

Green Thread® Product Data

Applications

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

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.

Pipe is available in **1" through 24"** diameters with pressure ratings up to 450 psig static at a maximum operating temperature of 225°F. Pipe diameters of **1" through 6"** are available in 20' random lengths and the **8" through 24"** diameters are in 19' or 39' random lengths.

Green Thread pipe in larger diameter (30" - 42") and higher pressure are available upon 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. See Bulletins A1350 & A1351 for fitting details.

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.



Flanged

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



Nominal Dimensional Data

| Pipe Size (In) | I.D. | | O.D. | | Wall Thickness | | Liner Thickness | | Weight | | Capacity | |
|----------------|--------|------|--------|------|----------------|------|-----------------|------|----------|--------|----------|----------|
| | (In) | (mm) | (In) | (mm) | (In) | (mm) | (In) | (mm) | (Lbs/Ft) | (kg/m) | (Gal/Ft) | (Ft³/Ft) |
| 1 | 1.193 | 30 | 1.370 | 35 | 0.090 | 2.29 | 0.015 | 0.38 | 0.3 | 0.45 | 0.06 | 0.008 |
| 1½ | 1.760 | 45 | 1.960 | 50 | 0.100 | 2.54 | 0.015 | 0.38 | 0.5 | 0.74 | 0.13 | 0.017 |
| 2 | 2.152 | 55 | 2.390 | 61 | 0.119 | 3.02 | 0.025 | 0.64 | 0.7 | 1.04 | 0.19 | 0.025 |
| 3 | 3.279 | 83 | 3.516 | 89 | 0.119 | 3.05 | 0.025 | 0.64 | 1.0 | 1.49 | 0.44 | 0.059 |
| 4 | 4.281 | 109 | 4.521 | 115 | 0.120 | 3.05 | 0.030 | 0.76 | 1.3 | 1.93 | 0.75 | 0.100 |
| 6 | 6.351 | 161 | 6.645 | 169 | 0.147 | 3.73 | 0.030 | 0.76 | 2.4 | 3.57 | 1.65 | 0.220 |
| 8 | 8.361 | 212 | 8.717 | 221 | 0.178 | 4.52 | 0.030 | 0.76 | 3.9 | 5.80 | 2.85 | 0.382 |
| 10 | 10.363 | 263 | 10.795 | 274 | 0.216 | 5.49 | 0.030 | 0.76 | 5.9 | 8.78 | 4.38 | 0.586 |
| 12 | 12.286 | 312 | 12.758 | 324 | 0.236 | 5.99 | 0.030 | 0.76 | 7.7 | 11.50 | 6.16 | 0.823 |
| 14 | 14.038 | 357 | 14.548 | 370 | 0.255 | 6.48 | 0.030 | 0.76 | 9.5 | 14.10 | 8.04 | 1.075 |
| 16 | 16.040 | 407 | 16.610 | 422 | 0.285 | 7.24 | 0.030 | 0.76 | 12.2 | 18.20 | 10.50 | 1.403 |
| 18 | 17.830 | 453 | 18.466 | 469 | 0.318 | 8.08 | 0.020 | 0.51 | 15.2 | 22.62 | 12.97 | 1.734 |
| 20 | 19.835 | 504 | 20.503 | 521 | 0.334 | 8.71 | 0.020 | 0.51 | 17.8 | 26.49 | 16.05 | 2.146 |
| 24 | 23.840 | 606 | 24.618 | 625 | 0.389 | 9.88 | 0.020 | 0.51 | 24.9 | 38.39 | 23.19 | 3.100 |

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(In²) | Reinforcement Moment of Inertia (In⁴) | Reinforcement Section Modulus (In³) | Nominal Wall End Area (In²) |
| 1 | 0.23 | 0.06 | 0.07 | 0.36 |
| 1½ | 0.37 | 0.16 | 0.16 | 0.58 |
| 2 | 0.57 | 0.37 | 0.31 | 0.85 |
| 3 | 0.85 | 1.24 | 0.70 | 1.27 |
| 4 | 1.06 | 2.59 | 1.15 | 1.66 |
| 6 | 2.20 | 11.7 | 3.52 | 3.00 |
| 8 | 3.66 | 33.5 | 7.69 | 4.78 |
| 10 | 5.70 | 79.9 | 14.80 | 7.18 |
| 12 | 7.46 | 146.6 | 22.98 | 9.28 |
| 14 | 9.30 | 238.0 | 32.72 | 11.45 |
| 16 | 12.04 | 402.0 | 48.40 | 14.62 |
| 18 | 14.85 | 610.0 | 66.07 | 18.13 |
| 20 | 17.40 | 883.0 | 86.13 | 21.74 |
| 24 | 25.00 | 1,831.0 | 148.80 | 29.61 |

| Average Physical Properties | | | | |
|--|------------------------|----------------------------------|------------------------|----------------------------------|
| Property | 75°F psi | 24°C MPa | 225°F psi | 107°C MPa |
| Axial Tensile - ASTM D2105 | | | | |
| Ultimate Stress | 10,550 | 71 | 7,160 | 49.4 |
| Modulus of Elasticity | 1.61 x 10 ⁶ | 11,128 | 1.16 x 10 ⁶ | 8,012 |
| Poisson's Ratio $V_{a/h}$ ($V_{h/a}$) | | | | |
| 0.34 (0.72) | | | | |
| Axial Compression - ASTM D695 | | | | |
| Ultimate Stress | 33,300 | 230 | 17,800 | 122.7 |
| Modulus of Elasticity | 1.26 x 10 ⁶ | 8,687 | 0.54 x 10 ⁶ | 3,723 |
| Beam Bending - ASTM D2925 | | | | |
| Ultimate Stress | 23,000 | 158.6 | 16,000 | 110 |
| Modulus of Elasticity (Long Term) | 2.18 x 10 ⁶ | 15,031 | 1.11 x 10 ⁶ | 7,653 |
| Hydrostatic Burst - ASTM D1599 | | | | |
| Ultimate Hoop Tensile Stress | 46,300 | 319.2 | 49,540 | 342 |
| Ring Tensile - ASTM D2290 | | | | |
| | <u>Sizes</u> | | | |
| Minimum Hoop Tensile Stress | 1" - 1½" | 9,018 | 62.4 | - |
| | 2"-24" | 27,280 | 188 | - |
| Hydrostatic Design - ASTM D2992, | | | | |
| Procedure B - Hoop Tensile Stress | LTHS | 27,715 | 191.1 | 16,945* |
| Static 20 Year Life (* 200°F/93.3°C data) | LCL | 22,400 | 154.4 | 14,654* |
| Thermal Expansion Coefficient - ASTM D696 | | 1.26 x 10 ⁻⁵ in/in/°F | | 2.27 x 10 ⁻⁵ mm/mm/°C |
| Thermal Conductivity | | 0.23 BTU/hr-ft-°F | | 0.4 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 | |

Water Hammer:

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

| Pipe Lengths Available | |
|-------------------------------|---------------------------|
| Size (In) | Random Length (Ft) |
| 1-6 | 20 |
| 8-24 | 19 or 39 |

| Pressure Ratings⁽¹⁾ | | | |
|---------------------------------------|--|---|--------------|
| Size (In) | Maximum Internal Static Pressure (psig) | Maximum External Pressure (psig)⁽¹⁾ | |
| | | 75°F | 225°F |
| 1 | 450 | 360 | 292 |
| 1½ | 450 | 187 | 150 |
| 2 | 450 | 289 | 241 |
| 3 | 450 | 123 | 69 |
| 4 | 225 | 77 | 56 |
| 6 | 225 | 33 | 21 |
| 8 | 225 | 18 | 15 |
| 10 | 225 | 18 | 15 |
| 12 | 225 | 18 | 15 |
| 14 | 225 | 15 | 10 |
| 16 | 225 | 15 | 10 |
| 18 | 225 | 8 | 5 |
| 20 | 225 | 7 | 4.5 |
| 24 | 225 | 6.5 | 4 |

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

| ASTM D2996 Designation Codes | |
|-------------------------------------|-----------------|
| 1"-1½" | RTRP-11FY1-3111 |
| 2"-8" | RTRP-11FY1-3112 |
| 10" | RTRP-11FY1-3114 |
| 12"-24" | RTRP-11FY1-3116 |

| Recommended Operating Ratings | | | | | | | |
|--------------------------------------|---------------------------------------|--------------|--|--|--|-----------------------------|---|
| Size (In) | Axial Tensile Loads Max. (Lbs) | | Bending Radius Min. (Ft) Entire Temp. Range | Torque Max. (Ft Lbs) Entire Temp. Range | Parallel Plate Loading ASTM D2412 | | |
| | Temperature | | | | Stiffness Factor (In³/ Lbs/In²) | Pipe Stiffness (psi) | Hoop Modulus x10⁶ (psi) |
| | 75°F | 225°F | | | | | |
| 1 | 580 | 410 | 40 | 25 | 40 | 1,170 | 1.26 |
| 1½ | 960 | 660 | 60 | 60 | 70 | 640 | 1.50 |
| 2 | 1,480 | 1,030 | 80 | 180 | 200 | 910 | 1.58 |
| 3 | 2,190 | 1,520 | 110 | 230 | 240 | 330 | 1.89 |
| 4 | 2,740 | 1,900 | 140 | 380 | 230 | 140 | 1.81 |
| 6 | 5,680 | 3,950 | 210 | 1,070 | 540 | 100 | 2.13 |
| 8 | 9,430 | 6,550 | 270 | 2,490 | 730 | 60 | 2.24 |
| 10 | 14,690 | 10,200 | 340 | 4,510 | 1,620 | 70 | 2.95 |
| 12 | 19,210 | 13,350 | 400 | 7,000 | 2,800 | 80 | 3.27 |
| 14 | 23,950 | 16,650 | 460 | 9,970 | 3,600 | 60 | 2.46 |
| 16 | 31,000 | 21,550 | 530 | 14,700 | 6,500 | 60 | 3.20 |
| 18 | 39,000 | 26,500 | 583 | 21,200 | 4,296 | 38 | 2.89 |
| 20 | 45,500 | 31,000 | 648 | 27,600 | 4,995 | 32 | 2.89 |
| 24 | 65,500 | 44,500 | 778 | 46,800 | 8,106 | 30 | 2.89 |

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 Uninsulated Pipe ⁽¹⁾ | | | | |
|---|---|-------|-------|----------|
| Pipe Size (In.) | Continuous Spans of Pipe (Ft.) ⁽²⁾ | | | Gas 75°F |
| | 75°F | 150°F | 225°F | |
| 1 | 10.9 | 10.2 | 9.2 | 13.9 |
| 1½ | 12.6 | 11.8 | 10.7 | 16.9 |
| 2 | 14.1 | 13.2 | 11.9 | 19.0 |
| 3 | 15.9 | 14.8 | 13.4 | 23.2 |
| 4 | 17.0 | 15.8 | 14.3 | 26.2 |
| 6 | 20.5 | 19.1 | 17.3 | 32.8 |
| 8 | 23.3 | 21.7 | 19.7 | 38.0 |
| 10 | 26.0 | 24.2 | 22.0 | 42.6 |
| 12 | 27.9 | 26.0 | 23.5 | 46.3 |
| 14 | 29.5 | 27.5 | 24.9 | 49.6 |
| 16 | 31.4 | 29.3 | 26.6 | 53.1 |
| 18 | 33.1 | 30.8 | 28.0 | 55.8 |
| 20 | 34.5 | 32.1 | 29.1 | 58.9 |
| 24 | 37.6 | 35.2 | 31.9 | 64.4 |

⁽¹⁾Consult factory for insulated pipe support spacing.
⁽²⁾Max. mid span deflection 1/2" 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: 6" pipe @ 150°F with 1.5 specific gravity fluid, maximum support spacing = 19.1 x 0.92 = 17.6 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", Manual No. E5000, Section 3.

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

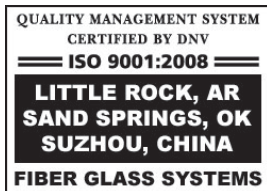
| Restrained Thermal End Loads and Guide Spacing | | | | | | | | | | |
|---|--|------------------------|--------------------|------------------------|--------------------|------------------------|--------------------|------------------------|--------------------|-------------------------|
| Size (In) | Operating Temperature °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) |
| 1 | 6.3 | 145 | 5.2 | 190 | 4.6 | 220 | 4.2 | 235 | 3.9 | 230 |
| 1½ | 9.2 | 240 | 7.6 | 315 | 6.6 | 365 | 6.1 | 385 | 5.7 | 380 |
| 2 | 11.3 | 370 | 9.3 | 490 | 8.2 | 565 | 7.4 | 595 | 7.0 | 585 |
| 3 | 16.8 | 550 | 13.9 | 720 | 12.2 | 835 | 11.1 | 885 | 10.4 | 870 |
| 4 | 21.8 | 680 | 18.0 | 908 | 15.8 | 1,040 | 14.4 | 1,100 | 13.5 | 1,080 |
| 6 | 32.1 | 1,420 | 26.5 | 1,870 | 23.3 | 2,170 | 21.2 | 2,190 | 19.9 | 2,250 |
| 8 | 42.2 | 2,350 | 34.8 | 3,110 | 30.6 | 3,600 | 27.9 | 3,800 | 26.1 | 3,740 |
| 10 | 52.2 | 3,660 | 43.1 | 4,850 | 37.9 | 5,600 | 34.5 | 5,930 | 32.3 | 5,820 |
| 12 | 61.8 | 4,790 | 51.0 | 6,340 | 44.8 | 7,330 | 40.9 | 7,750 | 38.3 | 7,610 |
| 14 | 70.5 | 5,980 | 58.2 | 7,910 | 51.2 | 9,140 | 46.6 | 9,670 | 43.7 | 9,490 |
| 16 | 80.6 | 7,740 | 66.5 | 10,240 | 58.4 | 11,830 | 53.3 | 12,520 | 49.9 | 12,290 |
| 18 | 89.4 | 9,542 | 73.8 | 12,629 | 64.8 | 14,594 | 59.1 | 15,436 | 55.3 | 15,155 |
| 20 | 99.3 | 11,181 | 82.0 | 14,798 | 72.0 | 17,100 | 65.7 | 18,087 | 61.5 | 17,758 |
| 24 | 119.3 | 16,064 | 98.5 | 21,262 | 86.6 | 24,569 | 78.9 | 25,987 | 73.9 | 25,514 |

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 1.2 times the static pressure rating of the lowest rated fiberglass component in the piping system are recommended. Contact the factory if test pressures exceed 450 psig before testing. The hydro test pressure should be repeated up to ten times 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 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 1.2 times the static pressure rating of the lowest rated fiberglass component in the system.



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