

Thermoflex[®] Tubing

Reinforced Thermoplastic Tubing for
Gas Injection Systems and Water
Movement for Shale Fields

Overview and Case Studies

East Texas Gas Producers Association

November 16, 2010

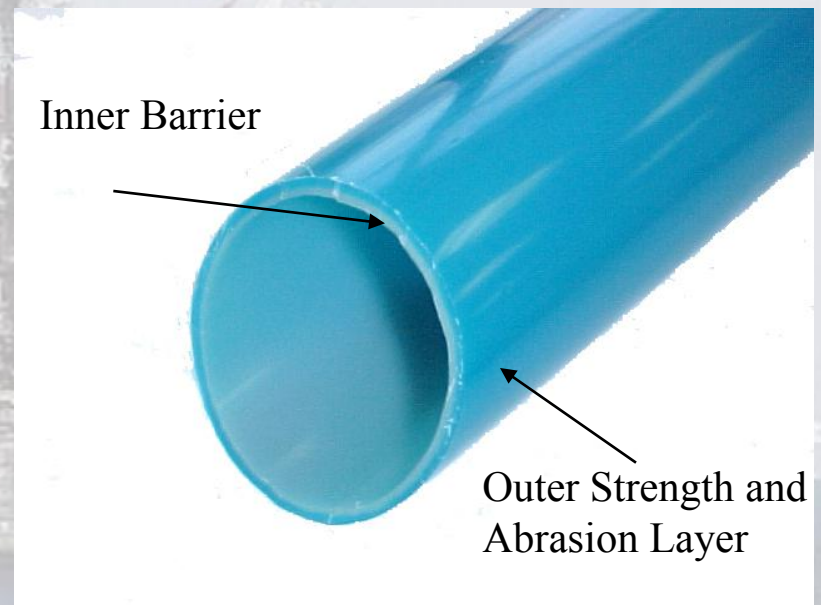


Key Considerations for Thermoflex[®] Piping Systems

- Liners Compatible with Fluids
 - Water only- HDPE
 - Water with Hydrocarbons. CO₂- Nylon
 - Water with Hydrocarbons, CO₂, H₂S- PPS
- Low Cost Rapid Installation with Minimal Joints
- Resistance to Cyclical Loading due to Pumping
- Flow Rate Requirements Can reduce Pipe Diameter and Costs

Liner Construction & Design

- Multi-layer Design
 - Inner Layer for Corrosion Resistance, Low Permeation and Higher Temp Strength . . . Nylon and Fortron
 - Outer Layer for Higher Temperature Strength, Abrasion Resistance . . . Capron or PP
- Fully Bonded



Nylon Chemical Resistance

- Nylon Inert to Hydrocarbons
 - Doesn't Soften and Swell
 - Doesn't Lose Strength
- Inert to Wet CO₂
- Not for H₂S over 200PPM

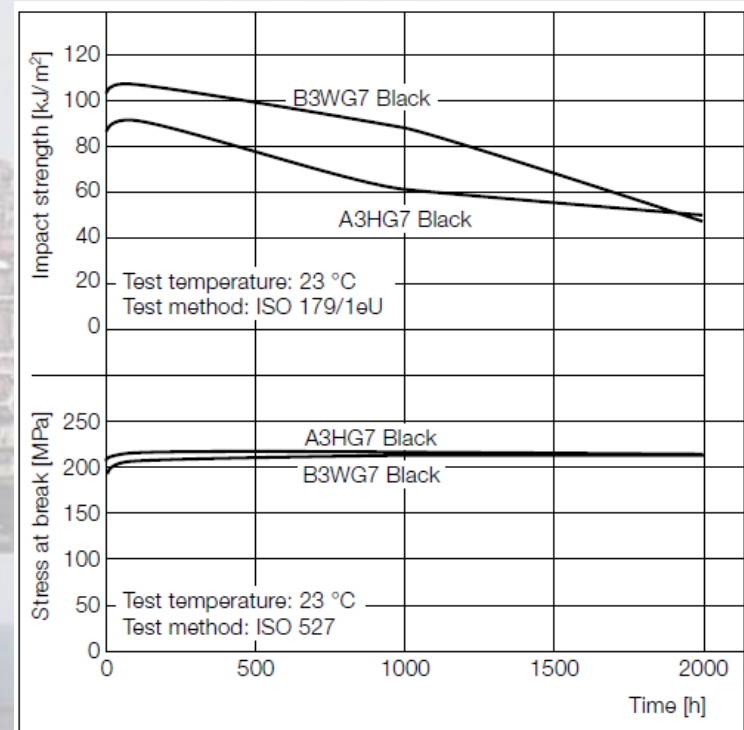
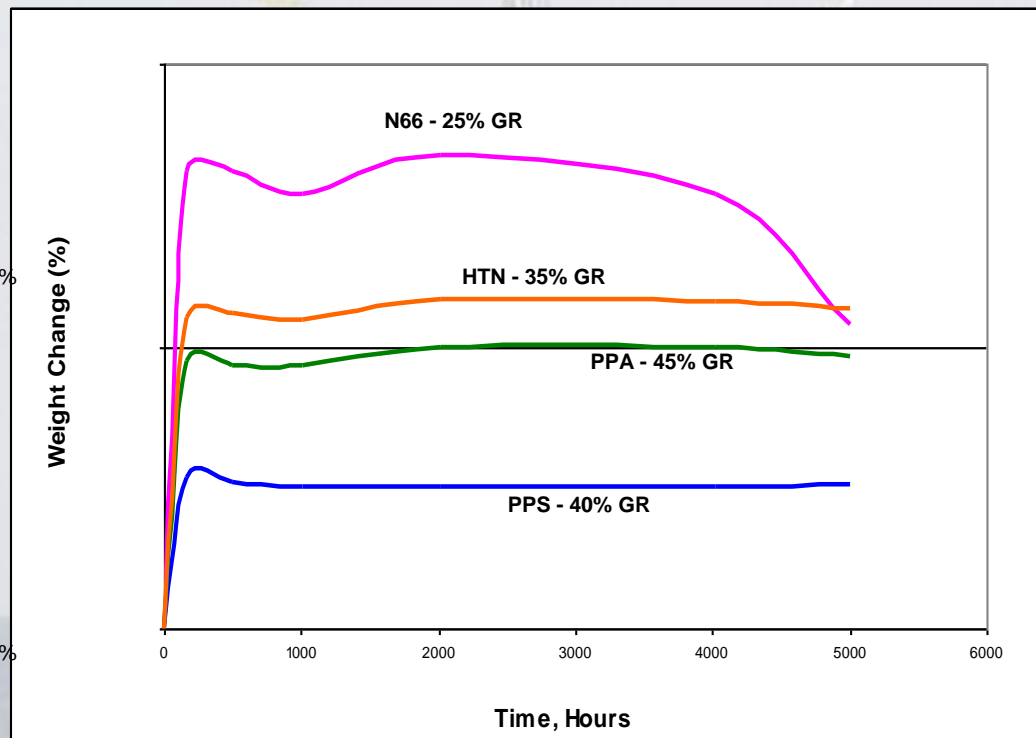


Fig. 6: Ultramid® A3HG7 Black and B3WG7 Black Resistance to engine oil (Elf XT 3341) at 150 °C

Long Term / Elevated Temp. Fuel Exposure Weight Change - Fuel CM15 (121°C)

10%

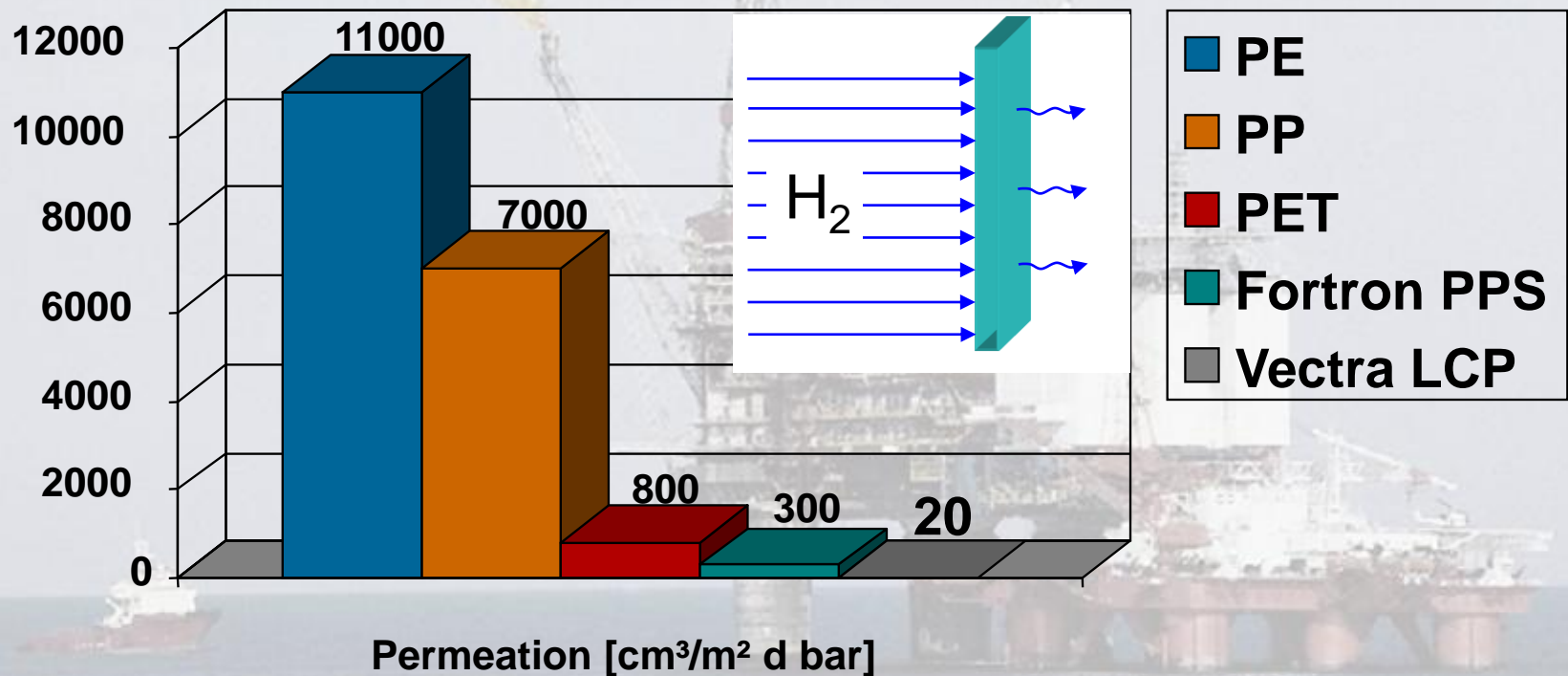


Polymer Estimated Life in Sour Environment (Years)

Temp (F)	Nylon	Fortron	HDPE
80C	1.2	>25	<.02
100C	.26	>25	NA
140C	.02	>25	NA

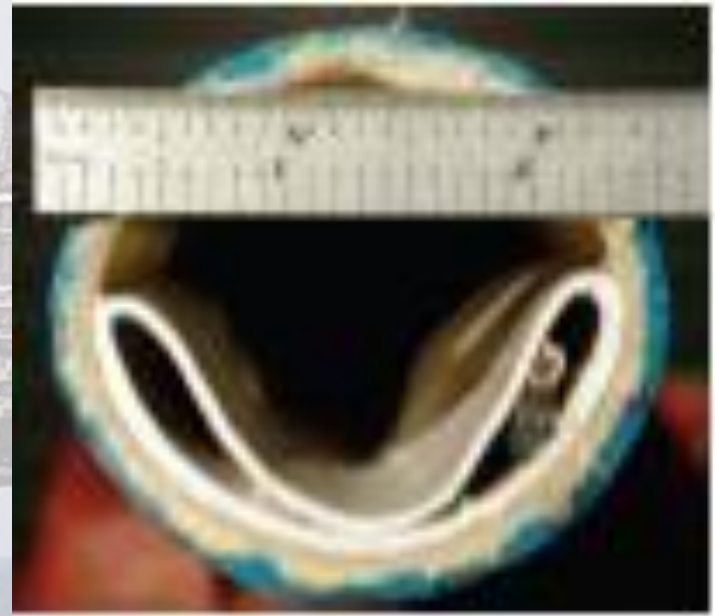
Source: Merl Report 2% H₂S, 3% CO₂, Balance methane in saturated brine water. Life defined as 50% reduction in yield strength

Hydrogen permeation of Fortron (PPS) at 23 °C



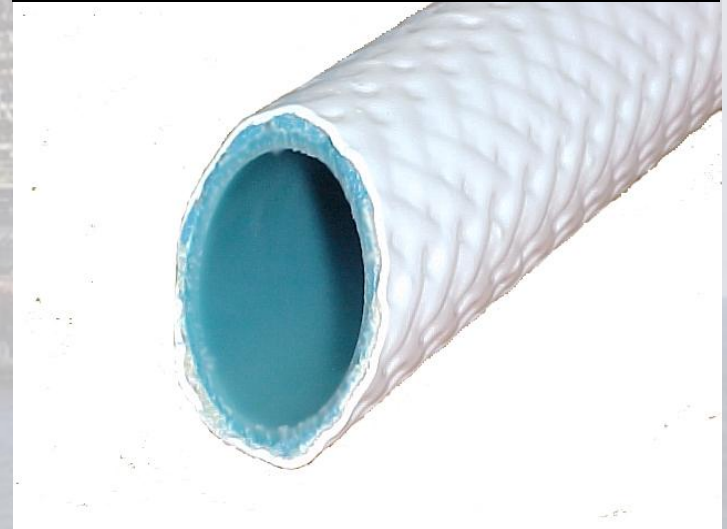
If Gas Builds on an Unbonded Layer

- Gas Builds Up in Un-bonded Layers with High Permeation Liners
- No Venting of Annulus With Low Permeation Liners



Reinforcement Layer Considerations

- Multi-layer Design
 - Cross Braids Provide Axial Strength
 - Longitudinal Braids Provide Tensile Strength to Minimize Stretch
 - Aramid Fibers for Fatigue and Strength
- Tubing Strength
$$P=(2*F*n)/D*L$$



Why Aramid Fibers vs. Glass

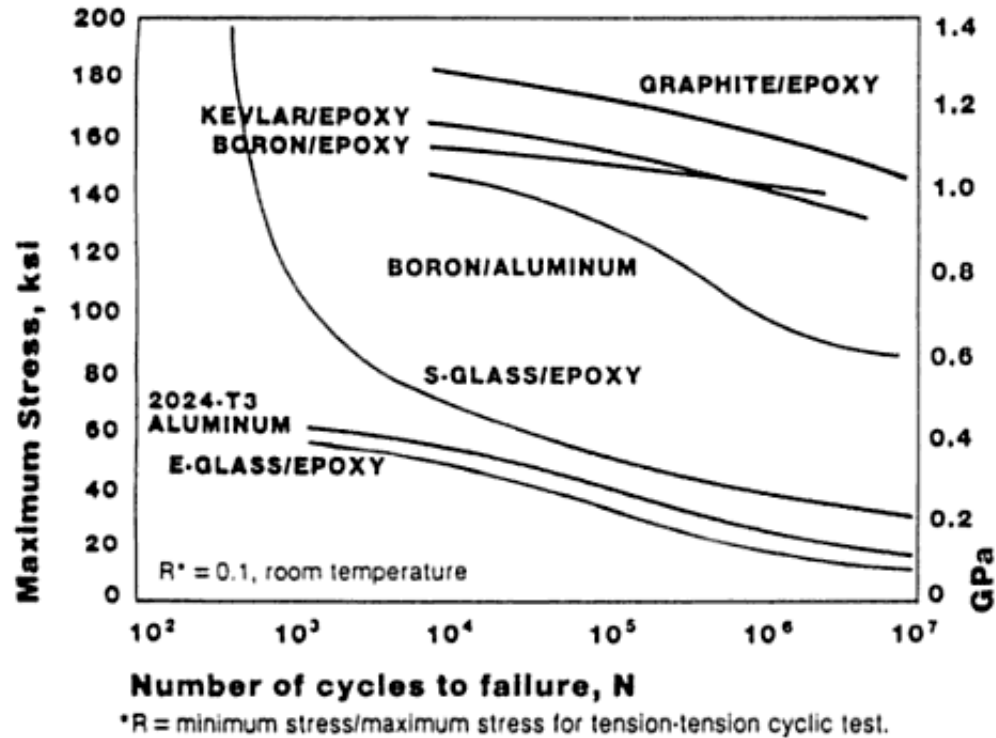


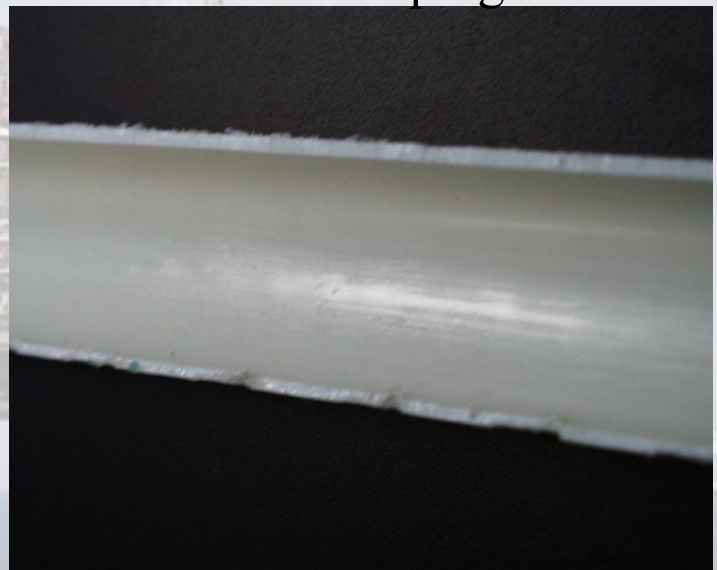
Figure 6.4 **S-N curve** to show the fatigue behavior of unidirectional composites and aluminum. From Ref. 62.

Paraffin Testing

There is Adhesion to Unlined
Metal Fittings



No Evidence of Paraffin Adhesion
On the Piping



Delivery of Tubing

- Comes in Spools
- Length Dependent Upon OD and Pressure Rating
- Spools are disposable
 - No Deposit, No Return
 - Easy to Break Down



Couplings and Terminations



- Required for Each End of the Tubing
- Threaded, Weld, & Flange Styles Available
- Zinc Chromate Plated Carbon or Duplex Stainless Steel
- Joint less Unions

Eliminating Welding



- Pre-fab Risers
 - Shop Fabricated
 - Pre Tested
 - Any Configuration
- Couples Right to Thermoflex Tubing



Tools For Coupling

- Portable Coupling Machines (250lbs)
- Up to 4.5”
- For Termination and Union Couplings
- 10,000PSI Hydraulic Pump



Installation Methods

- Direct Bury
 - Continuous Plowing
 - Trenching
- Pulled Through Existing Steel Pipe
 - Sizing Dependent Upon Restrictions in Steel
 - Pig with wire line and pull pipe



Equipment Required

- Trenching Equipment
 - Backhoe, Excavator etc.
 - Ditchwitch
- A-Frame
- Coupling Machine
- Backhoe can move Spools

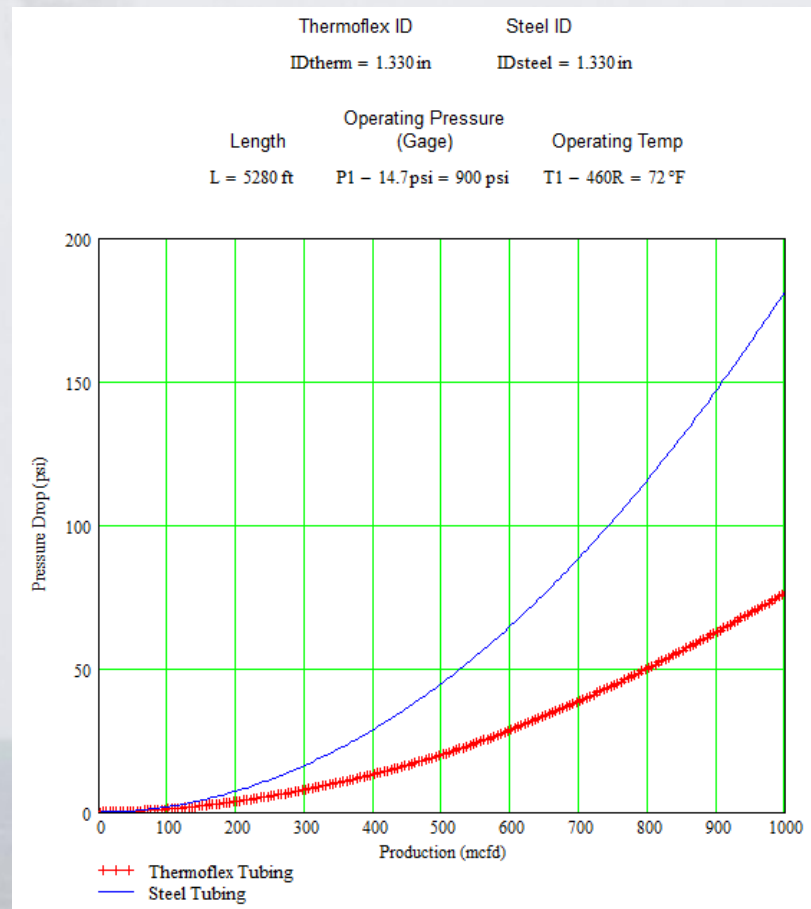


The Pipe is Light Weight

- 2 3/8" .78lbs/ft
- 4.5" 2.2lbs/ft
- Pull Off Spool by Hand
- Minimize the Equipment Requirements



Pressure Drop Benefits of Thermoflex vs. Steel



Gas Lift Example East Texas

- 300MCF/ Day
Injected per Well
 - 1.75" Thermoflex
 - 1500PSI
 - Three Wells
- One Trunk Line
 - Rated
1,200MCF/day
 - 2 3/8", 1500PSI



Gas Lift Example East Texas

- Install of 6,000ft in one Day
- Hydro Test at 2250PSI Next Day
- 40% Installation Cost Savings vs. Steel

Sour Gas Lift System East Texas

- 5,000PPM H₂S
- 2 3/8" 1,500PSI Fortron Lined
- 900PSI Operating Pressure
- Swampy Areas



Sour Gas Lift System East Texas

- Weld Style Couplings
- Steel Risers
- Hydro Test at 2250PSI



CO2 Injection System

- 1" ID Thermoflex \$4.10/ft
Replaced 1" ID Stainless for \$14.30/ft from 20ft to 1600ft
 - Wet CO2
 - H2S from 200PPM to 10,000PPM
- 40% Reduction in Installation Cost
- 5 Times more Rapid Installation vs. Steel
- Reference Jessie Perkins Whiting



Moving Water In Shale Fields

- Eliminate Trucking
- Blending of Brine and Fresh Water For Fracs
- Pressure vs. Distance Evaluation

Pulling Lengths

- Reel Remain in Place
- Drag out Single or Multiple Lines
- Multiple Colors for Different Type Lines
- Pull Two 5,000ft Lines per Day



Right of Way Considerations

- Pull first Trench Later
 - 25ft Right of Way
 - Minimizes Land Damage
- Drop Pipe in by Hand or with Sling on Backhoe



Laying with Steel

- Lay Parallel with Steel
- Steel will Slow down Installation



Boring

- Same Procedure as Steel
- Conduit not Necessary but can be Used
- Polyflow can Determine the Pull forces Required



Insertion into Existing Pipe

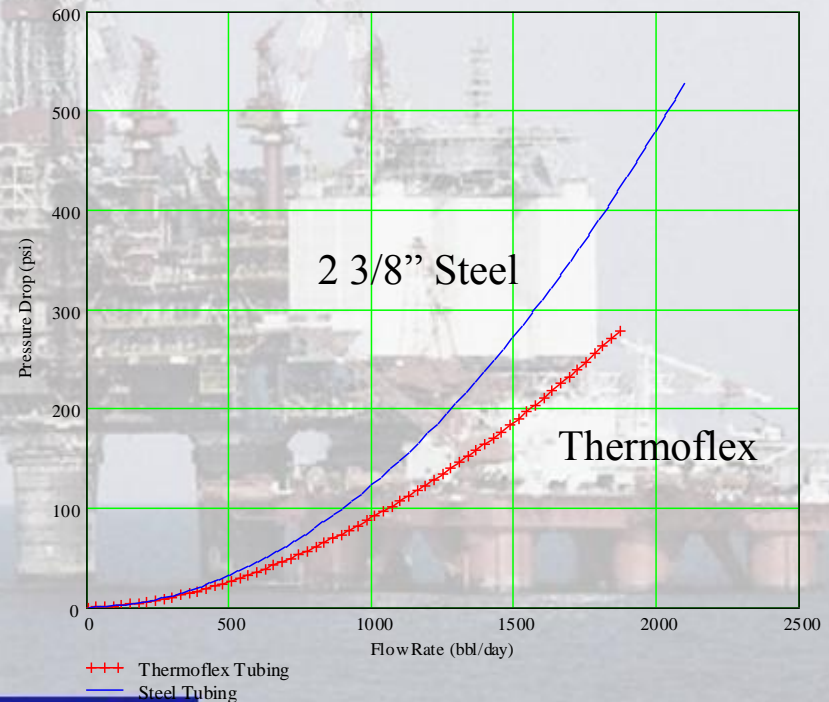
- Pull Through Steel, Fiberglass, HDPE, Composite
- Pig Through Cable and Pull Pipe Back
- Rapid Inexpensive Repair



Modeling Gathering Lines

- Liquid or Gas Modeling
- Comparison to Steel
 - Smaller Diameter for Equal Pressure Drop
 - Continuous Runs reduces Pressure Drops
- Less Erosion Issues vs. Steel

Thermoflex ID
ID = 1.880in
Operating Pressure (Gage)
P = 400psi
Operating Temp
T = 460°F = 120°F
Length
L = 9500ft



So Why Use Polymer Liners and Reinforced Tubing?

- Rapid Installation Time and Reduced Cost
- Enhanced Corrosion Resistance/
Hydrocarbon Resistance
- Flexibility for Tight Applications
- Reduced Pressure Drops