ULTRASONIC GEOMETRY
PROVEN ACCURACY FOR RELIABLE ASSESSMENT

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TECHNOLOGIES EXPLORED

Caliper based Inspection
- mechanical sensing

source: internet ROSEN / ENDURO

Ultrasonic Geometry Inspection
- ultrasonic sensing
THEORY OF APPLICATION

Pipe wall e.g. Steel

Coupling medium e.g. Diesel

Ultrasonic sensor

Time of Flight 1

Time of Flight 2

Wall Thickness (WT)

Stand-off (SO)

New sensor carrier

UG Module

Pipeline cross-section

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ADVANTAGES

Direct measurement
- Measure ID
- Nominal OD or WT not required
- WT sampling
- Welded fixtures visible

No sensor calibration
- Same baseline for all channels
- Real full circumference scan
ATLAS UG SETUP

- Multiple sensor ring module arrangement
- Stainless steel body with embedded sensors

Wall Thickness

- Sensor overlap (coverage redundancy)
- Circumferential resolution down to 8 mm
3D tool position and orientation

- get the data for every single ring
- calculate
  - center position
  - orientation
  - tilt angle
- apply coordinate transformation to data

➢ ability to handle
  ✓ tilt
  ✓ decentralization
  ✓ vibration
Axial resolution down to 1.5 mm.
ADVANTAGES – NON CONTACT

- Lift-off due to speed (higher depth)
- Incorrect shape due to deflection of arms

Flow Direction

Accurate shape acquisition

- Direct measurement
- Avoid lift-off
- Avoid sensor damage
- Bidirectional option
OVER SPEED EFFECT

- Mechanical Caliper rebound effect on girth welds: lift-off effect could be mistakenly interpreted as exceeding root penetration.

Mechanical Caliper speed: 2.5 m/s

Ultrasonic Geometry speed: 3.0 m/s
ADVANTAGES – WALL THICKNESS DATA

Detection and identification
• Welded sleeves
• Patches
• Welded fixtures
• Corrosion
TESTING AND SPECIFICATION
ILI DATA

- NPS: 12"
- Type: dent
- Depth: 14.0 mm
- Length: 343 mm
- Width: 144 mm
- O’clock position: 5:55
## FIELD VERIFICATION

<table>
<thead>
<tr>
<th>Field</th>
<th>ILI</th>
<th>NDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPS type</td>
<td>10&quot;</td>
<td></td>
</tr>
<tr>
<td>NPS type</td>
<td>dent</td>
<td></td>
</tr>
<tr>
<td>depth</td>
<td>10.4 mm</td>
<td>10.8 mm</td>
</tr>
<tr>
<td>length</td>
<td>116 mm</td>
<td>149 mm</td>
</tr>
<tr>
<td>o'clock position</td>
<td>2:34</td>
<td>2:10</td>
</tr>
</tbody>
</table>
FIELD VERIFICATION RESULTS

- Dig verification results record
  - 29 dig reports
  - 29 within specification
  - ILI tolerance: ± 1 mm
  - NDE tolerance: ± 1 mm
# Evo Series 1.0 Atlas UG

| Detection threshold for dents and ovalities at ≥ 90% POD with 80% certainty | 2 mm | 0.079 in |
| Detection threshold for dents and ovalities at ≥ 90% POD with 90% certainty | 2 mm | 0.079 in |
| Depth | ± 1 mm | ± 0.04 in |
| Length | ± 6 mm | ± 0.24 in |
| Width | ± 15 mm | ± 0.59 in |

1. Depth in percent can be calculated dividing the Depth (mm/in) by OD (mm/in), absolute value is provided as direct measurement NDT method
2. Depth sizing accuracy based on 1.5mm (0.06 in) axial sampling and 15mm (0.59 in) circumferential resolution
More than 4,000 km inspected Worldwide

Figures in km
Accumulated since March 2016
Geometry &

- crack inspection
- corrosion inspection

in a single run

Identify combined anomalies

- interaction threads
- intrinsic data correlation
- > 280 features reported
  - 17 verified
**DENT & EXTERNAL METAL LOSS**

<table>
<thead>
<tr>
<th>Dent value</th>
<th>ILI</th>
<th>NDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (mm)</td>
<td>3.0</td>
<td>3.6</td>
</tr>
<tr>
<td>Orientation</td>
<td>00:04</td>
<td>00:00</td>
</tr>
<tr>
<td>Type</td>
<td>Dent &amp; External Metal Loss</td>
<td></td>
</tr>
</tbody>
</table>
VERIFICATION BY LASER SCAN

Scan procedure

Scan result
NDE – LASER SCAN – ULTRASONIC DATA

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BENEFITS OF SUPERIOR DATA QUALITY
Progress in assessment methods
- from singular assessment parameter, e.g. depth
- to shape based assessment

Fatigue life assessment (MD4-9)
- based on axial and circumferential shape parameters

Strain calculation
- based on 3D data
<table>
<thead>
<tr>
<th>Type</th>
<th>Channels</th>
<th>Depth</th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical</td>
<td>24</td>
<td>5.0 mm</td>
<td>132 mm</td>
<td>107 mm</td>
</tr>
<tr>
<td>Ultrasonic</td>
<td>64</td>
<td>6.1 mm</td>
<td>108 mm</td>
<td>32 mm</td>
</tr>
</tbody>
</table>
PRCI MD4-9 ASSESSMENT PARAMETERS

US CCW

Relative deviation [%]

-100.0 -80.0 -60.0 -40.0 -20.0 0.0 20.0 40.0 60.0 80.0 100.0

Restraint length-based
Restraint depth-based ≤ 2% OD
Restraint depth-based > 2% OD
X1 restrained
X2 restrained
X3 restrained
X4 restrained
X1 unrestrained
X2 unrestrained
X3 unrestrained

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STRAIN ASSESSMENT

Geometry Data

Axial Curvature

Circumferential Curvature

Geometry Data

Axial Curvature

Circumferential Curvature

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STRAIN ASSESSMENT

Axial Membrane Strain

Axial Bending Strain

Circumferential Bending Strain

Axial Membrane Strain

Axial Bending Strain

Circumferential Bending Strain

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STRAIN ASSESSMENT
<table>
<thead>
<tr>
<th>Strain parameter</th>
<th>Mechanical</th>
<th>Ultrasonic</th>
<th>Rel. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial curvature</td>
<td>-4.4 \times 10^{-3} [1/mm]</td>
<td>-3.8 \times 10^{-3} [1/mm]</td>
<td>16 %</td>
</tr>
<tr>
<td>Circ. curvature</td>
<td>+4.3 \times 10^{-3} [1/mm]</td>
<td>+4.8 \times 10^{-3} [1/mm]</td>
<td>10 %</td>
</tr>
<tr>
<td>Axial membrane</td>
<td>0.3 %</td>
<td>0.2 %</td>
<td>50 %</td>
</tr>
<tr>
<td>Axial bending</td>
<td>2.6 %</td>
<td>2.3 %</td>
<td>13 %</td>
</tr>
<tr>
<td>Circ. bending</td>
<td>0.7 %</td>
<td>1.4 %</td>
<td>50 %</td>
</tr>
<tr>
<td>Combined internal</td>
<td>2.7 %</td>
<td>2.3 %</td>
<td>17 %</td>
</tr>
<tr>
<td>Combined external</td>
<td>2.7 %</td>
<td>2.3 %</td>
<td>17 %</td>
</tr>
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SUMMARY

- Ultrasonic geometry measurement – Atlas UG

- non contact → robust, immune to exaggeration
- high precision → state of the art &
- high resolution → progressive assessment methods
- combined inspection → single run: geometry & corrosion
  → single run: geometry & crack
  → interacting threads
THANK YOU!