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

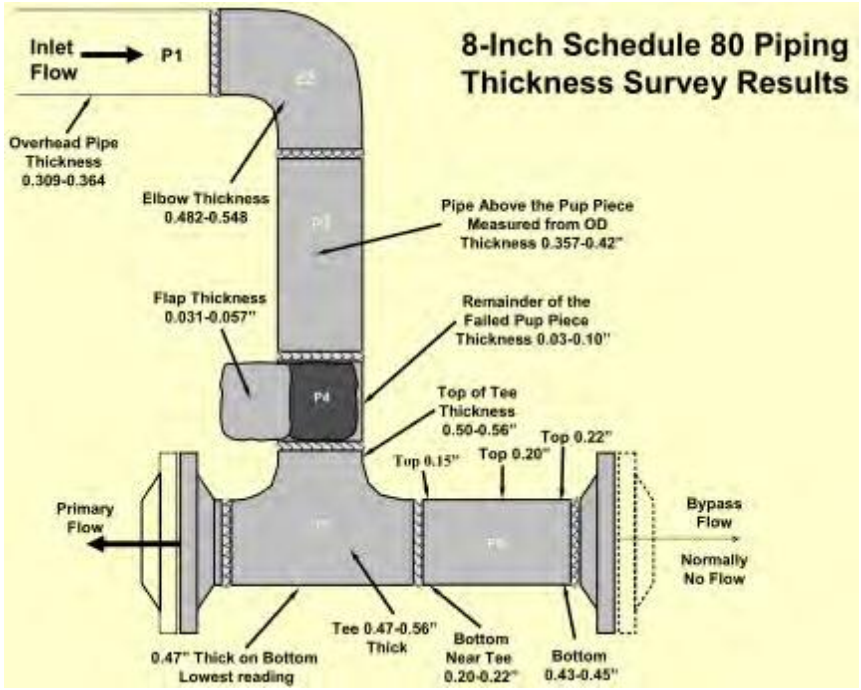
Mark Feydo, Steve Strachan, Bruce Pellegrino

Sensor Networks, Inc.
176-500 Technology Drive
Boalsburg, PA , 16827, USA
1-814-808-1067
www.sensornetworksinc.com

Outline

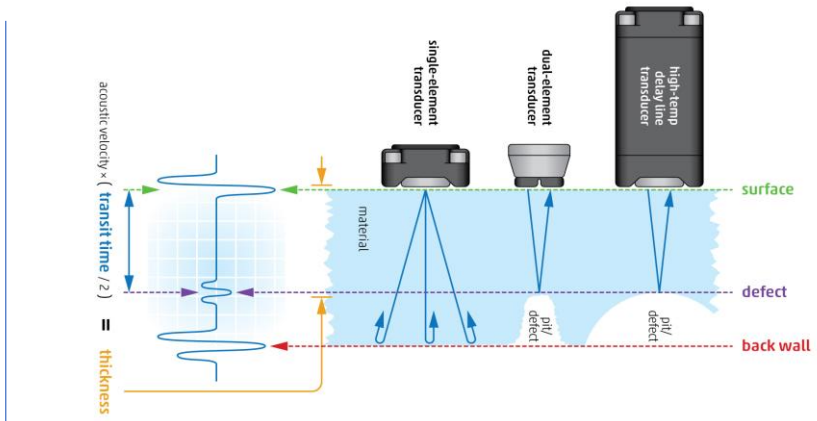
- Historical Overview:
  - Manual UTT vs Installed
  - Intrusive vs Non-Intrusive
- Applications
- Field Trials
- Conclusion

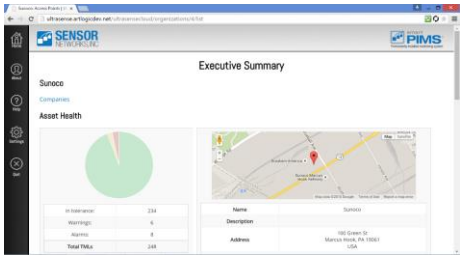
Manual Spot UT Thickness Can Provide False Confidence

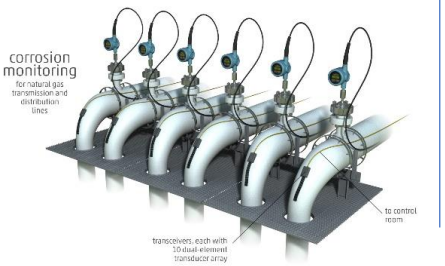


Non-Intrusive UT System Attributes

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

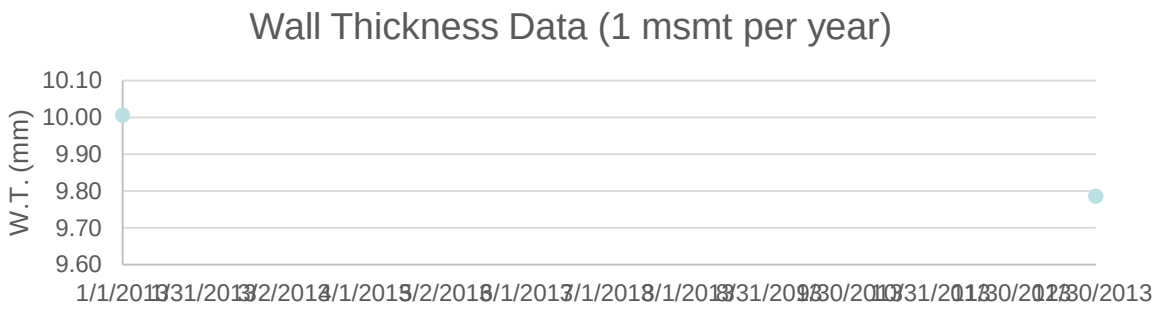


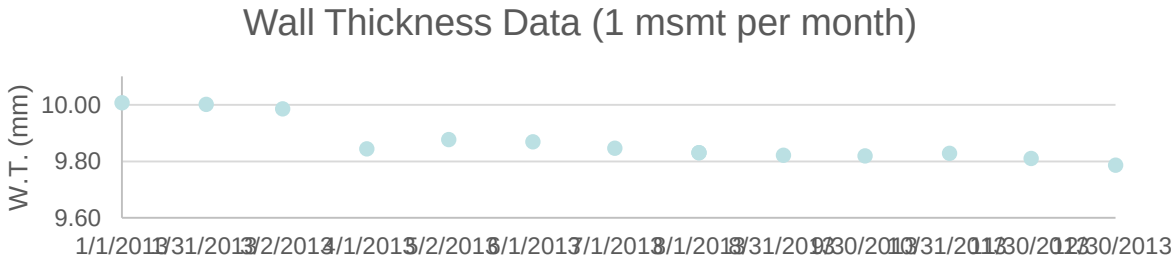


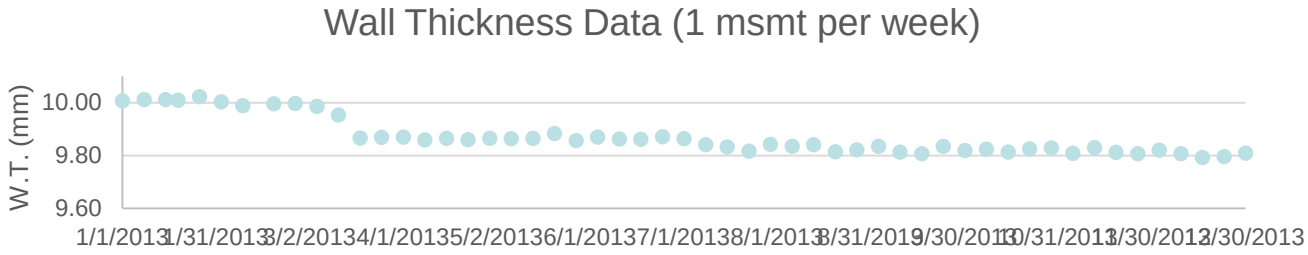


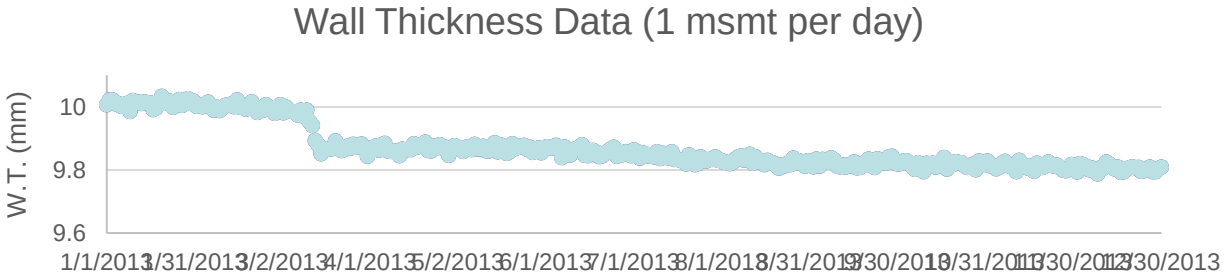
Installed Sensor System Topology

- 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



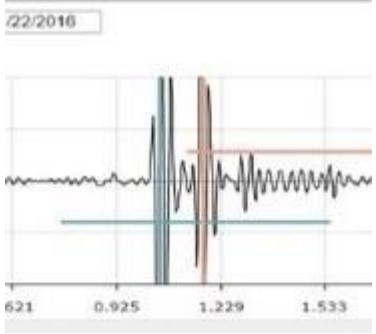






Data collection frequency is key to enhanced trending

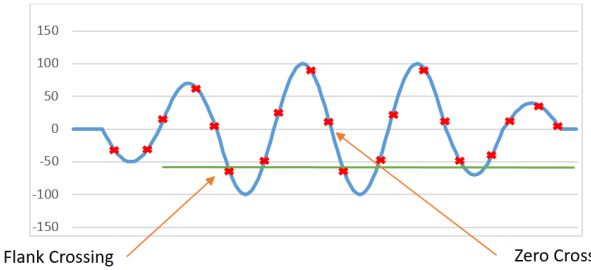
Minimizing variability for Precision Ultrasonic Measurements



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

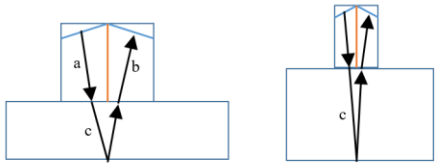


Digitized waveform and measurement references.

$$d_1 = \frac{1}{2} C_1 \Delta t \qquad (2)$$

$$C_1 = C_0(1 + k(T_1 - T_0)/100) \qquad (3)$$

Single-element transducer: Thickness = (Measured Time x Material Velocity) / 2



Dual-element, delay-line transducer concept.

Thickness = [(Measured Time – 'a' – 'b' – V-path Correction value) x Material Velocity] / 2

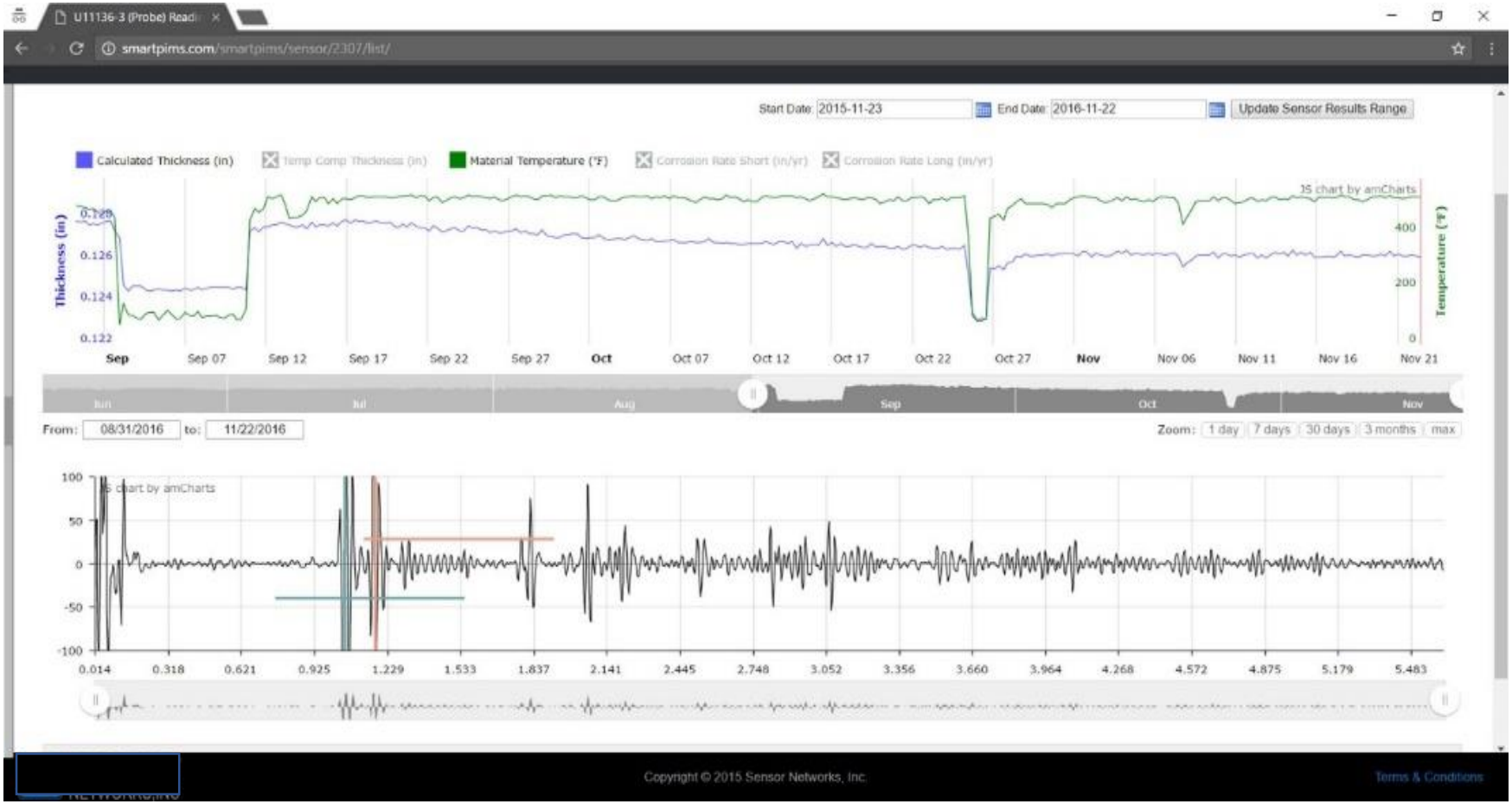
Improving Accuracy by Removing Variables

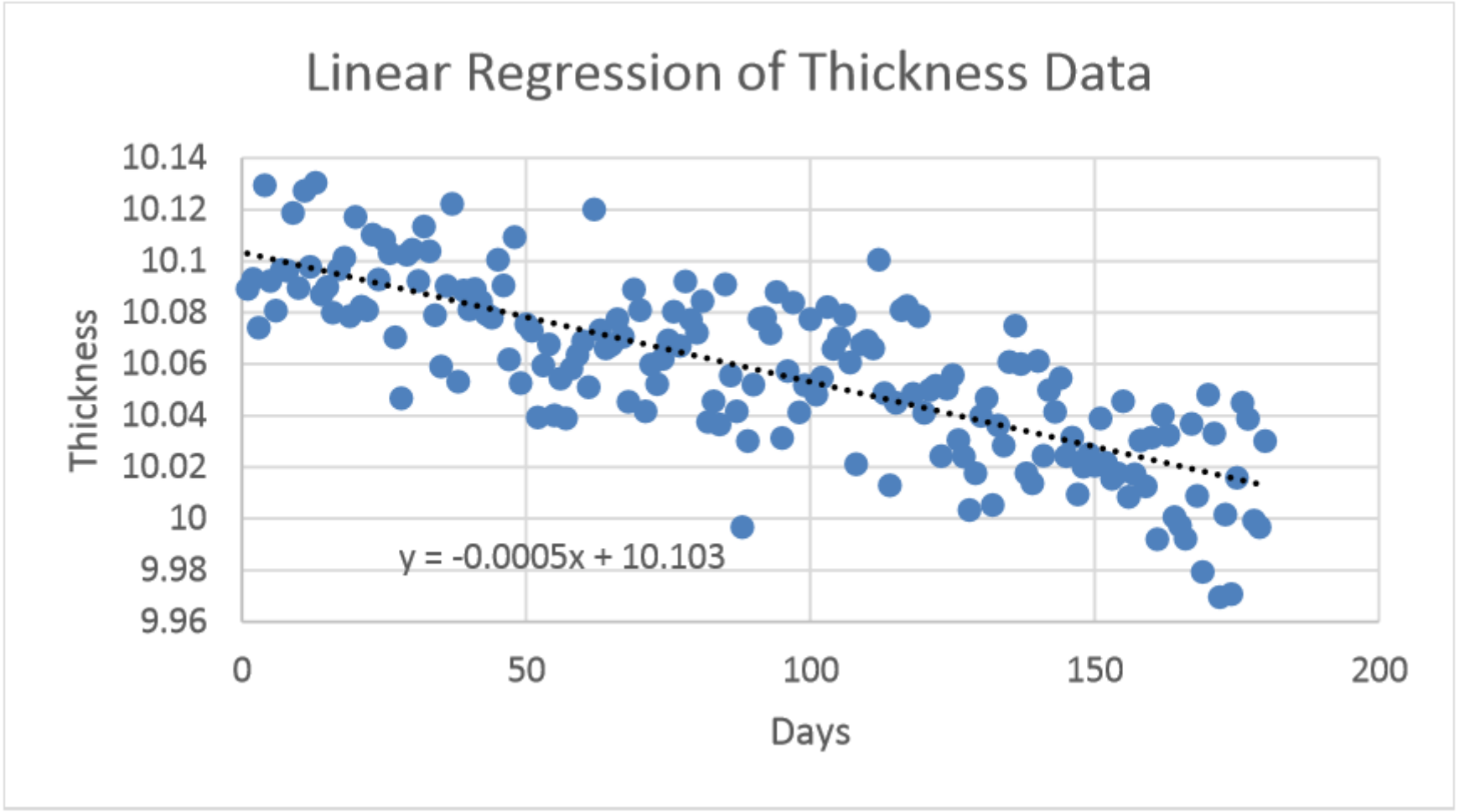
Factors Affecting Gauge Accuracy and Precision in the Field

Accuracy	Precision
Operator variability	*Operator variability*
Sound velocity and acoustic zero calibration	*Velocity and acoustic zero cal (msmt to msmt)*
Echo quality	Echo quality
Sound velocity uniformity	Electronic or ultrasonic noise
Surface roughness	*Transducer placement variability*
Transducer coupling variability	*Transducer coupling variability*
Temperature variation	Temperature Variation

** Parameters in italics are eliminated or reduced with installed sensors*

1 Reading/day Yields 0.0001” (2.5 micron) Thickness Resolution

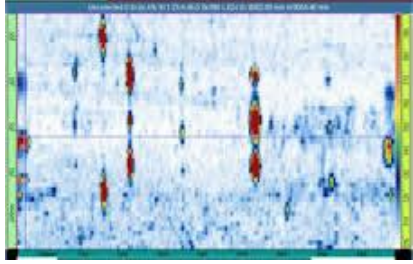


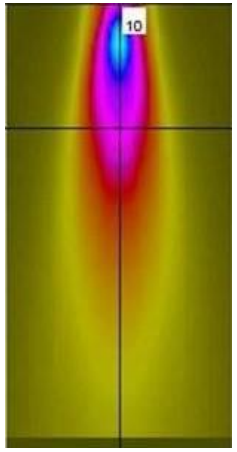


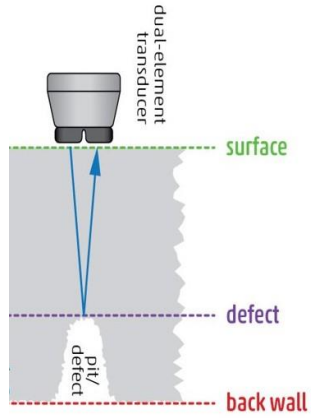
0.0005 mm/day (7 MPY) corrosion rate can be determined

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

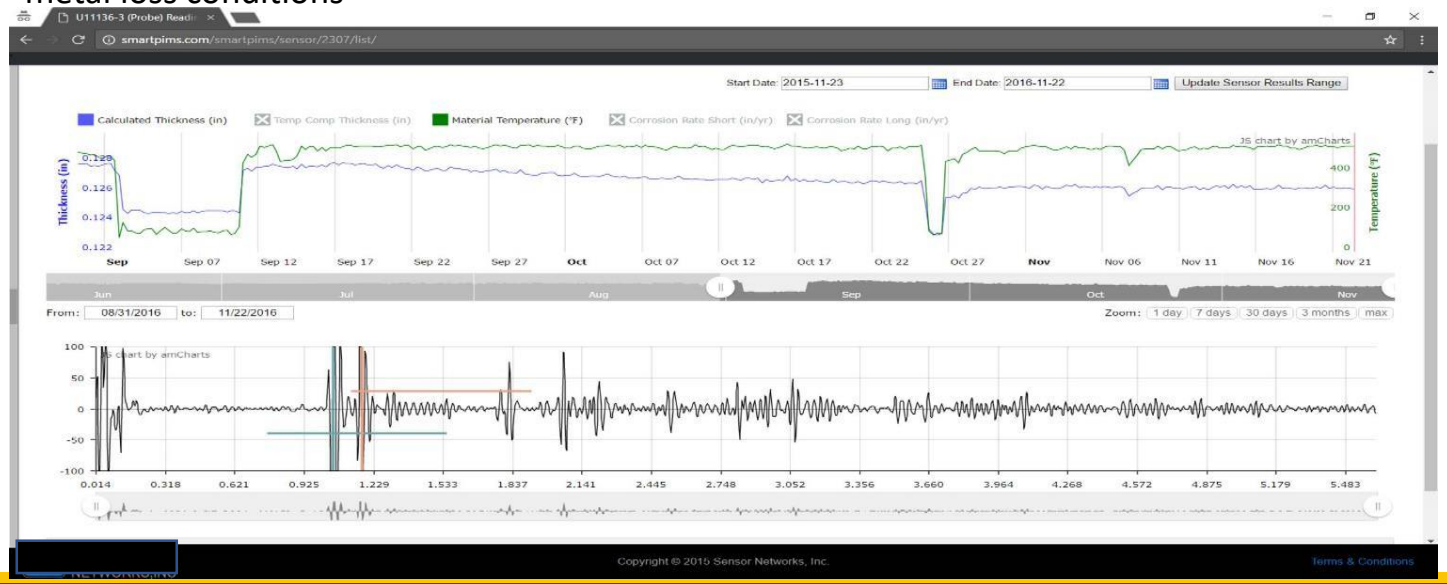
Overview: Customer wants to extend asset life to next turn-around corroding

Application: Atmospheric gas-oil, ~270C, 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



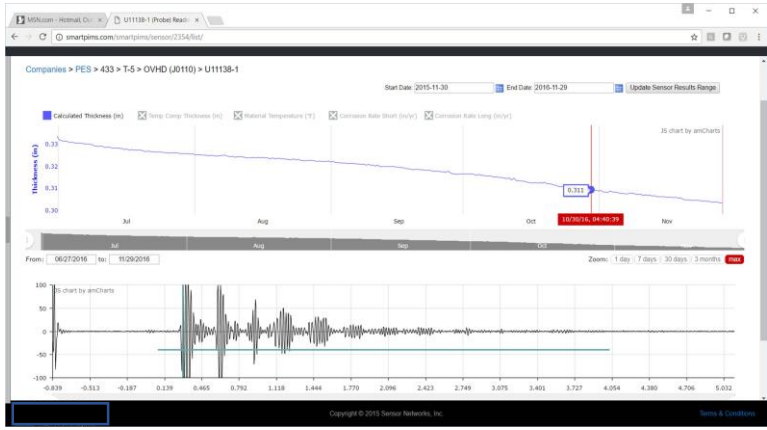
HydroFluoric (HF) Alky Unit Monitoring

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



Vacuum Fractionator

Overview: Customer built new unit to increase production. H_2S 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%

Crude Overhead Line

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:

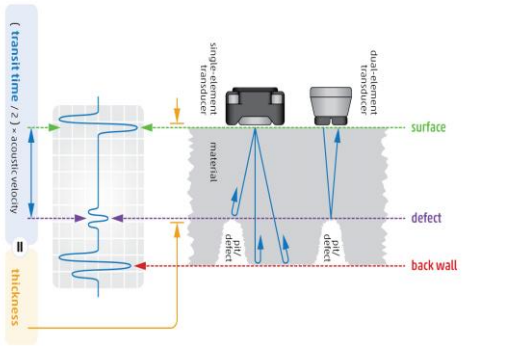
- An ILI report showed a number of low spots at three separate locations along a 100’ stretch of gas pipeline.
- Operator avoided fix/repair or bury/inspect more frequently by installing sensors on known low spots

Application:

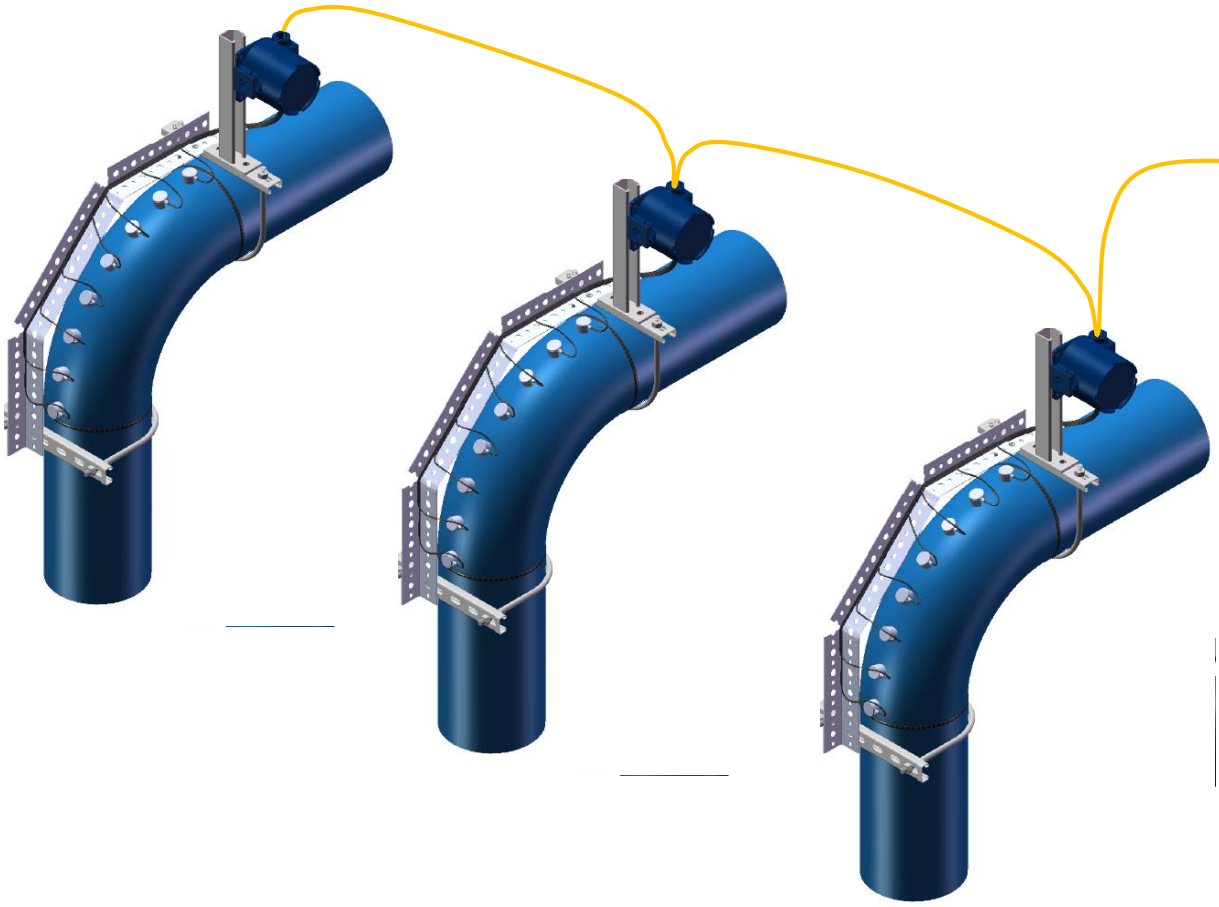
- 30” natural gas transmission line nominal ~.300”
- Low spots ranging from .120” to .240” – buried

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



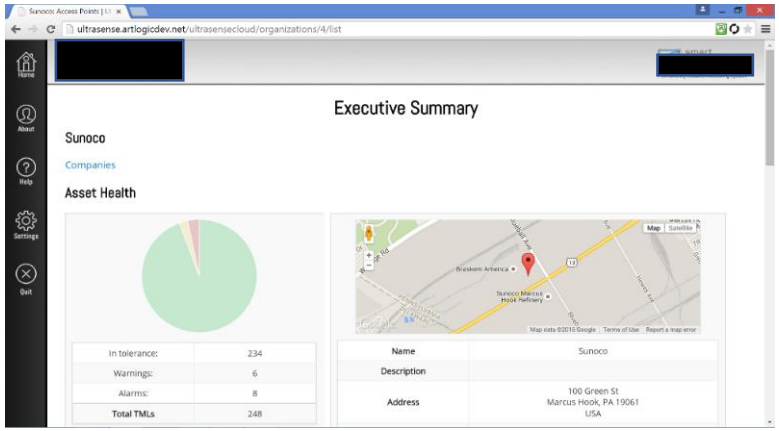
Process Control of Offshore Production

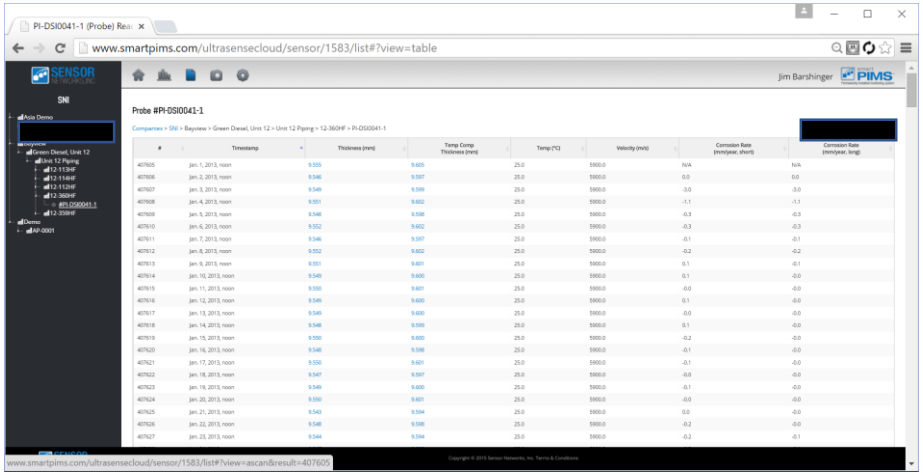


- Sand erosion monitoring
- 8–16 UT thickness monitoring sensors per pipe elbow extrados
- Monitor from 1 mm to 100 mm with 2.5 µ resolution
- 1–32 transmitters per single cable network tied directly to control room's DCS

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