Internal Corrosion Monitoring Methods

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Appalachian Underground Corrosion Short Course
Internal Corrosion Monitoring Methods

Why monitor?

“Significant pipeline failures resulting in loss of life and property have caused damages in excess of $7.0 billion in North America since 1995.”

(Source: Pipeline and Hazardous Materials Safety Administration /Energy Information Administration)
Why monitor?

It is the law -

“For onshore transmission pipelines, each operator must develop and implement a monitoring and mitigation program to identify potentially corrosive constituents in the gas being transported and mitigate the corrosive effects.”

Source:
DOT 49CFR192.478 Internal Corrosion Control: Onshore Transmission Monitoring and Mitigation
Internal Corrosion Monitoring Methods

The monitoring methods chosen must be capable of identifying corrosion and the constituents. This often requires more than one monitoring method used in sync.
Visual inspection is usually only performed following an incident.

Identifying the constituent of internal corrosion.
Internal Corrosion Monitoring Methods

Corrosion Constituents
Hydrogen Sulfide (H2S)
Corrosion Constituents
Carbon Dioxide (CO2)
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Corrosion Constituents
Oxygen (O2)
Site of excessive methanol injection
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Corrosion Constituents
Bacteria / MIC (APB)
Internal Corrosion Monitoring Methods

Corrosion Constituents
Bacteria / MIC (SRB)
Internal Corrosion Monitoring Methods

- Corrosion Coupons
- Electrical Resistance (ER) Probes
- Linear Polarization Resistance (LPR) Probes
- Ultra Sonic (UT) Probes
- Ultra Sonic Arrays
- Smart Pig Imaging
- Sampling of Process Fluids
Corrosion Coupons

- Simplest and most common method
- Made of a similar metal or alloy as the pipe or vessel being monitored
- Precisely weighed prior to and after exposure to the process fluid
- The loss of metal over a given time is termed as mills per year (MPY)
- Monitors for erosion, scale, paraffin and Microbiologically Induced Corrosion (MIC)
Internal Corrosion Monitoring Methods

- Corrosion Coupons (Cont’d)
  - choices, choices, choices
  - Flat
    - Single or Double Hole Mounting
    - Flow Profile
    - Perforated
      - Scale / Paraffin
    - EM Finish
  - Rod
    - Perforated
    - EM Finish
      - Square – watch thread detail
  - Disc
    - OD (3/4”, 1-1/4”)
Corrosion Coupons (Cont’d)
• Coupons should be provided in a moisture resistant package
  - never touch coupons with bare hands
• Coupon must have a traceable number
• Precisely weighed to (6) decimal points
• Label with write in information
  - Date In and Date Out - Person in Charge of the Coupon
  - Company Owner of the Coupon - Monitoring Location
Electrical Resistance (ER) Probes

- Referred to as “real time on-line” monitoring for gases, vapors, soils, wet hydro-carbons and non-aqueous liquids

- Probe with sensing element / electrode of a similar metal or alloy as the pipe or vessel being monitored
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- **Electrical Resistance (ER) Probes (Cont’d)**
  - Electrical current is applied to the element / electrode and the resulting resistance is measured against a reference element / electrode.
  - Resistance increases as the element / electrode loses metal through the corrosion process.
  - An external data logger is attached to energize the element and record the resistance and MPY readings.
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- Linear Polarization Resistance (LPR) Probes
  - Referred to as a “real time on-line” monitoring
  - Corrosion rates are measured directly
  - Quick response time and data quality
  - Limited to electrolytically conducting liquids

Prime Applications
- Cooling Water - Waste Water
- Production / Fractionation Water
- Amine Sweetening
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- Linear Polarization Resistance (LPR) Probes (Cont’d)
  - The corrosion rate is a result of an electrochemical mechanism due to the electrodes being immersed in the electrolytically conducting liquid
  - Consists of a probe with 1-3 replaceable electrodes of a similar metal or alloy as the pipe or vessel being monitored
  - An external data logger is required to energize the electrodes and log the readings
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- Ultrasonic (UT) Probes
  - A method referred to as “real time on-line” monitoring
  - Consists of a probe with a replaceable coupon made of a similar metal or alloy as the pipe or vessel being monitored
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- **Ultrasonic (UT) Probes (Cont’d)**

  - A transducer is energized generating an ultrasonic pulse through the coupon. The resulting wavelength changes as the coupon loses metal through the corrosion process.

  - Coupon is analyzed as a reference.
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➢ Ultra Sonic (UT) Probes (Cont’d)

- An external data logger is required to energize the transducer and log the data
Ultra Sonic Arrays

- A method referred to as “real time on-line” monitoring

- An array of ultrasonic sensors wrapped around pipes to map the wall thicknesses
Ultra Sonic Arrays (Cont’d)

- An external data logger is required to energize and log the data
Internal Corrosion Monitoring Methods

➡️ Smart Pig Imaging
- Inspection pigs gather information about the pipeline, which can include temperature and pressure, corrosion / metal loss, diameter, bends and curvature.

1) Magnetic Flux Leakage (MFL)
- sends magnetic flux into the pipe walls for leak, corrosion and flaw detection
Smart Pig Imaging (Cont’d)

2) Ultrasonics (UT)
- measures ultrasonic sound wave echoes from the ID to determine pipe wall thickness
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- Sampling of Process Fluids
  - Bacteria (SRB, APB)
  - Water (H2O)
  - Oxygen (O2)
  - Carbon Dioxide (CO$_2$)
  - Hydrogen Sulfide H$_2$S
  - Chlorides (Cl)
  - Paraffin
  - Iron (Fe)
  - Chemical Residuals
  - Corrosion (Aggressive)
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Considerations

- Must be exposed to the process fluids
- Fixed in place requires system depressurization
- Safely inserted and retracted at all operating pressures
- Resistant to process fluid velocities - lost coupons, damage to device or mounting riser

* wake frequency calculations
Considerations (Cont’d)

- Monitor where the corrosion is - long travels required
- Pigging operations - retract quickly
- Handled appropriately and delivered to a laboratory - Coupons - Sample Fluids
- Subject to improper analysis - Coupons - Sample Fluids - ER Probes
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Considerations (Cont’d)

• Interference from cathodic protection and galvanic corrosion (must be isolated)
  - Coupons
  - ER Probes
  - LPR Probes
  - UT Probes

• Interpreting data
  - ER Probes
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Considerations (Cont’d)

- Clearances and Access
  - Monitor at the bottom of a horizontal pipe
  - Monitor at the center of a vertical pipe

- Cost / Cost of ownership (in ascending order)
  - Coupons
  - Sampling
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Considerations (Cont’d)

• Cost / Cost of ownership (Cont’d)
  - ER Probes
  - UT Probes
  - LPR Probes
  - Ultra Sonic Arrays
  - Smart Pig Imaging

• Methods for any non aqueous process fluid
  - All except the LPR Probe

• Methods for any process fluid
  - All
Considerations (Cont’d)

• Local monitoring capable
  - All* except Smart Pig Imaging

• Remote monitoring capable
  - Coupons*
  - ER Probes
  - LPR Probes
  - UT Probes*
  - UT Arrays

* UT probes utilize a special weight loss coupon.
You Don’t Need to Monitor Everything…But You Do Need to Monitor What You Want to Keep!