

September 25, 2015

Composite Linepipe Technology

CRUG – 5th Annual Conference & Exhibition

Composite Linepipe

Agenda

- Oil and Gas Pipeline Materials
- Linepipe Types
- Composite Advantages / Disadvantages
- Composite Linepipe Design
- Composite Installation Methods
- Codes and Standards



Crude Oil and Gas Pipeline Materials

- Steel Pipe
 - Coated Steel Pipe (Fusion Bonded Epoxy [FBE])
 - Uncoated Steel Pipe (Bare Pipe)
 - Cathodically Protected Steel Pipe
 - Unprotected Steel Pipe (Not Cathodically Protected)
- Cast Iron Pipe
- Fiberglass Pipe
- Polyethylene Pipe
- Composite Pipe
- Nylon Pipe



Composites and Plastics in Pipelines and Piping

Linepipe Types

- Polyethylene Pipe (PE)
- Fiberglass Reinforced Thermoset Pipe (GRE)
- Spoolable Composite **Reinforced** Thermoplastic Pipe (RTP)
 - Glass Fiber Reinforced Plastic Pipe
 - Carbon Fiber Reinforced Plastic Pipe
 - Aramid Fiber Reinforced Plastic Pipe
 - Fabric or Tape Reinforced Plastic Pipe
 - Steel Reinforced Plastic Pipe



Manufacturers of Spoolable Composite Pipe for Oil and Gas, Liquids and Water Pipelines

- Shawcor (Canada)
- Fiberspar (Houston)
- FlexSteel (Houston)
- Future Pipe (Houston)
- PolyFlow (PA, Midland)
- SoluForce (AR, Netherlands)
- Anticorrosion Protective Services (Dubai)
- Nupi (Houston)

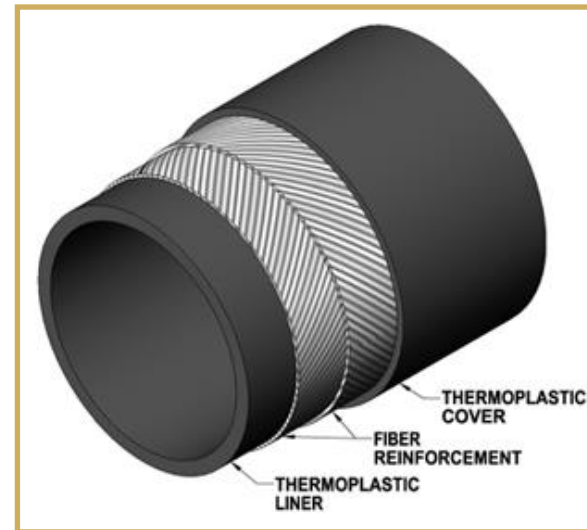
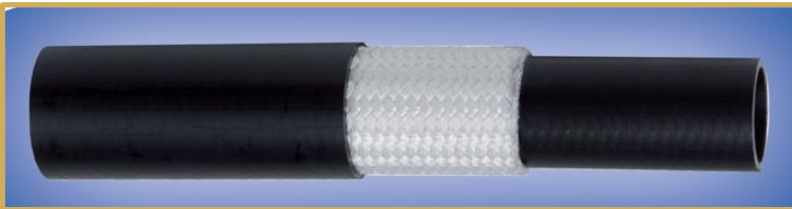
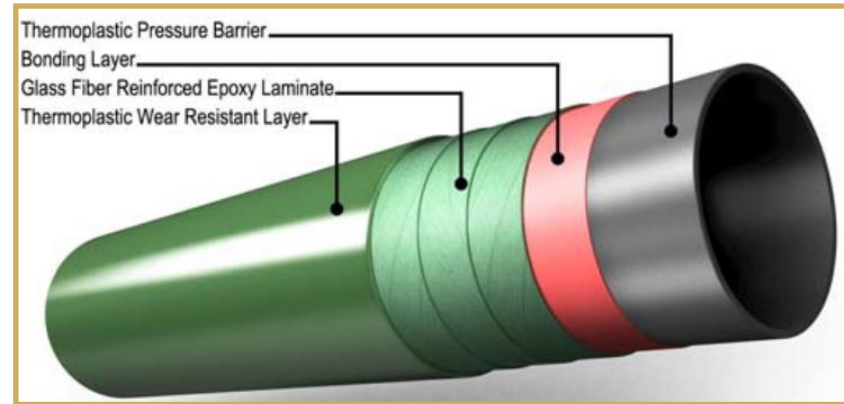
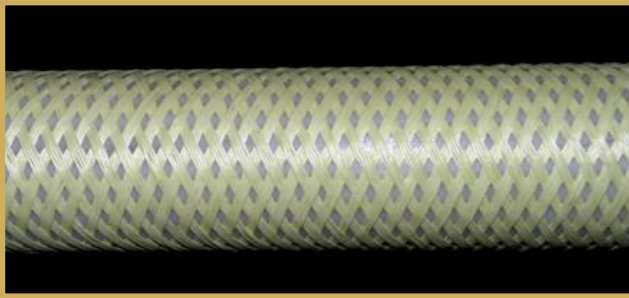


Spoolable Composite Thermoplastic Piping

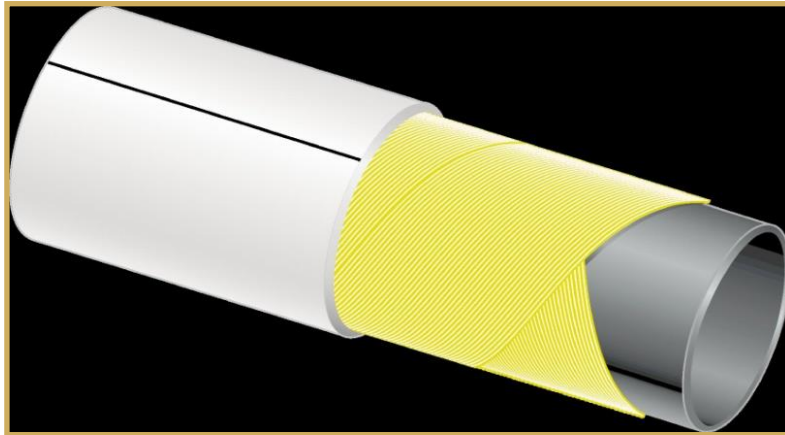
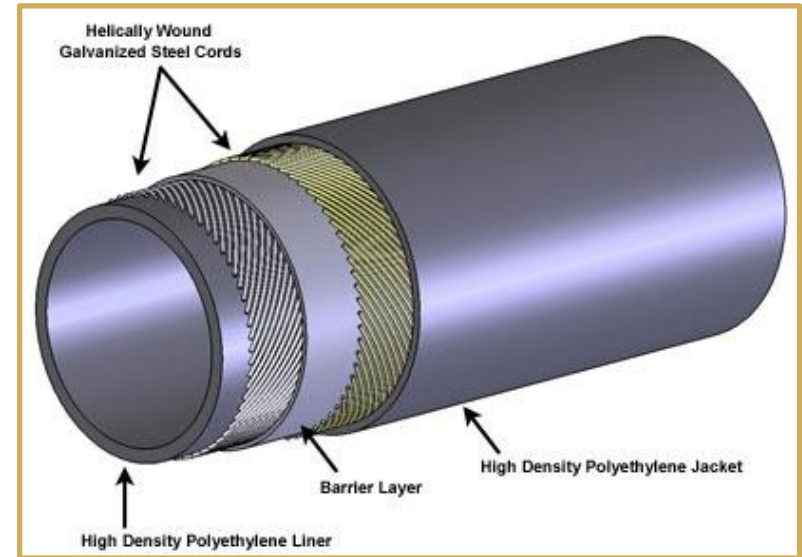
- Combination of the Best of PE and GFR Thermoset Piping
- Thermoplastic Materials
 - Polyethylene (PE)
 - Crosslinked Polyethylene (PEX)
- Reinforcements
 - Glass Fibers (GF)
 - Carbon Fibers (CF)
 - Aramid Fibers (AF)
 - Tapes (With or Without Fiber Reinforcements)



Spoolable Pipe Structures – Fiber Reinforced



Spoolable Pipe Structures – Metallic Reinforcement



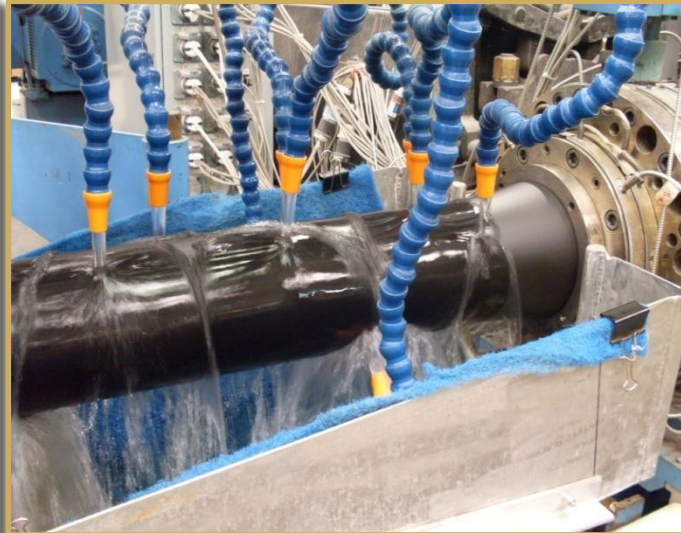
Common Sizes and Operating Pressures



- Diameters From 1 ¼" to 8"
- Pressures From 300 psi to 3,500 psi
- Estimate composites have 15% global market share in this diameter and pressure range.

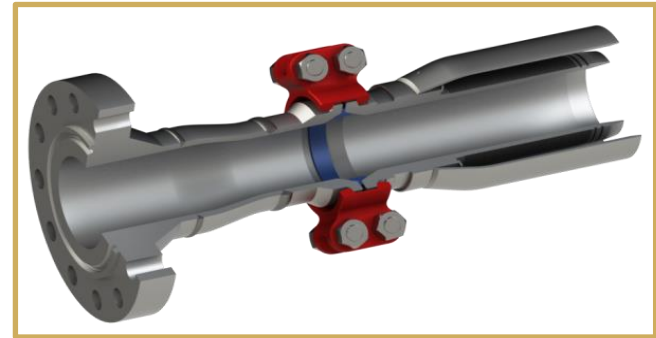
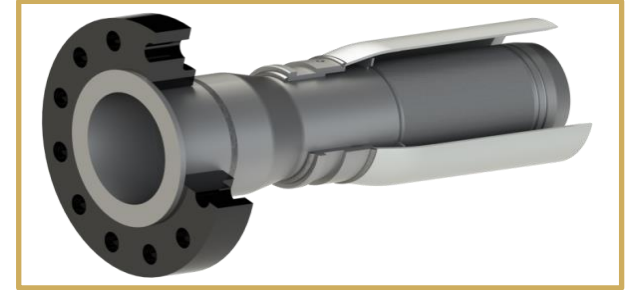
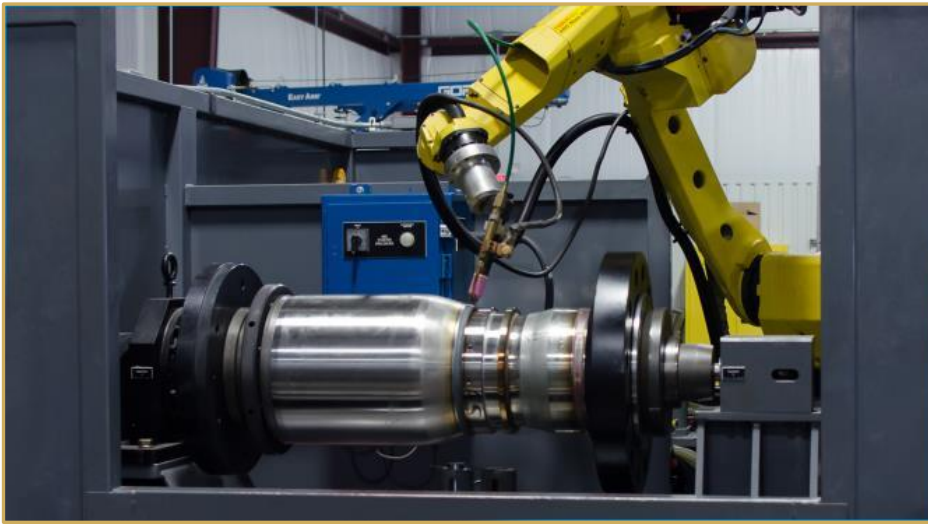


Composite Pipe Manufacturing



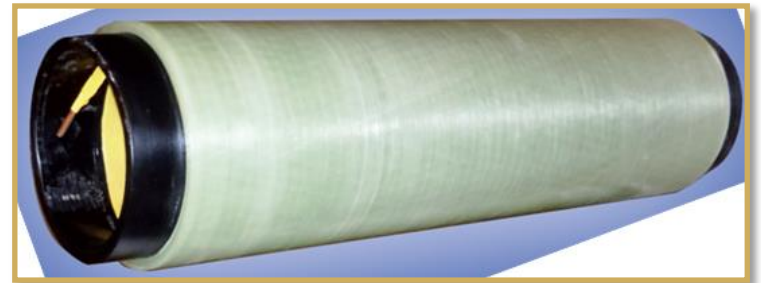
Qualified and Tested Installation Procedures

- Welding Procedures for the Manufacture of Fittings per ASME IX
- Welder Qualifications
- Crimping / Swaging / Joining Procedures



Pipeline Connection Systems

Crimp, Swage, Mechanical, Fusion



Applications

- Flow Lines or Gathering Lines for Transfer of
 - Crude Oil
 - Gas
 - Water
 - Condensate
 - Emulsion
 - Sour Applications (H₂S)
 - Gases of Liquids Containing CO₂
- EOR Injection Line
- Source Water and Disposal Lines for SAGD
- Fuel Gas Lines or Gas Lift Lines
- Rehabilitation of Failed Pipeline Through Liner Pulls
- Well Test Temporary Surface Line (Re-spool and Re-use)
- Waste Water Disposal Line

Note: Each manufacturer's design does not fit all applications.



Spoolable Composite Reinforced Thermoplastic Piping

- **Advantages**
 - Cost Effective – Less Expensive to Install vs. Steel (up to 40%)
 - No Welding, X-ray Inspection, Jeeping
 - Corrosion Resistance
 - Higher Pressure Capacity (>1,500 psi) than non-reinforced
 - Pipe Can Be Made in Long Lengths (Spoolable)
 - Fewer Connections Required
 - Pipe Can be Easily Installed – Multiple Methods
 - Mechanical End Connections - Joints



Spoolable Composite Reinforced Thermoplastic Piping

- Advantages, continued
 - Annular Space Between Thermoplastic Layers Can be Vented to Prevent Gas or Liquid Buildup Due to Permeation
 - Piping Doesn't Require Cathodic Protection
 - Can Handle Higher Service Temperatures Using PEX
 - Low Friction Rates – Higher Flow Rates
 - Quick to Install
 - Smaller ROW
 - Minimal Equipment Required



Spoolable Composite Reinforced Thermoplastic Piping

- Disadvantages

- “New” Technology – Lack of History Collected by Regulatory Agencies
- Only Available in Smaller Diameters (1 1/4” to 8”)
- Permeability
- Proprietary Designs
- Failure Mechanisms Not Fully Established
- Connections Are Weak Link in Some Systems
- Thermoset Layer Can Be Susceptible to Acidic and Caustic Chemicals



Installation – Trenching

- Minimal Equipment and Crew Needed
- Reduced ROW
- Rapid Deployment



Installation – Plowing

- Minimal Ground Disturbance
- Up to 4 Miles / Day
- 30% to 50% of the Cost of Trenching



Installation – Pipeline Rehabilitation

- Obtain Maximum Operating Pressure
- Fraction of Cost vs. New Pipeline Construction
- No De-rating
- Pulls in Excess of 10,000 Feet



Installation – Surface Permanent and Temporary Lines

- Rapid Deployment
- Temporary Pipelines
 - Well Testing
 - Frac Water Transport
- Early Production
- Re-spooling Capability
- UV Protection



Pipe Locating Technologies

- Similar to HDPE Pipe, Non Metallic Reinforced Pipes Require Supplemental Means of Locating (Tracer Wire)
- In Certain Installations, Steel Reinforced Pipes Can be Electrically Continuous and do Not Require Tracer Wire



Applicable Codes and Standards

- Metallic Reinforced Thermoplastic Pipe
 - API 17J / 17K / 15S
 - ASTM F2805
 - CSA Z662
 - ISO 18226
- Non-metallic Reinforced Thermoplastic Pipe
 - API 15HR / 15S
 - ASTM F2686
 - CSA Z662
 - ISO 18226
- Fittings
 - ASME B16.5



Qualification Testing

| Test Description | Applicable Standards |
|---------------------------------------|--|
| Regression Pressure Testing | ASTM D2992 Procedure B API RP 15S Section 5.1.2.3 |
| Short Term Burst Pressure Testing | ASTM D2992 Procedure A API RP 15S Section 5.1.2.3 |
| Minimum Bend Radius Pressure Testing | API RP 15S Section 5.3.2 |
| Elevated Temperature Pressure Testing | API RP 15S Section 5.2.1 |
| Low Temperature Pressure Testing | ASTM D1559 Procedure A |
| Axial Load Testing | API RP 15S Section 5.3.3 |
| External Load Testing | ASTM D2412 |
| Impact Resistance Testing | API RP 15S Section 5.5.2 |



Qualification Testing

| Test Description | Applicable Standards |
|---|-------------------------------------|
| Cyclic Pressure Testing | API RP 15S Section 5.1.5.1 |
| Vent Testing (Gases Venting from Annulus) | API RP 15S Section 5.3.1 |
| Fitting Gas Leak Testing | API RP 15S Section 5.3.1 |
| Aromatics Exposure | |
| Corrosions Testing and Design Pressure (FlexCord) | API 17J / ISO 13628-2 |
| Corrosion Protection | CSA Z662 |
| Thermal Expansion and Pressure Expansion Testing | API RP 15S Sections 5.5.4 and 5.5.5 |



Spoolable Pipe in Jurisdictional Systems

- Vast Majority of Spoolable Pipelines Are Used in Upstream Applications Outside the Scope of Existing Regulations
- Several States Are Considering or Have Passed Legislation that Results in the Regulation of Thousands of Miles of Upstream Flowlines with No Framework for Additional Inspectors or Other Resources Required to Implement the New State Laws
 - All Pipelines, Whether Spoolable, Plastic or Steel Would be Affected
 - Ohio Has Passed Legislation
 - New York, Pennsylvania and Texas Are Among the States Considering Proposals
- 192.14, Conversion of Service, Used to Make Formerly Non-jurisdictional Lines Fall Within Regulations



Spoolable Pipe in Jurisdictional Systems

- All Spoolable Composite Pipelines in Regulated Service (D.O.T.) Currently Require a Special Permit
- Special Permit **Advantages**
 - Enables PHMSA / State Agencies to Monitor New Technologies Over Time
- Special Permit **Disadvantages**
 - 90 - 180+ Days Approval Cycle is Typical and Most Oil and Gas Producers Cannot Accommodate the Delay – Catch 22



Spoolable Plastic Line Pipe Members – SC15 WG02

- Manufacturers



- End Users



- Suppliers / Labs



- Trade Associations



- Regulatory





Questions?