COMPOSITE PIPE APPLICATIONS AND DESIGN FACTORS TO EXTEND SYSTEM LIFE
PRESENTATION AGENDA

• Composite Pipe Design
• Composite Pipe Benefits & Limitations
• Design Factors to Extend Life
• Questions
What Is Composite Pipe?

• Plastic inner liner for corrosion resistance
• Reinforcement layer made of high strength materials examples: fiberglass, aramid fiber, steel
• Might include an epoxy layer
• External Jacket made of similar material to inner liner to protect and contain reinforcement layer
• Referred to as RTP Reinforced Thermoplastic Pipe or SCP Spoolable Composite Pipe
• Can be supplied on reels, in coils or stick lengths
Composite Pipe Industry Standards

- API RP 15S
- ASME B31
- ASME Composite pipe standard in development
- International regulations include local codes
  - CSA Z662 – Canada pipeline construction standard includes composite pipes
  - NTC 3728 – Colombia
- NOCs have developed internal standards including Saudi Aramco, KOC, YPF Argentina
Composite Pipe Pressure Ratings

- Steel reinforced pipe is rated on wall thickness and short term burst tests
- Fiber reinforced pipe is rated on regression testing per ASTM D2992

PSF = 0.67 as per API 15S
SFF = 0.67 as per CSA Z662
## COMPOSITE PIPE BENEFITS

<table>
<thead>
<tr>
<th></th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Corrosion Resistance</td>
</tr>
<tr>
<td>2</td>
<td>Erosion Resistance</td>
</tr>
<tr>
<td>3</td>
<td>Installation Time and Cost</td>
</tr>
<tr>
<td>4</td>
<td>Installation Safety</td>
</tr>
</tbody>
</table>
CORROSION RESISTANCE

- Based on historical data corrosion accounts for over 65% of buried pipeline failures in Alberta
- Suitable for corrosive applications
  - H2S
  - CO2
  - Produced Water
- Reinforcement material must be considered
- Liner material resistant to chemical depositions
EROSION RESISTANCE

- Suitable for high solids content
- Plastic materials have increased wear resistance in erosive flow regimes
- Wear of liner material will not impact strength of reinforcement layer

<table>
<thead>
<tr>
<th>Material</th>
<th>Coarse Sand 7 fps</th>
<th>Coarse Sand 15 fps</th>
<th>Fine Sand 7 fps</th>
<th>Fine Sand 15 fps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>0.65</td>
<td>1.81</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>Aluminum</td>
<td>1.81</td>
<td>7.48</td>
<td>0.14</td>
<td>0.86</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>0.06</td>
<td>0.46</td>
<td>nil</td>
<td>0.06</td>
</tr>
<tr>
<td>ABS</td>
<td>0.36</td>
<td>2.07</td>
<td>0.07</td>
<td>0.51</td>
</tr>
<tr>
<td>Acrylic</td>
<td>0.99</td>
<td>4.10</td>
<td>0.17</td>
<td>1.42</td>
</tr>
</tbody>
</table>
Flexpipe Experience with Corrosive / Erosive Oil & Emulsion Applications

- Number of lines assumes 2300 ft per line

![Graph showing the number of lines and miles installed from 2003 to 2014.](image)
INSTALLATION BENEFITS

• Smaller crew size: 2-4 people versus 10-12 for steel
• Less equipment & Lighter equipment
• Welding and weld inspection costs are eliminated
• Smaller Right Of Way requirement
• Spooled lengths up to and above 3500 ft
• Installation in ½ the time of steel
## INSTALLATION BENEFITS

Comparing installation costs of identical 6,500 ft flow lines

<table>
<thead>
<tr>
<th></th>
<th>6,500 ft FlexPipe Linepipe Flow Line</th>
<th>6,500 ft Steel Flow Line</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mobilization:</strong></td>
<td>2 Trucks:</td>
<td>6 Loads:</td>
</tr>
<tr>
<td></td>
<td>-1 x Track Hoe</td>
<td>-1 x Warehouse</td>
</tr>
<tr>
<td></td>
<td>-1 x Pipe Reels</td>
<td>-2 x Track Hoe’s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-1 x Grader</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-1 x Pipe</td>
</tr>
<tr>
<td><strong>Equipment:</strong></td>
<td>1 x 200D series track hoe for stripping top soil, digging, lowering and backfill</td>
<td>2 x 250 series track hoe’s and 1 x grader for top soiling 20 m ROW</td>
</tr>
<tr>
<td></td>
<td>-1 Supervisor</td>
<td>-1 Supervisor</td>
</tr>
<tr>
<td></td>
<td>-1 Equipment Operator</td>
<td>-2 Equipment Operators</td>
</tr>
<tr>
<td></td>
<td>-2 Laborers</td>
<td>-2 Welders (bead &amp; hot pass/cap)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-2 Welder’s Helpers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-3 Laborers</td>
</tr>
<tr>
<td><strong>Manpower:</strong></td>
<td>-1 digital deadweight</td>
<td>-1 digital deadweight</td>
</tr>
<tr>
<td></td>
<td>-2 recorders</td>
<td>-2 recorders</td>
</tr>
<tr>
<td><strong>Testing:</strong></td>
<td>Not Needed</td>
<td>Required, 100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>X-Ray:</strong></td>
<td>Not Needed</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Risers:</strong></td>
<td>Cathodic protection as required</td>
<td>Coating costs for risers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Demobilization:</strong></td>
<td>2 Trucks:</td>
<td>4 Loads:</td>
</tr>
<tr>
<td></td>
<td>-1x Track Hoe</td>
<td>-2x Track Hoe’s</td>
</tr>
<tr>
<td></td>
<td>-1x Pipe Reels</td>
<td>-1x Grader</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-1x Misc. equipment and materials</td>
</tr>
</tbody>
</table>
Composite Pipe Limitations

- Does not fit all applications
  - Pipe diameters
  - Operating pressures
  - Operating temperatures
- Relatively new to industry
  - Composite Pipe has been in use for 15 years versus steel pipe in use for 150+ years
  - Industry knowledge and understanding of Steel Pipe is very well developed
  - Education is needed on composite pipe and composite failure modes
- Not all composite pipe products perform the same
- Regulatory acceptance is not yet universal
Design and Construction Factors to Optimize Composite Pipe Life

Fitting and Riser System

- How repeatable is the fitting installation process? What opportunities are there for human error?
- When over-pressured, does the pipe or fitting fail first?
- As ground settles, how are shear loads next to fittings accounted for?
- What is the available temperature installation window?
- How is wall thickness variation accounted for to ensure distribution fitting clamping force around pipe?
Design and Construction Factors to Optimize Composite Pipe Life

Operating Factors

• Will the pipe grow axially or radially when pressurized? What must be done to compensate for the resulting movement?
• How are permeated gases accounted for?
  • Will service fluids lead to corrosion in composites reinforced with steel?
  • How are annulus spaces vented?
  • For fully bonded composites, how are voids where pressure can build prevented?
• Will pipe for surface lines survive ground fires?
• Will the pipe be used in an area that floods and is additional anchoring needed?
• Will the pipe survive cyclic fatigue due to water hammer?
• Does the supplier offer an application review to identify failure modes and ensure fit?
Design and Construction Factors to Optimize Composite Pipe Life

Installation Quality Control

• How much handling and impact damage can the product resist? Is sand bedding required?
• What is the available pipe installation temperature window?
• Can a third party be trained or does the vendor require that they install the fittings?
• Is detailed documentation of technical, installation, and training procedures provided?
• Is a process for tracking and documenting proper installation procedures provided? Recommend including a QC package in scope of work for third party contractors.
Composite pipe addresses corrosion and erosion issues while saving installation time and cost.

Verify application fit and use installation quality control systems to maximize value and extend system life.
FLEXPIPE OFFERS THE COMPLETE SOLUTION

Provide end-to-end solution for your individual needs