8.5	21	6.4
	200	61.0	44	13.4	33	10.1
16	80	24.4	5	1.5	4	1.2
	120	36.6	13	4.0	10	3.0
	160	48.8	23	7.0	18	5.5
	200	61.0	36	11.0	28	8.5

Pipe Size	X Straight Run		Y Offset for HP 16		Y Offset for HP 25	
in	ft	m	ft	m	ft	m
18	80	24.4	5	1.5	4	1.2
	120	36.6	11	3.4	9	2.7
	160	48.8	19	5.8	16	4.9
	200	61.0	31	9.5	25	7.6
20	80	24.4	4	1.2	4	1.2
	120	36.6	10	3.0	8	2.4
	160	48.8	17	5.2	15	4.6
	200	61.0	27	8.2	23	7.0
24	80	24.4	3	0.9	3	0.9
	120	36.6	8	2.4	7	2.1
	160	48.8	16	4.9	12	3.7
	200	61.0	25	7.6	19	5.8

Table 3

Burial Depths*

Product	Minimum		Maximum	
	ft	m	ft	m
1"-4" Red Thread HP16/HP 25	2	0.6	15	4.6
6"-24" Red Thread HP16/HP 25	3	0.9	15	4.6
1"-12" Green Thread HP16/HP 25	2	0.6	15	4.6
14"-24" Green Thread HP16/HP 25	3	0.9	15	4.6
1" - 12" Silver Streak	2	0.6	15	4.6
14" - 24" Silver Streak	3	0.9	15	4.6

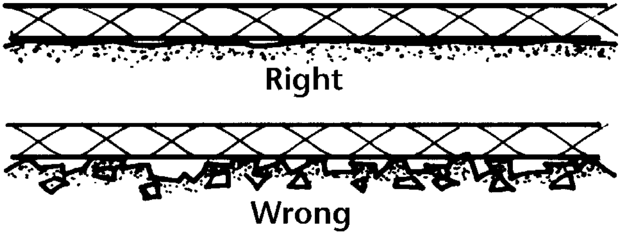
* Based on a 1000 psi composite constrained modulus. Contact the factory for detailed information for your specific application.

NOTE: Contact NOV Fiber Glass Systems' Applications Engineering for HP 32 & HP 40 systems.

Burial Depth:

Minimum burial depth in unpaved areas for pipe subjected to vehicular loads depends on pipe grade, pipe size, vehicle axle weight, and the bedding material. With a standard legal axle load of 34,000 lbs., the minimum depth of cover (from the top of the pipe to the surface) for moderately compacted non-clay bearing soils is shown in Table 3.

Maximum burial depth is dependent on the backfill material. For moderately compacted soils that do not contain large amounts of highly expansive clays, the maximum burial depth is shown in Table 3.



The pipe should always be buried below the frost line.

Trench Preparation - Final bedding of the trench must be as uniform and continuous as possible. Before backfilling, fill all gaps under the pipe with proper bedding material. Avoid sharp bends and sudden changes in slope. It is important to remove all sharp rocks, cribbage, or other foreign objects that could come in contact with the piping.

Bedding Requirements - Fiberglass pipe can be damaged by point contact or wear with the trench bottom and walls, improper bedding materials, or adjacent pipe. Use recommended bedding material a minimum of 6 inches thick at the bottom, sides, and top of the piping (refer to Table 4). Adjacent pipes should be spaced the greater of 6 inches or one pipe diameter. The piping can be laid directly on the trench bottom if the native soil meets the requirements of a recommended bedding material (refer to Table 4). In some situations, the trench bottom can be "scratched" such that a natural cradle of dirt is formed. Never

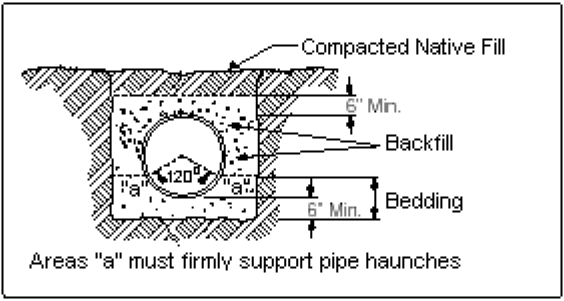


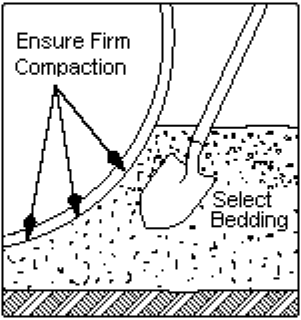
Table 4

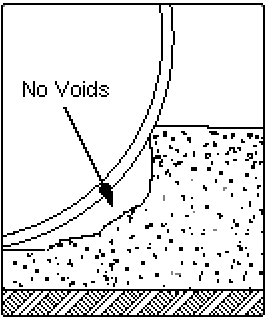
Recommended Bedding Materials

Bedding Material	Compaction Proctor Density
Crushed rock or pea gravel 3⁄4" maximum size	Not Required
Coarse-grained sand or soil with little or no fines	75-85%
Coarse-grained sand or soil with more than 12% fines	85-95%
Sand or gravel with more than 30% coarse-grained particles	85-95%
Sand or gravel with less than 30% coarse-grained particles	Greater than 95%

lay fiberglass piping directly against native rock or shale. Always use dry, unfrozen bedding materials that do not contain foreign objects or debris. Never use water flood for compaction. Slurries can be used that are intended for burial of flexible piping systems. When using slurries, care must be taken to prevent floating or deformation of the piping.

Pipe Support - Fiberglass pipe is flexible and requires the support of the bedding material to keep the pipe round in burial applications. It is very important that a recommended bedding material is properly compacted around the entire circumference of the pipe. (Refer to Table 4) Tamp the bedding material under the bottom half of the piping to prevent voids or areas of low compaction. Vibratory or similar tamping equipment can drive





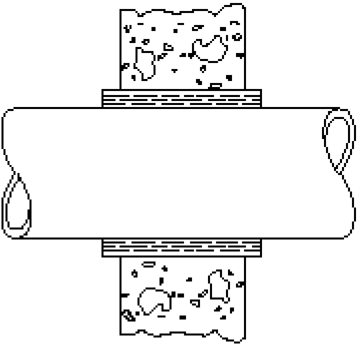
small stones or debris into the pipe wall if they are present in the bedding material. Avoid striking the pipe with tamping equipment as the pipe may be fractured.

High Water Tables or Vacuum - Consult factory for recommendations.

Road Crossings - When laying fiberglass pipe under road crossings, it may be necessary to pass the pipe through conduit to protect the pipe. Pad the pipe to prevent rubbing or point loads against the conduit.

Wall Penetrations

Where the pipe goes through or passes under a concrete structure, precautions must be taken to prevent bending or point loading of the pipe due to settling. A minimum 2" thick pad of



resilient material should be wrapped around the pipe to provide flexibility and prevent contact with the concrete. If bolts are used in the resilient material, care should be taken that the bolts, nuts, or washers cannot come into point load contact with the pipe. Bedding depth under the pipe should be increased to a minimum of 12" or one pipe diameter, whichever is greater, for one pipe joint length away from the concrete.

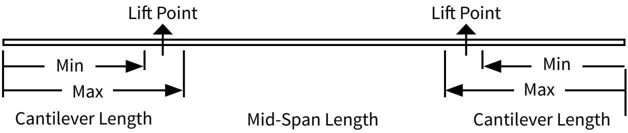
Timing - Test and cover the pipe as soon as possible to reduce the chance of damage to the pipe, floating of the pipe due to flooding, or shifting of the line due to cave-ins.

Two Point Lifting of Red Thread & Green Thread HP Series Piping The Lift Points table provides the locations for safe two point lifting with straps at least 4 inches in width. The cantilever

Lift Points

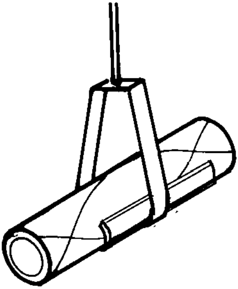
Nominal Size	Pipe Lengths (ft)		Cantilever Lengths (ft)		Mid-Span Lengths (ft)	
in	Number	Length	Min.	Max.	Min.	Max.
8	3	120	24	26	68	72
10	3	120	20	28	64	80
12	3	120	22	31	58	76
14	3	120	22	31	58	76
16	3	120	20	35	50	80
18	3	120	19	36	48	82
20	4*	160	31	37	86	98
24	4*	160	30	40	80	100
30	4*	160	30	40	80	100
36	4*	160	30	40	80	100
42	4*	160	30	40	80	100

* The same cantilever length applies for 3 pipe lengths.

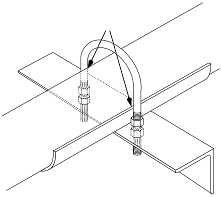


lengths are critical and should be followed without exception. Lifting and moving of the pipe should be performed by smooth motions. Avoid aggressive jerking or rough movement of pipe during installation.

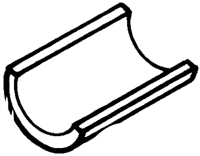
Anchors, Guides and Supports



Pipe Hangers - Pipe hangers such as those shown are often used to support pipe in buildings and pipe racks. However, the use of too many hangers in succession can result in an unstable line when control valves operate, and during pump start-up and shutdown. To avoid this condition, the designer should incorporate auxiliary guides periodically in the line to add lateral and axial stability.



Pipe Guides - Guides are rigidly fixed to the supporting structure and allow the pipe to move in the axial direction only. Proper guide placement and spacing are important to ensure proper movement of expansion joints or loops and to prevent buckling of the line.

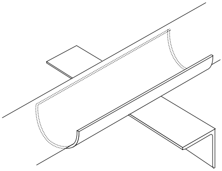


The guiding mechanism should be loose so it will allow free axial movement of the pipe. "U" bolts, double-nutted so they cannot be pulled down tight, are often utilized for guides.

Primary and secondary guides, i.e., those immediately adjacent to expansion joints, are spaced more closely than intermediate guides. Refer to Engineering & Piping Design Manual, for details.

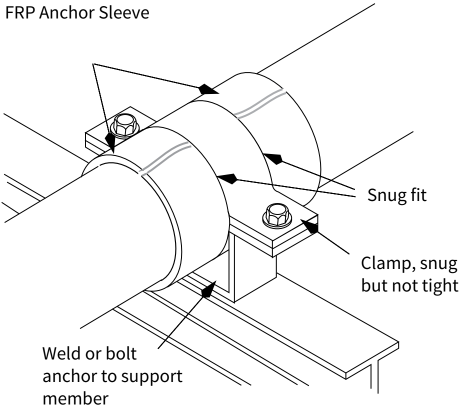
Piping entering expansion joints or expansion loops require additional guides. Refer to Engineering & Piping Design Manual for details.

Pipe Supports - Piping supports for the pipe should be spaced at intervals as shown in the product bulletins.



NOTE: Properly spaced supports do not alleviate the need for guides as recommended in the preceding section. Supports that make only point contact or that provide narrow supporting areas should be avoided. Some means of increasing the supporting area should be used; sleeves made from half of a coupling or pipe are suitable. Support pumps, valves and other heavy equipment independent of the pipe. Refer to pump and valve connection instructions on page 80.

Pipe Anchors - Pipe anchors divide a pipeline into individual expanding sections. In most applications, major pieces of connected equipment, such as pumps and tanks, function as anchors. Additional anchors are usually located at valves, near changes in direction of the piping, at blind ends of pipe, and at major branch connections. Provisions for expansion should be designed into each of the individual pipe sections.



Refer to Engineering & Piping Design Guide, for a thorough discussion on supports, anchors and guides.

Section 3

General Installation Instructions

Read This First
Cutting Fiberglass Pipe

Installation Statement

Important - Read this First

Before beginning the actual assembly procedures, read and make sure all installers thoroughly understand the following instructions.

All bonding surfaces must be clean, dry and factory fresh in appearance before applying adhesive. When end caps have been lost, surfaces will weather and result in loss of bond strength. When surfaces are weathered, re-taper (RT, GT, SS) spigots to achieve a factory fresh appearance. (Note: T.A.B. couplings that have weathered must be replaced.)

Matching tapered bell and spigot joints require a very thin adhesive bond line for maximum strength and durability. The adhesive used with tapered joints is very strong when used in bond lines a few thousandths of an inch thick. The same adhesive may be brittle in thick sections resulting in poor bond strength. To achieve a thin bond line, the matched tapered angles of the joint are designed to mechanically "lock-up" when wedged together.

Using mechanical force assures "lock up" and a thin bond line. Hammering a wooden block placed against the bell end of pipe, or using mechanical devices such as come-alongs should be used to "lock up" the joint.

NOTE: For T.A.B. joints, special T.A.B. wrenches are required to achieve the mechanical lock up in the joint.

Adverse weather conditions require special precautions when bonding pipe. (See page 24, Recommendations for Fabrication in Adverse Weather Conditions) The adhesive is very viscous (thick) when cool or when applied to cool pipe. The thick adhesive can actually be stiff enough to prevent joint "lock up." When the adhesive is hot or when it is applied to hot pipe, the available working time may be significantly reduced. For Installers new to fiberglass it is strongly recommended that the system be hydrotested within the first 2500' or 50 joints.

Matched tapered bell and spigot joints that are not "locked up" can fail prematurely.

Cutting Fiberglass Pipe

NOV Fiber Glass Systems' pipe should be cut using one of the methods referred to under Tools and Equipment on page 18.

1. Measure pipe, remembering to allow for spigot and fitting dimensions.
2. Scribe a cutting guide around the pipe to ensure a perpendicular cut for proper fit.
3. Hold the pipe firmly but not to the point of crushing. If chain vises or other mechanical holding devices are used, care should be taken to prevent crushing or point loading of the pipe. To prevent damage to the pipe, 180 degree sections of pipe can be used for protective covers.
4. Saw the pipe as smoothly as possible. The pipe ends should be square within 1/8 inch.

NOTE: For integral joint (IJ) bell ends, the bell end must be cut off before tapering. Measure the O.D. of the pipe near the bell end until you see the O.D. start to get larger. Cut the pipe at this point. Depending on pipe size the distance from the end of the bell can vary anywhere from 12" to 36".

Section 4

Fabrication of Red Thread HP, Green Thread HP and Silver Streak Pipe and Fittings

Tapering Pipe
Tapering Tool Reference Chart
Joint Assembly
Close Tolerance Piping
Joint Prep
Adhesive Mixing
Take-Off Dimensions
1"x6" Bell x Spigot Joints
8"x36" Bell x Spigot Joints
T.A.B. Joints
Joint Cure and Heat Collars
Repairs

Tapering Pipe

Various tools are available from NOV Fiber Glass Systems for making the tapered spigot in the field.

To reproduce a standard taper, the tapering tool must be marked or adjusted. The process varies depending on the tool being used and the product being tapered. Please refer to individual tool instructions for tapering.

Refer to Table 6 on page 40 for specific bulletin number and proper taper angle for each size and type of pipe. **Do not** taper over the bell end of integral joint pipe. See page 36 for cutting instructions.

1"-6" Tool - A hand-held tool that can be adapted for power when a large number of tapers is necessary. Different piping systems require different mandrels.

Model 2100/ 2102/2106 Tool - Power tool for tapering and scarfing Red Thread and Red Thread IIA piping.

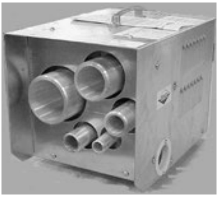
Model 2300/2306 Tool - Power tool especially designed for tapering 1" - 6" Green Thread piping.

8", 10", or 12" Tapering Tool - These tools are designed for manual or power (i.e., Ridgid® 300 or 700 power drive or equal) operation; there is a tool for each size pipe.

NOTE: Red Thread and Green Thread mandrels can be purchased separately and used on this tool.

1"-6" Tool

Model 2100/2101 Tool



Model 2300/2306 Tool

Model 2106/2306 Tool

8", 10" or 12" Tapering Tool

2"-12" Remote Power Tool - Tapers 2"-12" pipe. Must change angle for 8" and larger pipe. Recommended for 6" tapers.

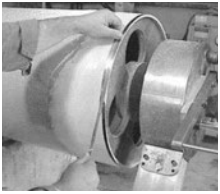
2”-12” Remote Power Tool

Additional material will be needed for 8" and larger tools: Sturdy work bench (preferably with a metal top) or stand to hold the tool. Strap Clamp kit to restrain pipe while tapering.

8"-16" Taper/Scarf Tool - This is an electrically powered tapering tool. When using the 8"-16" tool you must find a method to secure the pipe. This can be done with strap clamps, a heavy duty table for short sections or HD pipe stands for full lengths.

8”-16” Taper/Scarf Tool

18"-24" Tapering Tool - This is an electrically powered tapering tool. The tool comes with different size mandrels to taper 18"-24" pipe.



18”-24” Tapering Tool

Note for HP 32 pipe: For 2"-6" pipe, use the 2"-12" Remote Power Tool. For 8"-16" pipe, use the 8"-16" Single Point Taper tool. The 2"-12" Remote Power Tool can taper 8"-12" pipe if necessary but the 8"-16" tool is preferred for those sizes.

Note for HP 40 pipe: For 2"-16" pipe, taper angle is 1 ¾ degree.

Table 5

Extension Cord Length*

Wire Size AWG	Maximum Length (ft)
12	20
10	30
8	50

*The 8"-24" single point taper tools may not operate properly with an extension cord over 25'.

Table 6

Tapering, Scarfing and Cutting Tool Reference Chart

Tool	Product	Tool Taper Angle	Bulleting #	Comments
1" - 6" Hand Tapering	RT GT	1" = 3°; 1½ = 2½° 2" - 6" = 1¾°	TLS 6600	Specify product to receive correct mandrels. Order scarfing adapter kit for secondary containment power adapter separate. Uses Ridgid 700 or equivalent power drive with a Ridgid 774 adapter.
2100 Power	RT	1¾°	TLS 2000	Tapers 2" & 3"; Scarfs 3" & 4"
2102 Power	RT	1¾°	TLS 2000	Tapers 2"-4"; Scarfs 3"
2300 Power	GT	1¾°	TLS 2000	Tapers 2"-4"
2106/2306 Power	RT/GT	1¾°	TLS 2000	The 2106 tapers 2"-6" RT. The 2306 tapers 2"-6" GT. The tools are interchangeable between RT/GT. Mandrels can be purchased separate.
2700 Power	SS	1¾°	TLS 2000	Tapers 2"-4" Silver Streak
8" Tapering Tool	RT/GT	0 or 1°	TLS 6608 Taper TLS 6609 Scarf	Tapers and scarfs 8" Red Thread and Green Thread
10" & 12" Taper or Scarfing Tool	RT/GT	0 or 1°	TLS 6612 Taper TLS 6613 Scarf	Tapers and scarfs. Order scarfing adapter kit for Secondary Containment. Uses Ridgid 700 or equivalent power drive with a Ridgid 774 adapter.
8"-16" or 18"-26" Single Point Taper Tool	8"-26" RT, GT, SS	1° or 1¾°	TLS 6622 TLS 6621	Tapers or scarfs 8"-16" RT, GT, SS. Scarfs 8"-12" GT, or 8"-16" secondary containment.
2"-12" Remote Power Tool	RT, GT, SS	2"-6" - 1¾° 8"-12" - 1°	TLS 6601	Tapers 2"-12" pipe. Must change angle for 8" and larger pipe.
30"-42" Taper Tool	RT, GT, SS	1¾°	TLS 6636	Taper 30", 36", and 42"

Joint Prep for Red Thread, Green Thread and Silver Streak

All bonding surfaces must be clean and dry before bonding.

- For T.A.B. joints, clean with an acceptable solvent and clean rag. Wire brushes may also be used for cleaning T.A.B. surfaces; however, they must be clean and free of oily contaminates.
- All bonding surfaces must be clean and dry before bonding. For T.A.B. joints clean with an acceptable solvent and a clean rag. Never sand T.A.B. X T.A.B. surfaces.
- For smooth tapers, sandpaper or solvent (or both) may be used. Sand just light enough to remove any contaminates.
- Use caution as over-sanding can change the taper angle or end dimension, and create flat spots on the spigot.
- When surfaces have weathered, sand or retaper spigots and sand bells to achieve a factory fresh appearance. Cut at least 1" from spigots before retapering. T.A.B. couplings must be replaced.
- Bonding surfaces must be dry, so be sure all solvent has evaporated before applying adhesive.

When ambient temperature is below 70°F, pre warm the bonding surfaces. Use a hot air gun, propane torch or other clean burning heat source that has a spreader type tip, and apply heat uniformly to bell and spigot until warm to the touch. Check temperature by touching bonding surfaces with the back of your hand. Do not touch with the front of your hand as this may contaminate the joint. If hot to the touch, let cool before applying adhesive. When using a torch to preheat, warm the bell first. It is thicker and will hold heat longer. If an electric heating collar is used to pre warm, place the joint together dry, then heat the O.D. of the bell to avoid contaminating the spigot. Do not use chemical heat packs to pre warm. ⚠ **Warning:** Do not use propane torch around flammable gases or liquids.

NOTE: Use of a solvent as a cleaning method is optional.

⚠ **WARNING:** Before using heating devices or open flames be sure all safety checks and regulations are followed. Do not use if flammable gases or liquids are present.

Some alternate cleaning solvents are acetone, methylene chloride, and methyl ethyl ketone. After cleaning, be sure any residual solvent has evaporated before applying adhesive. DO NOT USE SOLVENTS THAT LEAVE AN OILY FILM ON THE BONDING SURFACES. Only use fresh solvent directly from the manufacturer's container. Do not use dirty solvent or solvent poured in a secondary bucket.

WARNING: Some degreasers and solvents are extremely flammable. Do not smoke or use near an open flame. Wear eye protection. Be sure to read warning labels on containers. Do not use alcohole as most alcohol contains water and could contaminate the joint.

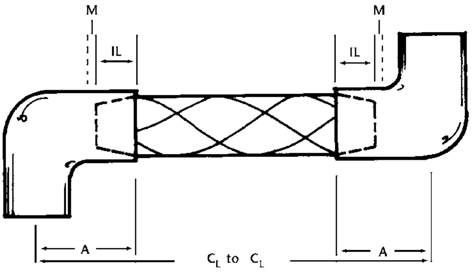
Never use gasoline, turpentine, or diesel fuel to clean joints.

Solvent containers may be under pressure. Use caution when removing inner seals, especially in warm weather. Use with adequate ventilation.

Close Tolerance Piping - The tapered bell and spigot system employed by FGS can be readily used to achieve dimensional accuracy where required by a particular pipe layout. When the installation is such that close tolerances must be maintained, you must follow these instructions. You must accurately reproduce tapers (spigots) in the field with the field tapering tools. This provides a means of achieving dimensional accuracy.

Calculation to Achieve a Desired Length - Most close tolerance installations are made to prints calling out CL to CL (center line to center line) dimensions.

When fabricating to these dimensions, follow these procedures per the figure below.



1. Obtain the center line to face dimension (A) of fittings to be used from Tables 8 or 9 on pages 46-50.

2. Create an insertion gauge by cutting a short section of pipe; 12" long for small diameters and 18" long for larger diameters. Taper the pipe using the instructions supplied with each tool. Check dry insertion. The insertion length should be within ± 1/8" of a factory spigot insertion. NEVER USE A FACTORY TAPER FOR A GAUGE.
3. Obtain insertion length (IL) by inserting the gauge (made with the tool being used) into a fitting and measuring. (**NOTE:** Measure each end of each fitting, because the insertion may vary for each bell.) You can prepare and use a short nipple as a standard insertion gauge.

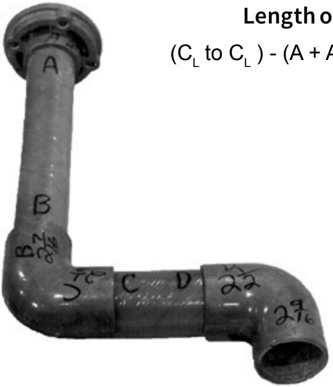
NOTE: You must prepare a new gauge if you change tapering tools or make any changes to the tool you are using.) Always add a make-up dimension (refer to Table 7) to this measurement, since the adhesive will act as a lubricant and allow greater penetration than when the surfaces are dry. Measure each end of each fitting with your gauge.

Table 7

Approximate Make-up Dimensions HP 16/HP 25 (M)*

Pipe Diameter, in	Approximate Make-up Dimensions*, in
1 and 1 1/2	1/16
2	1/8
3 and 4	3/16
6	1/4
8	3/8
10 and 12	5/8
14	3/4
16	1
18	1 1/4
20	1 1/2
24	1 3/4

4. To achieve a specified CL to CL dimension, the length of pipe to cut is equal to the CL to CL distance minus the sum of the center line to face dimension of the fittings ("A" dimension) plus the sum of the measured insertion lengths (IL) plus the sum of the make-up allowance (M), or length of pipe to cut = $(C_L \text{ to } C_L) - (A + A) + (IL + IL) + (M + M)$.



Length of Pipe to Cut =

$$(C_L \text{ to } C_L) - (A + A) + (IL + IL) + (M + M)$$

***CAUTION:** Make-up dimensions depend on the tightness of the dry fit. If the field developed dimensions vary, use field developed dimensions.

NOTE: Use field dimensions for HP 32/HP 40 systems.

Adhesive Mixing

When the weather is cool or the adhesive has been stored in a cool environment (below 70°F), pre warm the adhesive kits. (Do not heat above 100°F!)

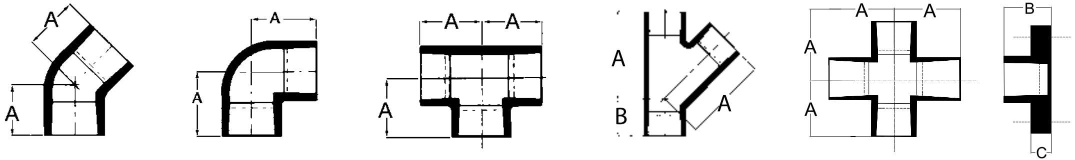
1. For epoxy empty all of the contents of the hardener bottle into the can of base adhesive.
2. Mix all of the base epoxy adhesive with all of the hardener. NEVER ATTEMPT TO SPLIT A KIT. Cut through the adhesive with the edge of the mixing stick to assist in mixing the two components.
3. Mix until the adhesive has a uniform color and a consistent flow off the mixing stick. Wipe down the sides, bottom, and under the rim of the can with the mixing stick to assure complete mixture.

Complete information and safety precautions are packaged with each adhesive kit. Review all safety precautions thoroughly before mixing the adhesive.

ADHESIVE DISPOSAL: Once the adhesive and hardener have been mixed and reacted, nothing can be extracted, and it is classified as non-hazardous material. Dispose of in a normal manner as other solid waste. Excess adhesive and hardener can be mixed, allowed to react, and disposed of as above. If extra jars of adhesive or hardener have accumulated without the other component to mix and react, contact your regional manager. Hardener jars, when empty are not subject to EPA regulation and can be disposed of in a normal manner. These guidelines are based on federal regulations. State and local regulations and ordinances should be reviewed.

Table 8.0

Take-off Dimensions for RT, GT, Fittings (Contact Company for SS Dimensions)



Size	45° Elbow	90°Elbow	Tee	Lateral		Cross	M/FW*	M/FW*
	A	A	A	A	B	A	B	C
1	2⅜	2¾	2¾	3⅞	2½	2¾	1¾	¾
1½	2⅞	3⅜	3⅜	5¼	3¼	3⅜	1¾	¾
2	2⅝	3⅜	3⅜	6⅝	2¾	3⅜	2¼ / 2⅛	¾
3	3¾	4⅝	4⅝	7¾	4¼	4⅝	2⅝	1⅜
4	3⅞	5⅛	5⅛	9	4⅜	5⅛	2⅝ / 3½	1⅜
6	4⅜	6⅛	6⅛	12½	5¾	6⅛	3 / 3¾	1½
8	8⅛	11⅝	11⅝	16¼	7⅜	11⅝	4	1¾
10	8⅝	13	13	19⅝	8¾	13⅛	4¾	2
12	9½	14	14	24¾	11¾	14	5	2¼
14	12½	19	19	32½	15¾	16	3⅛	2½
16	13¼	20¼	20¼	35¾	17¾	17¼	3⅛	2½

***Flanges**
M-Molded
FW-Filament Wound

Dimensions are used to calculate pipe length requirements to meet pipeline center line to center line dimensions.

Table 8.1a

Dry insertion depths for standard Red Thread HP 16 and Green Thread HP 16 pipe and fittings

Size	90° & 45° Degree Elbows & Tees		Crosses		Laterals		Molded Flanges		FW Flanges		Couplings		Integral Joints	
in	X-RT	X-GT	X-RT	X-GT	X-RT	X-GT	X-RT	X-GT	X-RT	X-GT	X-RT	X-GT	X-RT	X-GT
1	-	1	-	1	-	1	NA	1	-	1	-	-	-	1¼
1 ½	-	1	-	1	-	1	-	1	-	1⅛	-	-	-	1½
2	1½	1½	1½	1⅝	1½	1⅝	1½	1⅝	1½	1⅝	-	-	1¾	1½
3	1⅝	1⅞	1⅝	1⅞	1⅝	1⅞	1½	1⅞	1⅞	2	-	-	1¾	1¾
4	1½	1⅞	1½	1⅞	1½	1⅞	1¾	1⅞	1⅞	2⅝	-	-	2⅛	1⅞
6	2⅛	2⅜	2⅛	2⅜	2⅛	2⅜	2¼	2½	2½	2½	-	-	2⅜	2⅛
8	3¾	3¼	3¼	2⅞	3¼	2⅞	2⅝	2¼	3⅜	3⅜	3⅞	3⅞	3⅞	3⅜
10	3⅞	3⅝	3¼	3	3⅛	2⅞	3¾	3⅜	3	3	3 ¾	3⅜	3¾	3⅜
12	4	3¾	3⅝	3¼	3¼	3	3¾	3⅜	3	3	3⅞	3⅝	3⅞	3⅝
14	6⅛	6	3⅝	3⅝	3⅝	3⅝	-	-	2¼	2⅜	4⅜	4¼	4⅜	4¼
16	6⅛	6⅛	3⅞	3⅞	3⅞	3⅞	-	-	1⅞	2	4½	4½	4½	4½

The X values are the nominal dry spigot insertions used to set up tapering tools.

The tolerances for dry insertion are ±⅛" for 1"-6" and ±¼" for 8"-16”"pipe sizes. The final insertion referred to as the wet locked up position will be larger than the X dimension. Do not use these dry insertion depths for close tolerance piping calculations.

Table 8.2

Take off and nominal dry insertion dimensions for Silver Streak piping systems. Refer to Silver Streak bulletin or www.nov.com/fgs for more information.

Size	Coupled/Mitered	Filament Wound
in	in	in
2	1⅞	2⅝
3	2⅜	2⅞
4	2	3⅛
6	2⅞	2¾
8	3½	5¼
10	4⅜	5⅛
12	4⅞	6⅜
14	5½	4½
16	6¼	5⅝

Table 8.3

Dry insertion depth "X" for Stub Ends

Size	Green Thread	Red Thread[1]	Red Thread T.A.B.[2]
in	in	in	in
2	2 ⅛	2 ⅛	1 ⅞
3	2 ⅞	2 ¼	1 ⅞
4	2 ¼	1 ⅞	1 ⅞
6	3 ⅜	3 ¼	3

[1] Smooth Taper as built in field

[2] Factory T.A.B. spigot

Table 9a

Take off dimensions for RT/GT HP 25 products. X dimensions are nominal dry insertion lengths. Pipe must be driven together and fully locked up to assure full joint strength. Actual insertions should be +¼" for 8" and larger joints. Insertion depths are for tool set up only. Do not use insertion depths (x) for close tolerance piping. Refer to joint assembly instructions for complete information on joint lock up

Size	45° Degree Elbows (Long Radius) (in)			90° Degree Elbows (Long Radium) (in)			Tee (in)			FW Flanges (in)		Van Stone Flanges (in)	Coupling (in)		Integral Joint (in)	
in	A	X-RT	X-GT	A	X-RT	X-GT	A	X-RT	X-GT	X-RT	X-GT	A	X-RT	X-GT	X-RT	X-GT
1	-	-		-	-		-	-		-	-	-	-	-	-	-
1 ½	-	-		-	-		-	-		-	1⅛	-	-	-	-	-
2	-	-	2½	-	-	2 ½	-	-	2½	-	1¾	-	-	-	-	-
3	-	-	2¾	-	-	2 ¾	-	-	2¾	-	2⅞	-	-	-	-	-
4	-	-	3	-	-	3	-	-	3	-	3¼	-	-	-	-	-
6	-	-	2¾	-	-	2 ¾	-	-	2¾	-	3⅝	-	-	-	-	-
8	12½	6	5⅛	19½	6	5⅛	13½	6	5⅛	-	3⅜	6¼	5¾	5¼	4⅝	4⅛
10	14½	6½	6½	23¼	6½	6½	15¾	6½	6½	-	5	7	5½	5¼	5¾	5⅜
12	16½	7	7	27	7	7	17¾	7	7	-	5⅝	7¾	6⅛	5⅞	6¼	6
14	17¾	5¾	5¾	30	5¾	5¾	19½	5¾	5¾	-	4⅝	8	5¾	5¼	6	5⅜
16	20	-	5¾	34	5¾	5¾	21½	5¾	5¾	-	4½	9	6⅜	5⅛	6⅜	5⅛
18	24⅞	-	10⅞	40	-	-	26⅜	-	-	-	7⅜	10½	-	-	-	-
20	29⅝	-	12⅝	47¼	-	-	31¼	-	-	-	8	12½	-	-	-	-
24	35⅞	-	15⅝	57	-	-	35	-	-	-	10⅜	15½	-	-	-	-

Dimensions are used to calculate pipe length requirements to meet pipeline center line to center line dimensions.

Table 9b

Dry insertion depth for Green Thread HP 32 fittings

Size	90° & 45° Degree Elbows & Tees	FW Flanges
in	X-GT	X-GT
1*	-	-
1½*	-	-
2*	-	-
3*	-	-
4*	-	-
6*	-	-
8*	-	-
10*	-	-
12*	-	-
14	8⅛	6¾
16	9⅝	8
18	10⅛	8⅜
20	11⅞	10
24	15	12¾

* These sizes are rated to HP 40. See Table 9c for HP 40 insertion depths.

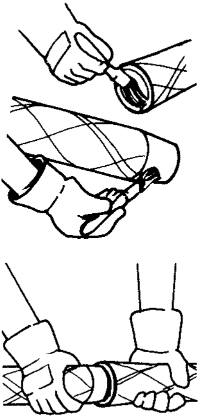
Table 9c

Dry insertion depth for Green Thread HP 40 fittings

Size	90° & 45° Degree Elbows & Tees	FW Flanges
in	X-GT	X-GT
1	-	-
1½	-	-
2	2½	1¾
3	3⅛	2½
4	3¾	3⅛
6	4⅜	3⅝
8	7⅜	6⅝
10	8½	7⅝
12	9⅞	8¾

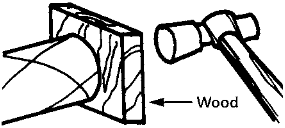
Installing 1" - 6" joints with a block of wood and a hammer

When ambient temperature is below 70°F, pre warm the bonding surfaces. Use a hot air gun, propane torch or other clean burning heat source that has a spreader type tip, and apply heat uniformly to bell and spigot until warm to the touch. Check temperature by touching bonding surfaces with the back of your hand. Do not touch with the front of your hand as this may contaminate the joint. If hot to the touch, let cool before applying adhesive. When using a torch to preheat, warm the bell first. It is thicker and will hold heat longer. If an electric heating collar is used to pre warm, place the joint together dry, then heat the O.D. of the bell to avoid contaminating the spigot. Do not use chemical heat packs to pre warm. ⚠ **WARNING: Do not use propane torch around flammable gases and liquids.**



Brush adhesive on both the bell and spigot bonding surfaces, applying a thin uniform coating to each . To minimize contamination, apply adhesive to the bell first. Adhesive should always be worked into the machined surface by applying pressure during application. This will "wet out" the machined surface and maintain the required thin bond line. Be sure that adhesive is deep down into the bell past the insertion depth and that all machined taper surfaces on the spigot and the cut end of the pipe are uniformly covered. Excess adhesive will make the joint more difficult to lock.

Align and lock the joint. For 2" or smaller pipe, insert the spigot into the bell until surfaces touch, then push and turn at the same time until a lock is achieved. Only a quarter to a half turn is usually needed. On 3"-6" diameter pipe or on fittings, pushing and turning to lock the joint is impractical and driving force must be used. A hammer may be used to assist in joint lock-up. Place a 2x4 board flat across the bell. The first few raps should be light to prevent any tendency of the joint to back out.



If the adhesive or the pipe surfaces are cool, push and hold for a few seconds to allow time for the adhesive to start flowing out of the tapered joint.

Check lock up by moving a free end of the pipe in an up and down or side to side motion. The movement must be sufficient to move the joint being checked. No movement should be visible in the joint. If any movement exists, the joint is not properly locked up. Avoid excess movement as this could damage the spigot.

For installing 8" - 16" fittings and pipe with manual come-alongs and strap clamps, the following recommendations should be followed:

- Strap clamps should only be tightened by hand. Do not use cheater bars or wrenches to tighten them for the clamps may be overstressed.
- The clamps should be covered to prevent flying debris should a clamp failure occur.
- If the strap slips on the pipe surface, Emery cloth placed between the strap and pipe will increase the frictional resistance to slipping. Abrasive powders such as Ajax® or Comet® powdered cleaners will likewise increase the resistance to slippage.
- Only use on pipe joint sizes 8" - 16".

Hydraulic come-alongs are required on all matched tapered joint sizes 18" and larger. When pipe joints are pulled together with come-alongs, they must be vibrated during joint make up. The vibrating reduces the joints resistance to movement.

Installing 8" - 16" HP 16 and HP 25 products using an FGS Hydraulic Come-along. (See manual TLS6618) Hydraulic Come-alongs are recommended for long pipe runs. All threaded parts should be checked before every use to ensure engagement of threads to prevent tool damage and possible physical injury.

The operator should be positioned in a safe position to the side of the pipe. The hydraulic pump is supplied with a pressure gauge to allow monitoring of the loads. Do not exceed the recommended loads.

One strap clamp is supplied with each come along kit. A Strap Clamp kit or bolt up style metallic fitting clamps are available on request.

The 8" - 16" hydraulic come -alongs are supplied with wedge style pipe clamps. Attach the clamps and drive the wedges on tight. Clean and prep the bonding surfaces and apply adhesive. Stab the joint together by hand and attach come-along chains. Use the hand pump and apply the required pressure from table 10. As the joint is pulled together use a 5 lb dead blow hammer (supplied with the come-along) to vibrate the joint hitting it 360 degree around the IJ head or fitting. Keep pressure on the joint until all of the adhesive has squeezed out and there is not forward movement seen at the joint. With full pressure on, hit across the joint three times. When the pressure drop is 200 psig or less, the joint is considered locked up. After the pipe has been properly supported, you may remove the come along and clamps and move to the next joint immediately. Come along pressure must be left on until all pipe movement, blocking up, etc. is finished and the pipe is secure.

Table 10

Hydraulic Come-Along Pressures

Pipe Grade	Pipe Size	Hydraulic Pressure
	in	psig
RT, GT, SS	8-10 12-16	1500 - 1750 1750 - 2000
HP 16 Products	18-42	1500 - 2600
HP 25 Products	8-12 14-16 18-24 30-36 42	2000 2500 3000 4500 5000

Joint Support During Cure

During joint assembly, the uncured bonded joint MUST be supported at all times until the adhesive is fully cured. Blocks, sand bags or skids may be used to support the pipe during installation. At least two supports are required for each pipe length. Place the supports 5’ from each end. After the joint has been pulled together and locked up, leave the come-along pressure on until the supports have been placed under the pipe and the pipe is heading in the right direction/orientation. If the middle of the pipe starts to sag, place supports under them as well. Excess movement across the joint before it has cured could result in damage to the pipe spigots. After the joint has been supported properly you may remove the clamps and go to the next joint.

Installing 18"- 42" Pipe and Fittings with Hydraulic Come-Along

Hydraulic come-alongs are required for 18" an larger products. The operator should be in a safe position to the side of the pipe. **Check all threaded parts before each use to ensure full engagement of the threads and prevent tool damage and possible physical injury.** The hydraulic pump is supplied with a pressure gauge to monitor the pressure loads. Steel fitting clamps and 1 1/4" bolts are shipped with each come-along unit. Do not over pressurize as this could lead to joint back out.

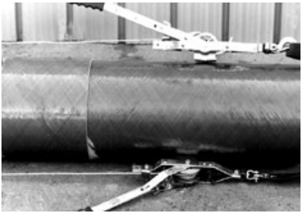
Bolt up style pipe and fitting clamps are available in 18" - 42" sizes. The fitting clamps are narrower than the pipe clamps. The come -along clamps are supplied with a small hook on the handle. This hook is designed to hold the two clamps together while the bolts are tightened. The use of an impact wrench and a portable air compressor is recommended. Basic wrenches can be used but add time to the process.

Place the clamps approximately 3' from the end of the joint on both sides. Screw the cylinder base extension to the cylinders. and place between the clamps. Tighten bolt tight to prevent slippage. Place a bolt through the cylinder base with no threads and tighten. Connect chain thru the cylinder bases. Prep joint and apply adhesive. Using a tractor or side boom slowly stab the joint together. Tighten chains and hang through the "claw" on the cylinders. Apply the required pressure from Table 10. As the joint is pulled together use a 5 lb dead blow hammer (supplied with the come-along) to vibrate the joint hitting it 360 degree around the IJ head or fitting. Keep pressure on the joint until all of the adhesive has squeezed out and there is not forward movement seen at the joint. With full pressure on hit across the joint three times. When the pressure drop is 300 psig or less, the joint is considered locked up.

When installing 18" - 24" it is recommended that the come-alongs be left on for approximately 5 minutes before releasing come-along pressure to ensure lock up and the pipe has been properly supported.

When installing 30" - 42" joint the clamps must be left on until the joint is fully cured per the required cure time.

Ratchet-Type Cable Come-alongs are recommended when it is not practical to use hydraulic come alongs. Strap clamp kits or special fitting collars are available for use with the manual come alongs. Only use on 8" - 16"products.



Strap clamps should only be tightened by hand. DO NOT use cheater bars or wrenches to tighten them as this could result in personal injury.

The clamps should be covered to prevent flying debris should a clamp fail.

If the straps slip on the slick pipe or fitting surface, emery cloth placed between the strap and the pipe or fitting will increase the frictional resistance to slipping. Abrasive powders such as Ajax or Comet may also be used under the straps to help prevent sliding.

Two cable come-alongs are required to make up a joint. The come-alongs should be positioned on opposite sides of the pipe joint to achieve a straight pull. The come-alongs are attached to the pipe via heavy-duty strap clamp kits or metallic pipe clamps.. These straps/clamps should be placed far enough away from the joint to allow the positioning and use of the come-alongs. They are generally placed 24" - 36" away from the joint, one on each side of the joint but actual placement requirements will be governed by the size of the come-alongs.

Clean and prep the joint and apply the adhesive. Gently stab the joint together. The two come-alongs should be tightened at the same time to maintain a straight joint while pulling the joint together. Vibrating of the pipe by rapping the fitting bell or coupling surface with a 5# dead blow hammer will reduce the frictional resistance in the joint being pulled together. The load on the cables should be held firm until the joints are aligned and completely locked up. The joint is considered locked up when no forward movement is noted. After a joint is made up, do not aggressively move the pipe and joint until the adhesive is completely cured. Relieve tension on cables before attempting to remove strap clamps.

Operation of cable come-alongs should be in accordance with the device manufacturer's instructions.

Installing 18" - 30" Green Thread Flanges

1. Install the flange onto the spigot without adhesive to determine the dry-fit measurement. Use a dead blow hammer to force the flange onto the pipe spigot. See Photo #8

Photo #8

2. If the spigot extends through the bell dry you will need to cut the end of the spigot off. Scribe a cutting guide around the pipe spigot that sticks through the flange face. See Photo #9

Photo #9

3. Remove the flange from the pipe spigot.
4. To calculate the additional amount to be removed due to wet over dry insertion refer to Table 11 and the appropriate pipe diameter, draw a new scribe line on the pipe spigot. See Photo #10

Photo #10

5. Saw the pipe spigot off at the scribe line drawn. See Photo #11

Photo #11

6. Saw the spigot off as smoothly as possible. Sand the new spigot face to remove jagged edges. See Photo #12
7. Sand the spigot and flange I.D. using a heavy grit sand paper. Clean the bonding surfaces with acetone.

Allow bonding surfaces to dry completely. See Photo #13. Refer to standard cleaning/joint prep practices in this manual.

8. Bond the flange to the pipe spigot using a come-along and the appropriate pressure from Table 11. See Photo #14
9. Use wood blocks between the flange and the come-along bar to prevent damage to the flange face. See Photo #15
10. Remove any excess adhesive from the serrated flange face and the O-ring groove using a cutting agent.
11. Allow to gel and then post cure according to Table 13.

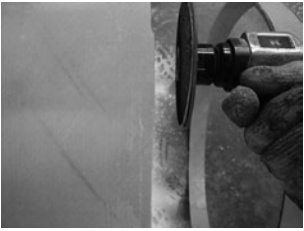


Photo #12

Photo #13

Photo #14

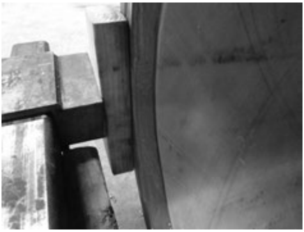


Photo #15

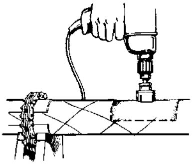
Table 11

Size		Spigot Removal		Come-Along Pressure	
in	mm	in	mm	psi	MPa
18	450	1.00	25.4	2500-2750	17.2-19.0
20	500	1.00	25.4	2500-2750	17.2-19.0
24	600	1.25	31.75	2500-2750	17.2-19.0
30	750	1.50	38.1	2750-3000	19.0-20.7

Installing 2" - 16" HP 32 and HP 40 Products

For 2" - 6" sizes use the sames methods referred to in the HP 16/ HP 25 system. Because the 8"- 16" HP 32/HP 40 systems have a steeper 1 3/4 taper angle vs the 1 degree on the HP 16/HP 25 system, hydraulic come-alongs are not required. Use FGS approved strap clamp kits (these can be purchased through FGS) or rubber lined riser clamps fitted to the pipe OD. Place clamps approximately 3' from the end of the joint and tighten securely where they will not slip. A gritty cleaning powder such as Ajax or Comet may be used under the straps if they start slipping. Attach ratchet or chain style come alongs rated to a minimum of 2000 lbs to the strap or riser clamps on each side of the joint. Clean and prep the joint and apply adhesive. Stab the joint together by hand and attach the come along. Slowly pull the joint together. A 5 lb dead blow or rubber hammer may be used to help vibrate the joint as it is being pulled together. Firmly hit the joint 360 degrees around the IJ head or fitting. Keep pressure on the joint until the adhesive has squeezed out and there is no forward movement seen. For all HP 32 and HP 40 systems, the come-alongs must be left on until the joint is fully cured.

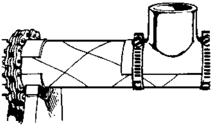
Saddles and Reductions (HP 16) - The recommended adhesives for RT or GT systems are ZC-275 or PSX 60. To develop full strength of an adhesive bonded joint, it is important to properly prepare the bonding surfaces as recommended in the following paragraphs. Heat curing the saddle joint reduces cure time, improves the chemical resistance as well as the ultimate strength of the bond.



Position the saddle on the pipe and mark around the saddle base. Use a sander or sanding tool (24 to 40 grit) to remove all surface gloss from the pipe O.D. where the saddle is to be bonded. (For large diameter pipe, a disc sander is usually more practical.) Use circular or random pattern motion during sanding to eliminate grooves on the pipe surface. After sanding, position the saddle on the pipe and mark the hole to be cut in the pipe. Cut a hole the same size as the saddle outlet using a pilot drill and circular hole or saber saw. Do not force the cutter or it will fray the edges of the hole excessively. Clean all bonding surfaces as required.

Apply a thick coat of adhesive to the O.D. of the pipe and the I.D. of the saddle, and the edges of the pipe wall exposed by the hole. Place the saddle over the hole and clamp with two hose clamps or a strap clamp. The clamps may be left on after the joint is cured.

Using a large screw driver, hand tighten the hose clamps alternately until secure and adhesive squeezes out all the way around the saddle. This will ensure that the pipe O.D. conforms to the saddle run. To cure a saddle it is recommended that two heating collars be used , one on each side of the saddle "run". An alternate method is to use a box lined with industrial heavy duty foil and an industrial heat gun. When using the foil method cut a 12" section of 2" pipe and insert heat gun in the end to prevent over heating. Allow adhesive to cure before bonding in the side run.



Installing Reducer Bushings - Install reducer bushings using a block of wood and a hammer and the same procedures as for bell and spigot pipe. The wood block should be sized to allow the reducer bushing to be counter-sunk in the bell. Some reducer bushings will be counter-sunk before they are actually locked up. For maximum chemical resistance with 8" and larger Green Thread reducer bushings, coat all machined surfaces with adhesive just before assembly.

Making Short Nipples - To make short nipples, be sure the overall length is equal to two insertion lengths plus a minimum of ½" (gap between mating fittings).

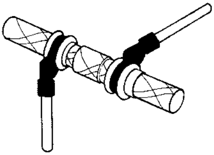
The most common way is to:

1. Cut off an existing section of pipe from the bell end that is long enough to be securely contained in a pipe vise or clamped to a table.

2. Use a factory taper or set your taper tool up and taper one end of a longer section of pipe. Cut pipe with taper to the required length you want your pipe nipple to be. Jam the tapered end in to the bell of the pipe in step 1. Be sure it is secure enough to hold the pipe nipple without spinning.

3. Taper the pipe. The same method “loose bell method" can be used with the 2000 series box tools. Never hold your hand over the end of the pipe when working with the box tools.”

T.A.B. Joints (Threaded and Bonded)



Two T.A.B. wrenches are recommended for 2" and 3" and are required for 4" and 6" T.A.B. x T.A.B. joints. T.A.B to smooth connections do not require T.A.B. wrenches. Prep bonding area and mix adhesive. Spread adhesive over both T.A.B. connections. Stab joint together and start thread engagement by hand and turn until hand tight. Place T.A.B. wrenches 12" away from the bonding area. Using the T.A.B. wrenches screw together until firm. Check lock up by moving the joint up and down. No movement should be visible at the joint.

Joint Cure

Ambient Cure - Cure time is the time required for the adhesive in the assembled joint to harden. Cure time depends on the type of adhesive and the ambient temperature, as shown in Table 12.

You can shorten cure time by applying heat. Although all of the adhesives will cure at ambient temperatures above 70°F, it is recommended they be heat-cured at temperatures of at least 275°F to maximize physical properties and corrosion resistance. See page 43 for instructions for using heat collars for heat-curing joints.

High Temperature Heat Collar (Table 13) - Refer to bulletin for complete operating instructions.

NOTE: Do not bend or fold heating collar as this may break the heating elements and cause the collar to work improperly or not at all.

Pipe and Fittings:

1. Use the same size heating collar as the pipe size you are installing, with the exception of flanges. Do not use a heating collar that is designed for a larger size pipe.
2. With the uninsulated flap on the bottom (next to the fitting), carefully wrap the heating collar around the joint. Feed the strap through the square ring. ⚠ **CAUTION:** The uninsulated flap is extremely hot when the collar is on. DO NOT TOUCH with bare hands.
3. Tighten the straps until the heating collar is snug against the joint.

Flanges:

1. For 1", 1½" and 2" flanges, an industrial heat gun may be used to cure the joint. Be sure that the end of the gun is at least six inches from the opening of the flange.
2. For 3" through 16" flange joints, use a heating collar that is one pipe size smaller. Remove the straps from the heating collar.
3. Carefully turn the collar inside out with the heated area facing the I.D. of the pipe. Place the heating collar in the I.D. of the flange. A split ring of pipe may be used to hold the collar in place while the joint is curing.

Allow the joint to return to ambient temperature before applying stress to the joint.

NOTE: High Temperature electric heating collars are designed to fit around fittings, and will overlap on pipe joints and couplings. Exceeding the recommended cure time on pipe joints where the heating collar overlaps may shorten the life of the heating collar and/or damage the pipe.

Table 12

Adhesive Ambient Cure Time

Adhesive Type	Temperature, °F	Cure Time, hr
2000	110	1
	90	3
	80	4
	70	9
	60	16
	50	24
8000	110	1
	90	2
	80	4
	70	6
	60	12
	50	18

Table 13

Adhesive Cure Time for Electric Heating Collars

Pipe System & Adhesive Grade	Pipe Size	Cure Time (minutes)				
		Pipe(1)	Fitting(2)	Flange	HP 20/HP 25	HP 32/HP 40
Red Thread Green Thread Silver Streak 2000 or 8000 Series Adhesive	1-6	15	20	15	N/A	N/A
	8	20	20	20	30	60
	10	30	30	30	35	60
	12	30	30	30	40	90
	14	35	35	35	45	90
	16	40	40	40	60	90
	18(3)	90	90	90	120	N/A
	20(3)	90	90	90	120	N/A
	24(3)	90	90	90	120	N/A
	30(4)	120	120	90	N/A	N/A
	36(4)	120	120	90	N/A	N/A

The use of insulation is required below 40°F to prevent heat loss.

NOTE: These cure times are for environments warmer than 70°F. If cooler, see "Cold Weather Installation Tips" or consult NOV Fiber Glass Systems. Adhesives will cure in 24 hours at ambient temperatures of 70-100°F.

(1) Includes sleeve couplings.

(2) 1", 1 ½" & 2" flanges require the use of an industrial heat gun. Air temperatures inside the flange should be no greater than 400°F and no less than 250°F.

(3) Below 50°F, the heating collars should be wrapped in insulation to reduce heat loss and are required below 40F.

(4) 18" and larger heat collars require multiple plug 20 amp power outlets.

Heat Packs - Heat packs that cure joints in approximately one hour are also available. Refer to bulletin for complete instructions that are included with each kit. Observe all safety precautions listed on the instruction sheets that accompany the heat packs.

CAUTION: The adhesive bead will cure faster than the adhesive in the joint. It is important that the joint not be pressurized until it has been subjected to the proper time-temperature cycle. A temperature versus time to pressure curve is indicated in the instructions packaged with each adhesive kit.

Repairs for Red Thread, Green Thread & Silver Streak Piping Systems

Contact a NOV Fiber Glass Systems field service rep for HP 32/HP 40 repairs.Fiberglass piping systems HP 16/HP 25 are repaired by cutting out a fitting or a damaged section of pipe and replacing it with new material.

CAUTION: Always determine exactly what fluid has been in the piping system as it may be flammable. Contact may be harmful to humans. Take necessary precautions.

Always use the same pipe grade, fittings, and adhesive on new parts as is in the existing system. Do not mix pipe grades.

Inspecting for Potential Causes of Joint Failure

Joint Back Out – If the bead is no longer next to the edge of the bell, the joint backed out before the adhesive cured.

Cocked Joint – If a joint is cocked or misaligned, there will usually be a large gap between the bell and spigot on one side.

Improperly Cured Joint – If the adhesive bead is soft or flexible, the adhesive is not sufficiently cured.

Weathered Joint – If the machined area appears yellow, the joint may have been exposed to UV degradation.

Repairing Weather Damage

If machined surfaces of pipe or fittings are exposed to direct sunlight prior to installation, a loss of joint bonding strength may occur. If ultraviolet exposure is greater than two hours, the following steps must be taken:

1. For exposed spigot ends, use 60 to 80 grit sand paper or Emery cloth and lightly sand to remove UV degradation. If UV degradation is too severe, cut 1" from the end of the pipe and retaper.
2. For exposed bell ends (pipe or fittings), sand thoroughly until the entire surface appears fresh. Hand sanding with 40 grit sandpaper is recommended. Use a light sanding operation to prevent changing the taper angle.

NOTE: Couplings or integral bells with T.A.B. threads that have been overexposed must be replaced.

Repairing Minor Damage

For damaged areas less than one inch in diameter in light chemical or water service.

Flanged Systems - If possible, simply replace the entire flanged length. Otherwise, cut out the damaged section, then bond new flanges to the remaining pipe ends according to recommended procedures. Next, fabricate a new flange-by-flange spool to the length required. Bolt in the new pipe section.

Flanged fittings should be removed from the system when damaged and replaced with a new fitting.

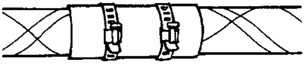
Tapered Systems - Make a patch to cover damaged area.

1. Cut a length of good pipe to adequately cover the damaged area and extend 3"-4" on either side of the damaged area.

2. Slit this "patch" lengthwise twice and remove a section so that about three-fourths of the circumference remains for 1"-4" pipe and one-half the circumference for 6" and larger pipe.

3. Thoroughly sand the inner surface of the patch and sand a corresponding area on the pipe around the damaged section.

4. Clean the bonding surfaces, then apply a thick coating of adhesive to both surfaces, snap the patch in place, and apply pressure with hose clamps. The clamps may be left on or removed after curing.

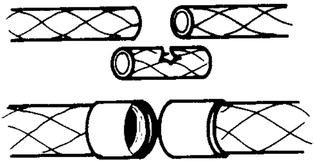


Repairing Extensive Damage

When the damaged area in the pipe wall is larger than one inch in diameter, or for repair of pipe in severe chemical service that requires a lined product, follow these instructions:

1. When damage is local (less than one inch long, but more than two inches around the circumference of the pipe), check to see if there is enough slack in the pipe to cut out the damaged section, re-taper the cut ends, and bond a sleeve coupling between the tapered ends.

2. When damage is extensive (too large for replacement by a single sleeve coupling), cut out the damaged section, taper the cut ends, and install two sleeve couplings and a pipe nipple. This procedure requires sufficient slack in the line to make the final joint by lifting the pipe (or moving the pipe to one side) to engage the bell and spigot joint.



3. If the line cannot be moved sufficiently to install a sleeve coupling or a sleeve coupling spool piece, taper both ends of the pipe and install flanges.

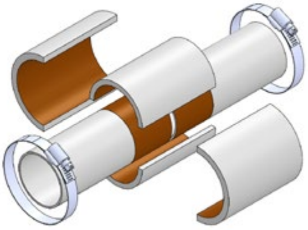
4. If it is impossible to taper the pipe in the ditch, you can install a new section of pipe by over wrapping the plain cut ends.

    a. Clean an area large enough for installers to work on both sides and under the pipe. Cut out the damaged section of pipe and measure the gap. Cut a section of good pipe that is not more than one-half inch shorter than the length to be replaced (1⁄4" maximum gap on each end).

    b. Sand the ends of the pipe to remove all resin gloss. Align the replacement pipe section with the pipeline and block up all sections to maintain alignment. All sections must be rigid so they will not move during the over wrapping procedure. Tack welds should be used by placing 1" x 2" patches of glass cloth and adhesive (four patches spaced at 90° intervals around the pipe). See Overwrapping.

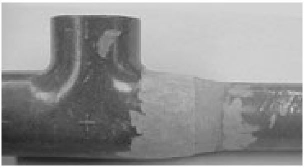
Repairing Leaking Joints

Repair Coupling for HP Tapered Products – Repair couplings are available from NOV Fiber Glass Systems for most applications. These couplings may be used on Red Thread HP 16, Green Thread HP 16, Silver Streak and Bondstrand 3000/3200 piping services up to 200°F. Contact your local FGS representative for recommendations for severe chemical services or temperatures above 200°F.



For the 2” through 10” RT, GT and SS products Bondstrand Maintenance Repair Couplings can be used for services up to 150 psig. For 12” products the pressure is rated up to 125 psig. For sizes 4” – 12” Red Thread FM Maintenance Coupling Kits may be used on RT, RTFM, GT, SS for a pressure rating up to 200 psig as long as ZC 275 adhesive is used. For installation guidance and instructions please review installation bulletin INS2004.

Overwrapping – If a joint leaks because of improper installation, you can repair it by over wrapping with glass cloth and resin. The temperature in the work area should be 70°F- 90°F. Be sure to protect the over wrap from the sun. System must be open to atmosphere to prevent pressure from building and blowing through wrap.



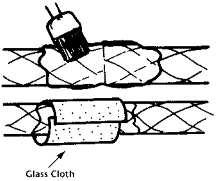
1. Use FGS 10 oz. glass cloth. Components for the epoxy over wrap are available in the 8088 repair kit (see Table 14).
2. Use a grinder or sander with coarse grit to remove gloss five inches on either side of the joint.
3. Bevel the shoulder to blend in with the pipe wall and add putty to make a smooth transition from fitting to pipe. The length of this putty should be held to a minimum, because the putty has limited pressure capabilities.

CAUTION: There must not be any pressure on the line or any fluid leaking from the joint when performing this procedure.

4. Re-sand and clean surfaces including bevel.
5. Thoroughly mix the adhesive and hardener with the stir stick until there is a uniform color and a consistent flow off the stir stick.

NOTE: Cure time is the time before the line can be tested. Times may vary depending upong temperature, humidity, etc.

6. Using a paint brush, apply the mixed adhesive to all sanded areas.
7. Each piece of glass cloth must be slightly longer than the previous piece, because the O.D. of the pipe becomes larger as you add glass cloth. Cut the first piece to allow for two inches of overlap. When this length is no longer sufficient to overlap at least one-half inch on the ends, determine a new length with two inches of overlap.



8. Center a piece of glass cloth over the joint. Pull on the cloth while positioning it and wet it out by painting with adhesive. Brush to remove any trapped air bubbles in the wrap. Start at one end of the cloth and work around the circumference, wetting the cloth with resin. Work the cloth

away from the starting end and from the center of the cloth to the sides. The cloth must be thoroughly wetted with adhesive, but do not spend a lot of time in one area as the cloth will wet out (lose its shiny, white appearance) with time. By the time the cloth has been worked down smoothly with no air beneath it, most of it will be wetted out. An alternate method would be to place a section of clean cardboard or kraft paper on a work table/section of plywood adjacent to the joint to be wrapped. Spread the dry glass out on the table. Wet out each layer by pouring a small amount of adhesive on the glass and spreading it out with the wooden mixing stick or the brush. Be sure the glass is wet out thoroughly but not saturated (dripping). Use the same adhesive to wet out the prepped pipe/fitting surface. Center wet glass over the damaged area or the center of the joint and carefully pull tension around the joint with enough pressure to squeeze out adhesive. Work out any air under the wrap by pushing it out to the side.

9. To prevent thick sections or humps in the over wrap, center the next piece of glass cloth on the joint starting from a new point on the circumference. Never do more than 12 layers at once time. For joints that require more than 12 layers split the procedure into two or more stages. Allow to cure and cool. Lightly sand the glossy areas and repeat Step 8 until all layers are applied.

10. Should the over wrap start to give off heat, discontinue wrapping and let the joint cure and cool with a fan. Sand the cured layers to remove the gloss before restarting the over wrap procedure.

11. Pay particular attention to the bottom of the over wrap as this is the area that may sag and is most difficult to see. Excessive adhesive use may cause this condition.

12. In temperatures above 90°F, protect the over wrap from direct sunlight with some type of sun shade.

Table 14

Weldfast 8088 Overwrap Repair Kits

Pipe Size (in)	Layers of Glass 16 bar	Layers of Glass 25 bar	Glass Width 16 bar (in)	Glass Width 25 bar (in)	Number Kits Required for 16 bar[1]	Number Kits Required for 25 bar[1]
1"	4	6	4"	4"	0.25	0.25
1½"	4	6	4"	4"	0.25	0.25
2"	6	6	6"	6"	0.75	1
3"	6	7	6"	6"	0.75	1
4"	6	7	6"	8"	1	1
6"	6	9	8"	8"	1.5	2
8"	8	12	8"	8"	1	1.5
10"	10	15	8"	8"	1.75	2
12"	12	18	8"	9 layers 8" 9 layers 10"	2	3
14"	14	20	8"	10 layers 8" 10 layers 10"	3	4
16"	16	23	8"	2 layers 8" 11 layers 10"(2)	4	5
18"	18	26	10"	13 layers 10" 13 layers 12"(2)	4.5	Use Bulk Material
20"	20	29	10"	9 layers 10" 10 layers 12" 10 layers 13"(3)	5	Use Bulk Material
24"	24	34	10"	10 layers 10" 10 layers 12" 14 layers 16"(4)	7.5	Use Bulk Material

NOTE: An 8088L (Large) repair kit is available for 8" and larger over wraps. A 2088 over wrap kit is available for applications with temperatures at or below 200°F.

(1) For 1" – 6" sizes use the 8088S kit. For 8" through 16" sizes use 8088L Glass is also available in bulk 125 yard rolls in widths of 8", 9 ¼" and 12" and can be used with any 8000 series or 2000 series adhesive.

(2) Stagger 8" wide glass to the 10" required width.

(3) Stagger 8" or 9¼" wide glass to 10" stagger 12" wide glass to 13" required width.

(4) Stagger 8" or 9¼" wide glass to 10" and 12" wide glass to the 16" required width.

Section 5

Installation Considerations

Hydrotesting

Testing
System Start-Up
Water Hammer
Fliberglass Flanges
Connecting to Other Systems
Painting PIpe

These procedures must be followed in order to avoid serious personal injury or property damage. Failure to do so will result in loss of warranty, and buyer, installer, or any employee, agent, or representative thereof, assumes the risk of any damage or injury to person or property.

Hydrotest Frequency

Hydro tests should be performed on sections of the installation as they are completed to ensure installation procedures are satisfactory. The first hydro test should be performed early during a system assembly to ensure installation techniques are providing the performance required. Long pipe line installations should be hydro tested before 2,500 feet have been installed. Fitting intensive systems as found in industrial systems should be hydro tested before 50 joints have been installed.

Hydrostatic testing should be performed to evaluate the structural integrity of a new or modified piping system. Hydro test pressures must meet any local jurisdiction or code requirements and not exceed the hydro test pressure limits for the particular product.

Safety Precautions

Before hydro testing, supports, anchors and guides must be in place prior to testing an above ground system. A buried piping system must be properly bedded and have sufficient backfill cover between joints to hold the pipe in place. The joints should be left uncovered for visual inspection during test. Never stand over or at the end of a line that is under pressure.

Locate pressure gauges away from the end of the pipe. A pressure gauge with the test pressure at midscale is recommended. When filling the system for hydro testing, open vents to prevent entrapment of air in the system. Then close the vents and slowly pressurize to the test pressure.

Hydro Test Procedures

In order to provide a high degree confidence in the piping system, FGS recommends a 10 cycle hydro test at 1.5 times the design operating pressure not to exceed the recommendations in the product data bulletins ranging from 1.25 to 1.5. Be sure you do not exceed the maximum rating of any other element in the piping system such as valves, expansion joints, various seals and gaskets that may have a lower pressure rating than the fiberglass. The maximum static rating can be found in bulletins CI1200, CI1225, CI1300, CI 1320, CI1325, CI 1330, CI1340, CI1350, CI1351, CI1360 and CI1370

Filling the Line

When filling the system for hydro testing, open high point vents to prevent entrapment of air. High point vents can be made from saddles, tees or flanges with a valve connection. For systems that do not have high point vents it is recommended that soft pipeline pigs be used to remove trapped air. If air is trapped in the system and you have a failure, catastrophic damage could occur.

Hydro Test Start Up

Allow the temperature to stabilize before starting test. Slowly increase pressure to recommended pressure. Initial pressurization should be gradual to prevent pressure surges or water hammer.

Hydrotest

The hydro test pressurization cycle may be repeated up to ten times from 0 psig (or city water or static head pressure) to the test pressure to provide an additional degree of confidence in the piping system. The intermediate pressure cycles should be held a minimum of 5 to 10 minutes. The final pressurization should be held for a period of one to two hours to allow the system to stabilize and slow leaks or pressure drops to be detected. The pressure may be lowered as deemed necessary by the on-site safety engineers prior to a full visual inspection of the piping system after the final pressure cycle.

Monitor the test pressure closely to avoid over pressurization. Pipe lines exposed to the sun can heat up quickly resulting in a pressure rise. If this happens bleed the line to original test pressure. The reverse is possible if the line is exposed to cold temperatures. If left under pressure over night during cold weather the water may cool resulting in a system pressure drop. Allow the water to warm back up to original input temperature before assuming a leak.

Checking The Line For Leaks

Walk the line to check for leaks. Do not stand or walk near the top or end of the line. Generally you are looking for moist spots under the joints. Brown kraft paper under the joints can help ease the visual ability to spot a leak. Do not repair a leak while the system is pressurized.

De-Pressuring The Line

Upon completion of hydro test, slowly open vents and drains to relieve the pressure on the system. Be sure you open vents to allow for complete drainage of the system and prevent a vacuum type failure . If the drain is open and the vents are closed the system could create a vacuum resulting in damage to the pipe.

It is highly recommended that piping systems operating at 150°F or higher and/or have a critical medium, should be tested to the maximum allowable test pressures as determined in the previous paragraphs.

Air Testing: Hydrostatic test should be used instead of air or compressed gas if possible. When air or compressed gas is used for testing, tremendous amounts of energy can be stored in the system. If a failure occurs, the energy may be released catastrophically, which can result in property damage and personal injury. In cases where system contamination or fluid weight prevents the use of hydrostatic test, an air test may be used with extreme caution. To reduce the risk of air testing, use the table below to determine maximum pressure. When pressurizing the system with air or compressed gas, the area surrounding the piping must be cleared of personnel to prevent injury. Hold air pressure for one hour, then reduce the pressure to one half the original. Personnel can then enter the area to perform soap test of all joints. Again, extreme caution must be exercised during air testing to prevent property damage or personnel injury. If air or compressed gas testing is used, NOV Fiber Glass Systems will not be responsible for any resulting injury to personnel or damage to property, including the piping system. Air or compressed gas testing is done entirely at the discretion and risk of management at the job site.

Pipe Size	**1"-6"**	**8"-12"**	**14"-42"**
psig	25	15	10

System Operation and Startup

On any pressurized piping system, initial start-ups should be gradual to prevent pressure surges which may damage or weaken the piping.

One method is to slowly fill the system while bleeding the air before starting any pumps or opening valves connected to pressurized piping. An alternate method is to start the centrifugal pump against a closed, adjacent valve; then slowly open the valve to gradually build up system pressure. The air should be bled off while the line is filling as in the first method.

For positive displacement pumps, consult NOV Fiber Glass Systems' Engineering for recommendations.

Water Hammer - Avoiding Problems

Water Hammer is pressure surge in a piping system that causes a violent movement of the system. Usually this pressure surge is caused by a sudden valve closing, electrical outage, pump failure, or some other out-of-the ordinary situation. The pressure surge is usually brief, but damage can be severe. In FRP piping, water hammer usually results in failed fittings due to pipe system movement. Careful location of supports, anchors and guides during design will help control movement of the piping during water hammers. Reducing the pressure surges by installing slow operating valves, a pump bypass or surge protectors in the system is recommended.

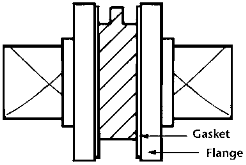
Air in a system can also cause water hammer. Be sure to bleed air out of the piping prior to full pressure operation. Any pipe system which moves suddenly, creates a lot of noise, or is unstable, may be influenced by water hammer.

Fiberglass Flanges

Before bonding the flange onto the pipe, make sure the bolt holes line up with the mating bolt holes on the other system. Do not bolt the flange before bonding, unless insertion depth of the spigot is previously checked to be certain that the spigot does not bottom out or extend through the flange. The use of flat washers on all nuts and bolts is required. The maximum allowable torque is indicated on each flange and is also shown in Tables 15 and 16.

Connecting to Flat-Face Flanges:

Fiberglass flanges may be joined to flat-face flanges at the recommended torque levels when using proper gaskets.



Filament Wound Flanges

Figure 8.3

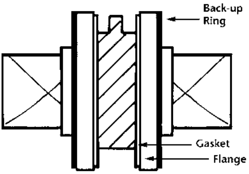
Connecting to Raised-Face Steel Flanges:

When connecting to a raised-face steel flange, one of the following must be utilized:

Option 1 - Use filament wound fiberglass flanges,

Option 2 -Use molded fiberglass flanges and machine the steel flange face until it is flat or use a metal spacer ring to fill the void between the raised-face steel flange and the fiberglass flat-face flange (normally more difficult than machining the steel flange face). If metal spacer rings are not available, it is acceptable to use spacer rings made from materials that are at least as hard as the fiberglass flange.

Option 3 - Use metal back-up rings behind molded fiberglass flanges (See Figs. 8.4 and 8.5).



Compression Molded Flanges

Figure 8.4

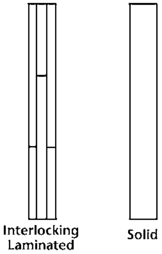


Figure 8.5

Back-Up Ring Thickness	
Pipe Size	**Ring Thickness**
1"-12"	9/16"

Connecting to Lug or Wafer Valves:

Most lined valves need a flat surface to seal against and a sealing surface that is close to their own I.D. to properly seat the lining. Unlined valves with sealing components in the face are in the same category as lined valves.

Sometimes the sealing ridges on the valve face can fall in the wrong place for the grooves in fiberglass flange faces, or they can be too close to the I.D. to seal. When connecting to valves with other than flat-faced flanges, follow these recommendations:

1) For unlined lug and wafer valves without integral seals, use filament wound flanges with no back-up rings or molded flanges with metal back-up rings. (See Fig. 8.3, 8.4, and 8.5)

2) For lug and wafer valves that are lined or have integral seals, use a ¼" steel spacer plate with an I.D. equal to Schedule 40 steel or as required by the valve manufacturer. (See Fig. 8.6).

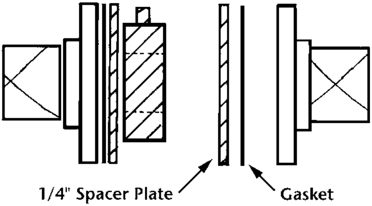


Figure 8.6

Summary

- **Molded flanges** are designed to be used against flat-face flanges. When joining to raised-face flanges and lug or wafer valves, steel back-up rings should be used, or spacers fabricated from any material capable of preventing the flange face from bending.
- **Filament wound flanges** may be mated to raised-face flanges and lug or wafer valves with no back-up rings or spacers if the bolt torque limits shown in Tables 15, and 16 are not exceeded.
- When using lug and wafer valves with integral seals, it may be necessary to use a ¼" thick steel flange between the valve and the fiberglass flange to achieve a proper seal. A ⅛" thick full-face gasket should be used between the steel flange face and the fiberglass flange.

Standard Bolting Conditions

NOV Fiber Glass Systems' flanges are designed to meet ANSI B16.5 bolt hole standards. **For RT, GT & SS**, full-face gasket materials, 1/8" thick, with a Shore A hardness of 60 to 70 durometer, are recommended.

Flat gaskets made from Teflon® and PVC usually have high durometer ratings and are not acceptable.

Table 15

Stub End Flanges

Size in	Number[1] of Bolts	Machine[2] Bolt Size	Stud[2] Bolt Size	Max. Torque ft-lb
2	4	⅝-11x3	⅝-11x4	66
3	4	⅝-11x4½	⅝-11x5½	66
4	8	⅝-11x4½	⅝-11x5½	66
6	8	¾-10x5	¾-10x6	150

[1] ANSI B16.5 Class 150 lb. bolt hole standard.

[2] Bolt lengths are nominal. When joining our flanges to flanges of other material or manufacturer products, bolt lengths must be calculated.

Table 16

Bolt, Washer & Torque Requirements for RT/GT HP 16, SS Flanges & Flanged Fittings[1], ANSI B16.5 Class 150

Flange Size in	Number of Bolts[3]	Machine Bolt[2] Size	Stud Bolt [2] Size	Maximum Allowable Torque ft-lb
1	4	½ - 13x3	½ - 13x4	25
1 ½	4	½ - 13x3	½ - 13x4	25
2	4	⅝ - 11x3	⅝ - 11x4	30[4]
3	4	⅝ - 11x4½	⅝ - 11x5½	30[4]
4	8	⅝ - 11x4½	⅝ - 11x5½	30[4]
6	8	¾ - 10x5	¾ - 10x6	30[4]
8	8	¾ - 10x5½	¾ - 10x6½	100
10	12	⅞ - 9x6	⅞ - 9x7½	100
12	12	⅞ - 9x6½	⅞ - 9x7½	100
14	12	1 - 8x7	1 - 8x8	100
16	16	1 - 8x7	1 - 8x8	100
18	16	1⅛ - 7x7½	1⅛ - 7x8¾	200
20	20	1⅛ - 7x7½	1⅛ - 7x8¾	200
24	20	1¼ - 7x7¾	1¼ - 7x9½	200

[1] Most flanged fittings are available with molded flanges. Filament wound flanges are available on request.

[2] Bolt lengths are nominal. When joining our flanges to flanges of other material or manufacturers products, bolt length must be calculated.

[3] 1"-24" flanges are ANSI B16.5 Class 150 lb. bolt hole standard.

[4] HD filament wound flanges are available in 2"-6" sizes with a maximum allowed torque of 100 ft. lbs.

Recommended Bolt Torquing Sequence for NOV Fiber Glass Systems' Flanges

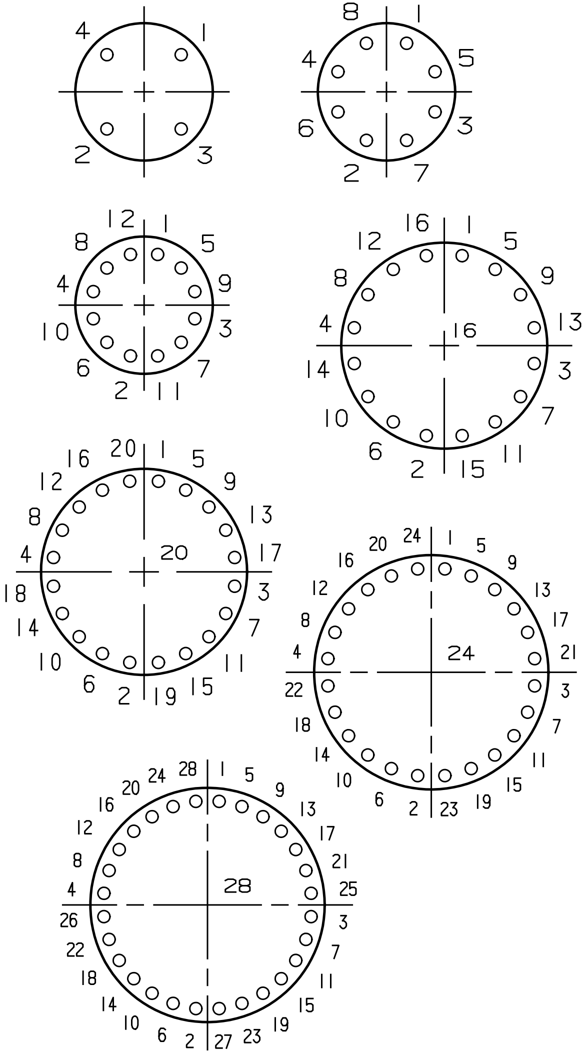
Before bonding the flange onto the pipe, make sure the bolt holes line up with the mating bolt holes on the other system. Do not bolt the flange before bonding unless insertion depth of the spigot is previously checked to be certain that the spigot does not bottom out or extend through the flange. Certain flanged fittings have recessed bolt holes to provide clearance for bolt installation during assembly. The number and depth of the recesses are shown in Table 17 for standard fittings. To determine the bolt length and size requirements see Table 16. The required bolt length must account for the recess depth and mating flange thickness. Stud bolts are recommended for ease of assembly and the use of washers under nuts is required.

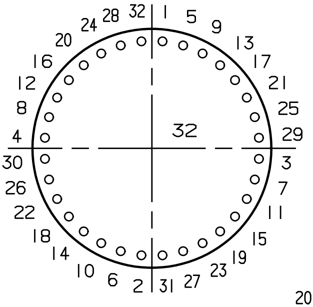
Table 17

Recessed Bolt Hole Data for Flanged Fittings

Flange Size in	Recess Depth in	Washer O.D. in	Number of Recessed Holes		
			45° Elbows	90° Elbows	Tees
3	¼	1$\frac{5}{16}$	4	-	-
8	½	1½	4	4	8
10	⅝	1¾	4	4	8
12	¾	1¾	4	4	8
14	½	2	4	-	-
16	½	2	4	-	-

Recommended Bolt Torquing Sequence for Flanges

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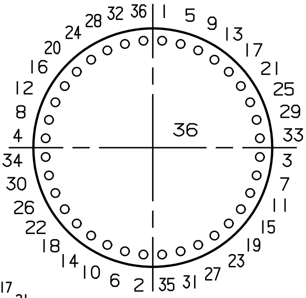
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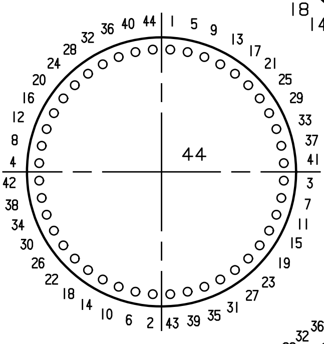
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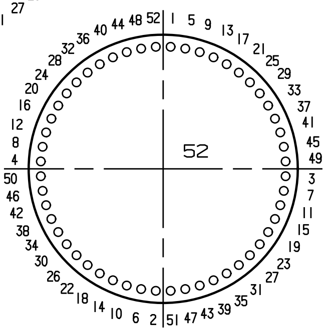
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Connecting to Other Systems

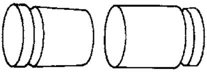
It is often necessary to connect a fiberglass piping to another piping system or make a connection that will not be possible using flanges. Two types of adapters are available: bell or spigot by grooved ends and bell or spigot by threaded ends.

Adapters

NOTE: When using adapters with spigot ends, it may be necessary to cut off a portion of the factory pipe bell if the groove or threads are not fully exposed.

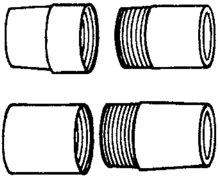
A. Grooved Adapters

RT, GT, SS Product: Do not use couplings designed for plastic or cement-lined steel as they can leak due to a difference in groove dimensions. Grooved adapters are machined to ES Cut Groove dimensions. Use standard high pressure (Victaulic Style HP70ES) coupling or equivalent.



B. Threaded Adapters

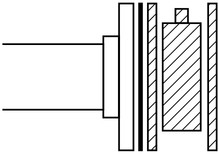
When using threaded adapters, thread them into the other system before bonding onto fiberglass pipe. Otherwise, unless a union is used, it may be impossible to turn the adapter into the mating thread. Use soft set, nonmetallic thread lubricant or two wraps of plumber's tape. **CAUTION: Do not over-tighten. Tighten the adapters as if they were brass or other soft material.**



NOTES:

1. The use of NOV Fiber Glass Systems' adhesive to bond a steel or metal pipe into a fiberglass flange is not recommended.
2. If mating a fiberglass system to steel, the preferred method is with flanges. Terminate the old system with their flange and bolt our flange on the new system.
3. Be sure to check the anchors, guides, and supports of an existing system to avoid transfer of any stresses or thermal expansion loads into the fiberglass system.
4. Do not try to cut or machine threads in fiberglass pipe or fittings.

Special Bolting Conditions



It is often necessary to mate fiberglass flanges with other components which do not have a full flat-face surface such as raised face flanges, butterfly or check valves having partial liner facings, and Van Stone flange hubs. The addition of a hard spacer ring or steel back-up ring placed between the raised face and the outer edge of the flange to form a full flat face on the mating flange is recommended. The purpose of the spacer is to fill the gap outside the raised face to prevent bolt loads from bending and breaking the fiberglass flange.

Pump & Equipment Connection - Fiberglass pipe connections to pumps or other equipment that involve vibration, shock loads or other mechanical movements should include flexible connectors. These flexible connectors allow for the absorption of vibration and eliminate the placing of undue strain on the pipe and fittings. A bellows-type expansion joint is recommended.

Painting Pipe - All piping O.D. surfaces should be clean and dry before painting. Use a fast-drying solvent such as acetone or trichloroethylene to clean the O.D. of RT, GT, or SS. For longer lasting results the O.D. should be thoroughly sanded or sand blasted. If sand blasting, be careful not to cut or groove the pipe O.D. with an aggressive spray. Fiberglass pipe can be painted with any good quality epoxy ester or two-part epoxy paint. Contact your local paint supplier for a detailed recommendation.

Section 6

Helpful Information

Conversions

Conversions
Decimal Equivalents of Fractions
Definition of Terms
How to Read Flanged or Reducing Fittings
How to Figure a 45° Offset

	Metric Units	U.S. Equivalents
Lengths	1 millimeter	0.03937 inch
	1 centimeter	0.3937 inch
	1 meter	39.37 inches or 1.094 yards
	1 kilometer	1093.61 yards or 0.6214 mile
Areas	1 square millimeter	0.00155 square inch
	1 square centimeter	0.155 square inch
	1 square meter	10.764 square feet or 1.196 square yards
	1 square kilometer	0.3861 square mile
Volumes	1 cubic millimeter	0.000061 cubic inch
	1 cubic centimeter	0.061 cubic inch
	1 liter	61.025 cubic inches
	1 cubic meter	35.314 cubic feet or 1.3079 cubic yards
Capacities	1 milliliter (0.001 liter)	0.0338 U.S. fluid ounce
	1 liter	2.1134 U.S. liquid pints
	1 liter	1.0567 U.S. liquid quarts
	1 liter	0.2642 U.S. gallon
Weights	1 gram	0.03527 avoir. ounce or 15.4324 grains
	1 kilogram(1000 grams)	2.2046 avoir. pounds

	U.S. System Units	Metric Equivalents
Lengths	1 inch	25.4 millimeters or 2.54 centimeters
	1 foot	0.3048 meter
	1 yard	0.9144 meter
	1 mile	1.6093 kilometers
Areas	1 square inch	645.16 square millimeters or 6.452 square centimeters
	1 square foot	0.0929 square meter
	1 square yard	0.8361 square meter
	1 square mile	2.59 square kilometers
Volumes	1 cubic inch	16,387.2 cubic millimeters or 16.3872 cubic centimeters
	1 cubic foot	0.02832 cubic meter
	1 cubic yard	0.7646 cubic meter
Capacities	1 U.S. fluid ounce	29.573 milliliters
	1 U.S. liquid pint	0.47317 liter
	1 U.S. liquid quart	0.94633 liter
	1 U.S. gallon	3.78533 liters
Weights	1 grain	0.0648 gram
	1 avoir. ounce	28.35 grams
	1 avoir. pound	0.4536 kilogram
	1 Troy ounce	31.1035 grams

Decimal Equivalents of Fraction

inches	Decimal of an inch
1/64	0.015625
1/32	0.03125
3/64	0.046875
1/20	0.05
1/16	0.0625
1/13	0.0769
5/64	0.078125
1/12	0.0833
1/11	0.0909
3/32	0.09375
1/10	0.1
7/64	0.109375
1/9	0.111
1/8	0.125
9/64	0.140625
1/7	0.1429
5/32	0.15625
1/6	0.1667
11/64	0.171875
3/16	0.1875
1/5	0.2
13/64	0.203125
7/32	0.21875
15/64	0.234375
1/4	0.25
17/64	0.265625
9/32	0.28125
19/64	0.296875
5/16	0.3125
21/64	0.328125
1/3	0.333
11/32	0.34375
23/64	0.359375
3/8	0.375
25/64	0.390625
13/32	0.40625
7/16	0.4375

inches	Decimal of an inch
29/64	0.453125
15/32	0.46875
31/64	0.484375
1/2	0.5
33/64	0.515625
17/32	0.53125
35/64	0.546875
9/16	0.5625
37/64	0.578125
19/32	0.59375
39/64	0.609375
5/8	0.625
41/64	0.640625
21/32	0.65625
43/64	0.671875
11/16	0.6875
45/64	0.703125
23/32	0.71875
47/64	0.734375
3/4	0.75
49/64	0.765625
25/32	0.78125
51/64	0.796875
13/16	0.8125
53/64	0.828125
27/32	0.84375
55/64	0.859375
7/8	0.875
57/64	0.890625
29/32	0.90625
59/64	0.921875
15/16	0.9375
61/64	0.953125
31/32	0.96875
63/64	0.984375
1	1.0

Definition of Terms

Adapter – A fitting used to join two pieces of pipe, or two fittings, which have different joining systems.

Adhesive – A material formulated to bond together pipe and fittings resulting in high strength and corrosion resistant fabrications.

Anchors – Device to positively restrain the movement of the pipe against all lateral and axial forces.

Bell and Spigot – A joining system in which two truncated conical surfaces come together and bond adhesively. The bell is the female end. The spigot is the male end.

Bushing – A fitting used to join two different sizes of pipe by reducing the size of the female end of the joint. Joints may come threaded or tapered.

Catalyst – See hardener.

Collar – See coupling.

Compressive Force – The force that occurs when a pipe is subjected to crushing loads. Axial compressive forces occur when a piping system is anchored to restrain thermal growth.

Compression Molding – A process for making fittings in which a molding compound is formed and cured into the finished part configuration through pressure and heat in a die.

Concentric Reducer – A pipe fitting used to join two different sizes of pipe while maintaining the same center line.

Contact Molding – A process for making fittings in which cut pieces of fiberglass reinforcement are laid on a mold, saturated with resin, and cured to the finished part shape.

Coupling (collar) – A short heavy wall cylindrical fitting used to join two pieces of the same size pipe in a straight line. The coupling always has female connection ends which can be bell, threaded or a mechanical joining method.

Cure – The hardening of a thermoset resin system by the action of heat or chemical action.

Cure Stages – Stages describe the degree to which a thermoset resin has cross-linked. Three stages, in order of increasing cross linking, include B stage, gelled, fully cured.

Cure Time – The time required for a thermoset material to react and develop full strength. The time is dependent upon the temperature of the material.

Curing Agent – See hardener.

Cut and Mitered Fittings – Fittings manufactured by cutting, assembling and bonding pipe sections into a desired configuration. The assembled product is then over wrapped with resin-impregnated roving or glass cloth, to provide added strength.

Epoxy Resin – A thermosetting resin, usually made from Bisphenol A and epichlorhydrin, cured by a variety of agents such as anhydrides and amines. These resins contain cyclic ether groups. See thermoset.

FRP – Fiberglass Reinforced Plastic.

Filament Wound – A manufacturing method for pipe and fittings in which resin impregnated continuous strand roving wraps around a mandrel to achieve high reinforcement concentration and precise filament placement.

Fillers (extender, pigments, inerts; i.e., sand, etc.) – Materials added to a resin which do not affect the cure of the resin but may influence the physical properties of the resin system.

Fitting Types – The classification of fittings by the method of manufacture; i.e., molded, cut and mitered, filament wound, contact molded.

Gel Time – The time it takes for a resin system to harden to a rubber-like state.

Guide – Device that allows free axial movement of the pipe, but restrains lateral movement.

Hand Lay-Up – The forming of resin and fiberglass into finished pipe products or fittings by manual procedures. These procedures include over wrap techniques, contact molding, hand molding and others.

Hardener (accelerator, catalyst, curing agent, promoter) – Chemicals added to the resin, single or in combination, which speed up the hardening process, or cause hardening to occur.

Heat Blanket or Heat Collar – An electrical device used to heat a fabrication to reduce cure time.

Hydrostatic Test – A pressure test of a completed fabrication to confirm good quality. Typically, the system is filled with water and held at the selected pressure while checking for leaks.

Impact Resistance – The ability of a part to absorb a striking blow without damage.

Joining (connecting systems) – Any of a variety of methods for connecting two separate components of a piping system together. Included are bell and spigot, threaded and coupled, mechanical devices, etc.

Joint – A term used to describe an individual length of pipe or the actual joining mechanism; i.e., adhesive bonded bell and spigot, threaded and coupled, etc.)

Liner – A generic term used to describe the interior surface in pipe. Generally, liners are resin-rich regions from 0.005 to 0.100 in. thick. Liners may be reinforced with fibrous material such as veil or mat. Liners can provide extra corrosion protection for severe chemical service. They also form a leak barrier (elastomer bladder). The manufacturer may add a liner before, during, or after construction of the pipe wall depending on the manufacturing process.

Lock-Up –A bell and spigot joint engaged sufficiently to eliminate pivot action in the joint.

Matrix – The material used to bind reinforcement and fillers together. This material may be thermoplastic or thermosetting and dictates to a large extent the temperature and chemical service conditions allowable for a pipe or fitting.

Mechanical Force – Physical exertion of power used to achieve lock-up in tapered bell and spigot joints.

Molded Fittings – Pipe fittings formed by compressing resin, chopped fiber and other ingredients in a mold under heat and pressure.

Molding – Any of several manufacturing methods where pressure or compression molding shapes resin and reinforcing materials into final products.

Polyester Resin – Any of a large family of resins which are normally cured by cross linking with styrene. The physical and chemical properties of polyester resins vary greatly. Some have excellent chemical and physical properties while others do not. Vinyl esters are a specific type of polyester resin. Other polyester resins with properties suitable for use in the manufacture of fiberglass pipe include: isophthalic Bisphenol A fumarate and HET acid polyesters. Each type of resin has particular strengths and weaknesses for a given piping application.

Pot Life – The time available to use thermoset adhesives after the reactive materials have been mixed.

Pressure Rating – The maximum anticipated long term operating pressure a manufacturer recommends for a given product. Also referred to as working pressure, pressure class or design pressure.

Reinforcement – Typically, fibers of glass, carbon or synthetic material used to provide strength and stiffness to a composite material.

The type of fiber used as reinforcement plays a major role in determining the properties of a composite, as does the fiber diameter and the type of sizing used. Terms relating to the physical form of the reinforcement include:

Chopped Fiber - Continuous fibers cut into short (0.125 to 2.0 in.) lengths.

Filament - A single fiber of glass; e.g., a mono filament.

Mats - Coarse fabric sheets made from chopped strands randomly placed and held together by resin binders.

Milled Fibers - Glass fibers, ground or milled, into short (0.032 to 0.125-in.) lengths.

Roving - A collection of one or more filaments wound into a cylindrical package. The typical form of glass fiber used in the manufacture of filament wound pipe.

Veil - Surfacing mat of porous fabric made from glass or synthetic filaments. Used to provide a resin rich layer or liner.

Yarn - Glass fiber filaments twisted together to form textile-type fibers.

Yield - The number of yards of material made from one pound of the product.

Resin (polymer) - As applied to fiberglass pipe, resin is the polymer or plastic material used to bind the glass fibers together.

Resin – The polymer (liquid plastic) material which hardens with cure to provide a solid form, holding the fiberglass reinforcement in place. Resins provide the corrosion resistance in FRP parts.

Saddle – A fitting which is bonded to the exterior of a pipe to make a branch connection.

Shelf Life – The storage time for a material until it becomes unusable.

Socket Joint – A joining system in which two straight cylindrical surfaces come together and bond adhesively.

Spacers – Wooden strips used to support pipe during storage and handling.

Stress – The force per unit of cross sectional area. Measured in pounds per square inch (psi). This should not be confused with hydraulic pressures, measured as psig or psia, which can induce stress.

Support Spacing (span) – The recommended maximum distance between pipe supports to prevent excessive pipe deformation (bending).

Surge Pressure – A transient pressure increase due to rapid changes in the momentum of flowing fluids. Water hammer is one type of surge pressure. Rapid opening or closing of valves often result in a surge pressure or water hammer.

Thermal Conductivity – The rate at which a material (pipe) transmits heat from an area of high temperature to an area of lower temperature. Fiberglass pipe has low thermal conductivity.

Thermal Expansion – The increase in dimensions of a material (pipe) resulting from an increase in temperature. A decrease in temperature results in thermal contraction.

Thermoset – A polymeric resin cured by heat or chemical additives. Once cured, a thermoset resin becomes essentially infusible, (cannot be re-melted) and insoluble. Thermosetting resins used in pipe generally incorporate reinforcements. Typical thermosets include:

- Vinyl esters
- Epoxies
- Novolac or epoxy Novolac
- Unsaturated polyesters

Thrust Forces – Commonly used to describe the forces resultant from changes in direction of a moving column of fluid. Also used to describe the axial or longitudinal end loads at fittings, valves, etc., resultant from hydraulic pressure.

Torque – Used to quantify a twisting moment (torsion) in pipe. Torque is measured as a force times the distance from the force to the axis of rotation. Torque is expressed in foot-pounds (ft-lb) or inch-pounds (in-lb).

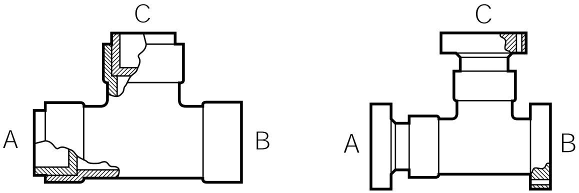
Two Holing – A method of aligning flanges onto pipe or fittings so that the bolt circle will mate with the adjoining flange.

Vinyl Ester – A premium resin system with excellent corrosion resistance. Vinyl ester exhibits high versatility, temperature resistance and excellent corrosion resistance to acids.

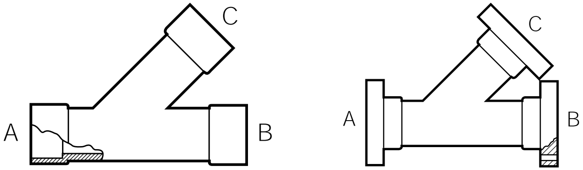
Water Hammer – Pressure surges in a piping system caused by sudden change in fluid velocity, such as operation of a valve, pump, or other component.

Working Life – Same as POT LIFE.

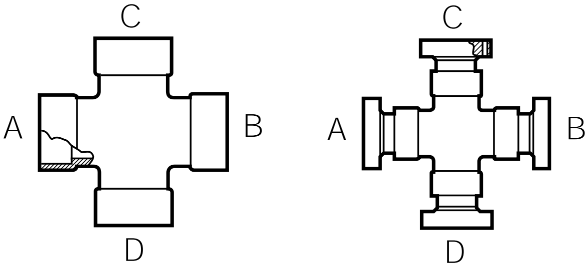
How to Read Flanged or Reducing Fittings



Tee
Run x Run x Branch



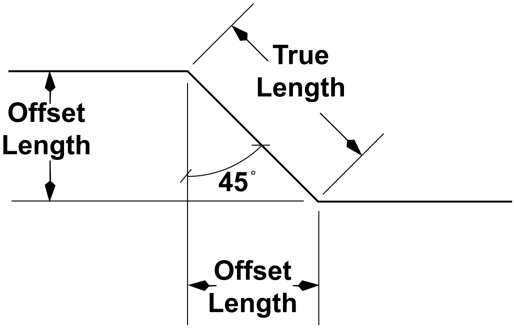
Lateral
Run x Run x Branch



Cross
Run x Run x Branch x Branch

The above sequence should be used when describing fitting outlets. Drawings or sketches showing outlet types, locations, sizes and dimensional requirements are required for more complicated fitting configurations.

How to Figure a 45° Offset



True Length = offset x 1.414
Offset = true length x .707

Examples:
IF: offset = 12"
12" x 1.414 = 16.968 = 1'-5"
true length = 1'-5"
(to nearest 1⁄16")

IF: true length = 24"
24 x .707 = 16.968 = 1'-5"
offset length = 1'-5"
(to nearest 1⁄16")

Notes:

Notes:

Fiber Glass Systems
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INS1000ENG March 2017

Pipe Installation Handbook

Straight Socket and Butt & Wrap Joints

- CENTRICAST™ PRODUCTS
  CL-1520
  CL-2030
  RB-1520
  RB-2530
- F-CHEM™
- Z-CORE™

www.nov.com/fgs

NOV Fiber Glass Systems

NOV FIBER GLASS SYSTEMS PIPE INSTALLATION HANDBOOK

Straight Socket Joints and Butt & Wrap Joints

This fabrication manual is offered to assist you in the proper fabrication and installation procedures when assembling your NOV Fiber Glass Systems piping system.

If you do not find the answer to your questions in the manual, feel free to contact your Regional Manager, local distributor, or the factory.

The products must be installed and used in accordance with sound, proven practice and common sense.

The information supplied in our literature must be considered as an expression of guidelines based on field experience rather than a warranty for which we assume responsibility. NOV Fiber Glass Systems offers a limited warranty of its products in the *Terms and Conditions of Sale*. The information contained in the literature and catalogs furnished cannot ensure, of itself, a successful installation and is offered to customers subject to these limitations and explanations.

It is our policy to improve its products continually. Therefore, the company reserves the right, without notice, to change specifications and/or design at any time without incurring an obligation for equipment previously sold. Descriptions contained in this catalog are for the purpose of identification and neither limit nor extend the standard product limited warranty set forth in the *Terms and Conditions of Sale and Trade Customs.*

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CL = Centricast Plus CL-2030 or Centricast CL-1520 Piping Systems
RB = Centricast Plus RB-2530 or Centricast RB-1520 Piping Systems
ZC = Z-Core Piping Systems
FC = F-Chem Piping Systems

FABRICATION AND INSTALLATION ASSISTANCE

Installing fiberglass pipe is easier than installing carbon steel, stainless steel and lined steel due to light weight. Learning the proper methods to prepare and make-up socket or butt & wrap joints can help ensure the reliability and long-term performance of your piping system.

We offer the TQI Plus (ASME B31.3) Fabrication and Assembly certification program. Qualified Field Service Representatives train fabrication and assembly crews, conduct and supervise fabrication work, and inspect work in progress.

For complete information concerning these training seminars, contact your local distributor or Regional Manager.

CAUTION

As this pipe may carry hazardous material and/or operate at a hazardous pressure level, you must follow instructions in this manual to avoid serious personal injury or property damage. In any event, improper installation can cause injury or damage. In addition, installers should read and follow all cautions and warnings on adhesive kits, heat packs, propane torches, etc. to avoid personal injury. Also, observe general safety practices with all saws, tools, etc. to avoid personal injury. Wear protective clothing when necessary. Make sure work surfaces are clean and stable and that work areas are properly ventilated.

Safety Data Sheets (SDS) are available on our web site at www.nov.com/fgs.

PART I
PIPE PRODUCTS

DESCRIPTION OF PIPE PRODUCTS

The performance characteristics of a fiberglass pipe system depend on several important elements including the resin and curing agent, as well as the manufacturing process and type and thickness of the pipe's corrosion barrier.

Our piping systems are manufactured using epoxy, vinyl ester, or isophthalic polyester resin systems. All are heat cured for optimum chemical resistance and physical properties. Match your temperature, pressure and chemical resistance requirements to the piping system.

Fiberglass piping systems offer:

a. Smooth iron pipe size O.D.
b. Used with standard IPS pipe hangers
c. High strength for long spans
d. Excellent corrosion resistance
e. Lightweight
f. Complete line of fittings and accessories available
g. Costs can be optimized by selecting pipe grades for specific services
h. Full vacuum capability in premium grades
i. Easy to repair if damaged

Centrifugally Cast Pipe

Centrifugally cast FRP pipe (Centricast) consists of reinforcement fabric layers saturated with thermosetting resin, then cured in a casting machine. Cast pipe features a pure resin interior barrier for maximum corrosion resistance. The glass fabric gives the pipe its structural strength and the resin provides the corrosion resistance. Pipe is available in premium epoxy (ZC), epoxy (RB) and vinyl ester (CL) resin grades.

a. Sizes 1" - 14" diameter
b. Straight socket adhesive joint method
c. No special fabrication tools required
d. 10 mil resin-rich exterior resistant to UV attack

Filament Wound Pipe

Our filament wound pipe begins with resin-saturated fiberglass or other man-made materials as an inner liner or corrosion barrier. The liner is then covered with a resin impregnated filament wound matrix of fiberglass. The matrix is applied under controlled tension in a predetermined pattern to the specified wall thickness.

Custom Filament Wound Product (F-Chem) is available in epoxy, vinyl ester, isophthalic polyester and fire retardant resin grades.

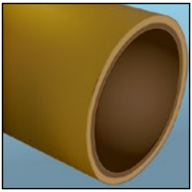
a. Sizes 1" - 72" diameter
b. Joining methods include:
- Plain end butt and wrap
- Matched tapered bell & spigot

c. No special fabrication tools required

PIPE GRADES

CENTRICAST PLUS RB-2530

Highly corrosion resistant epoxy pipe grade handles most caustics, salts, solvents, many acids and chemical process solutions up to 250°F, 100 mil pure resin corrosion barrier. Pipe has durable heavy wall construction for long spans, great impact resistance, tensile, bending and compressive strengths.



CENTRICAST RB-1520

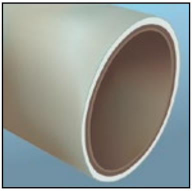
Epoxy pipe grade recommended for many caustics, acids, salts, solvents and chemical process solutions up to 250°F, 50 mil pure resin corrosion barrier. Pipe has long spans, integral socket joints, and low thermal expansion loads for the lowest installed cost.

Z-CORE

Premium epoxy pipe with proprietary resin for outstanding corrosion resistance to aggressive solvents and strong acids, including 98% sulfuric acid. Rated for temperatures up to 275°F, 100 mil resin-rich liner. Heavy wall construction for great impact resistance, long spans and low thermal expansion.

CENTRICAST PLUS CL-2030

Highly corrosion resistant vinyl ester pipe grade used for over 25 years in the harshest hot acid, chlorine, and other chemical services up to 200°F, 100 mil pure resin corrosion barrier also provides impact and abrasion resistance. Pipe has high strength heavy wall construction.

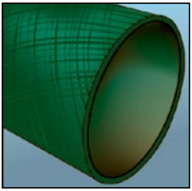


CENTRICAST CL-1520

Vinyl ester pipe grade used for many hot acid, chlorine and corrosive chemical services up to 200°F, 50 mil pure resin corrosion barrier. Long spans, integral socket joints, and low thermal expansion loads provide for a low installed cost system.

F-CHEM and F-CHEM AR*

Custom filament wound construction offers more flexibility in resin systems, corrosion barriers and wall thickness than our standard products. Let us assist you in selecting the right pipe for a specific application.



*AR grade is manufactured for added abrasion resistance.

FITTINGS

Fittings are color coded. **Epoxy Fittings**: RB fittings are brown; Z-Core fittings are dark green or black. **Vinyl Ester Fittings:** CL fittings are off-white. Be sure to use the correct grade of pipe and fittings for your service. Consult **Bulletins** for pressure rating limits on various fittings. Be sure your system pressure requirements do not exceed the lowest rated component fittings.

Most compression-molded fittings have a center line dot or cross which will assist you in making measurements. Take-off dimensions for most standard fittings are shown in Tables 6 on page 21. The positive stop or "land" in the socket helps you make exact fabrications.

ADHESIVES

Adhesives are formulated for specific use with the companion pipe grades. Use only the recommended adhesive with each pipe grade - do not mix systems! Standard adhesives are a two-component system (Parts A and B) which must be mixed prior to use. CL-200 Quick Set (QS) adhesives are available for reduced cure time where necessary. **Detailed instructions for adhesives are provided with each kit.** Read these instructions thoroughly and follow the recommended procedures. The pot life and cure time of the adhesive is dependent on temperature; refer to pages 6, 28, 30, and 36. Ambient temperatures above 100°F require extra care by the fabricator to assure sufficient working time of the adhesive. Refer to *Adverse Weather Recommendations* on page 11.

ADHESIVE SELECTION

Standard adhesive kits are designed to be used with specific piping systems as shown below.

TABLE 1. Adhesive Selection

Use with these piping systems	Kit Number(1)(2)(3)	Maximum Service Temperature
Z-Core	Weldfast™ ZC-275	275°F
Centricast Plus CL-2030 & CL1520	Weldfast CL-200	200°F
Centricst Plus CL-2030 CL-1520	Weldfast CL-200 QS(4)	200°F
Centricast Plus RB-2530 & RB-1520	Weldfast ZC-275	250°F
F-Chem	Vinyl Ester Butt Weld Kit	250°F

Notes:

1. Although all of the adhesives will cure at ambient temperatures above 70°F, it is recommended they be heat-cured at temperatures of at least 275°F to maximize physical properties and corrosion resistance. See pages 27-30 for instructions for using heat blankets or collars for heat-curing joints.

2. For complete detailed instructions on using adhesive, refer to the step-by-step instruction bulletin included in the adhesive kits.
3. Refer to *Chemical Resistance Guide*, for adhesive chemical resistance rating.
4. Quick-set adhesive for use when faster cure time is required and the ambient temperature is below 90°F. Weldfast CL-200-QS is the same as Weldfast CL-200 except a third component, Part C, has been added to the kit.

ADHESIVE WORKING LIFE

Working life or pot life is the time it takes for the adhesive to harden in the mixing can. Refer to Table 2.

TABLE 2. Adhesives Estimated Pot Life

Pipe Resin Systems	**Adhesive**	**Pot Live @ 70°F (min.) (see note)**	**Pot Live @ 90°F (min.) (see note)**
Epoxy	275	30-40	15-25
Vinyl Ester	200	20-30	6-12
Vinyl Ester	200QS	7-15	4-7
Vinyl Ester	Butt Weld*	20-40	8-15

NOTE: Pot life is the time available for fabrication. Times may vary depending upon temperature, humidity, etc.

* Based on 16 ml of catalyst per quart of resin.

TABLE 3. Approximate Number of Bonds per Kit

	Pipe Size (in.)									
	1	1½	2	3	4	6	8	10	12	14
Number of Joints	12	10	8	5	3	2	1	½	½	⅓

FABRICATION ACCESSORIES

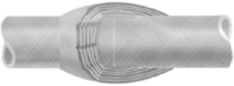
Heat Blankets and Heat Collars: Silicone heat blankets and high temperature heat collars are offered for use in curing of adhesive socket joints. The blankets and collars have a pre-set thermostat which controls the temperature of the unit. See pages 27-30 for instructions and cure times for adhesive joint fabrications.

Heat Guns: High wattage electric heat guns are also available to heat adhesive joints. The heat guns are 1600 watt capacity.

JOINING SYSTEMS

Socket Joint:
Straight socket adhesive joints have positive stop lands for precise makeup.

Butt & Wrap Joint:
Two pieces of plain end pipe or pipe and fittings are butted together, then several layers of resin saturated mat or woven roving are wrapped around the area and cured. Highly reliable joint in critical service applications.



PART II
SITE CONSIDERATIONS

STORAGE AND HANDLING

Pipe and Fittings
Fiberglass reinforced pipe, fittings, and adhesives require special storage and handling. Care should be taken in transporting, unloading, handling, and storing products to prevent impact and other damage.

When transporting pipe, the spacers under and between the pipe joints must be of sufficient width to avoid point loading, which could produce cracking or buckling damage. A minimum of four spacers should be used for supporting 14" and larger 40' long pipe joints. More spacers should be used for smaller pipe or if pipe is stacked over eight feet high.

Due to its light weight, lifting equipment is usually not required for 1" - 14" pipe. When lifting equipment is required, use nylon slings or chokers. Do not allow chains or cables to contact the pipe during transport or handling. If a pipe or fabrication is more than 20 feet long, use at least two support points.

For storage, a board (2 x 4 minimum) should be placed under each layer of pipe approximately every five feet. The intent is to support the pipe and distribute the load evenly. The pipe should also be braced on either side of the pipe rack to prevent unnecessary pipe movement. Avoid placing pipe on sharp edges, narrow supports, or other objects that could cause damage to the pipe wall. When storing pipe directly on the ground, select a flat area free of rocks and other debris that could damage the pipe.

Pipe is furnished factory packaged in compact, easy-to-handle bundles complete with protective end caps. Leave these caps in place until installation time to protect the pipe ends as well as to prevent dirt or other material from getting into the pipe. Fittings are packaged in cardboard boxes and should be stored in a dry area. If fittings are removed from the boxes, protect machined bells and spigots from exposure to direct sunlight.

Pipe can be damaged when joints or bundles of pipe are dropped during handling or shipping. Severe localized impact blows may result in damage to the fiberglass reinforced structure in the pipe wall. **Before installation, inspect the pipe's outer surface and inner surface (if possible) for any damage.** Do not use damaged pipe unless inspected and approved by a company representative. If impact damage occurs, the damaged areas may be recognized by a star type fracture on the interior of cast pipe or the exterior of filament wound pipe. Pipe that has been damaged should have a length cut away approximately one foot either side of the damaged or cracked area.

Note:
Do not allow the bell end of the pipe to support any pipe weight.

Do not allow deformation of the pipe due to supports or straps.

Adhesive
We recommend adhesives be stored in a dry area where temperatures do not exceed 80°F. Refer to adhesive instructions included in each kit for storage life recommendations. Vinyl ester adhesives are particularly susceptable to damage caused by high temperature storage.

TOOLS, EQUIPMENT and SUPPLIES REQUIRED FOR INSTALLATION

For maximum efficiency, the following tools and equipment are recommended prior to any installation:

- Fab Tables, Pipe Stands, Jacks & Vise
- Hand Tools
    - Level - Marking Pen - Tape Measure - Pipe Wrap
    - Hacksaw (22-28 teeth/inch)
- Power Tools
    - 1" or 2" drum sander
    - Disk sander
    - Circular power saw with a grit edge abrasive blade, aluminum oxide, carbide or diamond.
    - Band Saw with 16-22 teeth/inch at speeds of 200 - 600 ft./min.
    - Saber saw with carbide-tipped blade
    - Chop saw with aluminum oxide blade
    - Heat gun and heat blanket may be required
- Expendables
    - Impermeable Gloves
    - Chemical Splash Goggles
    - Clean, Dry, Lint-Free Shop Cloths
    - Sandpaper Disc/Emery Cloth (36-60 grit)

We suggest securing an area where work can be planned, staged, and quickly executed more efficiently. Power tools greatly reduce the time required to sand pipe and fittings prior to bonding.

Equipment for Cool Weather (Below 70°F) pipe assembly:

- Heat source
    - Portable torch with spreader tip, or
    - Portable electric heat lamp, or
    - Industrial heat gun
- A means of maintaining adhesive kits at 70°-80°F:
    - A box with a 25 watt light bulb, or
    - Inside of a vehicle.
- Heat assisted curing
    - Electric heating collars or blankets
    - Chemical heat packs

RECOMMENDATIONS FOR FABRICATION IN ADVERSE WEATHER CONDITIONS

FRP piping can be installed in adverse weather conditions when the necessary precautions are taken. Actual work will often be more quickly completed in high temperature conditions. Low temperatures can increase the work time 20%-35% over normal shop conditions. A similar increase is common for high moisture conditions.

Hot Weather Installation Tips

Hot weather conditions, temperatures above 90°F, will greatly reduce the working time of the adhesive. The following steps are recommended when fabricating in hot weather conditions:

1. Avoid direct sunlight on the joining surfaces.
2. Store adhesive in a cool area.
3. Keep mixed adhesive in an ice chest with sealed bag of ice or ice pack.
4. Refer to the field fabrication instructions supplied in adhesive kit for the proper amount of catalyst in vinyl ester kits.
5. Butt weld laminates must be "staged" by applying no more than four layers of fabmat at a time. Staging prevents excess exothermic heat. Sand the bonding surface after each stage has gelled and cooled to less than 120°F.

Cold Weather Installation Tips

Adhesive cure time is directly related to the temperature. Colder temperatures result in longer cure times.

The following steps should be used when fabricating in colder temperatures:

1. Adhesive kits should be placed in a warm room for six to twelve hours before application in order to reach temperatures of 80°F -100°F. This will make mixing much easier and speed cure times. Or use a box with a 25 watt light bulb to warm adhesive kits.
2. When possible, piping should be bonded indoors into subassemblies. The warmer conditions of these areas will allow faster cure times.
3. Pre-warm bonding surfaces to 80°F -100°F when temperature falls below 70°F.
4. Refer to the field fabrication instructions supplied in the adhesive kit for the proper amount of catalyst for vinyl ester kits.

5. A heat gun, collar or blanket may be used to obtain a faster cure time. Apply a layer of fiberglass insulation or a welding blanket around the heat collars or blankets when installation temperatures are below 50°F.

Extreme Moisture

Adhesive Joints

- If fittings or pipe have moisture on the bonding surface, wipe them dry prior to sanding.
- Sand pipe or fittings immediately before applying the adhesive to bond the joint. Sand surfaces until a fresh, dry surface is present, then remove dust with a clean dry cloth, and apply adhesive.
- Cure per the previous recommendations for normal, extreme heat or extreme cold temperatures.

Laminate Joints

- Keep the glass fabric dry, as resins will not saturate wet fabric. Discard glass fabric which has been wet or exposed to rain, as moisture can remove the bonding agent.
- In high humidity environments, keep the glass fabric in the plastic wrap until ready to use.
- If it is raining, move the work to a shelter, or construct a temporary shelter.
- Bonding surfaces must be sanded immediately prior to application of the resin to the pipe or fitting. Sand or grind until a fresh, dry surface is present, then wipe off the dust and apply resin.
- Saturate the fabric with the resin and apply a coat of resin to the sanded surface prior to applying the fabric.
- Refer to recommendations for conditions of extreme heat, cold, or normal conditions for curing.
- When a laminate requires staging, repeat the above precautions for each step.
- Moisture will not affect the cured laminate joint.

BURIAL RECOMMENDATIONS

These are general guidelines only. For more details see *Engineering and Piping Design Guide*.

A. Burial Depth

1. Minimum Burial Depth
   Minimum depth in unpaved areas for pipe subjected to vehicular loads depends on pipe type, pipe size, vehicle axle weight, and the bedding material. With a standard legal axle load of 34,000 lbs., the minimum depth of cover (from the top of the pipe to the surface) for moderately compacted non-clay bearing soils is shown in Table 4.

   The pipe should always be buried below the frost line.

2. Maximum Burial Depth
   Maximum burial depth is dependent on the backfill material. For moderately compacted soils that do not contain large amounts of highly expansive clays, the maximum burial depth is shown in Table 4.

TABLE 4. Burial Depths*

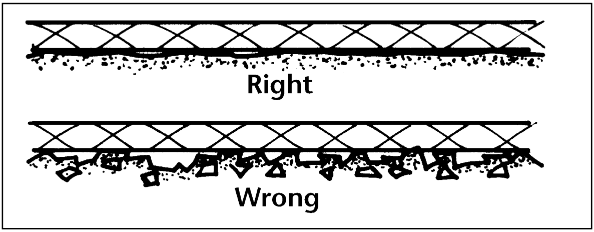
Product	Minimum (ft.)	Maximum (ft.)
Centricast CL-1520	2	20
Centricst CL-2030	2	20
Centricast RB-1520	2	20
Centricst RB-2530	2	20
Z-Core	2	20
F-Chem Custom Piping**	3 - 5	12 - 20

* Based on 1000 psi soil modulus. Refer to *Engineering & Piping Design Guide,* for detailed information for your specific application.

** F-Chem is designed for specific burial applications according to AWWA M45.

B. Trench Preparation

Final bedding of the trench must be as uniform and continuous as possible. Before backfilling, fill all gaps under the pipe with proper bedding material. Avoid sharp bends and sudden changes in slope. It is important to remove all sharp rocks, cribbage, or other foreign objects that could come in contact with the piping.



C. Bedding Requirements

Fiberglass pipe can be damaged by point contact or wear with the trench bottom and walls, improper bedding materials, or adjacent pipe. Use recommended bedding material a minimum of 6 inches thick at the bottom, sides, and top of the piping (refer to Table 5). Adjacent pipes should be spaced the greater of 6 inches or one pipe diameter. The piping can be laid directly on the undisturbed trench bottom if the native soil meets the requirements of a recommended bedding material (refer to Table 5). Never lay fiberglass piping directly against native rock or shale. Always use dry, unfrozen bedding materials that do not contain foreign objects or debris. Never use water flood for compaction. Slurries can be used that are intended for burial of flexible piping systems. When using slurries, care must be taken to prevent floating or deformation of the piping.

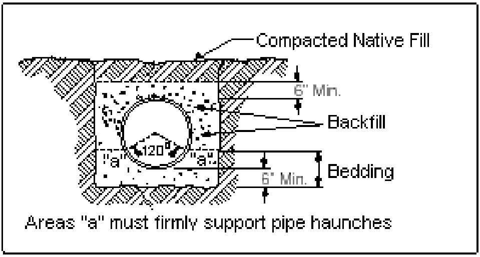


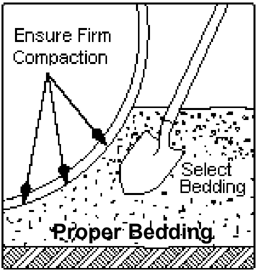
TABLE 5. Recommended Bedding Materials

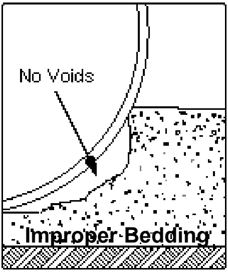
Bedding Material	Compaction Proctor Density
Crushed rock or pea gravel ¾" maximum size	Not Required
Coarse-grained sand or soil with little or no fines	75-85%
Coarse-grained sand or soil with more that 12% fines	85-95%
Sand or gravel with more than 30% coarse-grained particles	85-95%
Sand or gravel with less than 30% coarse-grained particles	Greater than 95%

D. Pipe Support

Fiberglass pipe is flexible and requires the support of the bedding material to keep the pipe round in burial applications. It is very important that a recommended bedding material is properly compacted around the entire circumference of the pipe. (Refer to Table 5) Tamp the bedding material under the bottom half of the piping to prevent voids or areas of low compaction. Vibratory or similar tamping equipment can drive small stones or debris into the pipe wall if they are present in the bedding material. Avoid striking the pipe with tamping equipment as the pipe may be fractured.

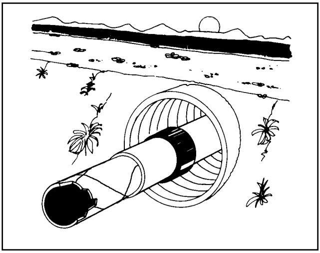
Consult the factory if the pipe will be subject to vacuum or high water tables.





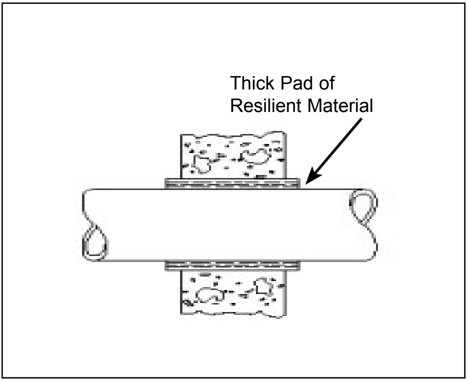
E. Road Crossings

When laying fiberglass pipe under road crossings, it may be necessary to pass the pipe through conduit to protect the pipe. Pad the pipe to prevent rubbing or point loads against the conduit.



F. Wall Penetrations

Where the pipe goes through or passes under a concrete structure, precautions must be taken to prevent bending or point loading of the pipe due to settling. A minimum 2" thick pad of resilient material should be wrapped around the pipe to provide flexibility and prevent contact with the concrete. If bolts are used in the resilient material, care should be taken that the bolts, nuts, or washers cannot come into point load contact with the pipe. Bedding depth under the pipe should be increased to a minimum of 12" or one pipe diameter, whichever is greater, for one pipe joint length away from the concrete.

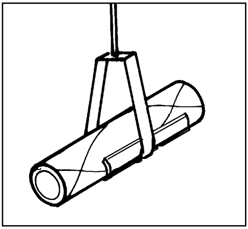


G. Timing

Test and cover the pipe as soon as possible to reduce the chance of damage to the pipe, floating of the pipe due to flooding, or shifting of the line due to cave-ins.

ANCHORS, GUIDES AND SUPPORTS

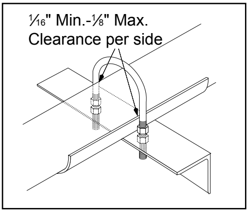
A. Pipe Hangers



Pipe hangers such as those shown are often used to support pipe in buildings and pipe racks. However, the use of too many hangers in succession can result in an unstable line when control valves operate, and during pump start-up and shutdown. To avoid this condition, the designer should incorporate auxiliary guides in the line to add lateral stability.

B. Pipe Guides

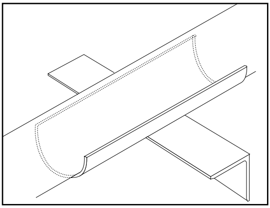
Guides are rigidly fixed to the supporting structure and allow the pipe to move in the axial direction only. Proper guide placement and spacing are important to ensure proper movement of expansion joints or loops and to prevent buckling of the line.



The guiding mechanism should be loose so it will allow free axial movement of the pipe. “U” bolts, double-nutted so they cannot be pulled down tight, are often utilized for guides.

Pipe entering expansion joints or expansion loops requires additional guides. Refer to Engineering & Piping Design Manual, for details.

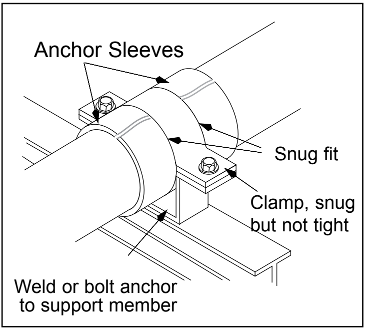
C. Pipe Supports:



Piping supports for pipe should be spaced at intervals as shown in the pipe product bulletins.

Note: Properly spaced supports do not alleviate the need for guides as recommended in the preceding section. Supports that make only point contact or that provide narrow supporting areas should be avoided. Some means of increasing the supporting area should be used; sleeves made from half of a coupling or pipe are suitable. Support pumps, valves and other heavy equipment independent of the pipe. Refer to pump and valve connection instructions on page 48.

D. Pipe Anchors:



Pipe anchors divide a pipeline into individual expanding sections. In most applications, major pieces of connected equipment, such as pumps and tanks, function as anchors. Additional anchors are usually located at valves, near changes in direction of the piping, at blind ends of pipe, and at major branch connections. Provisions for expansion should be designed into each of the individual pipe sections.

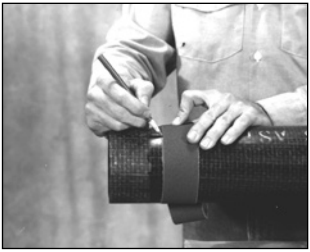
Do not install more than one expansion joint or expansion loop between two anchors.

Do not anchor pipe by applying external pressure as point loads, such as a "U"-bolt, directly to the bare pipe.

Refer to Engineering & Piping Design, for a thorough discussion on supports, anchors and guides.

CUTTING PIPE

Pipe should be cut using one of the methods referred to under Tools and Equipment on page 10.



1. Measure pipe, remembering to allow for spigot and fitting dimensions.
2. Scribe a cutting guide around the pipe to ensure a perpendicular cut for proper fit.
3. Hold the pipe firmly but not to the point of crushing. If chain vises or other mechanical holding devices are used, care should be taken to prevent crushing or point loading of the pipe. To prevent damage to the pipe, 180 degree sections of the pipe can be used for protective covers.
4. Saw the pipe as smoothly as possible. The pipe ends should be square within ⅛ inch.

NOTES:

a. Centricast pipe should be above 55°F when cutting. Preheat with a heat blanket if ambient temperature is below 55°F.

b. Z-Core pipe should be warmed to a minimum ID temperature of 100°F prior to cutting using a heat blanket.

c. Inspect the inside diameter of the pipe after cutting to be sure it has not been damaged by saw cracking or during handling.

ASSEMBLY LAYOUT

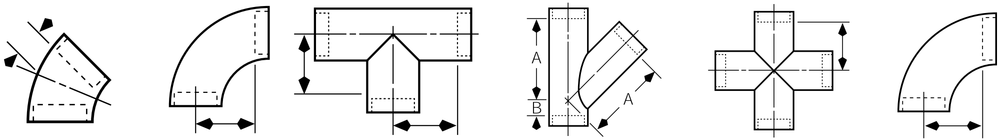
Refer to Table 6 on page 21 for "Take-Off Dimensions" for socket joint fittings or Tables 8 and 9 on pages 22-23 for F-Chem fittings. The method for calculation is similar to the method for any other piping system:

a. Determine the required finished length of the pipe spool sections from the drawing.
b. Subtract the take-off dimension for each fitting in the spool section.
c. Cut the pipe to the length determined as the take-off dimension (b. above).
d. As a double check, dry fit the pipe and fitting(s) to confirm the finished length is correct.
e. Mark the cut pipe lengths with the pipe spool identification number from the blueprint to avoid later confusion. Many pipe lengths can be cut at one time to allow improved efficiency in pipe fabrication.

Consult Fittings & Accessories Bulletins for complete fitting dimensions and other data.

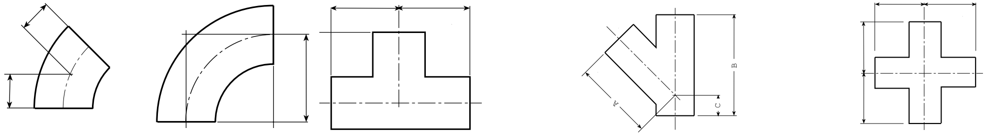
TABLE 6. Take-off Dimensions for CL, RB & ZC Socket Fittings

Pipe stop to fittings' center line dimensions. The dimensions are used to calculate pipe length requirements to meet pipeline center line to center line dimensions.



Size	Fig. 265C 45° Elbow		Fig. 255C 90° Elbow	Fig. 275C Tee		Fig. 266C		Fig. 285C Cross	Fig. 257C LR 90° Elbow
	PM	HLU		PM	HLU	A	B		
In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1	1 5/16	9/16	1 5/16	1 5/16	2 5/16	-	-	-	3 13/16
1½	1	15/16	1 7/16	1 7/16	2 11/16	-	-	-	4 11/16
2	1 7/16	11/16	2	2	2 11/16	5 11/16	13/16	1 3/8	4 11/16
3	1 15/16	1 3/16	2 5/8	2 5/8	3 11/16	7 1/8	1 1/8	2 3/16	5 15/16
4	2 1/4	2 3/16	3 1/4	3 1/4	4 11/16	9 3/16	7/8	3 1/2	7 3/16
6	2 15/16	3 3/16	4 3/16	4 3/16	6 3/16	15 9/16	5 5/16	4 3/16	9
8	-	3 5/16	4 7/8	-	5 1/16	18 11/16	5 5/16	5 3/16	12
10	-	3 11/16	-	-	8 3/16	22 7/16	6 7/16	8 3/16	13 11/16
12	-	4 11/16	-	-	9 3/16	27 15/16	7 5/16	9 3/16	16 3/16
14	-	5 3/8	-	-	9 5/8	-	-	-	18

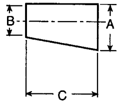
TABLE 8. Take-off Dimensions for 14" - 72" F-Chem Plain End & Flanged Fittings



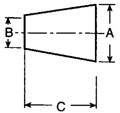
Size	45° Elbow	90° Elbow	Tee	Lateral			Cross
				A	B	C	
in	in	in	in	in	in	in	in
14	8 ¾	21	18	30	42	12	18
16	10	24	20	32	46	14	20
18	11 ¼	27	21	38	54	16	22
20	12 ½	30	22	38	54	16	22
24	15	36	24	42	60	18	24
30	18 ⅝	45	30	52	72	20	30
36	22 ½	54	33	62	84	22	33
42	26	63	36	72	96	24	36
48	29 ⅞	72	42	---	---	---	---
54	33 ½	81	45	---	---	---	---
60	37 ¼	90	54	---	---	---	---
72	44 ¾	108	60	---	---	---	---

TABLE 9. Take-off Dimensions for 14" - 72" F-Chem Plain End & Flanged Reducers

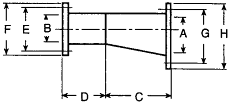
Size (inch)						
A B	C	D	E	F	G	H
14X10	10	10	14 ¼	16	18 ¾	21
14X12	5	10	17	19	18 ¾	21
16X12	10	10	17	19	21 ¾	23 ½
16X14	5	12	18 ¾	21	21 ¾	23 ½
18X14	10	12	18 ¾	21	22 ¾	25
18X16	5	12	21 ¼	23 ½	22 ¾	25
20X16	10	12	21 ¼	23 ½	25	27 ½
20X18	5	12	22 ¾	25	25	27 ½
24X18	15	12	22 ¾	25	29 ½	32
24X20	10	12	25	27 ½	29 ½	32
30X20	25	12	25	27 ½	36	38 ¾
30X24	15	12	29 ½	32	36	38 ¾
36X24	30	12	29 ½	32	42 ¾	46
36X30	15	15	38 ¾	36	42 ¾	46
42X30	30	15	38 ¾	36	49 ½	53
42X36	15	15	42 ¾	46	49 ½	53



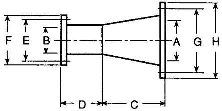
Plain End Eccentric



Plain End Concentric



Flanged Eccentric



Flanged Concentric

PART III
SOCKET JOINT FABRICATION

Straight socket adhesive joints are designed for:

1. High strength
2. Easy, quick fabrications
3. Minimum of tools and procedures
4. High reliability

The adhesives provide reinforcement in the bond area and are designed to prevent void areas. There are only a few important procedures, but you must follow them correctly to achieve a good bond. (**Note: Follow complete detailed instructions supplied with each adhesive kit.)**

PREPARATION OF 1"-14" CL, ZC & RB PIPE AND FITTINGS FOR BONDING

Key requirements for a good bond are:

1. **CL, ZC and RB piping**: Measure the length of the socket, add 1/2" and thoroughly sand the pipe OD with 36-60 grit material until there are no glossy areas. Resand the fittings sockets with 36-60 grit material to thoroughly clean the bond area. A clean, rough surface provides a bond area for good adhesion. Do not use a flapper wheel to sand pipe OD or fitting socket. Use a clean, dry rag or paper towel to remove sanding dust. **Do not use solvents. Do not use compressed air to blow sanding dust off the prepared ends as it may contain contaminates detrimental to bond strength.**

"Shoe Shine" method using Emery cloth of 36-60 grit abrasive.

Disk power sander for large diameter pipe. Use 36-60 grit abrasive.

High speed die grinder for sanding sockets. Use drum with 36-60 grit abrasive.

Never sand the joint surfaces more than two (2) hours before making the joint.

2. Thoroughly mix the adhesive until the color is consistent. A poor mix may result in a leaky connection. Do not mix less than a full kit or try to estimate partial quantities.

3. Thoroughly wet-out the fitting socket (see note 1 for 1" - 2" joint) by working a thin layer (approx. 1⁄16") of adhesive into the bonding surface of the fitting. In a similar manner, apply a generous layer (1⁄8" minimum) onto the pipe's OD. Also coat the cut end of the pipe to prevent chemical attack. **Caution:** Do not continue to use the adhesive once it has begun to set up in the can.

4. Push the fitting smoothly, straight onto the pipe. Do not turn, twist, or work the fitting as that could pull air into the joint and create a void area. Slight rotation (approx. ½") after insertion is acceptable for fitting alignment. Be sure there is squeeze-out all around the hub of the fitting.

5. Refer to page 29 for ambient temperature joint cure. Do not move the joint during the gelling period of the cure cycle. Movement can cause out-of-plumb fitting alignment and a leaky joint. Though not required, heat cure is highly recommended for piping systems carrying fluids at temperatures above 120°F. Refer to pages 27-31 for heat curing.

Warning: Do not use the heat blanket or collar on the CL or RB joints until the adhesive fillet is gelled and firm to the touch.

Note: 1", 1 1/2", & 2" Centricast Pipe - Small diameter adhesive socket joints may be obstructed by excessive adhesive if the following instructions are not followed. Apply adhesive to the fitting socket forcing it into the sanded surface. Make sure all of the bonding surfaces are completely coated with adhesive. Remove the adhesive with the applicator leaving only a very thin film to wet all the bonding surfaces.

Any excessive adhesive left in the fittings socket will be forced into the pipe during joining and may obstruct fluid flow in the system. Wet the end of the pipe leaving a small bead of adhesive. The adhesive will prevent chemical attack of the pipe end. Apply a thin film of adhesive to the pipe forcing it into the sanded bonding surface. Next coat the bonding area of the pipe only with adhesive at least ¼" thick. Make sure there is not excessive adhesive on the end of the pipe or in the pipe bore before placing the fitting on the pipe.

JOINT CURE

A. Ambient Cure

Cure time is the time required for the adhesive in the assembled joint to harden. Cure time depends on the type of adhesive and the ambient temperature, as shown in Table 10.

Heat Assist Gel: Place an industrial heat gun (1600 watt) approximately 6" away from the fitting and point at the socket. Continuously rotate slowly around the fitting until the bead is firm to the touch.

Heat Cure: We recommend heat curing all Z-CORE joints with electric heating blanket for maximum joint strength, corrosion resistance, accelerated assembly time, or if the ambient temperature falls below 70ºF. See pages 28-31 for Instructions for Using Heat Blankets and Collars.

TABLE 10. Adhesive Ambient Cure Time

Adhesive Type	Cure time (hrs.) based on temperature (°F)					
	40-50	51-60	61-70	71-80	81-90	91-100
Epoxy: 275	N/R	N/R	N/R	24	24	24
Vinyl Ester: CL-200(1) CL-200QS(2)	N/R N/R	N/R N/R	N/R 4	24 2	24 1	24 N/R

(1) Heat cure highly recommended for piping systems carrying fluids above 120°F.

(2) Times will be longer a colder temperatures and shorter at higher temperatures.

N/R= Not recommended.

ADHESIVE DISPOSAL: Once the adhesive and hardener have been mixed and reacted, nothing can be extracted, and it is classified as non-hazardous material. Dispose of in a normal manner as other solid waste. Hardener jars, when empty are not subject to EPA regulation and can be disposed of in a normal manner. These guidelines are based on federal regulations. State and local regulations and ordinances should be reviewed.

INSTRUCTIONS FOR USING HEAT BLANKET AND CONTROLLER

Caution: Refer to Heat Blanket Instructions for complete operating instructions

- Use only with 120 volt power outlet. Special 240 volt heat collars are available.
- Blanket should not be used in wet conditions.
- Tears, cuts or punctures in the blanket can create a potential safety hazard.

1. Use only the proper size heat blanket for the pipe being joined. See Table 11 on page 29.
2. Wrap the blanket around the joint placing the thermistor side out and the smoother side of the blanket down against the joint. Wrap around the joint until reaching the overlap. Once the blanket starts to overlap, place the tail of the blanket through the slit in the thick end of the blanket and pull it tight. The entire joint should be covered now and the small amount of blanket left should be laid out off of the thermistor. Now run the straps around the pipe, put them through their respective slots, and then pull tight. This will ensure a tight-fighting heat blanket providing you with the best cure.

Note: Check heat blanket temperature to be sure it is heating properly.

3. Flange joints require heating from the inside. First, lay the blanket flat with the thermistor down. Next, roll up the blanket from the tail so that once rolled up, the thermistor is facing out towards the inside of the pipe. Insert the blanket into the pipe or fitting to the depth of the adhesive joint. Leave the cord and the remaining part of the blanket exposed. The blanket may be held in position against the ID of the joint being heated by inserting a short section of smaller FRP pipe inside the rolled blanket.
4. Avoid excess flexing of the blanket. Abnormal flexing can cause breakage and shorten the service life of the blanket. DO NOT crease the heat blanket.
5. DO NOT use cleaning solvents. Solvents penetrate the rubber and damage the heating wires.
6. DO NOT carry or move the blanket by lifting it with the cord alone. Support the weight of the blanket separately from the cord to avoid abusing the cord-to-blanket connection.

Improper sizing or use of the heat blankets can cause excess heating which can damage both the piping and heat blankets.

TABLE 11. Heat Blanket Models				
Pipe Size	**1"-3"**	**4"-8"**	**10"-14"**	**16"-20"**
Model	B	C	D	E

Heat Blanket Cure Time

High temperature heat collars are to be used to cure Z-Core, CL and RB Centricast pipe and fittings bonded with ZC-275 and CL-200 series adhesive. The adhesive must be gelled before applying heat blankets. The use of high temperature heating blankets maximizes the strength and the corrosion resistance of the joint. The recommended cure times varies with pipe size as shown in Table 12. These cure times are valid for fabrication in environments between 70°F and 100°F. Please refer to Part II, Site Considerations, Adverse Weather Conditions for adverse environmental considerations.

TABLE 12. Heat Blanket Cure Times		
Adhesive Grades	**Pipe Size**	**All Joints & Fittings (hours)**
ZC-275	1"-14"	1
CL-200	1"-14"	½

Based on controller style heat blanket

The cure time refers to the time a powered heat blanket must remain on the joint being cured. Once the cure time has been reached the blanket may be removed. The joint will be structurally sound and may be moved as required to further the piping system assembly. The joint should be allowed to cool to ambient temperature prior to hydro testing.

INSTRUCTIONS FOR USING *HIGH TEMPERATURE HEAT COLLAR* (Refer to Heat Collar Bulletin for complete operating instructions.)

Note: Allow adhesive to gel before applying heating collar.

- Do not bend or fold heating collar as this may break the heating elements and cause the collar to work improperly or not al all.

For Pipe and Fittings:

1. Use the same size heating collar as the pipe size you are installing, with the exception of flanges. Do not use a heating collar that is designed for a larger size pipe. See Table 14 on page 31.
2. With the un-insulated flap on the bottom (next to the fitting), carefully wrap the heating collar around the joint. Feed the strap through the square ring. **Caution:** The un-insulated flap is extremely hot when the collar is on. DO NOT TOUCH with bare hands.
3. Tighten the straps until the heating collar is snug against the joint.

For Flanges:

1. For 1", 1½" and 2" flanges, an industrial heat gun may be used to cure the joint. Be sure that the end of the gun is at least six inches from the opening of the flange.
2. For 3" through 16" flange joints, use a heating collar that is one pipe size smaller than the product you are working with. Remove the straps from the heating collar.
3. Carefully turn the collar inside out with the heated area facing the I.D. of the pipe. Place the heating collar in the I.D. of the flange. A split ring of pipe may be used to hold the collar in place while the joint is curing.

For Saddles:

1. Place the heating collar over the saddle outlet. During cool weather, a wind shield is recommended to keep heat on the joint. Saddles must be heat cured for two hours.

Allow the joint to return to ambient temperature before applying stress to the joint.

Note: ***High Temperature*** electric heating collars are designed to fit around fittings, and will overlap on pipe joints and couplings. Exceeding the recommended cure time on pipe joints where the heating collar overlaps may shorten the life of the heating collar and/or damage the pipe.

The use of insulation may be necessary below 40°F to prevent heat loss.

High Temperature Heat Collars Cure Times

High temperature heat collars are to be used to cure Z-Core and RB series Centricast pipe and fittings bonded with ZC 275 series epoxy adhesive. The adhesive must be gelled before applying heat collars. The use of high temperature heating collars maximizes the strength and the corrosion resistance of the joint. The recommended cure times varies with pipe size as shown in Table 13. These cure times are valid for fabrication in environments between 70°F and 100°F. Please refer to Part II, Site Considerations, Adverse Weather Conditions for adverse environmental considerations.

TABLE 13. High Temperature Heat Collar Cure Times

Pipe Size	All Joints & Fittings (hrs.)
1" - 6"	½
8" - 14"	1

TABLE 14. High Temperature Heat Collar Models (For use with ZC and RB pipe only)

Pipe Size	Model Number	
	110 VAC	240 VAC
1"	005990-500-0	005990-500-1
1 ½"	005990-501-0	005990-501-1
2"	005990-502-0	005990-502-1
3"	005990-503-0	005990-503-1
4"	005990-504-0	005990-504-1
6"	005990-505-0	005990-505-1
8"	005990-506-0	005990-506-1
10"	005990-507-0	005990-507-1
12"	005990-508-0	005990-508-1

The cure time refers to the time a powered heat collar must remain on the joint being cured. Once the cure time has been reached the collar may be removed. The joint will be structurally sound and may be moved as required to further the piping system assembly. The joint should be allowed to cool to ambient temperature prior to hydro testing.

PART IV
BUTT & WRAP JOINT FABRICATION

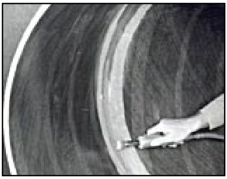
Surface / End Preparation

Note: It is essential to good fabrication that pipe and fitting surfaces be sanded, clean, dry, and free of oil, grease, and solvent contamination.

1. Prepare both ends of the pipe, or pipe and fitting to be joined, by sanding the bonding surfaces with 36 to 60 grit abrasive. The sanded area should extend at least ½" beyond the widest layer of glass.

Example: 14" Pipe Size.
The widest layer of fiberglass is 8", therefore, sand the pipe ends to a distance of 4 ½" from each cut end.

2. Never sand the joint surfaces more than two (2) hours before making the joint.
3. Wipe the sanded area with a clean, dry, lint-free cloth, and avoid touching the surfaces with bare hands or dirty gloves. Do not use solvents.



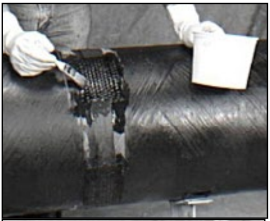
Interior Surface Preparation

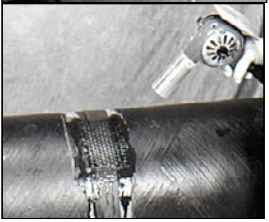
For 24" and larger piping, where accessible, use a die grinder to sand the interior surface of the pipe 3" from the joint ends. This will provide a proper bonding surface for applying the veil, mat, and resin to the pipe's interior surface.

Sealing and Securing The Pipe Ends

Coat the sawed ends of the pipe and/or fittings with catalyzed resin or Weldfast CL-200 Adhesive before joining the ends. Mix Weldfast CL-200 per the instructions in the Weldfast Kit. Sealing the pipe ends protects the fiberglass reinforcement from chemical attack.

Hot Patches





Hot patches are used to prevent joint movement during the Field Weld procedure. Hot patches are small pieces of Fabmat, approximately 4" x 6", which are included in the Field Weld Kit. Two (2) patches should be used on pipe up to 20" diameter, and three (3) patches on all pipe larger than 20". Only a small amount of resin is required to apply hot patches. Mix one pint of resin with 12 ml. of catalyst. Saturate the patches with the catalyzed resin, and apply to the piping with the mat side to the pipe.

The hot patches need to harden before applying joint filler. Heat may be applied to accelerate hardening of the catalyzed resin.

Joint Filler

Weldfast CL-200 adhesive is used to fill gaps and voids caused by uneven saw cuts and differences in pipe outside diameters.

Mix according to the instructions provided in the Weldfast Kit. Apply enough catalyzed adhesive to fill all of the gaps and provide smooth transitions where the pipes join. Let the adhesive harden and re-sand the joining surfaces before applying the Field Weld resin and glass. Heat may be applied to accelerate hardening of the adhesive.

Mixing The Standard Lay-Up Resin

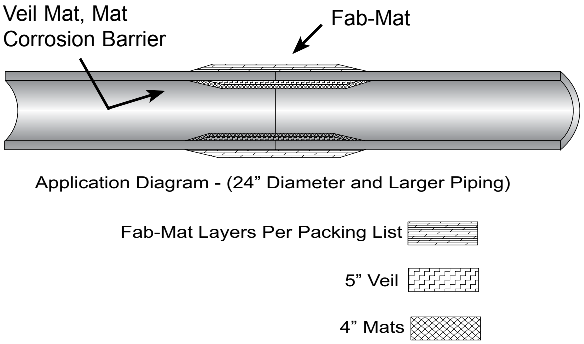
1. Measure the recommended amount of catalyst using the graduated measuring beaker. See the Cure Times Chart on page 37.

2. Pour the measured catalyst into 1 quart of vinyl ester resin and stir until completely blended. When the resin is properly blended, the color will consistent and will start to foam.

The standard mix of resin is 16 ml. of catalyst for each quart of vinyl ester resin. After the first quart of resin is mixed and a layer of fiberglass has been applied, it may be evident that the ratio of catalyst should be changed to allow more or less working time. If more working time is required, use as little as 13 ml. of catalyst to each quart of resin. This will normally double the pot life and the curing time. If a quicker cure is required, use up to 22 ml. of catalyst for each quart of resin. This will shorten the pot life and cure time.

IMPORTANT NOTE! Never use less than 13 ml. or more than 22 ml. of catalyst for each quart of resin. "Smoking" or "crazing" of a joint indicates an over-catalyzed resin. Joints made with over catalyzed resin will be structurally weak, provide poor chemical resistance, and should not be used.

Inside Corrosion Barrier (24" Diameter and Larger Piping)



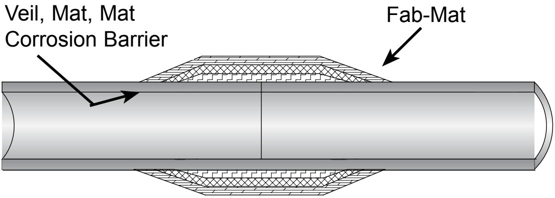
Application Diagram - (24” Diameter and Larger Piping)

Inside corrosion barriers improve the structural and chemical integrity of the pipe. When possible, always make inside corrosion barriers when joining large diameter pipe, using the following procedures:

1. Wet the sanded surface of the piping interior with a light coat of catalyzed resin.
2. Arranging the materials

on a flat surface or table top, pre-wet two layers of 4" wide, fiberglass mat, and one layer of veil. Be sure the veil is the top layer.

3. Apply the pre-wetted layers, centering the glass over the joint. Be sure the veil is toward the center of the pipe.



Fab-Mat Layers Per Packing List

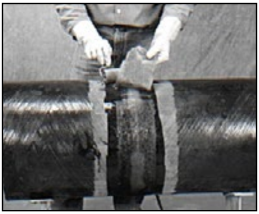
Application Diagram - (Smaller Than 24” Diamerter Piping)

5” Veil

4” Mat

Exterior Corrosion Barrier (Smaller Than 24" Diameter Piping)

If an inside corrosion barrier cannot be made, a corrosion barrier must be made on the exterior joining surfaces of the piping, using the following procedures:



1. Wet the sanded surface of the piping exterior with a light coat of catalyzed resin.
2. Arranging the materials on a flat surface or table top, pre-wet two layers of 4" wide fiberglass mat, and one layer of veil. Be sure the veil is the top layer.
3. Apply the pre-wetted layers, centering the glass over the joint. Be sure the veil is against the pipe.

Applying the Fiberglass Reinforcement

Apply all the fiberglass layers, as supplied in the Field Weld Kit, for the pressure rating and size of the pipe being joined. Start with the narrowest Fabmat at the pipe surface and proceed to the widest Fabmat. (See Application Diagram for the proper sequence and staging of fiberglass strips to be laid-up.)

Pre-wet with resin, a layer of fiberglass on a table or flat surface. Pick up the wetted layer of fiberglass and place it over the joint. Apply each layer of Fabmat with the mat side down. As each layer is applied, roll out the wrinkles or trapped air with the 3" paint roller.

The catalyzed resin should be continuously worked into the glass until it begins to gel (warms and begins to harden). No more than 4 layers of Fabmat should be applied before the resin is allowed to gel. After each stage has gelled and cooled, sand lightly to remove any burrs before additional layers are applied. Do not move the piping until the joint has hardened and cooled.

Mixing and Applying The Finish Coat
After all the layers of fiberglass have been applied to the joint, and the joint has gelled or semi-hardened, apply a final coat of catalyzed resin using the 3" paint roller or a brush. This finish coating is in a separate container marked "Finish Coat Resin." This resin should be catalyzed using the same procedure as for the standard lay-up resin. If less than one quart of Finish Coat Resin is required, reduce the recommended amounts of catalyst proportionately.

Application of the special Finish Coat Resin is critical to developing a chemical resistant piping surface and joint.

ADHESIVE DISPOSAL: Once the adhesive and hardener have been mixed and reacted, nothing can be extracted, and it is classified as non-hazardous material. Dispose of in a normal manner as other solid waste. Excess adhesive and hardener can be mixed, allowed to react, and disposed of as above. If extra jars of adhesive or hardener have accumulated without the other component to mix and react, contact your Regional Manager. Hardener jars, when empty are not subject to EPA regulation and can be disposed of in a normal manner. These guidelines are based on federal regulations. State and local regulations and ordinances should be reviewed.

JOINT CURE
The minimum required cure time is 24 hours at 70°F. Inadequate joint strength will result if the catalyzed resin is cured at temperatures less than 60°F. Heat cure at 200°F to 275°F will accelerate cure time and increase joint strength.

Heat cure is highly recommended for piping systems carrying fluids at temperatures above 120°F. Before pressurizing the piping system, or moving the piping, cure the joint. See the Cure Times Chart below.

Note: See pages 48-50 for hydrostatic testing and system start-up procedure.

TABLE 14. VINYL ESTER BUTT WELD KIT CURE TIMES

Temp (°F)	Part A Shelf Life (months)	Part B Shelf Life (months)	Pot Life (min.)	Gel Time (min.)	Joint Cure Time (hours)
40-49	6	12	N/R	N/R	N/R
50-59	5	12	N/R	N/R	N/R
60-69	3-4	12	20-40	25-45	36
70-79	3-4	12	20-40	25-45	24
80-89	2-3	9	15-35	18-38	24
90-100	1-2	4	8-15	10-18	16
200-250	-	-	-	-	2-4

PART V
INSTALLATION CONSIDERATIONS

FLANGE & FITTING ALIGNMENT

As with any piping system, flanges must be set for proper alignment of bolt patterns and fittings must be set to be plumb. Arrangement of the work pieces before adhesive bonding is the key to easy fabrication.

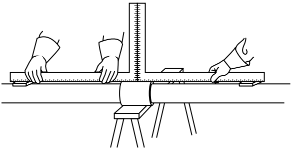
1. Level the pipe on the work table or pipe stands.
2. Dry-fit components to check dimensions.
3. Layout levels, plumb bobs that will be needed.
4. Follow the recommended procedures in sanding, adhesive mixing and bonding.
5. Immediately after inserting the pipe into the fitting socket, adjust the fabrication for correct alignment. For example, a flange may need to be rotated slightly for correct bolt hole alignment. About ½" of rotation on a flange should be the limit of movement. The same applies for plumbing an elbow. Excessive movement can create entrapped air and a leak path when the system is pressurized.
6. Hold the fabrication rigid - no movement - until the adhesive gels. This may require tape, pipe supports, or shims.
7. Check the fabrication during the gel stage to be sure it has not been bumped or moved.
8. Thoroughly heat-cure the joint before applying pressure.

Note: If a fabrication has been moved so that the bond is questionable, pull it apart and re-fabricate. If the adhesive is fresh and soft, simply re-apply adhesive to the pipe and fitting. If the adhesive has begun to gel, it is probably easier to let it cure, sand it off and re-do the entire joint procedure.

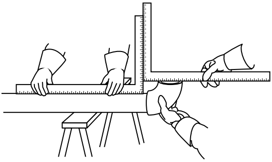
Pipe Alignment: Proper alignment is one of the most important tasks performed by the pipe fitter. If done correctly, installation will be much easier and the piping system will be properly fabricated. If alignment is poor, however, fit-up will be difficult and the piping system may not function properly.

Methods of alignment vary widely throughout the trade. The procedure in this manual will enable you to obtain good alignment.

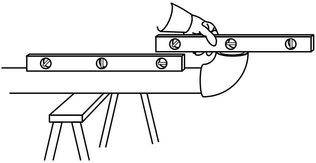
Pipe-To-Pipe: Bond pipe lengths together with coupling. Take a long straight edge and place on top of pipes. Measure several locations to make sure both pipes are parallel with the straight edge. Adjust pipes as needed. Move straight edge to the side of the pipes and repeat measurements. Correct alignment by moving pipes as needed. Hold pipes rigid until adhesive is gelled.



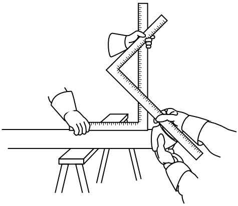
90 Degree Elbow-To-Pipe: Install fitting on pipe to close visual alignment. Center square on top of pipe. Center second square on elbow's alternate face. Move elbow until squares are aligned. Hold rigid until adhesive is gelled.



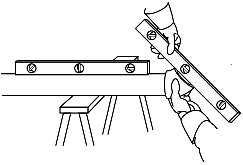
Alternate Method: Use same procedure to bond fitting to pipe. Level pipe in stand. Place spirit level on elbow's alternate face and adjust if needed. Move spirit level to opposite direction and rotate to level. Hold rigid until adhesive is gelled.



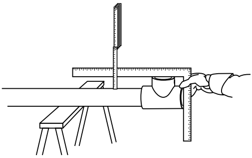
45 Degree Elbow-To-Pipe: Install fitting on pipe to close visual alignment. Follow procedure described above; squares will cross. To obtain correct 45 degree angle, align the same numbers on the inside scale of the tilted square and adjust fitting to conform. Hold rigid until adhesive is gelled.



Alternate Method: Use same procedure to bond pipe and fitting. Center spirit level on pipe. Next, center 45 degree spirit level on face of elbow and move elbow until 45 degree bubble is centered. Hold rigid until adhesive is gelled.

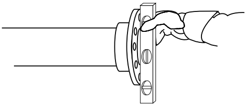


Tee-To-Pipe: Place square on tee as illustrated. Center rule on top of pipe. Blade of square should be parallel with pipe. Check by measuring with rule at several points along the pipe. Move square 90 degrees to side of pipe and recheck plumb by measuring with rule along side of pipe. Hold rigid until adhesive is gelled.



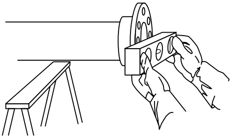
Flange-To-Pipe:

Step 1 Level pipe in stands or vise.



Step 2 Install flange on pipe to close visual alignment. Align top two holes of flange with spirit level. Move flange until bubble is centered.

Step 3 Use spirit level to adjust flange face to be vertical or plumb.

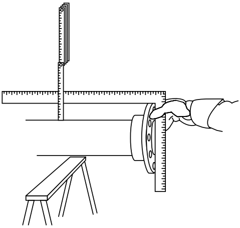


Step 4 Rotate assembly 90 degrees and repeat Step 3.

Step 5 Hold rigid until adhesive is gelled.

Alternate Method:

Step 1 Install flange on pipe to close visual alignment. Align top two holes of flange with spirit level. Move flange until bubble is centered.



Step 2 Center square on face of flange. Center rule on top of pipe. Move flange until square and pipe are parallel.

Step 3 Center square on face of flange. Center rule on side of pipe and align as in Step 2.

Step 4 Hold rigid until adhesive is gelled.

FLANGE GASKET & O-RING REQUIREMENTS

For RB, CL, & ZC, full-face gasketing materials, 3⁄16" thick, with a Shore A hardness of 60 to 70 durometer, are recommended. **F-Chem** flanges require full-face gasketing material ¼" thick or O-ring seals depending on pressure ratings. Refer to Table 15.

Flat gaskets made from Teflon® and PVC usually have high durometer ratings and are not acceptable.

TABLE 15. Gasket & O-Ring Requirements for F-Chem Stub Flanges & Flanged Fittings

Pipe Size (in.)	Pressure Rating (psig)	Gasket(1)		O-Ring(2)	
		I.D. (in.)	O.D. (in.)	Cross Section	I.D.
14	50-100 125-150	14 3⁄16 -	21 -	- .275	- 15.475
16	50-100 125	16 3⁄16	23 ½	- .275	- 17.455
18	50-100 125	18 3⁄16 -	25 -	- .275	- 19.455
20	50-75 100	20 3⁄16 -	27 ½ -	- .275	- 21.629
24	50-75 100	24 3⁄16 -	32 -	- .275	- 26.129
30	50-75 100	30 3⁄16 -	38 ¾ -	- .375	- 31.975
36	50-75 100	36 3⁄16 -	46 -	- .375	- 36.180
42	50 75-100	42 3⁄16 -	53 -	- .375	- 44.620
48	50 75-100	48 1⁄16 -	59 ½ -	- .500	- 50.680
54	50-75	-	-	.500	56.770
60	50-75	-	-	.750	62.590
72	50-75	-	-	.750	75.340

(1) Use ANSI 16.1 class 125 lb drilling gasket with a hardness of 50 to 70 durometer on the Shore A scale.
(2) Use O-Ring with a hardness of 50-70 durometer on the Shore A scale.

STANDARD BOLTING CONDITIONS
Flanges meet OD, bolt circle diameter, number of holes and bolt hole diameter dimensions for ANSI B16.1, 125 lb. cast iron sizes 1"-72" and ANSI B16.5, 150 lb. steel for 1"-24" diameters.

Notes:

1. Standard Bolt Description:
   Diameter - Threads per inch x length.
2. Bolt lengths are nominal. When joining flanges to flanges of other material or manufacturers, the bolt length must be calculated.
3. Use two washers with each bolt. Use SAE standard washers under all nuts and bolt heads up to 48" size. Use USS wrought washers for 54" and larger sizes.
4. Bolt torque based on National Course threads.
5. ANSI B16.1, 125 lb and ANSI B16.5, 150 lb. flange dimensional designs are identical for sizes 1-24".

TABLE 16. Bolt, Washer & Torque Requirements for CL, RB, ZC Flanges & Fabricated Flanged Fittings

Flange Size (in.)	No. of Bolts	Machine Bolt Size	Stud Bolt Size	Maximum Allowable Torque ft. lbs. Dry/Lubricated
1	4	½-13x3	½ -13x3½	10/10
1 ½	4	½ -13x3½	½ -13x4	20/15
2	4	⅝ -11x3½	⅝ -11x4½	50/35
3	4	⅝ -11x3½	⅝ - 11x4½	50/35
4	8	⅝ - 11x4½	⅝ - 11x5	50/35
6	8	¾ - 10x4½	¾ - 10x5½	50/35
8	8	¾ - 10x5½	¾ - 10x6½	50/35
10	12	⅞ - 9x8	⅞ - 9x9	50/35
12	12	⅞ - 9x8	⅞ - 9x9	50/35
14	12	1 - 8x10½	1 - 8x12	50/35
Integral Flanged Fittings				
1	4	½ - 13x3	½ -11x3½	10/10
1 ½	4	½ - 13x3½	½ - 13x4	20/15
2	4	⅝ -11x3½	⅝ -11x4½	30/20
3	4	⅝ -11x3½	⅝ -11x4½	30/20
4	8	⅝ -11x4½	⅝ -11x5	30/20

TABLE 17. Bolt, Washer & Torque Requirements for Van Stone-Type Flanges

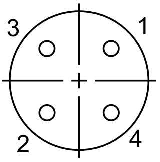
Flange Size (in.)	Backing Flange Material	No. of Bolts	Machine Bolt Size	Stud Bolt Size	Max. Allowable Torque (ft.lbs.) Dry/Lubricated
2	FRP	4	⅝-11x5	⅝-11x5½	50/35
3		4	⅝-11x5	⅝-11x5½	50/35
4		8	⅝-11x5	⅝-11x6	50/35
6		8	¾-10x5½	¾-10x6½	50/35
2	Steel	4	⅝-11x4	⅝-11x4½	50/35
3		4	⅝-11x4	⅝-11x4½	50/35
4		8	⅝-11x4	⅝-11x4½	50/35
6		8	¾-10x4	¾-10x5	50/35

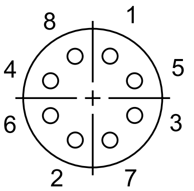
TABLE 18. Bolt, Washer & Torque Requirements for F-CHEM Flanges & Flanged Fittings

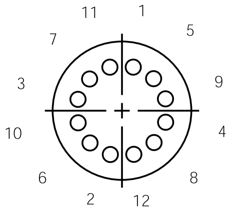
Pipe Size (in)	Pressure Rating (psig)	No. of Bolt Holes	Machine Bolt (1) Size	Stud Bolt (1) Size	Bolt Torque (ft. lbs.) (Nom)	(Max)
14	50	12	1-8x4½	1-8x6	75	100
	75	12	1-8x5	1-8x6	85	110
	100	12	1-8x5	1-8x7	90	120
	125	12	1-8x5½	1-8x7	50	100
	150	12	1-8x6	1-8x7	50	100
16	50	16	1-8x4½	1-8x6	75	100
	75	16	1-8x5	1-8x6	85	110
	100	16	1-8x5½	1-8x7	90	120
	125	16	1-8x6	1-8x7	50	100
18	50	16	1⅛-7x5	1⅛-7x6	75	100
	75	16	1⅛-7x5½	1⅛-7x7	85	110
	100	16	1⅛-7x6	1⅛-7x7	90	120
	125	16	1⅛-7x6½	1⅛-7x8	50	100
20	50	20	1⅛-7x5	1⅛-7x7	90	120
	75	20	1⅛-7x5½	1⅛-7x7	105	140
	100	20	1⅛-7x6	1⅛-7x8	75	125
24	50	20	1¼-7x5½	1¼-7x7	90	120
	75	20	1¼-7x6	1¼-7x8	105	140
	100	20	1¼-7x6½	1¼-7x8	75	125
30	50	28	1¼-7x6	1¼-7x8	105	140
	75	28	1¼-7x6½	1¼-7x8	120	160
	100	28	1¼-7x7	1¼-7x9	75	125
36	50	32	1½-6x6½	1½-6x9	105	140
	75	32	1½-6x7½	1½-6x9	120	160
	100	32	1½-6x8	1½-6x10	100	150
42	50	36	1½-6x7	1½-6x9	120	160
	75	36	1½-6x8	1½-6x10	100	150
	100	36	1½-6x8½	1½-6x10	100	150
48	50	44	1½-6x7½	1½-6x9	120	160
	75	44	1½-6x8	1½-6x10	100	150
	100	44	1½-6x9	1½-6x11	100	150
54	50	44	1¾-5x8	1¾-5x10	100	175
	75	44	1¾-5x9	1¾-5x11	100	175
60	50	52	1¾-5x8½	1¾-5x11	100	175
	75	52	1¾-5x9½	1¾-5x12	100	175
72	50	60	1¾-5x9½	1¾-5x11	125	200
	75	60	1¾-5x11	1¾-5x13	125	200

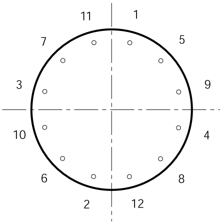
(1) Special bolt lengths are required for blind flanges.

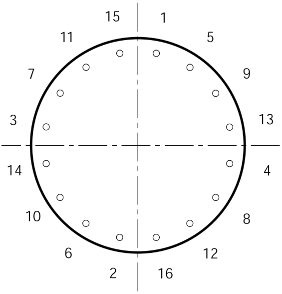
Recommended Bolt Torquing Sequence for Flanges

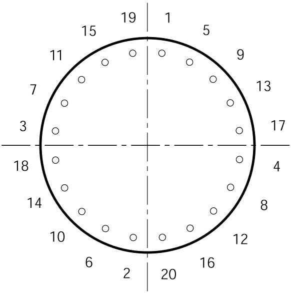


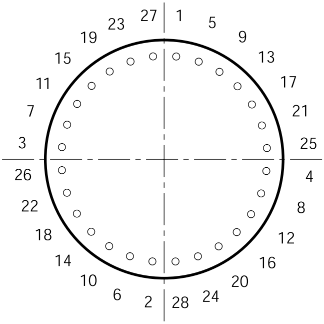


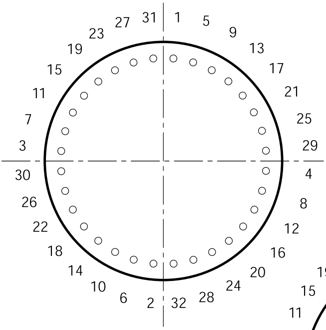








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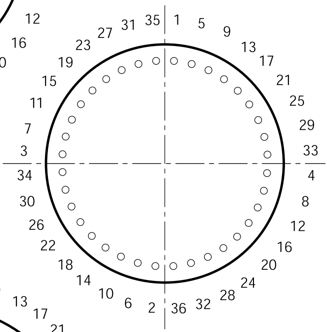
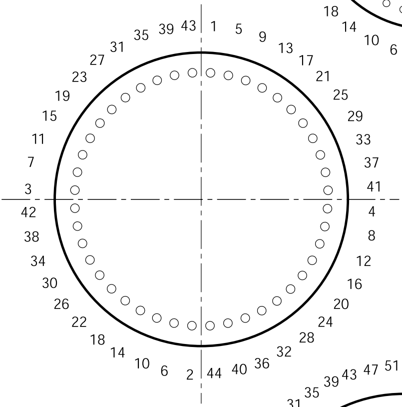
4 8 12 16 20 24 28 32
2 6 10 14 18 22 26 30
3 7 11 15 19 23 27 31


1 5 9 13 17 21 25 29 33
4 8 12 16 20 24 28 32 36
2 6 10 14 18 22 26 30 34
3 7 11 15 19 23 27 31 35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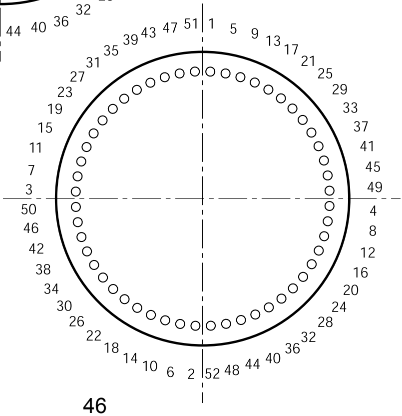
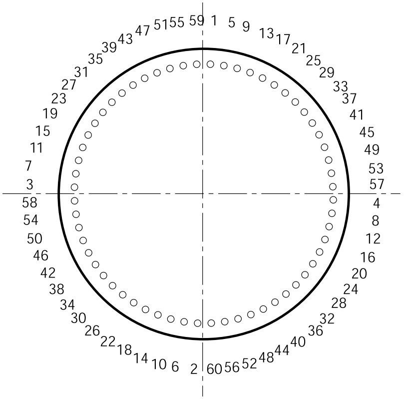
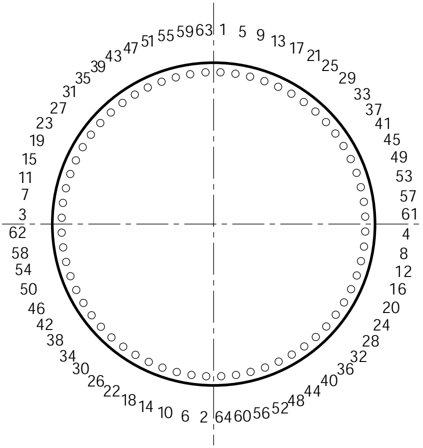
4 8 12 16 20 24 28 32 36 40 44
2 6 10 14 18 22 26 30 34 38 42
3 7 11 15 19 23 27 31 35 39 43

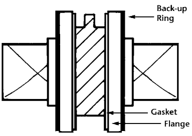

1 5 9 13 17 21 25 29 33 37 41 45 49
4 8 12 16 20 24 28 32 36 40 44 48 52
2 6 10 14 18 22 26 30 34 38 42 46 50
3 7 11 15 19 23 27 31 35 39 43 47 51



SPECIAL FLANGE BOLTING CONDITIONS



Often it is necessary to mate flanges with components that do not have a full flat face surface such as raised face flanges, butterfly or check valves with partial liner facings, and Van Stone flange hubs. The addition of a hard spacer ring or steel back-up ring placed between the raised face and the outer edge of the flange to form a full flat face on the mating flange is recommended. The purpose of the spacer is to fill the gap outside the raised face to prevent bolt loads from bending and breaking the flange. Spacer rings are not required if a Van Stone-type flange is used when connecting to raised face flanges, valves or pumps.



Compression Molded Flanges

FIGURE 8.4

Back-up Ring Thickness	
Pipe Size	Ring Thickness
1" - 12"	9⁄16"

CONNECTING TO OTHER PIPING SYSTEMS

It is often necessary to connect our piping to another piping system or make a connection which will not be possible using flanges. Threaded connections are offered - primarily for instruments, thermo wells, etc. Select the appropriate fitting from the Fittings & Accessories Bulletins. Victaulic-type grooved adapters are also available for use with Series 77 coupling in certain sizes.

Threaded Joints

1. Before making any threaded joints, be sure all bonded joints are fully cured.
2. Apply thread lubrication to both male and female threads. A material which remains soft for the life of the joint is preferred. Be sure the thread lube is suitable for the fluid service.
3. Tighten the joint to seal. Do not over-torque. FRP threads should be handled carefully - as if they are brass.

Notes:

1. The use of adhesive to bond a steel or metal pipe into a flange is not recommended.
2. If mating our piping system to steel or other FRP system, the preferred method is with flanges. Terminate the old system with the other FRP flange and bolt our flange on the new system.
3. Be sure to check the anchors, guides, and supports of an existing system to avoid transfer of any stresses or thermal expansion loads into the system.
4. Do not try to thread pipe or fittings. This is very difficult and risky. Purchase the required factory part.

Tips: If no thread lube is available, the use of Weldfast Part "A" will usually be acceptable. Two wraps of Teflon® tape may also be used in lieu of thread lubricant.

Pump & Equipment Connection
Pipe connections to pumps or other equipment that involve vibration, shock loads or other mechanical movements should include flexible connectors. These flexible connectors allow for the absorption of vibration and eliminate the placing of undue strain on the pipe and fittings. A bellows-type expansion joint is recommended, although rubber hose has also been used with success.

HYDROSTATIC TESTING AND SYSTEM STARTUP
Hydrostatic Testing: When possible, piping systems should be hydrostatically tested prior to being put into 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. To hydrostatically test the line, observe the following:

Water is usually introduced into the system through a one-inch diameter or smaller pipe. Provision for bleeding air from the system should be made. Water should be introduced at the lowest point in the system and the air bled off through a partially open valve or loose flange at all high points in the system. Slowly close the valve, and bring the system gradually up to the desired pressure.

Test pressure should not be more than 1-½ times the working pressure of the piping system, and never exceed 1-½ times the rated operating pressure of the lowest rated component in the system. When testing is completed open all of the high point air bleeds before draining the piping. This will prevent vacuum collapse of the pipe.

For systems with severe chemical or temperature applications, a cyclic test may replace the static test. Contact us for recommendations.

Warnings:
Air Testing: Hydrostatic test should be used instead of air or compressed gas if possible. When air or compressed gas is used for testing, tremendous amounts of energy can be stored in the system. If a failure occurs, the energy may be released catastrophically, which can result in property damage and personal injury. In cases where system contamination or fluid weight prevents the use of hydrostatic test, air test may be used with extreme caution. To reduce the risk of air testing,

use the table below to determine maximum pressure. When pressurizing the system with air or compressed gas, the area surrounding the piping must be cleared of personnel to prevent injury. Hold air pressure for one hour, then reduce the pressure to one half the original. Personnel can then enter the area to perform soap test of all joints. Again, extreme caution must be exercised during air testing to prevent property damage or personnel injury. If air or compressed gas testing is used, we will not be responsible for any resulting injury to personnel or damage to property, including the piping system. Air or compressed gas testing is done entirely at the discretion and risk of management at the job site.

For larger diameters, contact Fiber Glass Systems.

Pipe Diameter	**1"**	**1½"**	**2"**	**3"**	**4"**	**6"**	**8"**	**10"**	**12"**	**14"**
psig	**25**	**25**	**25**	**25**	**25**	**25**	**14**	**9**	**6**	**5**

System Start-Up: On any pressurized piping system, the initial start-up should be gradual to prevent excessive loads and pressure surges which may damage or weaken the piping.

One method is to slowly fill the system while bleeding off all air before starting any pumps or opening valves into pressurized piping. An alternate method is to start the centrifugal pump against a closed, adjacent valve; then slowly open the valve to gradually build up system pressure. The air should be bled off while the line is filling as in the first method.

For positive displacement pumps, consult Engineering for recommendations.

WATER HAMMER - AVOIDING PROBLEMS

Water hammer is a term generally used to describe situations where a pressure surge in the piping system causes violent movement of the system. Usually this pressure surge is caused by a sudden valve closing, electrical outage, pump failure, or some other out-of-the ordinary situation. The pressure surge is usually brief, but damage can be severe. In FRP piping, water hammer usually results in broken fittings due to pipe system movement caused by pressure. Insufficient system anchors, guides and supports allow excessive movement of the piping and creates fitting breaks.

If you suspect water hammer, consult with the project engineer as soon as possible to eliminate the problem. This may require installing slow operating valves, a pump bypass or surge protectors in the system.

More anchors, guides or supports may need to be added. If you can easily move the piping by pushing on it, changes in the pipe support arrangement to restrict movement probably need to be made.

Air in a system can also cause water hammer. Bleed air out of the piping prior to full pressure operation. Any pipe system which moves suddenly, creates a lot of noise, or generally seems unstable is a candidate for problems due to water hammer.

PART VI
SYSTEM REPAIR & MODIFICATION

Should a leak occur during pressure testing or start up of the piping system, the normal procedure to repair is to cut out a fitting or a damaged section of pipe and replace it with new material.

Determine the fluid that has been in the piping system before beginning repairs to avoid contact with chemicals.

Systems often require modification, added instrumentation, or new branches. Components are available to easily accomplish this.

Always use the same pipe grade, fittings, and adhesive on new parts as is in the existing system. Do not mix pipe grades. If you have questions about the chemical service, pipe grade selection, existing system operating conditions, or other matter, call your local Distributor or Regional Manager.

Notes:
1. Most leaks in a piping system are due to poor fabrication or improper installation (i.e., not properly anchored, guided or supported).
2. When making repairs, be sure all surfaces to be bonded are dry, clean and thoroughly sanded. Good adhesive connections cannot be made on wet or contaminated surfaces.

REPLACING DAMAGED PIPE

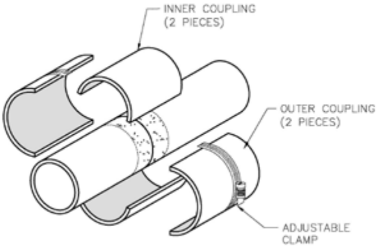
Pipe leaks through the pipe wall are usually the result of physical damage to the pipe from impact, vacuum, excessive bending, or other abusive conditions. The damaged section should always be replaced by using the following procedures:

Flanged Systems: If possible, replace the entire flanged length. Otherwise, cut out the damaged section and bond new flanges to the remaining pipe ends according to recommended procedures. Next, fabricate a new flange-by-flange spool to the length required. Bolt in the new pipe section.

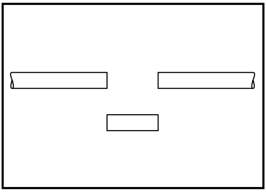
Flanged fittings should be removed from the system when damaged and replaced with a new fitting.
Attempt to find the cause of the damage and take corrective action. Solve the problem; don't just replace a part.

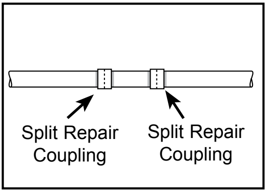
Socket/Bonded Systems: Cut out the section of pipe which leaks, making sure cuts are square. Dry the pipe ends. Cut a new length of pipe to the same length as that which was cut out. Use split repair couplings to adhesive bond the new pipe into place.

1. Before fabricating connection, all seepage or fluid at the joint area must be eliminated.
2. Sand the outer surface of the pipe thoroughly for a distance of at least 1" on either side of the anticipated contact area of the coupling, using 36 to 60 grit abrasive. Sand the inner and outer surface and mating edges of the inner two-piece coupling and sand the inner surface and mating edges of the outer two-piece coupling.
3. Brush away all the dust from the sanded areas taking care not to contaminate the sanded surfaces. Do not use a solvent wipe.
4. Slide the hose clamp over one of the pipe ends and out of the way of the joint area.
5. Mix the adhesive in accordance with the instructions provided with the adhesive kit.
6. Coat the inner and outer surfaces and mating edges of the inner coupling with a thin layer of adhesive and set aside.
7. Coat the inner surface and mating edges of the outer coupling with a thin layer of adhesive and set aside.
8. Coat the cut edges of the pipe with a thin layer of adhesive.
9. Coat the sanded outer surfaces of the mating pipe sections with a thin layer of adhesive.
10. Place the two-piece inner coupling on the pipe joint, centered over the butted pipe ends.
11. Place the two-piece outer coupling over the inner coupling with the seam rotated 90 degrees away from the seam of the inner coupling.



12. Place the hose clamp over the center of the outer coupling and tighten.
13. Remove the excessive adhesive.
14. Heat cure the adhesive in accordance with the instructions found in the adhesive kit.





Alternate Method: Use Flanges to install a new section of pipe. Cut out the damaged pipe length. Bond flanges to the remaining pipe ends using proper procedures. Fabricate a flange-by-flange spool to the required length and bolt into place.

REPLACING DAMAGED FITTINGS

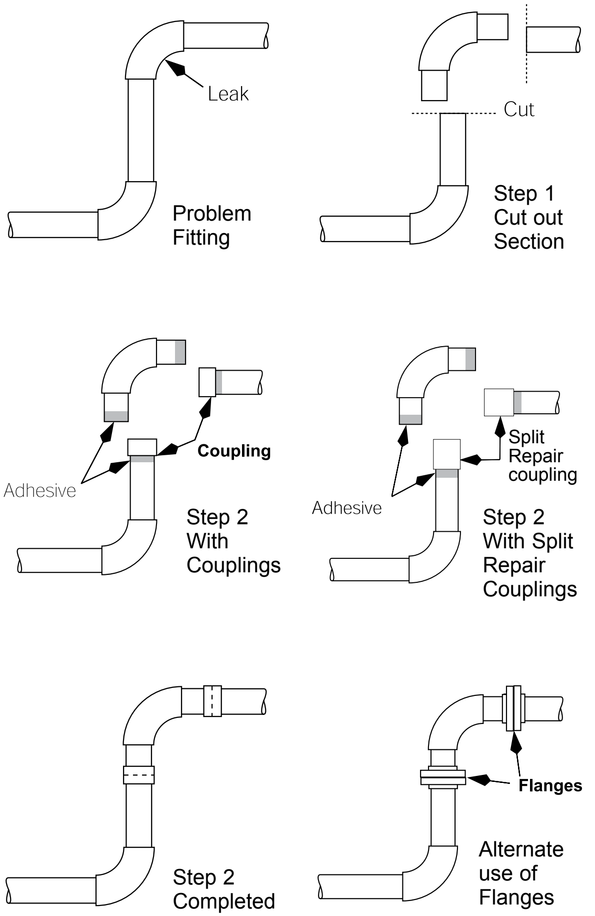
In socket adhesive systems which develop a leak in either a fitting or the socket joint area of a fitting, it will usually be necessary to cut out the leaking part and replace it.

When possible, anchors, guides and supports should be loosened and some movement allowed during fabrication. Use couplings to install new pipe stubs and the new required fitting. Where the system is very rigid, it may be necessary to use flanges to allow bolting in of the replacement part. Also, if fittings are close-coupled, a series of fittings may have to be removed and replaced. Certainly, this is not desired, and an alternate overwrap method might be considered; see page 58.

Procedures to be followed are:

1. Determine the best location to cut the pipe section which contains the leak. Leave enough pipe length to make socket joints per the recommended procedures.
2. Dry the system.
3. If you can move the pipe ends, use couplings to bond the new part into place. Otherwise, use split repair couplings, similar to the procedures below.

Alternate Method: If the piping arrangement does not allow the use of couplings, bond flanges to the pipe ends and bolt the replacement fitting or section into place.

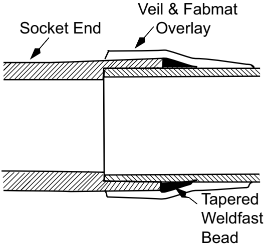


OVERWRAP

A leaking fitting, pipe or joint can be over wrapped with a resin and glass lay-up. This requires resin, catalyst, fiberglass reinforcement, tools, and a clean, dry work area. Many times an overwrap is the preferred method, particularly when fittings are in a close, complex manifold or assembly. Custom overwrap kits are available for each pipe size and pressure classification. Contact Fiber Glass Systems.

Application Procedure: Before making the over-wrap, read these instructions carefully.

1. Sand the surface area thoroughly for an equal distance on each side of the leak. The sanded surface should extent at least ½" beyond the widest layer of glass supplied with the kit. Remove all surface glazes, paint, oil, grease, scale, moisture, or other foreign material to ensure proper bonding of the resin material to the surface.
2. Use the applicator brush to remove all dust from the sanded area.
3. If repairing a socket joint, use the Weldfast adhesive supplied in the kit to form a tapered bead as shown in this sketch. The bead will provide a smooth transition from fitting to pipe.



4. Lay out the precut fabmat and surfacing veil on a flat, clean, dry surface (i.e., cardboard, plywood, etc.).
5. Add contents of Part "B" tube(s) to container of Part "A" (resin). Using one of the wooden stirrers, mix the contents thoroughly for at least one minute.
6. Use the applicator brush to apply a liberal, even coating of the resin mixture to the entire sanded surface.
7. Using the 3" roller, thoroughly saturate the fabmat laid out on your working surface. Apply wet-out fabmat to the joint to be overlaid placing the mat side down. Using the 3" roller, continue to roll out the material until all entrapped air has been rolled out and the fabmat is contoured smoothly to the surface.
8. For joint sizes 4" and larger, repeat step #7 above.
9. Place surfacing veil over the fabmat and, again using the 3" roller, apply a liberal amount of resin and work out all air as in step #7.

Be sure that the pipe surface is thoroughly wet out with catalyzed resin.

Some guidelines on the overwrap are:

1. The overwrap should be equally spaced on each side of the point of the leak.
2. The overwrap should be around the entire circumference of the pipe or fitting.
3. The pressure rating and pipe diameter will determine the overwrap thickness. Consult Fiber Glass Systems' Technical Services to determine specific information about design of the overwrap.
4. The resin system of the overwrap should be compatible with the resin system of the existing pipe or fittings.
5. Cure the overwrap completely before pressure testing.

TEMPORARY FIXES

Pipe Leaks: The use of a conventional metal pipe clamp is a good method for containing a small leak.

Socket Leaks: Materials are available in the marketplace for making "ace bandage" types of over wraps.

Fitting Leaks: A pinhole type leak can sometimes be stopped by applying a thickness of adhesive over a dry, sanded area.

Caution: If hazardous materials or high pressures are present, replace the damaged pipe or fitting at once. Do not try a temporary repair. Make a permanent repair as soon as possible.

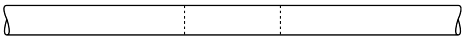
TAPPING INTO A LINE

The two most common methods for adding a branch or tapping into an existing line are the use of a tee or saddle. Saddles are often rated for lower pressure than the pipe; check the rating of the system versus the saddle. Consult Fittings & Accessories Bulletins.

Generally, the use of flanges to install a new tee is preferred.

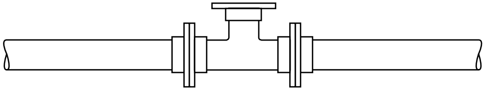
Installing a Flanged Tee:

1. Cut the pipe, leaving enough pipe to bond flanges onto the existing pipe ends.



2. Using recommended procedures, and with the system dry, bond flanges to the existing pipe ends. Be sure your measurements are exact for the new fitting to fit correctly. Cure the adhesive.

3. Install the new tee.

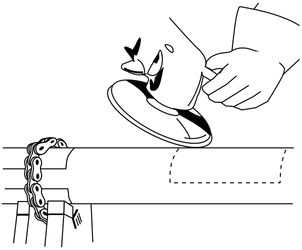


The procedure for installing an adhesive socket tee will be the same as for replacing a damaged socket fitting (see page 53).

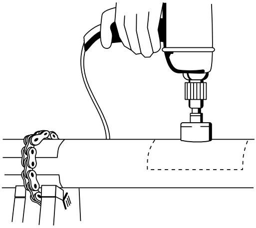
Saddles: Bonding a Saddle onto pipe is similar to making a regular adhesive socket joint. The preferred method is:

1. Lay out the required dimensions. Mark the area to be sanded by positioning the saddle on the pipe and marking the pipe.

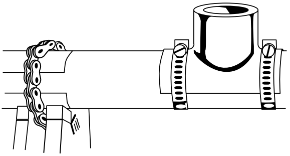
2. Sand the entire area where the saddle will bond to the pipe. A power sander or die grinder will save time. Refer to page 24 procedures concerning pipe and fitting preparation. Also, sand the bonding surface of the saddle.



3. Locate the center of the branch hole.
   a. Saddle with a cement socket outlet (1"-14"). Cut a hole the same size as the saddle outlet using a hole saw with pilot drill. Do not force the cutting tool as this will make a rough hole.



   b. Saddles with an IP thread outlet (¼"-1"). Prepare the surface as above. Install the saddle prior to drilling the hole. After saddle connection has cured, place a thin metal sleeve in the outlet to protect the threads, drill out the opening and coat the cut edges with adhesive. This eliminates clogging the smaller outlets with the adhesive when the saddle is pressed into position.



4. Generous amounts of adhesive must be applied to the pipe and the underside of the saddle; coat the cut edges of the hole in the pipe. Press the saddle over the hole and press into place. Use two hose clamps to tightly band the saddle onto the pipe.
5. Tighten the clamps so that the adhesive is squeezed out around the saddle. Dress the edges and clean the squeezed adhesive out of the branch as best as you can.
6. Cure the fabrication per the adhesive recommendations. The clamps can either be removed or remain on after the cure is completed.
7. Pipe or fittings in the branch run can now be fabricated.

PART VII
HELPFUL INFORMATION
CONVERSIONS

Centigrade	Fahrenheit	Centigrade	Fahrenheit
-200	-328.0	24	75.2
-100	-148.0	25	77.0
-90	-130.0	26	78.8
-80	-112.0	27	80.6
-70	-94.0	28	82.4
-60	-76.0	29	84.2
-50	-58.0	30	86.0
-40	-40.0	31	87.8
-30	-22.0	32	89.6
-20	-4.0	33	91.4
-10	14.0	34	93.2
0	32.0	35	95.0
1	33.8	36	96.8
2	35.6	37	98.6
3	37.4	38	100.4
4	39.2	39	102.2
5	41.0	40	104.0
6	42.8	41	105.8
7	44.6	42	107.6
8	46.4	43	109.4
9	48.2	44	111.2
10	50.0	45	113.0
11	51.8	46	114.8
12	53.6	47	116.6
13	55.4	48	118.4
14	57.2	49	120.2
15	59.0	50	122.0
16	60.8	51	123.8
17	62.6	52	125.6
18	64.4	53	127.4
19	66.2	54	129.2
20	68.0	55	131.0
21	69.8	56	132.8
22	71.6	57	134.6
23	73.4	58	136.4

Centigrade	Fahrenheit	Centigrade	Fahrenheit
59	138.2	94	201.2
60	140.0	95	203.0
61	141.8	96	204.8
62	143.6	97	206.6
63	145.4	98	208.4
64	147.2	99	210.2
65	149.0	100	212.0
66	150.8	110	230
67	152.6	120	248
68	154.4	130	266
69	156.2	140	284
70	158.0	150	302
71	159.8	160	320
72	161.6	170	338
73	163.4	180	356
74	165.2	190	374
75	167.0	200	392
76	168.8	210	410
77	170.6	212	414
78	172.4	220	428
79	174.2	230	446
80	176.0	240	464
81	177.8	250	482
82	179.6	260	500
83	181.4	270	518
84	183.2	280	536
85	185.0	290	554
86	186.8	300	572
87	188.6	310	590
88	190.4	320	608
89	192.2	330	626
90	194.0	340	644
91	195.8	350	662
92	197.6		
93	199.4		

CONVERSIONS, Cont'd

	Metric Units	U.S. Equivalents
Lengths	1 millimeter	0.03937 inch
	1 centimeter	0.3937 inch
	1 meter	39.37 inches or 1.094 yards
	1 kilometer	1093.61 yards or 0.6214 mile
Areas	1 square millimeter	0.00155 square inch
	1 square centimeter	0.155 square inch
	1 square meter	10.764 square feet or 1.196 sq. yards
	1 square kilometer	0.3861 square mile
Volumes	1 cubic millimeter	0.000061 cubic inch
	1 cubic centimeter	0.061 cubic inch
	1 liter	61.025 cubic inches
	1 cubic meter	35.314 cubic feet or 1.3079 cubic yards
Capacities	1 milliliter (0.001 liter)	0.0338 U.S. fluid ounce
	1 liter	2.1134 U.S. liquid pints
	1 liter	1.0567 U.S. liquid quarts
	1 liter	0.2642 U.S. gallon
Weights	1 gram	0.03527 avoir. ounce or 15.4324 grains
	1 kilogram(1000 grams)	2.2046 avoir. pounds

	U.S. System Units	Metric Equivalents
Lengths	1 inch	25.4 millimeters or 2.54 centimeters
	1 foot	0.3048 meter
	1 yard	0.9144 meter
	1 mile	1.6093 kilometers
Areas	1 square inch	645.16 square millimeters or 6.452 square centimeters
	1 square foot	0.0929 square meter
	1 square yard	0.8361 square meter
	1 square mile	2.59 square kilometers
Volumes	1 cubic inch	16,387.2 cubic millimeters or 16.3872 cubic centimeters
	1 cubic foot	0.02832 cubic meter
	1 cubic yard	0.7646 cubic meter
Capacities	1 U.S. fluid ounce	29.573 milliliters
	1 U.S. liquid pint	0.47317 liter
	1 U.S. liquid quart	0.94633 liter
	1 U.S. gallon	3.78533 liters
Weights	1 grain	0.0648 gram
	1 avoir. ounce	28.35 grams
	1 avoir. pound	0.4536 kilogram
	1 Troy ounce	31.1035 grams

DECIMAL EQUIVALENTS OF FRACTIONS

Inches	Decimal of an Inch	Inches	Decimal of an Inch
1/64	.015625	29/64	.453125
1/32	.03125	15/32	.46875
3/64	.046875	31/64	.484375
1/20	.05	1/2	.5
1/16	.0625	33/64	.515625
1/13	.0769	17/32	.53125
5/64	.078125	35/64	.546875
1/12	.0833	9/16	.5625
1/11	.0909	37/64	.578125
3/32	.09375	19/32	.59375
1/10	.10	39/64	.609375
7/64	.109375	5/8	.625
1/9	.111	41/64	.640625
1/8	.125	21/32	.65625
9/64	.140625	43/64	.671875
1/7	.1429	11/16	.6875
5/32	.15625	45/64	.703125
1/6	.1667	23/32	.71875
11/64	.171875	47/64	.734375
3/16	.1875	3/4	.75
1/5	.2	49/64	.765625
13/64	.203125	25/32	.78125
7/32	.21875	51/64	.796875
15/64	.234375	13/16	.8125
1/4	.25	53/64	.828125
17/64	.265625	27/32	.84375
9/32	.28125	55/64	.859375
19/64	.296875	7/8	.875
5/16	.3125	57/64	.890625
21/64	.328125	29/32	.90625
1/3	.333	59/64	.921875
11/32	.34375	15/16	.9375
23/64	.359375	61/64	.953125
3/8	.375	31/32	.96875
25/64	.390625	63/64	.984375
13/32	.40625	1	1.0
7/16	.4375		

CONVERSION CONSTANTS

To Change:	To:	Multiply By:
Inches	Feet	0.0833
Inches	Millimeters	25.4
Feet	Inches	12
Feet	Yards	0.3333
Yards	Feet	3
Square Inches	Square feet	0.00694
Square feet	Square inches	144
Square feet	Square yards	0.11111
Square yards	Square feet	9
Cubic inches	Cubic feet	0.00058
Cubic feet	Cubic inches	1728
Cubic feet	Cubic yards	0.03703
Cubic yards	Cubic feet	27
Cubic inches	Gallon	0.00433
Cubic feet	Gallons	7.48
Gallons	Cubic inches	231
Gallons	Cubic feet	0.1337
Gallons	Pounds of water	8.33
Pounds of water	Gallons	0.12004
Ounces	Pounds	0.0625
Pounds	Ounces	16
Inches of water	Pounds per square inch	0.0361
Inches of water	Inches of mercury	0.0735
Inches of water	Ounces per square inch	0.578
Inches of water	Pounds per square foot	5.2
Inches of mercury	Inches of water	13.6
Inches of mercury	Feet of water	1.1333
Inches of mercury	Pounds per square inch	0.4914
Ounces per square inch	Inches of mercury	0.127
Ounces per square inch	Inches of water	1.733
Pounds per square inch	Inches of water	27.72
Pounds per square inch	Feet of water	2.310
Pounds per square inch	Inches of mercury	2.04
Pounds per square inch	Atmospheres	0.0681
Feet of water	Pounds per square inch	0.434
Feet of water	Pounds per square foot	62.5
Feet of water	Inches of mercury	0.8824
Atmospheres	Pounds per square inch	14.696
Atmospheres	Inches of mercury	29.92
Atmospheres	Feet of water	34
Long tons	Pounds	2240
Short tons	Pounds	2000
Short tons	Long tons	0.89285

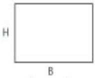
FEET HEAD OF WATER TO PSI

Feet Head	Pounds Per Square Inch	Feet Head	Pounds Per Square Inch
1	.43	100	43.31
2	.87	110	47.64
3	1.30	120	51.97
4	1.73	130	56.30
5	2.17	140	60.63
6	2.60	150	64.96
7	3.03	160	69.29
8	3.46	170	73.63
9	3.90	180	77.96
10	4.33	200	86.62
15	6.50	250	108.27
20	8.66	300	129.93
25	10.83	350	151.58
30	12.99	400	173.24
40	17.32	500	216.55
50	21.65	600	259.85
60	25.99	700	303.16
70	30.32	800	346.47
80	34.65	900	389.78
90	38.98	1000	433.00

Note: One foot of water at 62°F equals .433 pound pressure per square inch. To find the pressure per square inch for any feet head not given in the table above, multiply the feet head by .433.

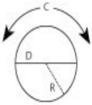
USEFUL FORMULAS

Geometric Properties: A = Area; A1 = Surface area of solids; V = Volume; C = Circumference



Rectangle

$A = HB$

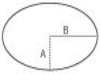


Circle

$A = \pi R^2$

$C = \pi D$

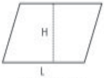
$R = D / 2$



Ellipse

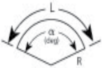
$A = \pi AB$

$C = 2\pi\sqrt{\frac{A^2 + B^2}{2}}$



Parallelogram

$A = HL$



Sector of Circle

$A = \pi R^2 \frac{\alpha}{360}$

$L = \pi R \frac{\alpha}{180}$

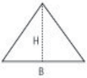
$\alpha = 57.296 \frac{L}{R}$

$R = 57.296 \frac{L}{\alpha}$

Sphere

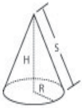
$A = 4\pi R^2$

$V = \frac{4\pi R^3}{3}$



Triangle

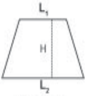
$A = \frac{BH}{2}$



Cone

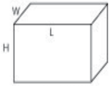
$A = \pi R(S + R)$

$V = \frac{\pi}{3} R^2 H$



Trapezoid

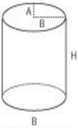
$A = H \frac{L_1 + L_2}{2}$



Rectanglular Solid

$A1 = 2\ (WL + LH + HW)$

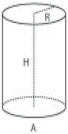
$V = WLH$



Elliptical Tanks

$A1 = 2\pi\left(AB + H\sqrt{\frac{A^2 + B^2}{2}}\right)$

$V = \pi ABH$



Cylinder

$A1 = 2\pi R(H + R)$

$V = \pi HR^2$

For Above Containers:

Capacity in gallons = $\frac{V}{231}$ when V is in cubic inches   Capacity in gallons = 7.48 x V when V is in cubic feet

DEFINITION OF TERMS

ACCELERATOR - Any of a number of chemicals added to the resin, singly or in combination, which speed the hardening process or cause the hardening to occur (hardener, catalyst, curing agent, promoter).

ADAPTER - A fitting used to join two pieces of pipe, or two fittings, which have different joining systems.

ADHESIVE - A material formulated to bond together pipe and fittings resulting in high strength and corrosion resistant fabrications.

BELL AND SPIGOT - A joining system in which two truncated conical surfaces come together and bond adhesively. The bell is the female end. The spigot is the male end.

BUSHING - A fitting used to join two different sizes of pipe by reducing the size of the female end of the joint. Joints may come threaded or tapered.

CATALYST - See hardener.

CENTRIFUGAL CASTING - A process for making pipe in which the resin, fiberglass reinforcement and other ingredients are placed into the interior of a spinning steel rotary mold, forming the pipe through centrifugal force and the application of heat.

COLLAR - See coupling.

COMPRESSION MOLDING - A process for making fittings in which a molding compound is formed and cured into the finished part configuration through pressure and heat in a die.

COMPRESSIVE FORCE - The force that occurs when opposing loads act on a material, crushing, or attempting to crush it. In pipe, circumferential compressive forces result from external collapse pressure, or heating of an end-restrained fiberglass pipe.

CONCENTRIC REDUCER - A pipe fitting used to join two different sizes of pipe while maintaining the same center line in both.

CONTACT MOLDING - A process for making fittings in which cut pieces of fiberglass reinforcement are laid on a mold, saturated with resin, and cured to the finished part shape.

COUPLING (collar) - A short heavy wall cylindrical fitting used to join two pieces of the same size pipe in a straight line. The coupling always has female connection ends which can be bell, threaded or a mechanical joining method.

CURE - The hardening of a thermoset resin system by the action of heat or chemical action.

CURE STAGES - Stages describe the degree to which a thermoset resin has crosslinked. Three stages, in order of increasing cross linking, include B-stage, gelled, fully cured.

CURE TIME - The time required for a thermoset material to react and develop full strength and material properties. The time is dependent upon the temperature of the material.

CURING AGENT - See hardener.

CUT AND MITERED FITTINGS - Fittings manufactured by cutting, assembling and bonding pipe sections into a desired configuration. The assembled product is then over wrapped with resin-impregnated roving or glass cloth, to provide added strength.

EPOXY RESIN - A thermosetting resin, usually made from Bisphenol A and epichlorhydrin, cured by a variety of agents such as anhydrides and amines. These resins contain cyclic ether groups. See thermoset.

FRP - Fiberglass Reinforced Plastic.

FABMAT - A combination of woven roving and chopped strand mat held together with resin binders. Usually used for making contact molded fittings and butt weld joints.

FILAMENT WOUND - A manufacturing method for pipe and fittings in which resin impregnated continuous strand roving wraps around a mandrel to achieve high reinforcement concentration and precise filament placement.

FILLERS (extender, pigments, inerts; i.e., sand, etc.) -

Materials added to a resin which do not affect the cure of the resin but may influence the physical properties of the resin system.

FITTING TYPES – The classification of fittings by the method of manufacture; i.e., molded, cut and mitered, filament wound, contact molded.

GEL TIME – The time it takes for a resin system to harden to a rubber-like state.

HAND LAY-UP – Any number of methods of forming resin and fiberglass into finished pipe products by manual procedures. Hand lay-up products do not usually exhibit optimum strength of the reinforcing material since the fibers do not lie oriented for maximum performance. These procedures include overwrap techniques, contact molding, hand molding and others.

HARDENER (accelerator, catalyst, curing agent, promoter) –

Any of a number of chemicals added to the resin, single or in combination, which speed up the hardening process, or cause hardening to occur.

HEAT BLANKET or HEAT COLLAR – An electrical device used to heat a fabrication to reduce cure time.

HYDROSTATIC TEST – A pressure test of the completed fabrication to confirm good quality. Typically, the system is filled with water and held at the selected pressure while checking for leaks.

IMPACT RESISTANCE – The ability of a part to absorb a striking blow without damage.

JOINING (connecting systems) – Any of a variety of methods for connecting two separate components of a piping system together. Included are bell and spigot, threaded and coupled, mechanical devices, etc.

JOINT – A term used to describe an individual length of pipe or the actual joining mechanism; (i.e., adhesive bonded bell and spigot, threaded and coupled, etc.)

LINER – A generic term used to describe the interior surface in pipe. Generally, liners are resin-rich regions from 0.005 to 0.100 in. thick. Liners may be reinforced with fibrous material such as veil or mat. Liners can provide extra corrosion protection for severe chemical service. They also form a leak barrier (elastomer bladder). The manufacturer may add a liner before, during, or after construction of the pipe wall depending on the manufacturing process.

MATRIX - The material used to bind reinforcement and fillers together. This material may be thermoplastic or thermosetting and dictates to a large extent the temperature and chemical service conditions allowable for a pipe or fitting.

MOLDED FITTINGS - Pipe fittings formed of compressing resin, chopped fiber and other ingredients in a mold under heat and pressure.

MOLDING - Any of several manufacturing methods where pressure or compression molding shapes resin and reinforcing materials into final products.

OVER WRAP - A method of repair or joining in which fiberglass reinforcement and resin are fabricated over the selected area.

POLYESTER RESIN - Any of a large family of resins which are normally cured by cross linking with styrene. The physical and chemical properties of polyester resins vary greatly. Some have excellent chemical and physical properties while others do not. Vinyl esters are a specific type of polyester resin. Other polyester resins with properties suitable for use in the manufacture of fiberglass pipe include: isophthalic Bisphenol A fumarate and HET acid polyesters. Each type of resin has particular strengths and weaknesses for a given piping application.

POT LIFE - The time available to use thermoset adhesives after the reactive materials have been mixed.

PRESSURE RATING - The maximum anticipated long-term operating pressure a manufacturer recommends for a given product. Also referred to as working pressure, class or design pressure.

PROMOTER - See hardener.

REINFORCEMENT - Typically, fibers of glass, carbon or synthetic material used to provide strength and stiffness to a composite material. The type of fiber used as reinforcement play a major role in determining the properties of a composite, as does the fiber diameter and the type of sizing used. Terms relating to the physical form of the reinforcement include:

> **Chopped Fiber** - Continuous fibers cut into short (0.125 to 2 in.) lengths.
>
> **Filament** - A single fiber of glass; e.g., a mono filament.
>
> **Mats** - Coarse fabric sheets made from chopped strands randomly placed and held together by resin binders.
>
> **Milled Fibers** - Glass fibers, ground or milled, into short (0.032 to 0.125 in.) lengths.
>
> **Roving** - A collection of one or more strands wound into a cylindrical package. The typical form of glass fiber used in the manufacture of filament wound pipe.
>
> **Veil** - Surfacing mat of porous fabric made from filaments. Used to provide a resin rich layer or liner.
>
> **Yarn** - Glass fiber filaments twisted together to form textile-type fibers.
>
> **Yield** - The number of yards of material made from one pound of the product.
>
> **Resin (polymer)** - As applied to fiberglass pipe, resin is the polymer or plastic material used to bind the glass fibers together.

RESIN - The polymer (liquid plastic) material which hardens with cure to provide a solid form, holding the fiberglass reinforcement in place. Resins provide the corrosion resistance in FRP parts.

SADDLE - A fitting which is bonded to the exterior of a pipe to make a branch connection.

SHELF LIFE - The storage time for a material until it becomes unusable.

SOCKET JOINT - A joining system in which two straight cylindrical surfaces come together and bond adhesively.

STRESS - The force per unit of cross sectional area. Measured in pounds per square inch (psi). This should not be confused with hydraulic pressures, measured as psig or psia, which can induce stress.

SUPPORT SPACING (span) - The recommended maximum distance between pipe supports to prevent excessive pipe deformation (bending).

SURGE PRESSURE - A transient pressure increase due to rapid changes in the momentum of flowing fluids. Water hammer is one type of surge pressure. Rapid opening or closing of valves often result in a surge pressure or water hammer.

THERMAL CONDUCTIVITY - The rate at which a material (pipe) transmits heat from an area of high temperature to an area of lower temperature. Fiberglass pipe has low thermal conductivity.

THERMAL EXPANSION - The increase in dimensions of a material (pipe) resulting from an increase in temperature. A decrease in temperature results in thermal contraction.

THERMOSET - A polymeric resin cured by heat or chemical additives. Once cured, a thermoset resin becomes essentially infusible, (cannot be re-melted) and insoluble. Thermosetting resins used in pipe generally incorporate reinforcements. Typical thermosets include:

- Vinyl esters
- Novolac or epoxy Novolac
- Epoxies
- Unsaturated polyesters

THRUST FORCES - Commonly used to describe the forces resultant from changes in direction of a moving column of fluid. Also used to describe the axial or longitudinal end loads at fittings, valves, etc., resultant from hydraulic pressure.

TORQUE - Used to quantify a twisting force (torsion) in pipe. Torque is measured as a force times the distance from the force to the axis of rotation. Torque is expressed in foot-pounds (ft-lb) or inch-pounds (in-lb).

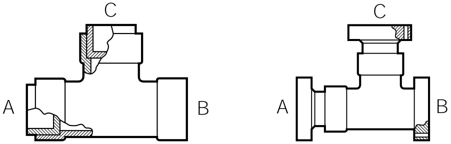
TWO HOLING - A method of aligning flanges onto pipe or fittings so that the bolt circle will mate with the adjoining flange.

VINYL ESTER - A premium resin system with excellent corrosion resistance. Vinyl ester exhibits high versatility, temperature resistance and excellent corrosion resistance to acids.

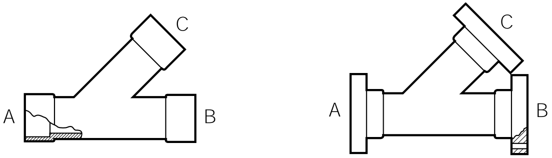
WATER HAMMER - Pressure surges in a piping system caused by sudden operation of a valve, pump, or other component.

HOW TO READ FLANGED OR REDUCING FITTINGS

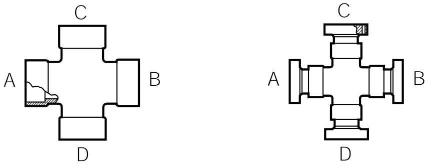
TEE



Run x Run x Branch (AxBxC)



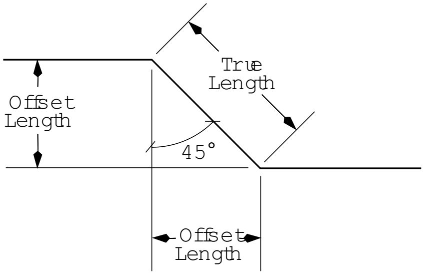
LATERAL (AxBxC)
Run x Run x Branch



CROSS (AxBxCxD)
Run x Run x Branch X Branch

The above sequence should be used when describing fitting outlets. Drawings or sketches showing outlet types, locations, sizes and dimensional requirements are required for more complicated fitting configurations.

HOW TO FIGURE A 45° OFFSET



True Length = offset x 1.414
Offset = true length x .707

EXAMPLES:
offset = 12"
12" x 1.414 = 16.968 = 1'-5"
true length = 1'-5"
(to nearest 1⁄16")
true length = 24"
24 x .707 = 16.968 = 1'-5"
offset length = 1'-5"
(to nearest 1⁄16")

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NOV Fiber Glass Systems

INS1010ENG July 2015

30”-42” Diameter Tapered Bell & Spigot Installation Instructions

Introduction

Installation instructions for adhesive bonded 30”-42” diameter Tapered Bell & Spigot joints. Installation training and certification is required for all bonders. Qualified on-site supervision of initial installation is recommended to ensure proper field practices are followed.

Field Checks

- Piping components should be visually inspected for physical damage

Bonding Environment

Hot Weather Recommendations

- A cool area is recommended for long-term storage of adhesive kits. Storage temperatures between 70-80°F (21-27° C) are ideal.
- When field temperatures exceed 90°F (32°C), store adhesive kits in ice chest with bagged ice or freezer pack. Remove adhesive kits just prior to use.
- Protect joints from direct sunlight to minimize heating of material and ultraviolet exposure.

Cold Weather Recommendations

- A warm area is recommended for long-term storage of adhesive kits. Storage temperatures between 70-80°F (21-27°C) are ideal.
- When the field temperature falls below 70°F (21°C), warm bond surfaces with a propane torch or another clean burning heat source. The surfaces should be warm to the touch but not hot. If the bond surface is too hot when adhesive is applied, it will set up prematurely. A bonder should be able to comfortably place the back of their hand on the bond surface. A torch should be used only to warm the bonding surface, not to force cure an adhesive joint.
- All bonded joints must be heat cured with electric heating collars.
- Freshly bonded joints should be heat cured when field temperatures are expected to fall rapidly. Heat curing reduces the cure time and the chances of pipeline contraction pulling the joint apart.
- **Note:** When temperatures fall below 32°F (0°C), it is recommended that all joints (when possible) be made in a portable, heated work space. The use of a portable kerosene heater (torpedo style) is also recommended during extreme cold weather to help maintain ambient temperature inside the pipe.

Joint Preparation & Assembly

Bonding surfaces require light sanding with 40-80 grit paper or Emery cloth within two hours before adhesive application. Mix the adhesive in accordance with the applicable adhesive bulletin. The adhesive must be brushed on with mild pressure onto the bell & spigot bonding surfaces to ensure a thorough wetting.

The adhesive layer on the leading edge of the spigot should be slightly thicker than the other areas. Apply a thin coat of adhesive to the spigot end to coat exposed glass fibers.

During cool weather (below 70°F (21°C), both the adhesive and bond surfaces should be warmed to improve the spread ability of the adhesive. Once warmed both surfaces will cool rapidly.

As the adhesive cools it will become thicker; therefore, it should be applied quickly using two installers per bell and two installers per spigot.

The working area around the joint may need to be covered to protect from sunlight, precipitation, wind and frigid weather. The weight of the pipe requires the use of a side boom tractor, crane or large excavator to move the pipe.

Insertion Depth Reference Marks

- Using a permanent marker, draw on the pipe a set of reference marks 24 inches from the spigot end of the pipe.
- The reference marks are positions used to determine the insertion depth of an assembled joint. During joint assembly the distance from the bell end to the reference marks should be measured and recorded in a quality record when possible.

Joint Installation

A pipe joint is made by lifting the pipe and carefully inserting the spigot into the bell until the spigot is seated in the bell. The joint should then be checked for proper alignment meaning the joint should be straight. If the joint is not aligned, the pipe must be maneuvered as required to align the pipe joint. A hydraulic come-along is required to complete the joint make-up. Attach the hydraulic come-alongs as instructed in the Come-Along Instructions.

The joint is pulled into final position by simultaneously pumping the two come-along hydraulic cylinders. The cylinder pressures should be increased slowly to the pressures listed in manual TLS6619 (come alongs)while vibrating the joints. The joint should be vibrated by two installers impacting the sides of the bell with 5 lb. dead blow hammers. The vibrating should continue after come-along’s pressure has been reached. The vibrations and come-along’s loads will cause the joint to pull together until made up. The cylinder pressure should not exceed 5,000 psig at any time.

As the joint pulls together, the hydraulic cylinder pressure will tend to drop during the process requiring additional strokes on the hydraulic pump to maintain the come-along’s pressure. The joint will be made up when the pressure drop becomes negligible (300 psi or less with three sharp blows of the dead blow hammer) and it is obvious the joint is no longer moving together. This can be confirmed by repeatedly measuring the distance from the face of the bell to the reference mark on the pipe spigot and comparing to previous measurements. Verify the hydraulic cylinders have not bottomed out giving the illusion of a made-up joint. The final insertion depth should be recorded for the quality records.

Excessive adhesive squeezed out of tapered joints, both on the I.D. and the O.D., should be removed. An electric heating collar is required and may be applied to the bell surface immediately. Leave the come-alongs in place for one hour.

These instructions apply to integral bell/spigot pipe, coupling/spigot pipe and fitting/spigot pipe joints.

Flange Installation

A flange pull-beam must be constructed to attach the come-along chains and pull the flange onto the pipe spigot. A steel channel 6 x 13 and 54 inches in length should be fabricated with two holes each large enough for a come-along chain to fit through. Locate the holes to clear the outer diameter of the flange by a minimum of ½".

Start by verifying the bell and spigot tapers are in spec using the factory gauges. Proceed by drawing a reference mark on the pipe with a permanent marker 18 inches from the end of the pipe spigot. Prepare the pipe spigot and flange bonding surfaces and then mix the adhesive. Pre-warm joints if necessary and apply adhesive to bell and spigot. Adhesive application methods are detailed above.

Lift and position the flange onto the spigot until it seats. Verify alignment of the flange onto the spigot. If properly aligned, then measure the distance from the face of the flange to the reference mark on the pipe spigot and record as the initial insertion depth.

Attach the hydraulic come-along collars to the pipe and connect the hydraulic cylinders, per the instruction for come-alongs to the collars and the pull-beam. Place two 4 x 4 or larger hardwood timbers between the pull-beam and the face of the flange. The timbers must be located outside the inner diameter of the flange to prevent interference with the spigot should it protrude beyond the face of the flange. The timbers should be smooth to protect the flange face from damage. The use of a 1/4" thick rubber pad between the flange and the timbers is recommended.

Increase the come-along pressure slowly to the pressures recomended in TLS6619 (come alongs) while vibrating the flange. The sides of the flange should be vibrated by two installers impacting the side of the flange with 5 lb. dead blow hammers. The come-along pressure will tend to drop during this process requiring additional strokes on the hydraulic pump to maintain come along pressure. The joint will be made up when the pressure drop becomes negligible (300 psi or less with three sharp blows of the dead blow hammer) and it is obvious the joint is no longer moving together. This can be confirmed by repeatedly measuring the distance from the face of the flange to the reference mark on the pipe spigot and comparing to previous measurements. Verify the hydraulic cylinders have not bottomed out giving the illusion of a made-up joint. The final insertion should be recorded for the quality records.

Any adhesive on the pipe surface behind the flange joint must be removed to allow the Van Stone bolt ring to seat flush against the flange.

During installation the pipe spigot may protrude beyond the face of the flange. Any spigot protrusion must be machined flush with the flange face by cutting or grinding. Should the spigot not protrude any squeezed out adhesive at the end of the spigot should be formed into a fillet.

Use standard bolt tightening sequence for 30"-42" flanges. (Refer to Matched Taper Joint Installation.) Maximum bolt torque is 400 ft-lbs.

Adhesive Cure

Electric Heat Collar Use

All bonded joints must be heat cured. Ensure the electric heating collars are in good working order prior to using. It is good practice to verify they are functioning properly at the end of each cure cycle.

Wrap heat collars over the surface of joint covering entire bonded area. Cure flanges from inside the pipe by turning the heat collar inside out. A narrow split ring of fiberglass pipe may be used to hold the heat collar in place against the inner surface of the pipe.

When ambient temperatures fall below 50°F (10°C) heat collars should be insulated for better heating efficiency. A 2-inch thick glass wool blanket or other insulating material with an R value of 7 or greater is recommended. The open ends of pipe and fittings should be blocked to prevent heat loss due to air flow.

On some fittings and pipe joints, the heating collar may overlap. When this occurs, place a cut section of 2" FRP pipe between the two heat collar layers that are overlapped and place a special cut section of 1/16" thick silicone rubber between the pipe and the heating collar. This will help prevent discoloration of the pipe.

When heat collars left on too long or the overlaps are not protected, some discoloration may occur. In most cases this will not affect the operation of the pipe. If unsure, contact the NOV Fiber Glass Systems personnel on site.

Pressure Testing

Contact NOV Fiber Glass Systems for recommendations concerning field hydro pressure tests. The test procedure must be reviewed and accepted by the pertinent site personnel prior to hydro pressure tests.

Supporting Documents	Description
ADH4000	Adhesive Systems Summary
TLS6619	18"-42" Come-Along Instructions
TLS6636	30"-42" Tapering Tool Instructions
TLS6640	1"-42" Heat Collar Instructions

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NOV Fiber Glass Systems

INS1020 June 2015

CERAM CORE®PIPING

Installation Data

Handling

The abrasion resistant liner may be damaged by severe impact or pipe deformation. Abusive handling can cause fracture and loss of some of the liner. Fine cracks in the liner will cause no problems, but if the liner is so severely damaged as to flake away chips and pieces, the overwrap will be exposed to abrasion and pipe will fail prematurely.

Caution:

1. Do not throw pipe from trucks onto rocks, into ditches or subject it to similar rough treatment.
2. Avoid striking the pipe. Any blow which causes a delamination of the overwrap will damage the liner.
3. A NOV Fiber Glass Systems representative should inspect the pipe before installation if there is any suspected damage.
4. Avoid striking end of pipe against objects which may damage liner, and keep flange protectors in place until ready to install.

Installation

Joining Methods

CERAM CORE pipe is joined by a self-aligning flange joint. The pipe is fabricated with flanges on both ends. An O-ring and an alignment ring, which are supplied by NOV Fiber Glass Systems, are required for matching the flange. When properly installed and compressed there will be a very minimal gap between the ends of the liner of adjacent pipe. See Table II for recommended bolt torque. Particular attention must be given to accurately align pipe bores at all joints. The rate of wear of the reinforcing overwrap vs. that of the ceramic bead liner is on the magnitude of 1000:1. Severe misalignment which will expose the overwrap to the abrasive material will cause an undercutting of the liner and early pipe failure. Misalignment should not exceed ½” bead diameter for optimum service (approximately $^{1}/_{32}$”). Transition fittings are necessary to join the pipe to systems with different inside diameters. (See the following section for details). If it is not possible to perfectly align pipe, such as when adapting to existing lines, it is preferable that the downstream side of the joint be oversized to avoid impact on a cut edge of the liner. In no case should the overwrap be exposed.

Fittings

CERAM CORE fittings are flanged with a radius sweep of three times diameter. Standard fittings available are 45° and 90° elbows, except on 14” and 16” diameters where 45° elbows only are available as standard.

Connecting to Other Systems

CERAM CORE pipe can be installed to new or existing systems by two methods:

Transition Fittings

When joining to materials other than **CERAM CORE** pipe or fittings, it is extremely important that the inside diameter of pipe-to-pipe and pipe-to-fitting match. Mismatched I.D.’s can cause the liner to be undercut and “scooped” away, causing premature failure. If the I.D. of the existing line or fitting at the point of entry into **CERAM CORE** is ±.050” (or more) larger or smaller than the I.D. of the pipe, a special adapter must be used to assure a smooth transition. Transition fittings for adapting to new or existing lines or other openings are considered essential and will be designed as needed for each installation upon receipt of the necessary dimensional information from the customer. A minimum of two transition fittings generally will be required on each installation.

When installing transition fittings it is recommended that the inside diameter of the transition fittings be aligned to the inside diameter of the existing system before the spool is connected to the transition fitting. Since transition fittings are usually one foot long, this procedure can be accomplished by sight. Also, make sure that there are no gaps between the existing system and the transition fittings which could cause undercutting.

Flanges

Flanges have standard ANSI B16.5 150 lb. flange bolt hole dimensions. Flange seals should be 60-70 durometer O-rings when joining pipe to pipe. Use a stiff grease to hold the O-ring in the groove when assembling the flanged joints. $^{1}/_{8}$” thick full face gaskets or half size O-rings should be used when joining pipe to other equipment. (See Table II.) When the piping system is being connected to another type of system (flange is flush), the inside diameter of the gasket should be such as to match the inside diameter of the pipe when the flange bolts are tightened. The bore of the pipe piece MUST be aligned as concentric as possible with the bore of the system to which it is being connected. If there are irregularities or “scooped away” places due to previous wear, these should be grouted with CeramSurf™ surfacing material (available from NOV Fiber Glass Systems).

Field Preparation

Special Equipment

Under normal circumstances, field preparations consist of having the proper torque wrenches, bolts, nuts, and washers. NOV Fiber Glass Systems normally manufactures all pipe sections to the desired length so the installer need only assemble flanged joints. The close tolerances necessary to maintain proper joint alignment are difficult to reproduce in field cut joints. For this reason field bonded joints should be eliminated or kept to a minimum. Special diamond blades and a large lathe or special NOV Fiber Glass Systems tools are required for the field installation of flanges. The following sections give a brief description of procedures necessary to make field joints. Additional tool instructions and matching tolerances are available upon request.

Cutting

The end of the pipe must be cut squarely and smoothly. Due to extreme hardness of the liner, standard cutting tools will not cut the liner without chipping. Therefore, when the pipe is cut anywhere except within two inches or less of the end (dressing cut), it is necessary to make two cuts (rough and dress) to produce the desired smoothness. If only a dressing cut is needed, then a single cut can be used.

Rough Cutting

Scribe or draw a line around the pipe at the desired rough cut dimension. Allow approximately one inch for dressing cut.

Using a power circular hand saw and abrasive blade, or hack saw, cut through the laminate to the liner completely around the pipe. **Note**: All glass fiber filaments should be cut.

Snap the pipe in two by placing pipe on support with cut slightly overhanging support. Apply a downward impact load to end of pipe with a 2x4 or rubber mallet while pipe is rotated such that one full rotation is made before separation. The pipe is now ready for the finish cut to dress up the edge.

Dress Cutting

The method to obtain a square cut requires a lathe large enough to turn the pipe and a tool post grinder equipped with a diamond blade. Only a diamond blade is hard enough to cut the ceramic liner. Water must be used at all times to keep the blade cool. The pipe must be rotated by hand unless the lathe is capable of extremely slow speed (1-2 RPM). Cut through the overwrap down to the liner, then advance the blade through the liner far enough to cut off in one revolution. Rotate the pipe into the blade. Do not overload the blade. With a little practice, the proper feed rate can be determined by listening to the motor pitch. Support the ring being cut off to prevent the liner from breaking as the saw approaches a complete cut.

Caution: Be sure the final dress cut removes all chipped or broken liner.

Bonding

Pipe Preparation

Scarfing the O.D. is necessary to remove the gloss and true the O.D. of the pipe to receive the flange. Scarf until a snug, dry fit is achieved between the pipe and the flange. This can be done on a lathe or with the NOV Fiber Glass Systems dressing tool. Eccentricity should not exceed ± .015".

Use **8000 Series** adhesive kits.

Clean the machined surfaces of both the pipe and flanges. Use solvent and the paper towels provided in the kit, carefully following the instructions provided in the kit.

Apply adhesive to both pipe and flange bonding surfaces being sure to cover all machined surfaces.

Lightly drive the flange onto the pipe. The flange face must be flush and square with the end of the pipe.

Wipe off all adhesive on the flange face. An uneven surface or filled grooves due to cured residual adhesive will cause gasket sealing problems. A rag slightly dampened with solvent may be used. DO NOT flood with solvent as this may wash adhesive out of the bond area and weaken the bond.

Heat curing the joints will cause beads of adhesive to exude from the bond. These must be removed when partially hardened, but not fully cured, by cutting away with a sharp knife. Be careful not to damage the gasket sealing surface. After clean up, fit to a mating flange to make sure there is no interference.

Buried Installations

Preparing the Trench

The final bedding of the trench should be done as uniform and smooth as possible. Rocks or high spots in the trench bottom cause uneven bearing on the pipe and may damage the liner due to stress during backfill and cause unnecessary wear at these points. This is particularly significant if pulsation is present in the lines due to pumps. Sharp bends and changes in elevation or lateral direction in the line must be accomplished through the use of appropriate elbows. A bell hole should be dug for each set of flanges so the pipe rests on the bottom of the ditch.

Rocky Areas

If the trench is excavated through rock or shale ledges, the trench should be slightly deeper and a layer of sand used in the bottom of the trench and over the pipe to assure protection of the pipe from the rocks.

Road Crossings

In laying pipe under road crossing, it is recommended that the pipe be laid through a conduit. Firm, well compacted bedding under the pipe at the entrance and exit is essential to prevent shear loads due to backfill and settling. Check Table I for burial depths when pipe will experience surface loads. If a flange joint occurs within the casing, centering devices must be installed at the recommended support spacing.

Backfilling

The installation should be backfilled with sufficient fill to hold in place with all of the fittings and joints left open for inspection during the testing period. Once the testing is completed, then the backfilling may be finished.

1. Timing

The pipe should be covered as soon as possible to eliminate the chance of damage to the pipe; floating of the pipe due to flooding and shifting of the line due to cave-ins.

2. Material

The material used for the backfill should be free of sharp rocks, heavy boulders, large clods of dirt and frozen lumps of dirt. Pipe should be completely supported underneath before overburden is applied. Frozen earth will eventually thaw leaving the pipe with insufficient support and voids around the pipe. Vibratory or similar tamping equipment can drive small stones into the pipe wall. Clean backfill should be used with this type equipment. Multiple lines in the same ditch should be separated with clean backfill or sand.

Above Ground Installations

Above ground installations can be broadly divided into two categories—lines which are laid directly on the surface of the ground and those which are hung or supported as in a typical plant. In either case, there are certain basic guidelines to be followed.

On any lines laid directly on the surface, care should be taken to insure that there are no severe bends and that adequate protection is provided in areas where possible mechanical damage could occur. If the line is connected into a system which could impart a vibration or pulsing action to the pipe, areas of point loading should be protected to prevent the pipe from abrading. Since pipe is flanged, wooden bolsters or similar supports should be provided at support spacing intervals so pipe will not rest on flanges. Pipe resting only on flanges may warp and make future rotation for best wear difficult.

Anchors

Pipe anchors divide a pipeline into sections. In most cases pumps, tanks, and other similar equipment function as anchors. Additional anchors are required at all changes in direction and at all changes in elevation. Anchors are required on both ends of elbows, either at the elbow or within 5 feet of the elbow ends. On long straight runs only, anchors should be installed at approximately 300 foot intervals. Do not use anchors which apply point loads directly to the bare pipe. Anchors that apply point loads can be used only if a protective sleeve is used between the pipe and the anchor. Guides must be used in conjunction with anchors. See Guide Spacing in **Manual CI1500 CERAM CORE**. When joining **CERAM CORE** product to other piping systems, the adjoining system must be securely anchored to prevent the transfer of thermal end load.

Supports

NOV Fiber Glass Systems pipe should be supported at intervals designated by the support spacing data in the literature. Supports that have point contact or narrow supporting areas should be avoided, and valves or other heavy equipment should be supported independently of the pipe. Standard sling, clamp, and clevis hangers and shoe supports designed for use with steel pipe can be used to support NOV Fiber Glass Systems pipe. Any other type of support that gives a wide band of contact with at least 120° of contact with the pipe can be used. Any support that does not provide 120° of contact should be at least 4” wide or have a width equal to 1/3“of the diameter of the pipe, whichever is larger. If it is not possible to achieve this, the pipe should be protected with a protective sleeve of rubber lined metal, or other means of increasing the supporting area. In all cases, the support must be wide enough so that the bearing stress does not exceed 85 psi.

Expansion

The forces created by the expansion of NOV Fiber Glass Systems systems are approximately only 1/25 that of Schedule 40 steel. In cases where the piping system has long runs or is subjected to large changes in temperature, the changes in length must be handled by anchors and guides. See Product Manual “CERAM CORE” for the anchor and guide spacing information. Consult a NOV Fiber Glass Systems representative for specific recommendations.

Pipe Rotation

For the longest service life and best economics, the system should be designed and installed so that pipe can be periodically rotated on a regular basis to insure even wear. This is particularly important where there is sliding abrasion on the bottom by heavy particles that do not remain suspended in the fluid stream. This precaution, plus careful alignment of the joints, will give a system with optimum performance. Since the pipe is extremely light, rotation can usually be accomplished by unbolting only a minimal number of joints and rotating several lengths at a time.

TABLE I
CERAM CORE Pipe Burial Depths(1)

Nominal Pipe Size		With H-20 Loading(2)		Without Live Loading
in	mm	Min. Burial Depth ft.	Max. Burial Depth ft.	Max. Burial Depth ft.
6	150	2	27	27
8	200	2	17	17
10	250	2	15	15
12	300	2	12	12
14	350	2	9	10
16	400	2	9	10

TABLE II
CERAM CORE Flange(6) Bolt Make-up Torque, Bolt, Washer, and O-Ring for Flanges and Flanged Fittings(3)

Nom Pipe Size in.	Max. Torque Ft.-Lbs.(3)	Bolt Size in.	Bolt Length in.	Washer Size(4) in.	No. of Bolts	O-Ring Sizes(5) ARP 268 N. Full Size	O-Ring Sizes(5) ARP 268 N. Half Size
6	30	3/4	4 1/2	1 1/2	8	442	264
8	100	3/4	5	1 1/2	8	448	273
10	100	7/8	5 1/2	1 3/4	12	452	277
12	100	7/8	6	1 3/4	12	457	280
14	100	1	6	2	12	459	281
16	100	1	6	2	16	465	284

(1) Basis for calculations are: (a) 3% maximum allowable diametrical deflection of the pipe; (b) soil modulus is 1000 psi; (c) the pipe is not subjected to a vacuum; (d) the water table is not above the top of the pipe. Other variables such as bedding constant assume worst case (most conservative) values. Reference ASTM D3839 for details on these assumptions (including an explanation of “soil modulus”). If actual conditions are different, contact your NOV Fiber Glass Systems representative.
(2) H-20 wheel loading is 32,000 lbs. per tandem axle; however, the allowable truck loading is now 34,000 lbs. per axle. Calculations are based on 34,000 lbs. per axle.
(3) The torque required to seal the gasket is usually lower than the maximum torque. Torque is based on non-lubricated bolts; therefore, torque levels should be lowered for lubricated bolts.
(4) Use SAE light washers.
(5) These numbers are from the SAE uniform numbering system. Full size O-rings are used with SF flange to SF flange. Half size are used with SF flange to smooth (flat) face flange.
(6) NOV Fiber Glass Systems flanges should be joined only to flat-faced flanges. When mating to raised-face flanges or lug-type valves, spacers are necessary.

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NOV Fiber Glass Systems

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