Fiber Glass Systems, L.P.

Time Tested Fiberglass Piping Systems

Fiber Glass Systems, L.P. is a leading worldwide manufacturer of fiberglass reinforced epoxy pipe products used primarily for onshore and offshore corrosion control in a variety of low to high pressure applications. Fiber Glass Systems, L.P. products range from 1½” to 36” diameter (38,1mm to 914,4mm) for oil and gas applications and 1” to 72” diameter (25,4mm to 1828,8mm) for chemical and industrial applications with temperature ratings up to 225°F (107,2ºC) in the oil and gas industry, 275°F (135,0°C) in the chemical/industrial sector.

Headquartered in San Antonio, Texas since 1980, Fiber Glass Systems, L.P. originally began operations in 1968 in Big Spring, Texas. Big Spring, Texas is located in the center of the United States oil and gas production industry, therefore FGS focused on developing products for applications in the oil and gas production market segment. Today we continue to maintain a fitting and pipe manufacturing facility in Big Spring along with a research laboratory and pipe producing operation in San Antonio.

Sales offices include San Antonio, Texas; Houston, Texas.; Midland, Texas.; Chickasha, Oklahoma.; Calgary, Alberta Canada; Nesvady, Slovakia; Aktau, Kazakhstan; Dubai, United Arab Emirates; Rio de Janeiro, Brazil; Port Harcourt, Nigeria and Singapore.

Fiber Glass Systems, L.P. became a wholly owned subsidiary of Varco International - Houston, Texas on May 30, 2000. In March 2005, Varco International merged with National Oilwell to become National Oilwell Varco (NOV). NOV is a worldwide leader in the design, manufacture and sale of comprehensive systems and components used in oil and gas drilling and production, the provision of oilfield tubular inspection, internal tubular coatings and other services, as well as in providing supply chain integration services to the upstream oil and gas industry.

In December 2000, Fiber Glass Systems, L.P. acquired Smith Fiberglass, headquartered in Little Rock, Arkansas, with plants in Little Rock, Arkansas., Wichita, Kansas and Harbin, China. These factories produce premium composite pipe products.
and fittings for application in oil and gas production, retail fuel distribution and chemical processing markets.

July 2001, Fiber Glass Systems. L.P. also acquired Fibercast, headquartered in Sand Springs, Oklahoma. These two companies share a 60 year history of quality products and proven performance in the chemical and industrial market. The merger expands the company’s capabilities by offering centrifugally cast and filament wound piping, as well as significant expertise in the design of piping systems for chemical, power generation, pulp and paper, petroleum marketing and other industries.

Answering the need for fiberglass piping in the marine offshore market, FGS built a 218,861 sq. ft. (23,120 sq. m.) factory in Suzhou, China and began production during the 4th quarter of 2004. The factory was strategically placed to service both the China and Korean shipyards. All services including material take-offs, stress analysis, spool drawings and fabrication services are offered.

FGS continuously strives for improved productivity, higher quality and increased performance. The culture of the company has been set to be a market leader in innovation and expanded application of fiberglass pipe and has lead the way by being the FIRST company in the industry to:

- Manufacture composite pipe
- Earn ISO 9001 Certification
- Achieve API 15LR, API 15HR and API Q1
- UL-Listed non-metallic pipe for fuel handling
- Produce downhole composite tubing and casing
Line Pipe
Standard and API Design

STAR® Fiberglass / RED THREAD® II
Line pipe for oil and gas production is manufactured in sizes ranging from 1 1/2” through 24” (40 to 600 mm) diameters and will handle pressures from 225 psi (1.6 MPa) to 4000 psi (27.6 MPa) depending on size and temperatures up to 200º F (93.3º C). These products are used to transport highly corrosive materials from an oil field’s central gathering station to injection wells. Additionally, line pipe is also used in lower to medium pressure oil and gas flow lines where corrosive fluids are encountered. FGS line pipe has a 20 year hoop stress (LCL) rating of up to 23,270 psi (160.5 MPa) at 150º F (65.6º C) according to ASTM D-2992 Procedure B. While the epoxy resin system contributes to the chemical and temperature resistance, the fiberglass reinforcement provides the greater load carrying characteristics.

Applications
• Flow or Injection Lines
• Transfer or Disposal Lines
• Tank Battery Piping
• Fire Water Lines
• Oil
• Natural Gas Production
• High Pressure CO₂ and Salt Water Injection
• Crude Oil, Salt Water, H₂S
• Light Chemicals:
  - Salts
  - Solvents
  - pH 2-13 Solutions

Benefits
Corrosion Control
Resists corrosion caused by CO₂, H₂S and saltwater. Requires no protective coating.

Reduced Line Pipe Installation Cost
Light and easy to handle. Less personnel and equipment needed during installation.

Improved Flow Capacity
Smother interior pipe surface increases efficiency and resists scale/paraffin build-up.
### Line Pipe Products

<table>
<thead>
<tr>
<th>PRODUCTS</th>
<th>SIZE RANGE</th>
<th>PRESSURE</th>
<th>CONNECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STAR™ Advanced Composite Thread</strong></td>
<td>1½”-8” (40-200 mm)</td>
<td>500-4000 psi (3.5-27.6 MPa)</td>
<td>API 5B 8 round</td>
</tr>
<tr>
<td><strong>STAR™ Precision Ground Thread</strong></td>
<td>2”-8” (50-200 mm)</td>
<td>500-3000 psi (3.5-20.7 MPa)</td>
<td>API 5B 8 round</td>
</tr>
<tr>
<td><strong>STAR™ Super Seal High Pressure</strong></td>
<td>1½”-6” (40-150 mm)</td>
<td>500-2500 psi (3.5-17.2 MPa)</td>
<td>Mechanical O-Ring (3 Threads per inch)</td>
</tr>
<tr>
<td><strong>STAR™ Super Seal</strong></td>
<td>2”-12” (50-300 mm)</td>
<td>500-1250 psi (3.5-8.6 MPa)</td>
<td>Mechanical O-Ring (4 Threads per inch - 2”-6”) (2 Threads per inch - 8”-12”)</td>
</tr>
<tr>
<td><strong>RED THREAD® II</strong></td>
<td>2”-24” (60-600 mm)</td>
<td>225-450 psi (1.6-3.1 MPa)</td>
<td>Threaded and Bonded (T.A.B.) Bell &amp; Spigot (Matched Taper)</td>
</tr>
<tr>
<td><strong>RED THREAD® II Performance Plus</strong></td>
<td>8”-24” (200-600 mm)</td>
<td>450 psi (3.1 MPa)</td>
<td>Bell &amp; Spigot (Matched Taper)</td>
</tr>
</tbody>
</table>
**Downhole Tubing and Casing**

**Integral Joint / Threaded and Coupled**

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**STAR® Fiberglass Tubing / Casing**

Fiber Glass Systems is the dominant downhole FRP producer in the industry due to its unique zero degree fiberglass layering sequence, which provides superior tensile performance. Tubing is offered in 1½” through 4½” diameters (38 mm - 115 mm) with pressure rating from 1000 to 4000 psi (6,9 to 27,6 MPa). Casing products range in size from 5½” through 9-5/8” diameter (140 mm - 225 mm) with pressure ranges from 1000 to 2500 psi (6,9 - 17,2 MPa).

FGS offers epoxy downhole tubing and casing products produced with three unique curing agents that will withstand temperatures up to 200°F (93.3°C). All products come in standard nominal joint lengths of 30 ft. (9,1 m). The company’s downhole products are used in a variety of highly corrosive applications with depths to 10,000 feet (3038 m). Tubing and casing are used primarily in saltwater injection wells, where injection fluids are corrosive, in observation wells for monitoring formations where steel can interfere with monitoring equipment, and in producing wells where steel products corrode easily.

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**Joining Systems**

FGS uses the industry standard API 5B EUE 10rd, EUE 8rd and OD 8rd steel compatible joining systems which are available either Threaded and Coupled (T&C) or Integral Joint (IJ). The joining system is a critical consideration in determining FRP’s (GRE) relative performance versus steel products. It impacts the number of times a string of pipe can be “tripped” in and out of a well, as well as the speed of installation and compatibility with other products. FGS has a continuing program to improve its joining systems and is credited with such innovations as the patented Advanced Composite Thread (ACT), containing graphite and ceramic which increases the make-up and break-out performance of the connection.

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**Applications**

- Disposal or Injection Tubing
- Production Tubing (ESP, Gas Lift or Rod Pump)
- Casing Liners
- Chemical Waste Disposal
- Geothermal
- Slotted Production Liners
- Observation Well Casing
- Open Hole Casing, Zone or to Surface

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**Improved Downhole Make & Break Performance**

**ACT Tubing**

Less breakout torque, tighter thread tolerances, less thread wear and higher thread shear.

**Superior Downhole Performance**

Unique axial and balanced hoop reinforcement
### Downhole Systems

<table>
<thead>
<tr>
<th>PRODUCTS</th>
<th>SIZE</th>
<th>PRESSURE</th>
<th>TEMPERATURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tubing</td>
<td>1 1/2”-4 1/2” (40-115 mm)</td>
<td>4000 psi (27.6 MPa)</td>
<td>200°F (93.3°C)</td>
</tr>
<tr>
<td>Casing</td>
<td>4 5/8”-9 5/8” (115-224 mm)</td>
<td>2000 psi (13.8 MPa)</td>
<td>200°F (93.3°C)</td>
</tr>
<tr>
<td>Shallow Well</td>
<td>1 1/2”-2 7/8” (40-73 mm)</td>
<td>1500 psi (10.3 MPa)</td>
<td>150°F (65.6°C)</td>
</tr>
<tr>
<td>Well Screens</td>
<td>1 1/2”-6” (40-400 mm)</td>
<td>---</td>
<td>200°F (93.3°C)</td>
</tr>
<tr>
<td>Slotted Liners</td>
<td>1 1/2”-6” (40-400 mm)</td>
<td>---</td>
<td>200°F (93.3°C)</td>
</tr>
</tbody>
</table>

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**STAR™Well**

The Fiber Glass Systems well simulation analysis program was developed to analyze actual well conditions so that the correct tubing products can be recommended to the customer. Often a series of conditions will be evaluated using the worst and best case scenarios, thereby assuring the customer that the product will give many years of trouble-free service.

**Advanced Composite Thread (ACT)**

Provides excellent sealability for high pressure fluids and gases with excellent make-up and break-out performance.

Patent No’s.: 4,999,389 and 5,179,140

**Zero Degree Layer Sequence**

Unique ZERO degree fiberglass layering sequence which provides superior tensile performance.

**Integral Joint (IJ)**

Also available in Threaded and Coupled (T&C)

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www.fiberglasssystems.com

info@starfiberglass.com
Connections

ACT, PGT, SSS and T.A.B.

Advanced Composite Thread (ACT)
The FGS premium molded thread connection is manufactured with a special composite consisting of epoxy, graphite and ceramic. These materials, with a Teflon based lubricant or proprietary sealant, and the consistent tolerances of ACT, provide exceptional sealability to high pressure fluids and gases with excellent make-up and break-out performance. The molded ACT connection provides higher thread shear and chemical resistance and is preferred over cut or ground fiberglass threads for downhole tubing. The ACT connections are manufactured as per industry API 5B EUE 10rd, EUE 8rd or OD 8rd thread. The connection is primarily offered as integral joint but, is also available threaded and coupled for downhole tubulars.

Precision Ground Thread (PGT)
Produced with numerically controlled grinding equipment, the tolerances provided by PGT require only the use of a Teflon base lubricant or proprietary sealant for make-up. This is an improvement over most typically cut or ground fiberglass threads, which require the application of Teflon tape coated with a Teflon base lubricant. The PGT connection is manufactured according to the industry standard API 5B EUE 10rd, EUE 8rd or OD 8rd thread. PGT is used for line pipe products and is supplied with integral joint connections.

STAR™ Super Seal (SSS)

STAR™ Super Seal High Pressure (SSSHP)
Fast, reliable, self restrained mechanical o-ring seal, the SSS and SSSHP are both an all-weather connection. Standard o-rings used are standard Nitrile for normal applications up to 200°F (93.3°C). Special o-rings are available for high concentrations of CO₂ and H₂S. The SSS 2” through 6” (50 mm - 150 mm) sizes utilizes a quality modified 4 thread per inch thread for restraint while 8” through 12” (200 mm - 300 mm) sizes are provided with 2 threads per inch. For SSSHP, a 3 thread per inch connection is used. This results in a 25% faster make-up and allows pressures up to 2500 psi (17,2 MPa).

Threaded and Bonded (T.A.B.)
T.A.B. is the primary joining method for 2” through 6” (50 mm - 150 mm) diameter Red Thread II pipe. Factory supplied ends have special profile, double-lead threads for quick, reliable assembly. Combined with specially formulated epoxy adhesive, T.A.B. joints promote positive make-up and prevent backout during cure.

For 8” through 24” (200 mm - 600 mm) sizes, the matching taper Bell and Spigot joining method is used. The pipe is supplied with one end belled (integral bell or factory bonded coupling) and one end tapered. Epoxy adhesive is used to secure the joint.
Quality

The Fiber Glass Systems commitment to quality extends throughout the company and supplier network. All products are closely monitored during production and thoroughly tested. Quality standards are strictly enforced and reinforced with production employee incentives and quality audits. Third party inspections are a normal occurrence at Fiber Glass Systems. The **API Q1 Quality Rating** is a requirement for approval by **API 15HR** and **API 15LR**. The quality and performance requirements of API assure the customer that, not only do we have a quality system, but they also receive a product qualified and approved for performance standards. Our adherence to this internationally recognized quality system is another indication of our commitment to our global role as a manufacturer of the highest quality fiberglass tubulars.

Service

Field support during the installation of the product is an integral part to ensure the reliability and long-term, worry-free performance of your piping system. FGS offers complete training and inspection service for all products throughout the world. Having trained personnel at the installation site enhances successful installation of these products.

Certifications and Approvals

- American Petroleum Institute
- American Water Works Association
- ASME/ANSI B31.3
- Factory Mutual (FM)
- Food and Drug Administration (FDA)
- NSF International
- Military Specifications
- Underwriters Laboratories Inc. (UL/ULC)
- American Bureau of Shipping (ABS)
- United States Coast Guard
- TUV

**API Q1 and API 15HR** Awarded the **FIRST** API Q1 and API 15HR approval for the manufacture of high pressure fiberglass pipe.

**ISO 9001:2000**
## Typical Physical Properties

### Line Pipe and Downhole Tubing / Casing

#### Line Pipe

<table>
<thead>
<tr>
<th>Materials Properties</th>
<th>UNITS</th>
<th>RANGE</th>
<th>UNITS</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulus of Elasticity - Axial</td>
<td>psi (x10^6)</td>
<td>1.5 - 2.0 GPa</td>
<td>10.3 - 13.8</td>
<td></td>
</tr>
<tr>
<td>Modulus of Elasticity - Hoop</td>
<td>psi (x10^6)</td>
<td>2.6 - 4.3 GPa</td>
<td>17.9 - 29.7</td>
<td></td>
</tr>
<tr>
<td>Poisson's Ratio</td>
<td></td>
<td>0.38 - 0.39</td>
<td></td>
<td>0.38 - 0.39</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion</td>
<td>in/in⁰F (x10^-6)</td>
<td>0.87 - 1.25 mm/mm/⁰C (x10^-9)</td>
<td>1.6 - 2.3</td>
<td></td>
</tr>
<tr>
<td>Coefficient of Thermal Conductivity</td>
<td>Btu/ft/hr/⁰F</td>
<td>0.20 - 0.23 W/m²K</td>
<td>0.35 - 0.40</td>
<td></td>
</tr>
<tr>
<td>Specific Gravity</td>
<td></td>
<td>1.8 - 1.99</td>
<td></td>
<td>1.8 - 1.99</td>
</tr>
<tr>
<td>Material Density</td>
<td>lb/ft³</td>
<td>112 - 124 kg/m³</td>
<td>1794 - 1986</td>
<td></td>
</tr>
<tr>
<td>Surface Roughness (Absolute)</td>
<td>in</td>
<td>0.00021 mm</td>
<td>0.00533</td>
<td></td>
</tr>
<tr>
<td>Flow Coefficient - Hazen Williams c</td>
<td></td>
<td>150 - 160</td>
<td></td>
<td>150 - 160</td>
</tr>
</tbody>
</table>

#### Pipe Properties

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</tr>
</thead>
<tbody>
<tr>
<td>Internal Pressure Ratings (Design - Static / Max.)</td>
<td>psi</td>
<td>225 - 4000</td>
<td>MPa</td>
<td>1.55 - 27.58</td>
</tr>
<tr>
<td>External Pressure Ratings (Min. / Max.)</td>
<td>psi</td>
<td>3.5 - 5500</td>
<td>MPa</td>
<td>1.6 - 37.9</td>
</tr>
<tr>
<td>Temperature Ratings (Design - Min. / Max.)</td>
<td>ºF</td>
<td>150 - 210</td>
<td>ºC</td>
<td>65 - 99</td>
</tr>
<tr>
<td>Tensile Ratings (Min. / Max.)</td>
<td>lb</td>
<td>980 - 59400</td>
<td>kg</td>
<td>445 - 26944</td>
</tr>
<tr>
<td>Design Life (API 15 HR)</td>
<td>Year</td>
<td>20</td>
<td>Year</td>
<td>20</td>
</tr>
</tbody>
</table>

### Absolute Roughness of .00021 in.

The smooth nature of FGS inner wall pipe surface results in improved flow characteristics, and operations cost savings.
### Downhole Tubing / Casing

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<td>psi (x10^6)</td>
<td>1.5 - 3.0</td>
<td>GPa</td>
<td>10.3 - 20.7</td>
</tr>
<tr>
<td>Modulus of Elasticity - Hoop</td>
<td>psi (x10^6)</td>
<td>3.2 - 4.5</td>
<td>GPa</td>
<td>22.8 - 31.1</td>
</tr>
<tr>
<td>Poisson's Ratio</td>
<td></td>
<td>0.16 - 0.38</td>
<td></td>
<td>0.16 - 0.38</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion</td>
<td>in/in°F (x10^-5)</td>
<td>0.87 - 1.25</td>
<td>mm/mm°C (x10^-6)</td>
<td>1.57 - 2.25</td>
</tr>
<tr>
<td>Coefficient of Thermal Conductivity</td>
<td>Btu/ft/hr/°F</td>
<td>0.20 - 0.23</td>
<td>W/m°C</td>
<td>0.30 - 0.40</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td></td>
<td>1.80 - 1.96</td>
<td></td>
<td>1.80 - 1.96</td>
</tr>
<tr>
<td>Material Density</td>
<td>lb/ft³</td>
<td>112 - 122</td>
<td>kg/m³</td>
<td>1794 - 1954</td>
</tr>
<tr>
<td>Surface Roughness (Absolute)</td>
<td>in</td>
<td>0.00021</td>
<td>mm</td>
<td>0.00533</td>
</tr>
<tr>
<td>Flow Coefficient - Hazen Williams c</td>
<td></td>
<td>150 - 160</td>
<td></td>
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### Pipe Properties

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</tr>
</thead>
<tbody>
<tr>
<td>Internal Pressure Ratings (Design - Static / Max.)</td>
<td>psi</td>
<td>1000 - 4000</td>
<td>MPa</td>
<td>6.9 - 27.6</td>
</tr>
<tr>
<td>Temperature Ratings (Design - Min. / Max.)</td>
<td>°F</td>
<td>150 - 210</td>
<td>°C</td>
<td>65 - 93</td>
</tr>
<tr>
<td>Tensile Ratings (Min. / Max.)</td>
<td>lb</td>
<td>5000 - 125000</td>
<td>kg</td>
<td>2268 - 56700</td>
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<tr>
<td>Collapse Rating (Min. / Max.)</td>
<td>psi</td>
<td>650 - 4400</td>
<td>MPa</td>
<td>4.5 - 30.3</td>
</tr>
</tbody>
</table>

FGS offers piping systems that can greatly enhance flow throughput when compared to piping systems made of other materials. This is due to a combination of increased cross sectional flow area and reduced absolute roughness of the pipe surface. These combined with the improved mechanical properties offered with an epoxy fiberglass reinforced material, result in the product of choice for high pressure, elevated temperature and corrosive applications.