Non-Intrusive Ultrasonic Corrosion-Rate Measurements in Lieu of Manual and Intrusive Methods

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Outline

• Historical Overview:
  • Manual UTT vs Installed
  • Intrusive vs Non-Intrusive

• Applications

• Field Trials

• Conclusion
Manual Spot UT Thickness Can Provide False Confidence
Non-Intrusive UT System Attributes

1. Non-invasive to pressure boundary = Safe
2. Direct measurement of the asset condition
3. Modular and versatile
4. Portable / battery operation
5. Non-reliant on IT departments
6. Accurate including Temp Comp.
7. Easy access to the data
8. Cost effective: Targeting <$1k / point
Installed Sensor System Topology

- Wired or wireless
- Common back-end data management software
- Many sensor-points per system (1 to 512)
- Technology is the enabler:
  - IoT
  - Lower-cost cellular
    - 2G, 3G, 4G, 5G
    - CAT-M1 for M2M
  - Lithium Batteries
  - Low-power ICs
Data collection frequency is key to enhanced trending.
Minimizing variability for Precision Ultrasonic Measurements

Precision UT is a time-based measurement:  
Thickness = (Time / 2) x Acoustic Velocity

1. **Same spot with exact same equipment**
2. Gating a precise time measurement
3. Correcting for temperature changes
4. V-Path correction
5. More frequent data with higher data fidelity allows precise trending

\[
\frac{d_1}{2} = C_1 \Delta t \quad (2)
\]

\[
C_1 = C_0 (1 + k(T_1 - T_0)/100) \quad (3)
\]
Improving Accuracy by Removing Variables

Factors Affecting Gauge Accuracy and Precision in the Field

<table>
<thead>
<tr>
<th>Accuracy</th>
<th>Precision</th>
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<tbody>
<tr>
<td>Operator variability</td>
<td>Operator variability</td>
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<tr>
<td>Sound velocity and acoustic zero calibration</td>
<td>Velocity and acoustic zero cal (msmt to msmt)</td>
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<td>Echo quality</td>
<td>Echo quality</td>
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<tr>
<td>Sound velocity uniformity</td>
<td>Electronic or ultrasonic noise</td>
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<tr>
<td>Surface roughness</td>
<td>Transducer placement variability</td>
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<tr>
<td>Transducer coupling variability</td>
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<tr>
<td>Temperature variation</td>
<td>Temperature Variation</td>
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* Parameters in italics are eliminated or reduced with installed sensors
1 Reading/day Yields 0.0001” (2.5 micron) Thickness Resolution
0.0005 mm/day (7 MPY) corrosion rate can be determined
Pit-track™

A unique ultrasonic hardware & software solution that allows asset owners to precisely monitor the growth of critical individual pits.

- **Dual-element transducer**
  - ~1/8” (3 mm) spot size (@ - 6 dB) at 3/8” (10 mm)
- Measure down to 0.040” (1 mm)
- Resolution to 0.0001” (2.5 micron)
- Temp range: -5° to 300 °F (-20 ° to 150 °C)

Multiple pits can be tracked with auto-alarm capability via e-mail. Used post ILI and/or in conjunction with conventional UT scan data Pit-track can monitor
5 FIELD DEPLOYMENTS
Atmospheric Gas-Oil Line Monitoring

**Overview:** Customer wants to extend asset life to next turn-around corrodng

**Application:** Atmospheric gas-oil, ~270°C, 3” measuring ~0.120” remaining wall

**Product Used:**
- Temporarily installed cellular w/ 4 HT probes
- Monitoring interval: 6 hours
- Install: 4 hours

**Outcome:** Refinery able to safely monitor process piping which was not scheduled to be repaired during outage and trend for future metal loss conditions
HydroFluoric (HF) Alky Unit Monitoring

**Product Used:**
- Cellular w/ 8 dual element probes temporarily attached, managed by refinery maintenance team
- Monitoring interval: 12 hours
- Installation time: 4 hours

**Outcome:** Objectives achieved
- Safe – kept personnel from climbing and cumbersome inspection positions on tower
- Economical – saved >$365K in inspection cost
- Easy to install/monitor, accurate, and semi-permanent solution
Overview: Customer built new unit to increase production. H₂S line prone to corrosion at two different 90s before overhead line. Elected to use non-intrusive permanently installed UT sensors to monitor pipe intrados, extrados, top, and bottom locations in lieu of installing a heat trace to maintain dew point.

Application: Vacuum Fractionator
~150C (300F)
• 12” Sch. 40 ... all nominal wall thickness 0.4” +/- 12%
Overview:
• Customer installed new overhead lines connecting units.
• Lines located in un-accessible areas and wanted data on corrosion rates and inspection needs.
• Customer installed permanently installed UT sensors to monitor pipe intrados, extrados, top and bottom locations

Application: Crude Overhead Line 100C-38C (212F-100F)
• 12” Sch. 40 ... all nominal wall thickness 0.4” +/- 12%
Pipeline Integrity

Overview:
• An ILI report showed a number of low spots at three separate locations along a 100’ stretch of gas pipeline.
• Operator avoided fix/repair or bury/inspect more frequently by installing sensors on known low spots

Application:
• 30” natural gas transmission line nominal ~.300”
• Low spots ranging from .120” to .240” – buried

Product Used: Modbus configuration w/ 8, 25’ dual element probes permanently attached and buried to monitor “low spots” as identified by masses screening
• Sensors were attached via epoxy & stopaq and buried
• Enclosure used to house DSI & act as collection point for techs
• Operator will vary frequency of manual readings
Process Control of Offshore Production

- Sand erosion monitoring
- 8–16 UT thickness monitoring sensors per pipe elbow extrados
- Monitor from 1 mm to 100 mm with 2.5 μ resolution
- 1–32 transmitters per single cable network tied directly to control room’s DCS
Web-based Data Management

- Auto archiving and record retention simplicity
- Alarms & Warnings via e-mail
  - Min T and Max rate
  - Ex. < 1.1 mm or > 0.01 mm / week
- Corrosion-rate calculation
- Automated reporting and e-mail alerts
- Google Maps & GPS asset location
- Accessible from any web-browser device
Conclusions

1. Higher-fidelity and higher-frequency data are available
2. Can be monitored locally or remotely
3. Can be temporarily installed without welding - Sensors can be easily moved
4. Short-term data obtained and trended faster
5. More economic and safer for personnel than manual UT even on short-term basis