Assessing Pipeline Integrity: In-Line Inspection Technologies and Capabilities

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Outline

> Why an In-Line Inspection (ILI)/Pigging Program?
> What does it take to Run ILI Tools
> In-line Inspections Technologies and Integrity Threats
> Why an ILI Validation Performance?
> Summary
Why an In-Line Inspection/Pigging Program?

- To maintain and demonstrate the Safety, Integrity and Reliability of pipeline systems
- To meet compliance with applicable regulations
- In-line inspection technologies are an integral part of our system-wide pipeline integrity management program
- ILI assessment provide additional information about the condition of pipeline
  - when line segments can’t be reasonably made piggable, hydrostatic testing and direct assessment are other acceptable assessment options

Prioritizing Pipeline Segments to be In-Line Inspected
- Based on Threat Analysis and Risk = Likelihood x Consequence
- Assess impact to Safety, Reliability, Compliance & Customers

The Phases of a Pigging Program
- Make pipeline segment piggable
- Run ILI tools and mitigate areas of concern
- Establish appropriate re-inspection intervals
Running In-Line Inspection Tools

> Installing launchers and receivers
> Removing pipeline obstructions
  - Reduced port valves, tight fittings and bends, unbarred tees/take offs
> Setting up above ground markers (AGMs)
  - 1-3 miles apart
> Setting up a safe and appropriate driving route for tracking purposes
> Setting up the tracking boxes at the AGM sites
> Develop a work plan and gas handling procedure with Operations
Core ILI Technologies

- Caliper/Geometry & Inertia Mapping Unit
- Magnetic Flux Leakage (MFL) Axial & Circumferential
- Ultrasound and ElectroMagnetic Acoustic Transducers (EMAT)

- Deformation & X-Y-Z
- Corrosion
- Crack-like Indications

Standard Suite of ILI Tools

- Gauge Plate
- Brush Pig
- Geometry
- MFL

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Major North America ILI Vendors

Additional In-Line Inspection Resources

> Pigging Products & Services Association [http://www.ppsa-online.com/](http://www.ppsa-online.com/)
> Standards
  – API 1163 “In-Line Inspection System Qualification”
### Core ILI Technologies & Integrity Threats

<table>
<thead>
<tr>
<th>Caliper &amp; Geometry</th>
<th>MFL &amp; C-MFL</th>
<th>Ultrasound &amp; EMAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dents</td>
<td>Internal &amp; External Corrosion</td>
<td>Stress Corrosion Cracking</td>
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<tr>
<td>Ovality</td>
<td>Gouges &amp; Scratches</td>
<td>Tow Cracking</td>
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<tr>
<td>Wrinkle Bends &amp; Buckles</td>
<td>Selective Seam Corrosion (C-MFL)</td>
<td>Hydrogen Induced Cracking</td>
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<tr>
<td>Pipeline X-Y-Z with IMU</td>
<td>Seam Weld (C-MFL)</td>
<td>Laminations</td>
</tr>
<tr>
<td>Bend Radius &amp; Angle</td>
<td>Girth Welds (MFL &amp; C-MFL)</td>
<td>Linear Crack-like and</td>
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<tr>
<td></td>
<td>Seam Weld Defects (C-MFL)</td>
<td>Manufacturing Indications</td>
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<td></td>
<td>Previous Repairs with Metal Banding</td>
<td>Internal &amp; External Corrosion</td>
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Magnetic Flux Leakage Technology

Magnetic Flux Leakage Behavior across a Pipeline Wall

Sources: Tuboscope & GE-PII
<table>
<thead>
<tr>
<th>Year Range</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>~1964 First</td>
<td>First Commercial MFL</td>
</tr>
<tr>
<td>Commercial</td>
<td>• 90-degree tool</td>
</tr>
<tr>
<td>MFL</td>
<td>• No odometer</td>
</tr>
<tr>
<td></td>
<td>• Survey logs displayed on BW photographic paper (1-joint: 3/4”)</td>
</tr>
<tr>
<td></td>
<td>• Only most significant anomalies reported</td>
</tr>
<tr>
<td></td>
<td>• Difficult to determine if anomalies were metal loss or gain</td>
</tr>
<tr>
<td></td>
<td>• No POD or POI</td>
</tr>
<tr>
<td>1966-71 Full</td>
<td>Full Circumference MFL</td>
</tr>
<tr>
<td>Circumference</td>
<td>• With odometer</td>
</tr>
<tr>
<td>MFL</td>
<td>• Survey logs displayed on BW photographic paper (1-joint: 3/4”)</td>
</tr>
<tr>
<td></td>
<td>• Anomalies graded in 3 categories (&lt; 30%, 30-50% and &gt; 50% WT)</td>
</tr>
<tr>
<td></td>
<td>• Low resolution</td>
</tr>
<tr>
<td></td>
<td>• No POD or POI</td>
</tr>
<tr>
<td>1978-86 HR</td>
<td>HR Circumference MFL</td>
</tr>
<tr>
<td>Circumference</td>
<td>• With odometer, speed, orientation measurements</td>
</tr>
<tr>
<td>MFL</td>
<td>• Survey logs displayed on computer software</td>
</tr>
<tr>
<td></td>
<td>• Probability of 80% and sizing 20% WT</td>
</tr>
<tr>
<td></td>
<td>• High resolution</td>
</tr>
<tr>
<td>1990, 2000 and</td>
<td>Beyond…</td>
</tr>
<tr>
<td>Beyond…</td>
<td>• With odometer, x-y-z orientation, GIS, speed control module</td>
</tr>
<tr>
<td></td>
<td>• Multi-diameter, tethered with Caliper/Geometry tools</td>
</tr>
<tr>
<td></td>
<td>• Survey logs displayed on advanced computer software</td>
</tr>
<tr>
<td></td>
<td>• POD of 80% and sizing 10% WT</td>
</tr>
</tbody>
</table>

Sources: Tuboscope & GE-PII
MFL Technology Today

- MFL technology is a mature process
- Feedback loop to ILI providers for continuous improvement
Multiple MFL Runs

Sample A

Growth of 35%
(0.4 mm/yr)

Sample B

New Corrosion
(Growth of 35%)

Repair

2004

2007

2004

2007
Caliper/Geometry Tools
Laser Scanning of Dents

High Resolution External Surface Laser Mapping of Dents
ILI & Laser Mapping Comparison
Crack Detection Tools

**Electromagnetic Acoustic Technology**

Electromagnetic Acoustic Technology does not need liquid coupling

**Ultrasound Technology**

Ultrasound Technology requires liquid coupling
EMAT Users Group
Why an ILI Validation Performance?

> Because there are inherent uncertainties with the technologies
  > Uncertainties need to be understood and properly accounted for

> Because the “largest defect that an inspection tool can miss is more important than the smallest defect the tool can find”

> Because not all indications reported by the ILI tools need to be excavated
  > Determine a high level of confidence that those indications not excavated will not pose a safety concern until the next re-inspection interval

> To determine and document that the ILI tools performed within their stated specifications
  > sizing (depth & length), type of feature, predicted burst pressure, etc

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Summary

- We all share a common goal: **zero incidents**
- Pipeline industry strong commitment to safety
- In-line inspection technologies are an integral part of our system-wide pipeline integrity management program
- We continue to experience great success with the ILI Tools/Analyst process
- An ILI performance validation program is essential
  - To understand and account for the uncertainties inherent in the process: *Tools/Analyst*
  - To assist with the appropriate Prioritization-Response-Remediation
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