

Thermoflex® Tubing

Reinforced Thermoplastic
Gathering, Disposal and Injection
Lines

Overview and Case Studies

December 17, 2009



Why Use Thermoflex Tubing

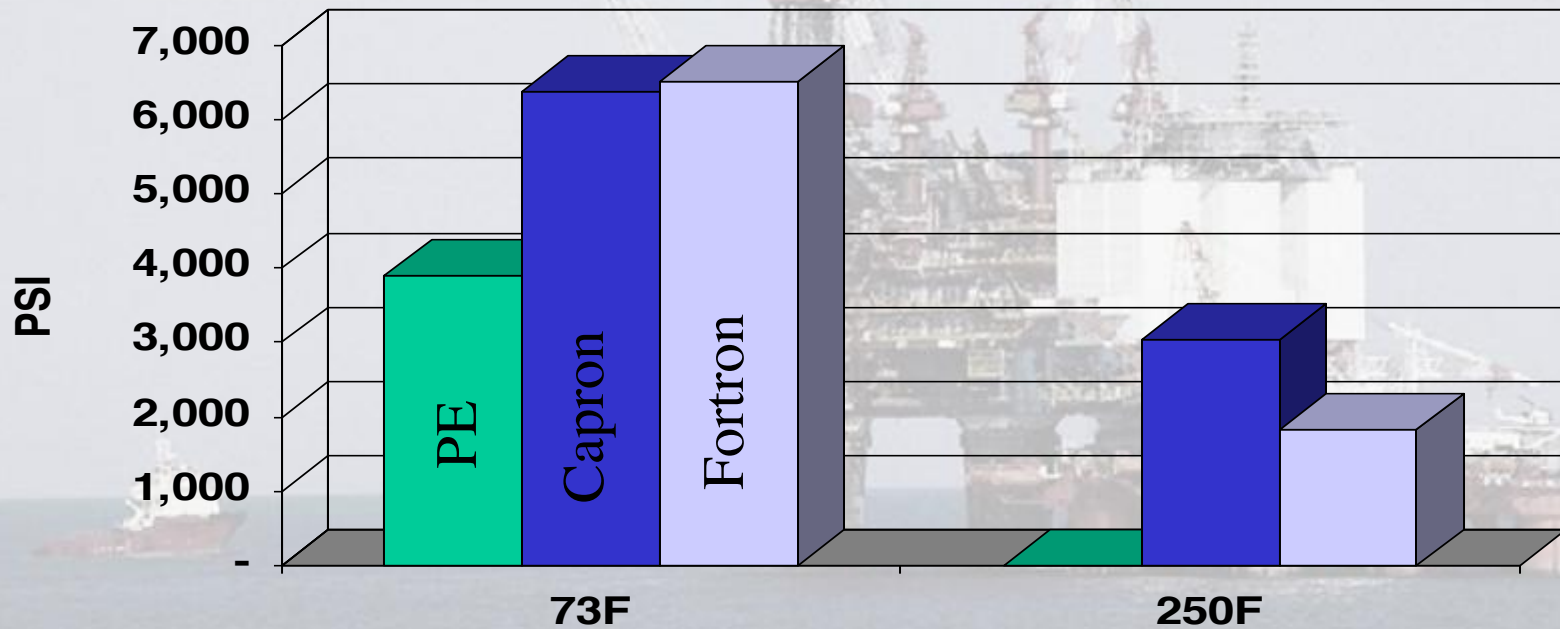
- Corrosion Resistance/ Hydrocarbon Resistance
- Rapid Installation vs. Steel
- Paraffin or Scale Issues
- Reduced Pressure Drop vs. Steel

Advantages of New Polymers

- Polyethylene has been Available for Years.
 - Good to 60C Operating Temperatures
 - Paraffin Adheres to Polyethylene
 - Poor Permeation Properties
- New Polymers with High Strength, Improved Corrosion Resistance, and Higher Temperature Performance Now Available
- Multi-Layer Technology has Reduced the Costs of Liners for Severe Applications

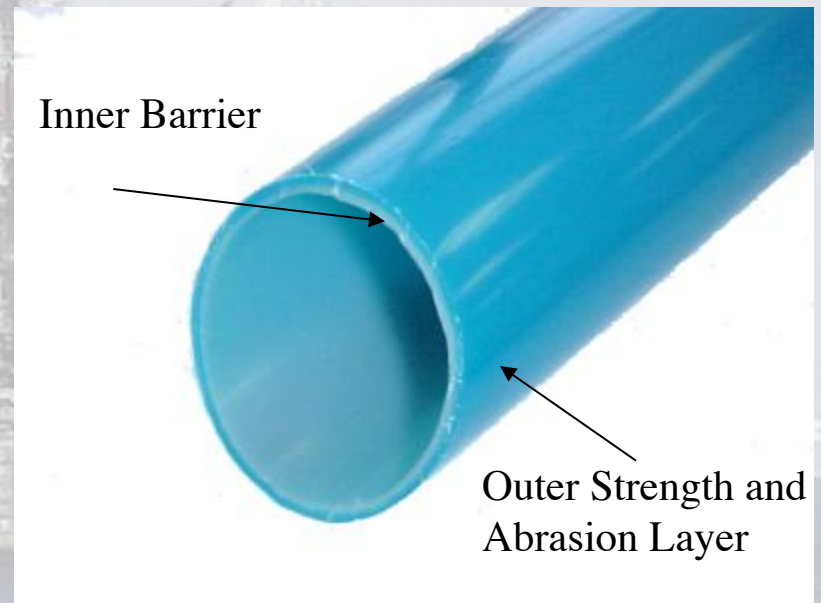
New Engineered Plastics Provide Higher Temperature Strength Not Available From Polyethylene (PE)

Tensile Strength (psi)



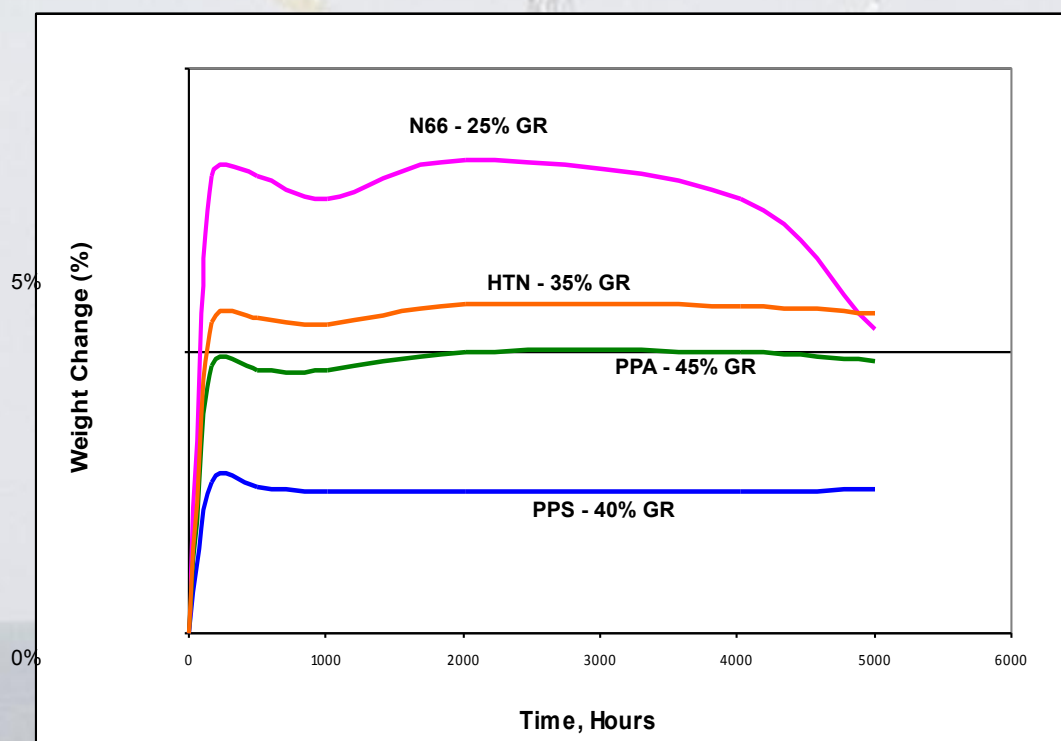
Liner Construction & Design

- 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
- Applications to 250F



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

10%

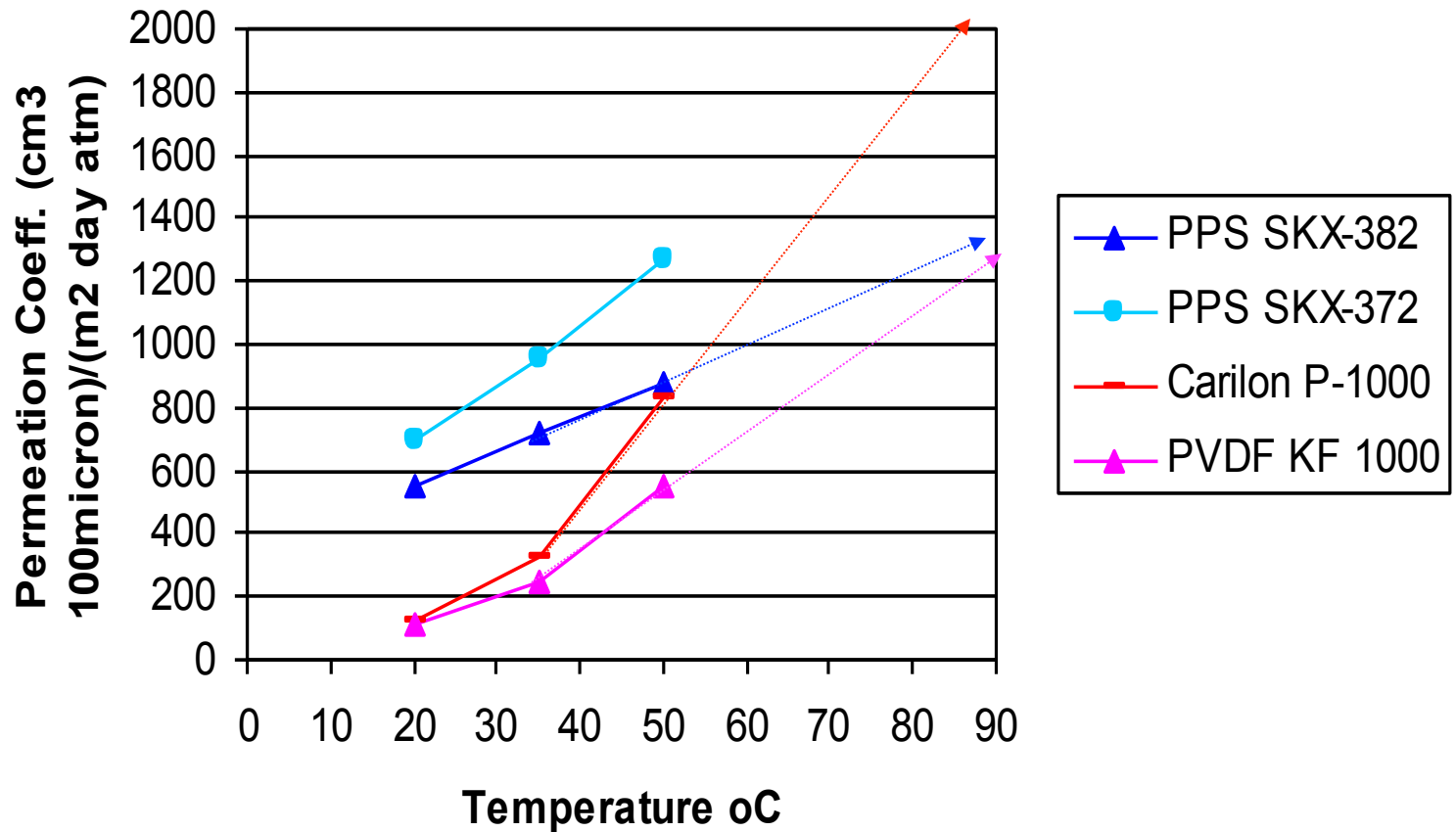


Polymer Estimated Life in Sour Environment (Years)

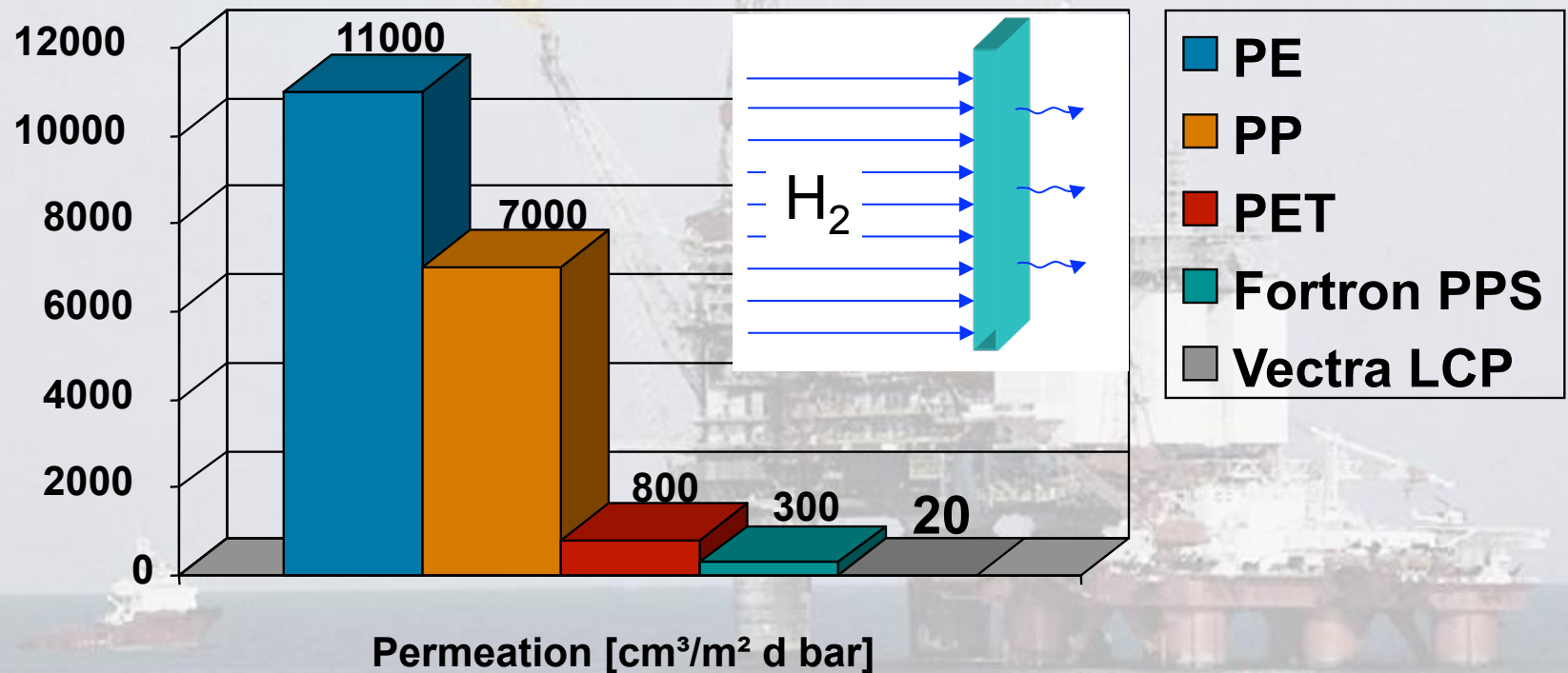
Temp (F)	Nylon	Fortron	HDPE
80C	1.2	>25	<.02
100C	.26	>25	NA
140C	.02	>25	NA

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

CO2 Permeability



Hydrogen permeation of Fortron (PPS) at 23 °C



Reinforced Tubing Design and Construction

- Multi-layer Design
 - Inner and Outer Barrier Layers
 - Center Layer Provides Higher Temperature Strength
 - Fiber reinforced with Kevlar for Strength, Tensile Load, and Burst

- Tubing Strength

$$P=(2*F*n)/D*L$$



Why Aramid Fibers vs. Glass

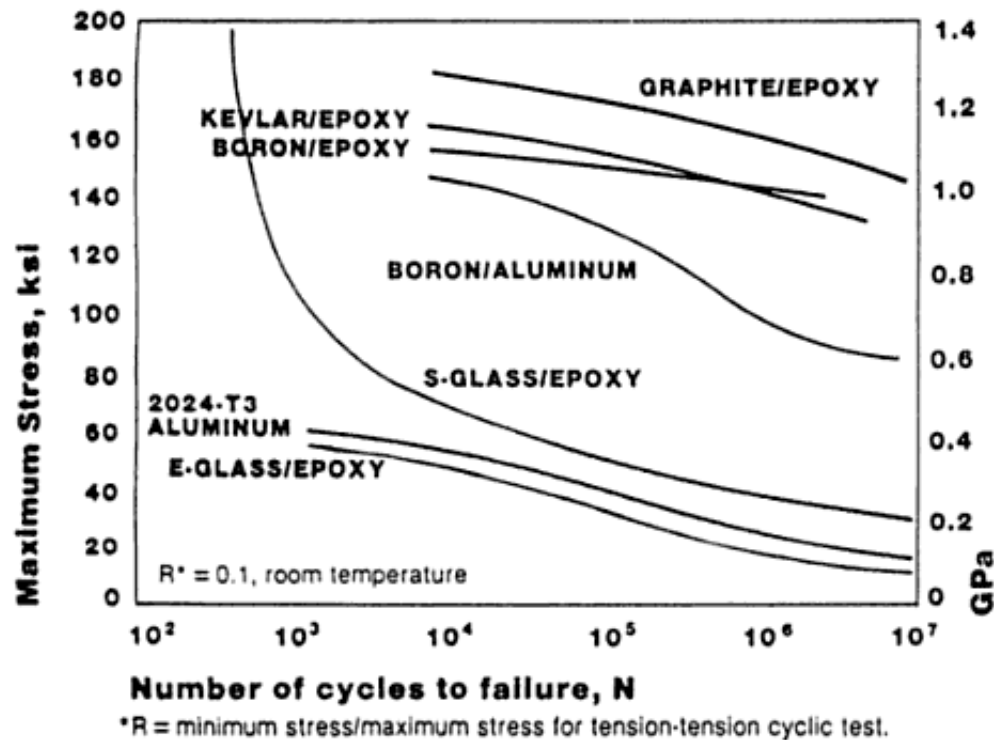
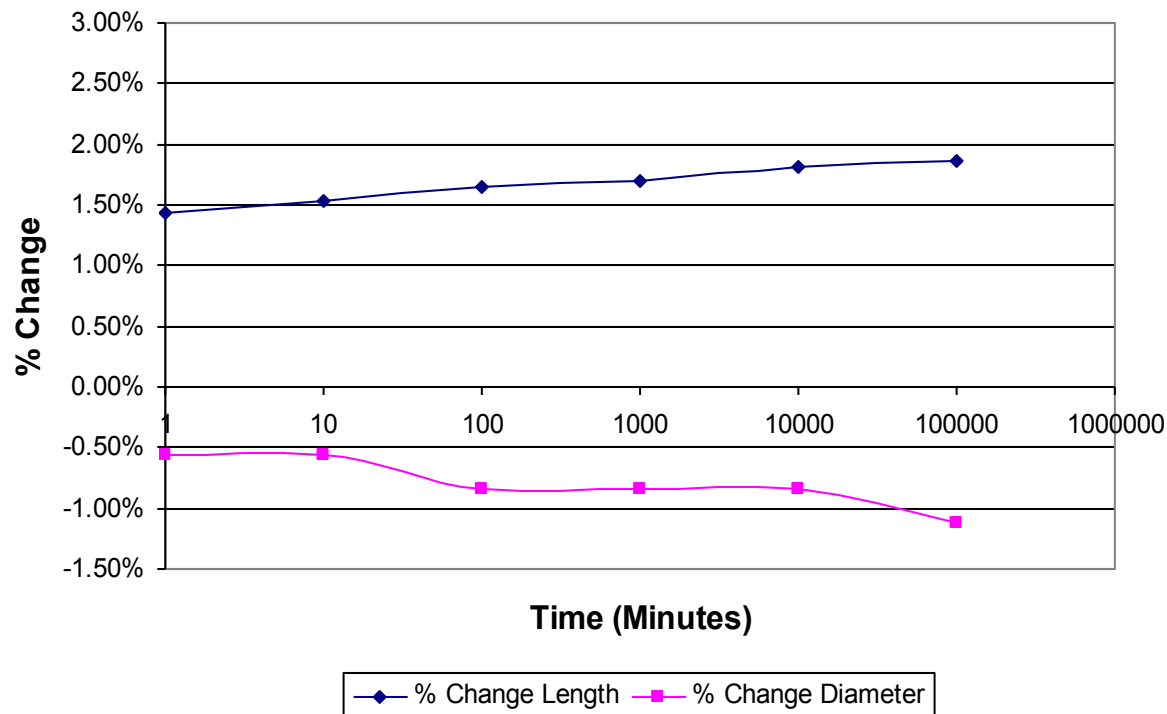


Figure 6.4 *S-N* curve to show the fatigue behavior of unidirectional composites and aluminum. From Ref. 62.

Creep Performance

Ø1.75 Creep Test @ 5000 lb



Design Strength vs. Short Term Burst Strength

2 3/8" 500PSI Rated	Burst Strength
Rated Braid Strength	500PSI
Design Braid Strength	893PSI
Short Term Burst Avg. Last 12 Months	2,297PSI

Testing Standards

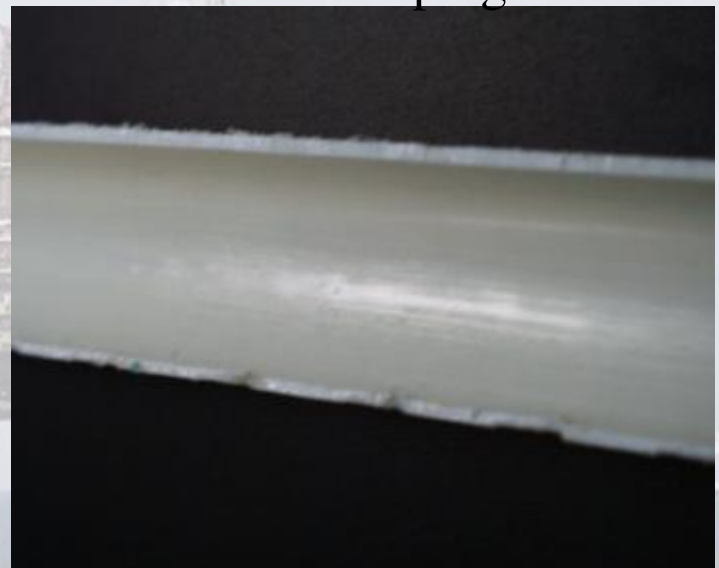
- API 15S Categorizes Composites into RTP & SCP
- ASTM D 2513 Thermoplastic Gas Pressure Pipe Not Fully Adequate
 - Reflects Poor Creep Properties of Polymers ASTM D1598
 - Reinforced Polymer Tubing Enhanced with Creep Resistant Fiber
- ASTM D2292 does not Reflect Excellent Fatigue Resistance of Thermoplastics and Aramid Fibers

Paraffin Testing

There is Adhesion to Unlined
Metal Fittings



No Evidence of Paraffin Adhesion
On the Piping



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

Tools For Coupling

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



Delivery of Tubing

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



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



Direct Bury

- Plow, Ditchwitch or Backhoe
- Pre-trenched ditches
Over 10miles/day
- Pull Pipe off
Stationary Spools
- Savings: \$5-6/ft
Installed vs. Steel



Trenching Requirements

- No Sand Bedding
- Trench Depth
Dependent on Frost
Conditions
- Can be Used for
Boring Applications

Capacitación y Instalación de la Tubería
Flexible Thermoflex en el Campo La Cira
Infantas

Octubre 12 -14 2007



West Virginia Brine Disposal Line

- 4.5" Thermoflex, 500PSI & 750PSI
- 10ft. Spools for Shipping
- 55,000ft in Three Weeks
 - Right of Way
 - Trench
 - Pipe Laying/Backfilling
 - Hydro



Gathering Line Line in California

- 500 PSI
- Very Light Soil May Require Watering of Backfill
- Trench Method a function of Soil Conditions



Water Flood Installation Through Hills

- Pull from Top to Bottom if Possible
- No Special Backfilling Requirements
- Tamping or Compaction a Function of Soil Conditions



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



Marcellus Tie In Lines

- Curving Right of Ways Requires Unspooling Along the Trench
- Trench Depth below Frost Line
- 3,000ft Tie In a Day with Three Man Crew



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



Rough Terrain



- Pull Length Determined by Turns
- Don't Use Trees for Turning Points

Boring

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



Equipment Required

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



Eliminating Welding



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



When Its Cold!

- Heating Unit Increases Flexibility below 20F
- 1.3hrs to increase 30F in Temperature



Gas Flow Line

- 300MCF/day
- 500psi Operating Pressure
- 1.75" OD Pipe
- Fortron Lined for Corrosion Issues



Inserting In Steel Pipe

- Pig Cable Through
- Pull Pipe Back Through
- Tensile Load Based Upon Drag
- Capable of Multiple Mile Pulls



Pull Through Steel Pipe

- Pull with Coupling or with Bolts for Tight Annulus
- Pull Strength Varies by Longitudinal Braids and Pipeline Layout
- Polyflow Models Pulls



Pulling Thermoflex Through

- 2 3/8" in 3" ID Steel
- Do not Recommend Pulling through Elbows
- Pull Speed 100ft/min



Offshore Rehabilitation

- Pull 3.5" Through 8" Flexible Steel Line for 6,000ft
- Single Pull Platform to Platform
- 90% Cost Savings vs. Replacement



Onshore to Offshore Pull

- 14,400ft Single Pull
- Through Existing 4", 6" and 8" Line
- Under 3,000lb Pull Force
- Neutral Weight to Water
- 2 Day Pull



Platform



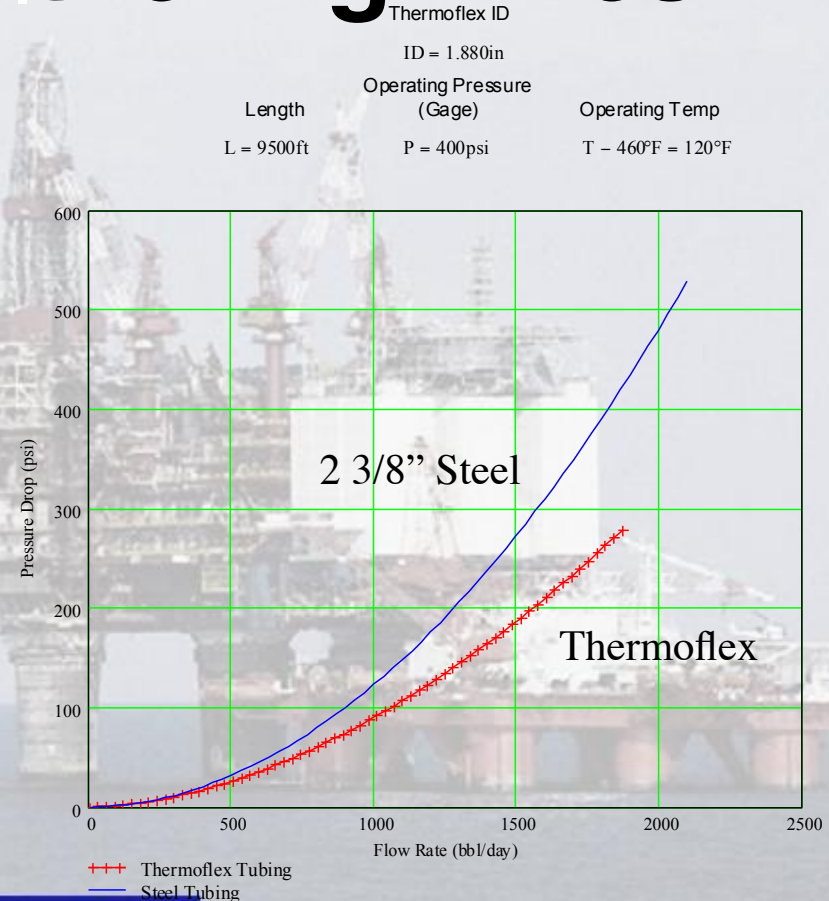
Double Walled System

- Pull Thermoflex Through Carbon Steel
- Flanged Terminations
- Fill Annulus with Packer Fluid/ Inert Fluid
- Monitor Pressure on the Annulus



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



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