Reinforced Thermoplastic Pipes

A Presentation for
South Dakota School of Mines & Technology

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Outline

- Introduction
- Benefits
- Construction and Materials
- Manufacture
- Installation
- Jointing Systems
- Standards and Codes
- Technical Considerations
What is Reinforced Thermoplastic Pipe?

- A cost effective alternative to using steel
- A high pressure pipeline system resistant to corrosion
- Spoolable, ready-made, pipeline system
- Reels can hold long lengths of pipe
- 150, 300, 600 and 900 ANSI product in 2”, 3”, 4”& 6” ID sizes
- Can handle normal operating temperatures
Pipe Concept

- Corrosion of steel pipelines costs the oil and gas industry billions of dollars
- Alternative materials include plastic pipe and rigid fiberglass pipe
- Reinforced Thermoplastic Pipe (RTP) combines the best features of both
  - Eliminates corrosion
  - Resists installation abuse
  - Allows high operating pressures
- Significantly better economics than steel pipe
Typical Applications

Flow lines for gathering and transfer of:
- Crude Oil
- Gas
- Water
- Condensate
- Single phase, 2 phase & 3 phase streams
- Sour applications (H₂S)
- Gases or liquids containing CO₂
% of Total Marketshare - Pipe in Alberta (2" to 6", 150 to 600 ANSI only)

ERCB Permitted, MOP: 200psi to 1500 psi, Sizes: 2" to 6"
Benefits

- Same benefits as thermoplastic pipe
  - Ease of installation
  - Plowable
  - No corrosion
- Higher pressure ratings
- Compact product designs
  - Long lengths
  - Suitable for pulling through failed pipelines
Construction

- Cover
- Structural Layer (Reinforcements)
- Liner
Materials – Liner and Cover

Thermoplastic resins

• HDPE - High Density Polyethylene
• PEX - Cross Linked Polyethylene
• PA - Polyamide
• PVDF - Polyvinylidene Fluoride
Materials – Reinforcements

- Reinforcing fibers:
  - Glass fibers
  - Carbon fibers
  - Aramids, para-aramids
  - High performance fibers (M5, Spectra, Vectran, Zylon etc.)
  - Steel strips, wires, or cords

- Reinforcement matrix (if used):
  - Thermoplastic resin (HDPE, PA, PVDF)
Construction Example – Flexpipe

- ECR-Glass Fibers
- HDPE Cover
- HDPE Liner
Pipe Manufacture Example - Flexpipe
Pipe Manufacture - Flexpipe
Installation

- Trenching
- Chain Ditching
- Plowing
- Liner Pull
- Bore
- Surface Lines
**Trenching**
- Easily lowered into the ditch
- Welders are not required
Chain Ditching
• Minimal crews and equipment required
Plowing

- Reduces size of crew required
Plowing
- Multiple lines and couplings can be plowed saving time and money
Liner-Pulls
• Inserted through failed steel line
• Line does not have to be de-rated
• No corrosion for the life of the pipeline
Bores
- Short distances under roads
Surface Lines
- White jacket Flexpipe
Mechanical Fittings

Flanged End Fitting
- Compatible with standard raised face flanges.

Pipe to Pipe Coupler
- Used to connect two RTP pieces together.

Weldneck Fitting
- Used to connect RTP to steel pipe, using standard field welding procedures.
Electrofusion Fittings
**Fittings Configuration**

Pre-fabricated flow joints
- Fabricated in controlled shop environment
- Fully inspected
- Available fully coated
Standards and Codes

- Overview
- API RP 15S
- API 17J & K
- ASTM D 2992
- CSA Z 662
- Department of Transportation
Standards & Codes

**American Petroleum Institute**

**API** - RTP products are designed, qualified, and manufactured in accordance with API RP 15S, API 17J or API 17K.

**ASTM International** – Some RTP products must meet the requirements of ASTM D2992, “Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for Fiberglass Pipe and Fittings”.

API RP 15S

- Titled “Recommended Practice for the Qualification of Spoolable Reinforced Plastic Line Pipe”

- Covers:
  - Product Construction
  - Raw Material Selection
  - Qualification Requirements
  - Quality Control Requirements
API RP 15S – Qualification Testing

- API RP 15S prescribes an extensive program of product testing including regression testing, cyclic testing, joint testing, gas testing, bent testing, and axial load testing.

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<thead>
<tr>
<th>Testing Type</th>
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<tr>
<td>Regression pressure testing</td>
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<tr>
<td>Elevated temperature pressure testing</td>
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<tr>
<td>Low temperature pressure testing</td>
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<tr>
<td>Minimum bend radius pressure testing</td>
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<tr>
<td>Installation pressure testing – samples retrieved after liner insertion *</td>
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<td>Installation pressure testing – samples retrieved after plowing*</td>
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<td>Short term burst pressure testing</td>
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<td>Pressure testing of samples subjected to reverse bending</td>
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<td>Axial load testing</td>
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<td>Vent testing - gases venting from annulus</td>
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<td>Impact resistance testing*</td>
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<td>Thermal expansion &amp; pressure expansion testing</td>
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<td>Kink testing*</td>
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<td>Fitting gas leak testing</td>
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<td>Thermal cycle testing*</td>
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API 17J & API 17K

- API 17 J - “Specification for Unbonded Flexible Pipe”
- API 17K - “Specification for Bonded Flexible Pipe”
- Covers:
  - Functional Requirements
  - Design
  - Materials
  - Manufacturing
  - Documentation
  - Acceptance Tests
  - Marking
ASTM D2992 – Regression Testing

- Mean Regression Line of Long Term Hydrostatic Pressure
- 97.5% Lower Confidence Limit
- Maximum Pressure Rating (MPR)
- Maximum Allowable Operating Pressure (MAOP)
- Lower Confidence Limit (LCL)
- Design Life

Log (Pressure) vs. Log (Time)
CSA Z662

- CSA Z662-07, “Oil and Gas Pipeline Systems”
  - Covers the design, construction, operation, and maintenance of oil and gas industry pipeline systems
  - Includes composite pipeline material for gathering and distribution applications
  - Defers to the qualification methods given in API 15S, API 17J and API 17K
DOT – Department of Transportation

- RTP is currently being installed in unregulated areas in the United States
- RTP is currently not included in DOT Parts 192 and 195
- Efforts are underway to work within the DOT special permit process to install RTP in regulated areas.

- ASTM Standard for RTP pipe is in development
  - Work item WK11803 has moved to the final stages within subcommittee F17.11
Technical Considerations

• Pressure Capability
• Strain Behavior
• Installation Parameters
• Operation Parameters
• Permeation
• Collapse
Pressure Capacity

- Pressure capacity is dependent on:
  - Temperature
    - Some materials are temperature dependent
  - Time
    - Contribution of thermoplastic liner decreases over time
    - Some reinforcements also exhibit creep
  - Reinforcement loading
    - Capacities are achieved through adjusting amount of reinforcement and wrap angle
  - Manufacturing process
    - Methods of handling, applying, and bonding reinforcements affect performance
Strain Behavior

- Desirable strain behavior can be achieved through careful selection of construction and wrap angles.
Installation Parameters

- Acceptable ranges for the following parameters are defined for a given design:
  - Maximum tensile loading applied to pipe and fittings
  - Minimum bend radius
  - Temperature range for pipe deployment and joining system installation
  - Exterior abrasions and kinks
Operating Parameters

- Cyclic pressure
  - Important to match pipe and fitting designs with applications within acceptable cyclic performance envelope
- UV resistance
- Chemical compatibility
- Pigging
- Hot oiling
- Heat tracing
Permeation

- Permeation considerations:
  - Does gas accumulate in annulus and create a pressure that could collapse the liner?
  - Can gases that permeate through the liner vent to atmosphere?
  - Will gases that permeate through the liner create an environment that is incompatible with reinforcement materials?
  - Will gases that exit the pipe due to permeation create an environmental concern?
Collapse

• Pipe must be designed to withstand liner collapse due to:
  – Internal vacuum
  – External pressure
  – Pressure in annulus due to permeation
The Evolution of Pipelining

RTP Products provide proactive solutions reducing the overall costs of pipelining projects, eliminating the threat of corrosion and reducing damage to the environment.
Thank you!

Questions?