In-Situ Pipeline Coatings for Methane Emissions Mitigation and Quantification from Natural Gas Pipelines

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Presentation Outline

• Problem & Approach
• Technical Status
• Key Accomplishments
• Lessons Learned
• Synergy Opportunities
• Project Summary
Many methane transport lines are old and in need of retrofit.

No effective way of long range, cost effective leak detection + protection.

Macroscopic deposit buildup on the interior of pipelines can cause reductions in transport efficiency.

Causes both operational losses (increased wear on transport pumps, increased fuel consumption), and product losses (reduced maximum throughput).
State of the Art

- Nothing – (By far the most common!)
- Mechanical brush pigging
- Chemical cleaning; detergents, solvents, acids
- Internal factory coatings, fusion bond epoxies, etc.
- Inhibition injection
- Corrosion resistant alloys
- Internal liners
- Use of drag reducing agents (DRAs)
Problem and Approach

- Utilize an in-situ applied treatment to reduce surface roughness, limit corrosion, deposits, and formation of leaks.
- Scalable to full length of a pipeline.
- Does not require costly trenching and replacement of the line.
Technical Status – Materials Development

• Nanocomposite material that chemically binds to surface.
• Applicable by in-situ pig batch method
• Requires minimal surface preparation
• Imparts corrosion resistance, water and oil repellency, and low surface roughness.
• Water-dispersible material with no VOC issues.
Technical Status – Application Development

- Flowloop formed from 4” diameter, 500’ long, previously weathered transport pipeline.
- Loop contains two 1.5D bends separated by a 10’ length.
- Test spools mechanically cleaned prior to treatment.
- Treatment applied to final thickness of 4mil, applied via compressed dry air.
Technical Status – Field Trial Deployment

<table>
<thead>
<tr>
<th>Material</th>
<th>Average Roughness Value (μinch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>50</td>
</tr>
<tr>
<td>DragX Treated</td>
<td>100-140</td>
</tr>
<tr>
<td>Commercial Steel - (New)</td>
<td>180</td>
</tr>
<tr>
<td>Steel – Mechanically Brush Pigged</td>
<td>300-400</td>
</tr>
<tr>
<td>Steel – After Chemical Treatment</td>
<td>350-700</td>
</tr>
<tr>
<td>Steel – After 90 days of weathering</td>
<td>1000-1400</td>
</tr>
<tr>
<td>Steel – After 365 days of weathering</td>
<td>&gt; 4000</td>
</tr>
</tbody>
</table>

- Surface roughness reduced to below that of factory new steel surface, and 40-fold vs heavily corroded.
Technical Status – Application to Complex Geometry Pipelines

Ability to treat weld seams and flange joints
Technical Status – Application to Complex Geometry Pipelines

Ability to treat multi-diameter pipelines
Technical Status – Cost/Benefit Analysis

- Post-pigging, pressure drop through pipeline is reduced by 25%.
- Strong correlation between directly measured surface roughness and back-calculated roughness.
- DragX will reduce pressure drop within line by over 50% over heavily corroded/rusted pipeline.
Accomplishments to Date

• Optimized physical characteristics of treatment to allow for similar durability to commercially available epoxies while requiring substantially less downtime and applied thickness.
• Imparted hydrophobicity and oleophobicity to highly corroded metal substrates with minimal surface preparation.
• Characterized corrosion resistance and chemical compatibility of DragX treatment under typical natural gas pipelines.
• Developed and optimized application method to apply on pipelines between 2 – 16” in diameter.
• Reduced frictional drag in a treated pipeline by 25%, and 10% over traditional pigging.
• Demonstrated application and refurbishment of complex geometry pipelines.
Lessons Learned

• The key driver of technology adoption is not preventative protection against corrosion, but improved economic performance.
• Regularly scheduled maintenance through pigging is relatively rare and high risk, meaning there is limited opportunities for smart pigging field trials.
• Limited ability to work with crude oil/unprocessed gas due to handling challenges.
• Further testing under high pressure conditions and erosion conditions.
Synergy Opportunities

– New substrates & fluids, corrosion protection of carbon steel

– New ways to monitor and gain actionable intelligence on pipelines.
Field Demonstration Opportunities

New and Existing Pipelines
- Existing Line Refurbishment
- Water Lines
  - Pre-Treatment
  - Post-Treatment

Oil-and-Gas Adjacent Fields
- Fracking Tubing
- Coiled Tubing
Project Summary

• Key Findings
  – Ease of deployment and short downtime is highly attractive to operators.
  – Ability to add economic value is the key driver of early stage adoption.

• Next Steps
  – Key targeted field trials in different verticals to demonstrate economic value.
  – Additional scale up and long term value analysis

• Take-Away Message
  – DragX is able to balance the key interests of operators, producers, and the public at large, reducing maintenance costs, enhancing safety, and improving product throughput.