Thermoflex® Tubing

Reinforced Thermoplastic
Gathering, Disposal and Injection
Lines

Offshore Rehabilitation of Existing
Steel Pipelines

December 9, 2009

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Background

- Existing Underwater Pipelines with Leaks are Expensive to replace or Repair
- Insertion of Thermoflex® Tubing is:
  - Low Cost
  - Requires Minimal Equipment
  - Long Term Corrosion Resistant Alternative
- Can Create a Double Walled System

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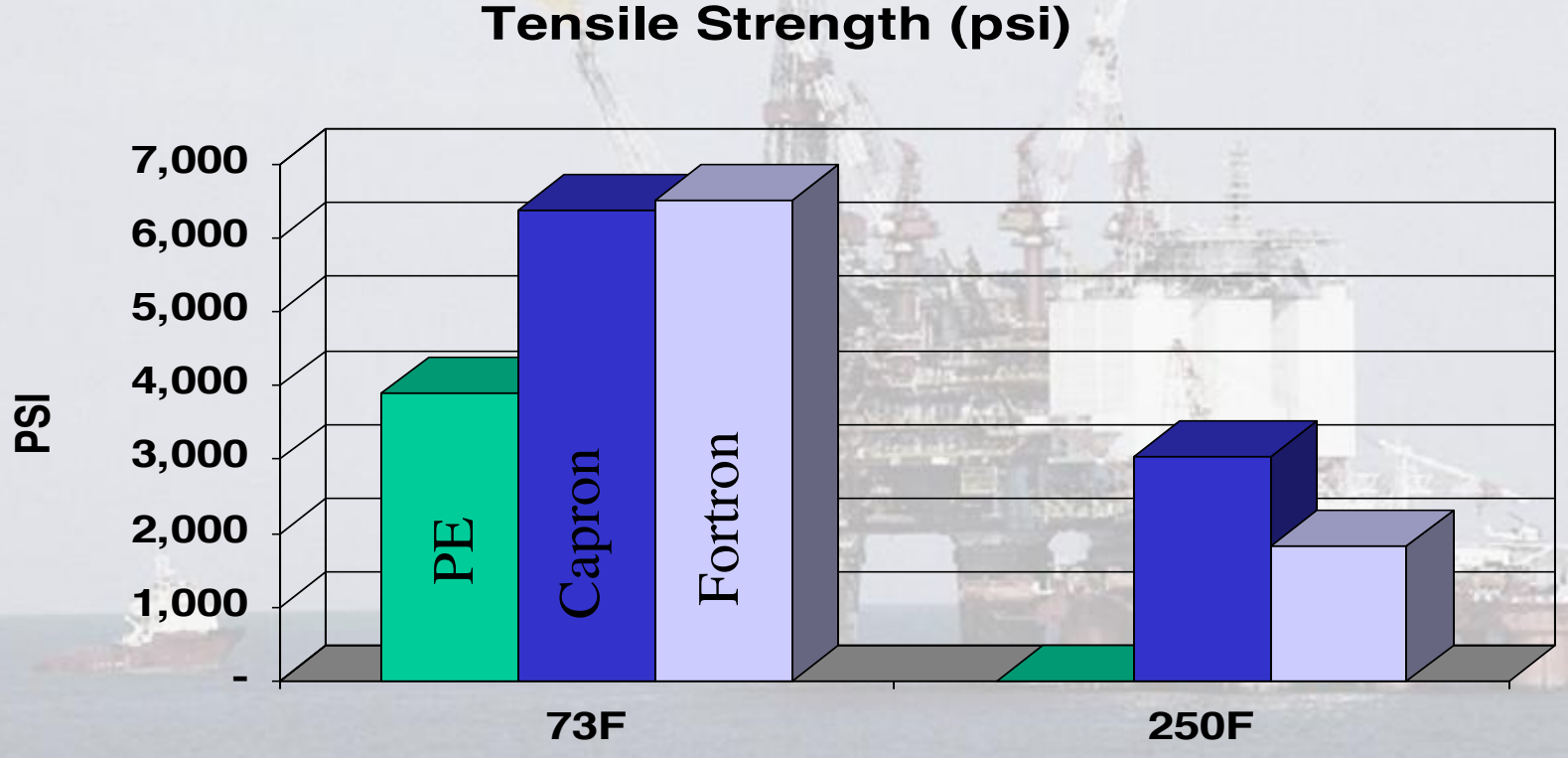
Presentation Today

What is Thermoflex Tubing

Case Studies Of Installations

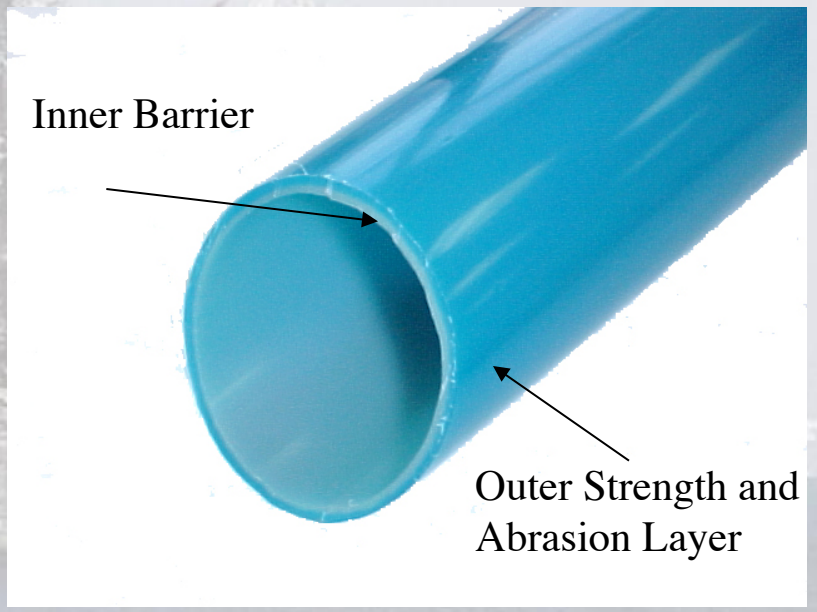
Next Steps

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



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



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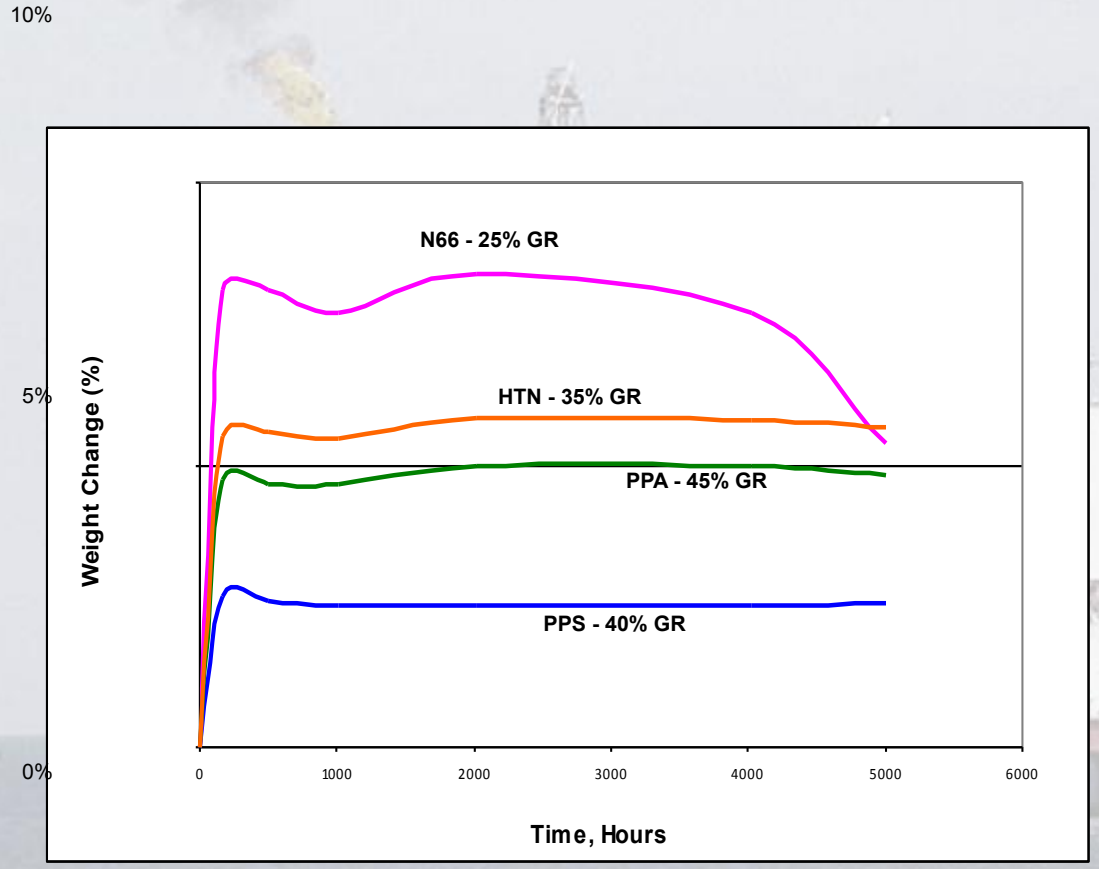
Long Term / Elevated Temp. Fuel Exposure

Weight Change - Fuel CM15 (121°C)



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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

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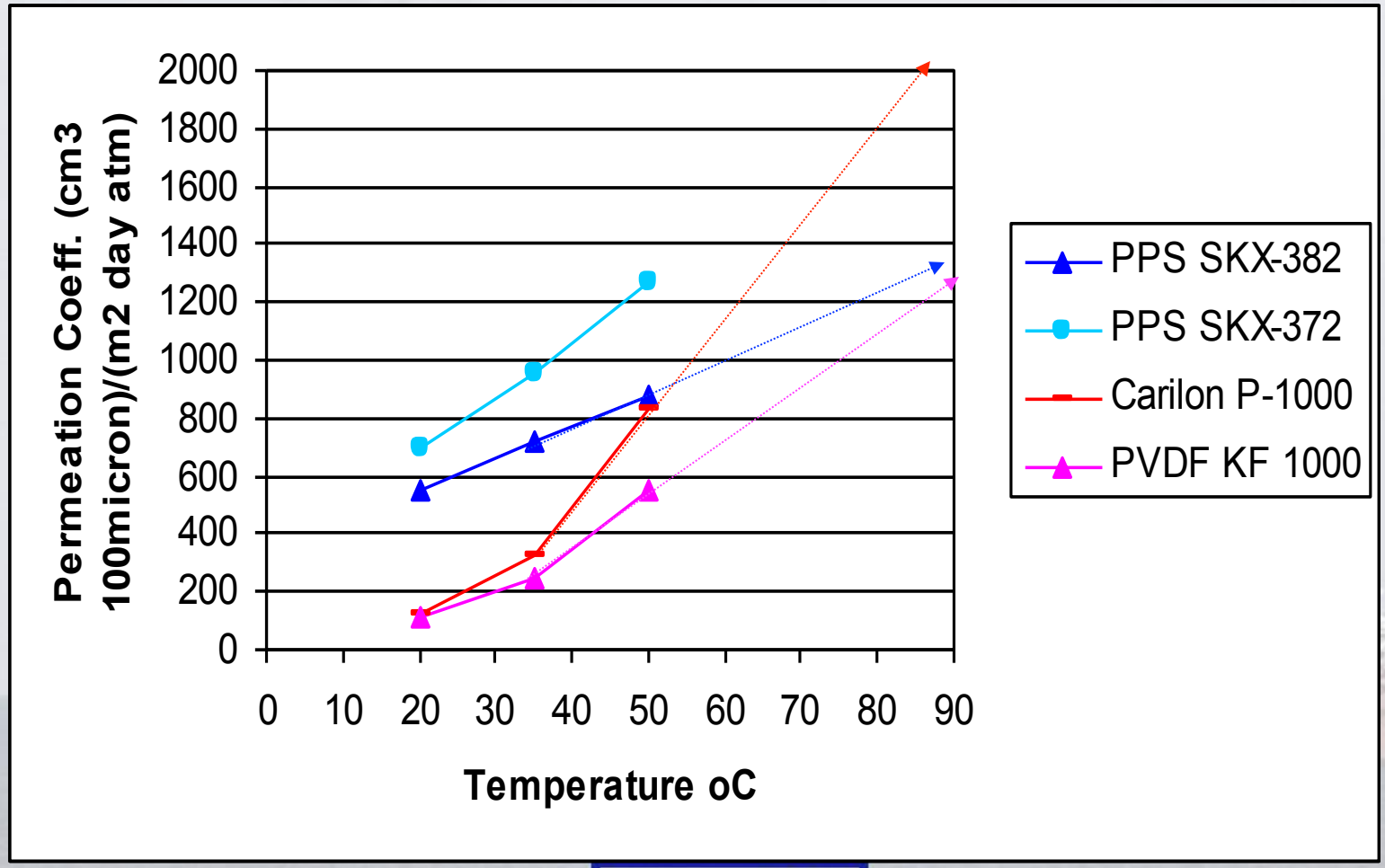
CO2 Permeability



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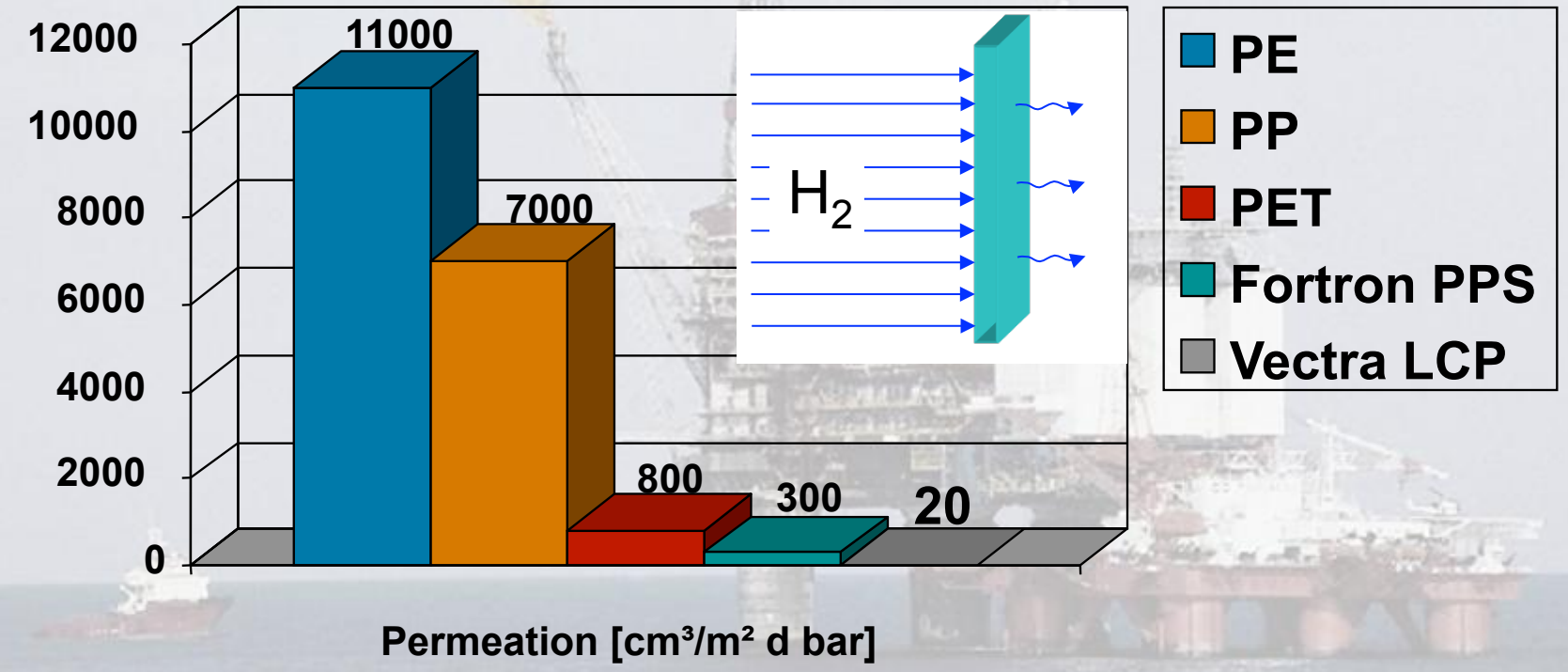
Hydrogen permeation of Fortron (PPS) at 23 °C



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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

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

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Why Aramid Fibers vs. Glass

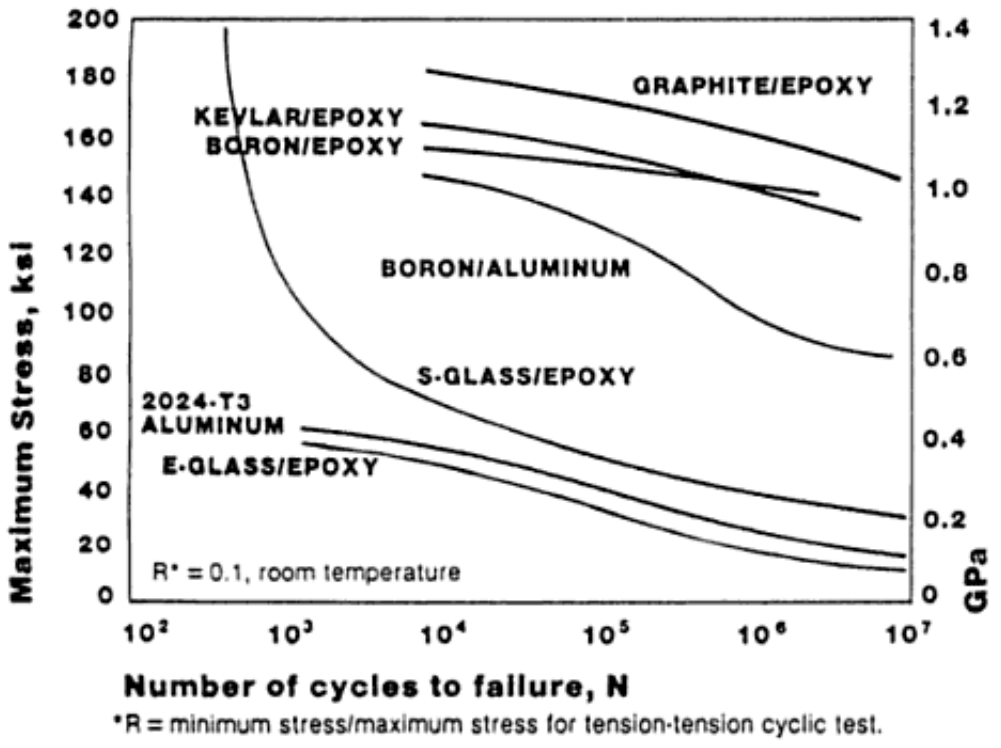
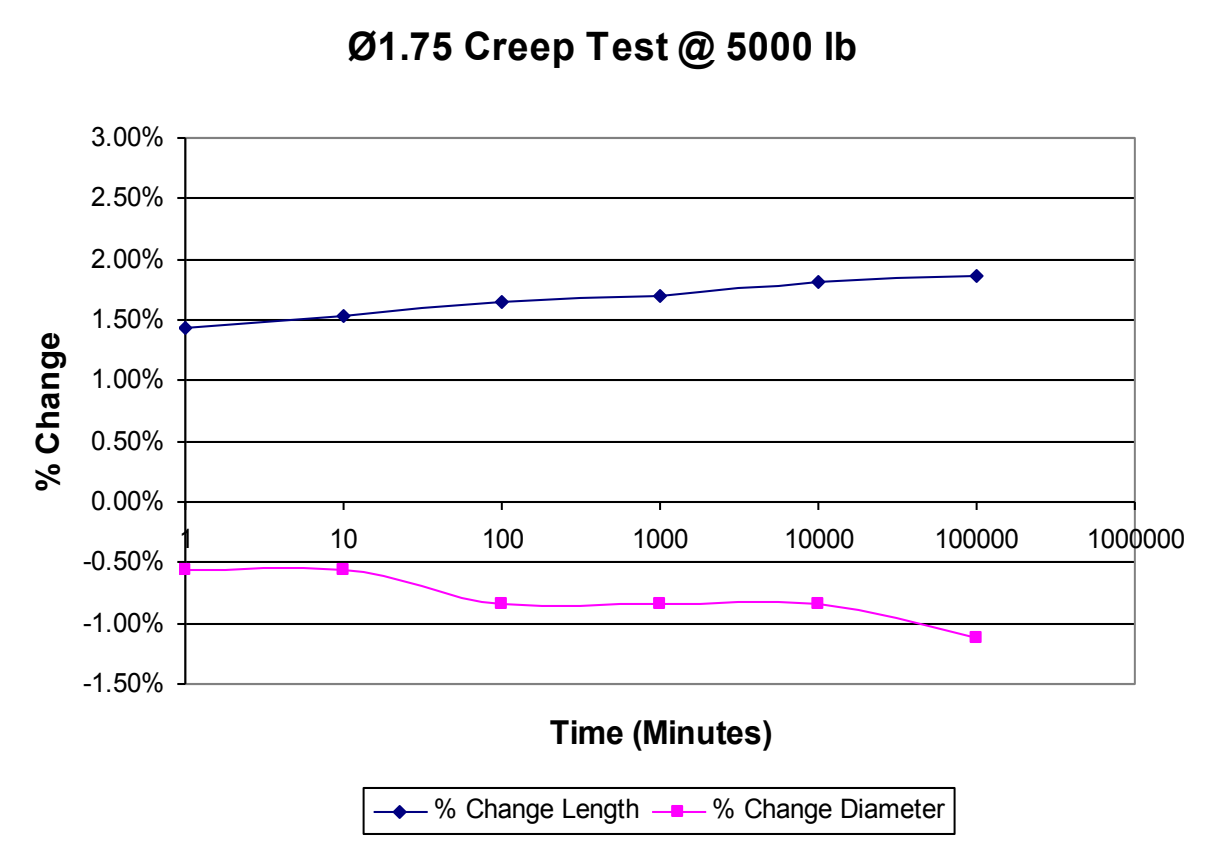


Figure 6.4 *S–N* curve to show the fatigue behavior of unidirectional composites and aluminum. From Ref. 62.

Creep Performance



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

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Rehabilitation Process

- Pig Line to Assure Path for Thermoflex
- Use Pig to Pull Rope or Cable Through the Line
- Pull Thermoflex back Through Line with the Rope or Cable
- Connect to Tie in Points

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Case Study for Crescent Petroleum

- Existing Flexible Steel Line Failure
- High Pressure Sour Gas with H2S (1,200PSI)
- 6,000ft (1.83Km) between Platforms
- Pulling 3.5” Thermoflex Through 8” Flex Steel

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Pull the Rope Through the Line

- Rope or Cable
  - Rope Lighter Weight
  - Less Pigging Pressure
- Flooding the line Reduces Drag
- Pig for Pulling the Rope
- Rope Rated for 34,000lbs

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Pulling Cone

- Attached to Thermoflex Termination Coupling
- 3” NPT Threads
- Holes In Cone to Allow for Water to Flood the Inside of Thermoflex Tubing

Prepping for the Pull

- Spools had 1,800ft length of Thermoflex
- Stage the Spools on the Platform

Pulling the Tubing

- Pull Force Never Exceeded 9,000lbs
- Pull one Length of Tubing, Stop, Attach Union Coupling, Pull Next Joint
- Pipe Pulled Through Flooded Steel Line

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Pulling From the Riser

Pipe after 6,000ft Pull
(1.83Km)

Union/Splice Assemblies

- Unions without Joints
- 250lbs (113kg) Machine
- 15 Minute Coupling Process

Terminations

- Flange Assembly to original Steel Assembly to to Seal off Annulus

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Hydro Test at 1850PSI

- Pressure line in Stages
- Stretch in Pipe Requires “Topping Off” Prior to Test
- Ran for 24 hours

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Results

- Total Project 8 days
- 90% less expensive than Replacing Steel
- Corrosion Resistant
- No Disposal of Old Lines

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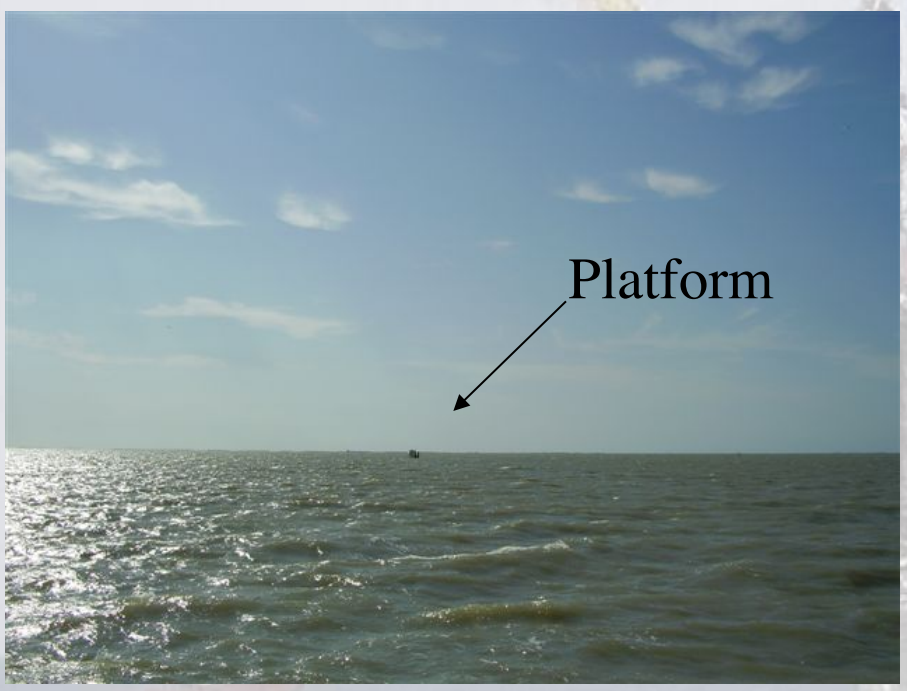
Pulling From Onshore to Offshore



- Gulf Of Mexico
- 14,400ft Pull
- Pigging Through Multiple Diameter Existing Pipe
- Oil /Brine Flow Line
- Install 2 3/8” Thermoflex

Pre-pulling Issues

- 4”, 6” 8” Line
- Riser Radii too Small
  - Lift Riser onto Barge
  - Terminate Pull Through Before Elbow
- Steel Riser but Could have used Thermoflex

Pulling from Land to Platform

- Staging Pipe on Land Easier
- Braided Rope vs. Cable because of Drag Weight
- Flooded Pipeline to minimize Drag
- 14,400ft . . . Under 3,000lb Pull Force

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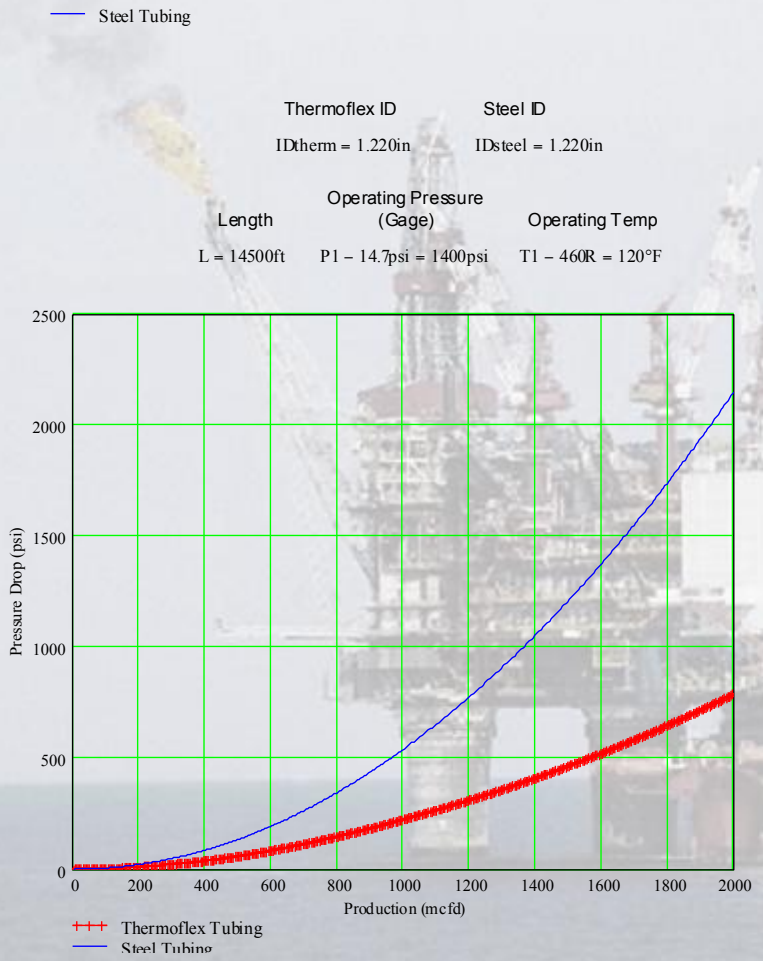
Results

- 2 Weeks to Pig
- 1.5 days to Pull
- Essential to Make Sure a Pig Gets Through before Project Starts

Key Planning Steps

- Model the Project
  - Optimal Pipe Size/ Type
  - Pull Through Risers?
  - Pull Force Requirement
- Determine Space Requirements
- Safety / Testing Requirements

Modeling



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