

# 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)

# Internal Corrosion Monitoring Methods

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.



# Internal Corrosion Monitoring Methods

Visual inspection is usually only performed following an incident.

Identifying the constituent of internal corrosion.





# Internal Corrosion Monitoring Methods

Corrosion Constituents  
Hydrogen Sulfide (H<sub>2</sub>S)



# Internal Corrosion Monitoring Methods

Corrosion Constituents  
Carbon Dioxide (CO<sub>2</sub>)





# Internal Corrosion Monitoring Methods

Corrosion Constituents

Oxygen (O<sub>2</sub>)

Site of excessive methanol injection





# Internal Corrosion Monitoring Methods

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



# Internal Corrosion Monitoring Methods

## ➤ 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")



# Internal Corrosion Monitoring Methods

- 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

The image shows a close-up of a corrosion coupon label. The label is yellow and has a white rectangular area with handwritten information. The text on the label includes:

- KCR-114 1 1/2x1/4 Washer 4xH
- Treating Engineer
- Coupon No: R1737
- Initial Wt: 19.3529
- Date In:
- Date Out:
- Company:
- Lease & well no. ....
- Field ..... City, State .....
- Chemical Treatment .....
- # ..... Final Wt. .... Wt. Differ. .... Mpy

# Internal Corrosion Monitoring Methods

## ➤ 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




# Internal Corrosion Monitoring Methods

- 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






# Internal Corrosion Monitoring Methods

- 
- 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

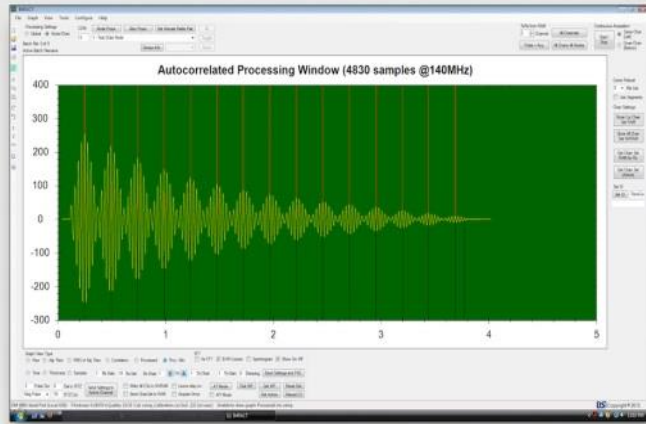
# Internal Corrosion Monitoring Methods

- 
- 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

# Internal Corrosion Monitoring Methods

## ➤ Ultrasonic (UT) Probes

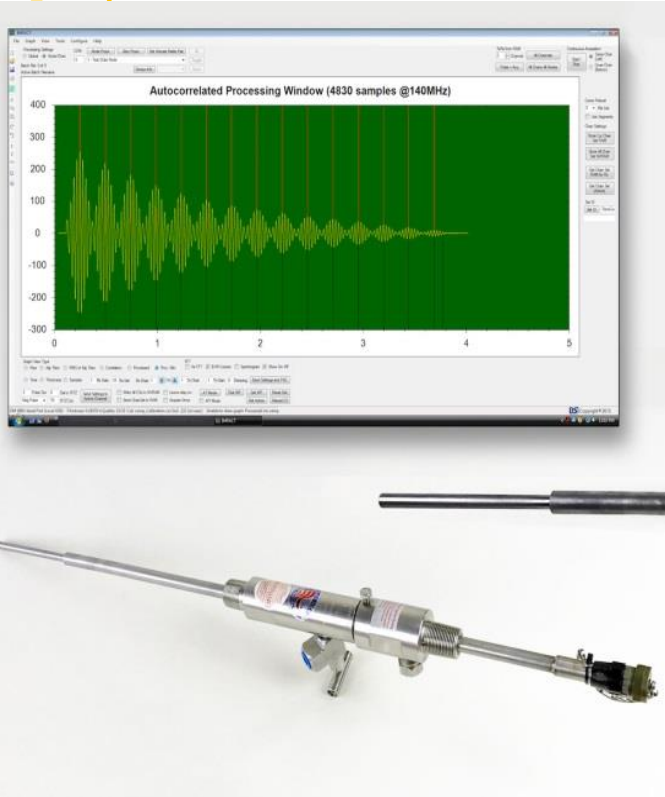
- A method referred to as “real time on-line” monitoring
- Consists of a probe with a replaceable coupon made of a similar metal or alloy as the pipe or vessel being monitored



# Internal Corrosion Monitoring Methods

## ➤ 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





# Internal Corrosion Monitoring Methods

## ➤ Ultra Sonic (UT) Probes (Cont'd)

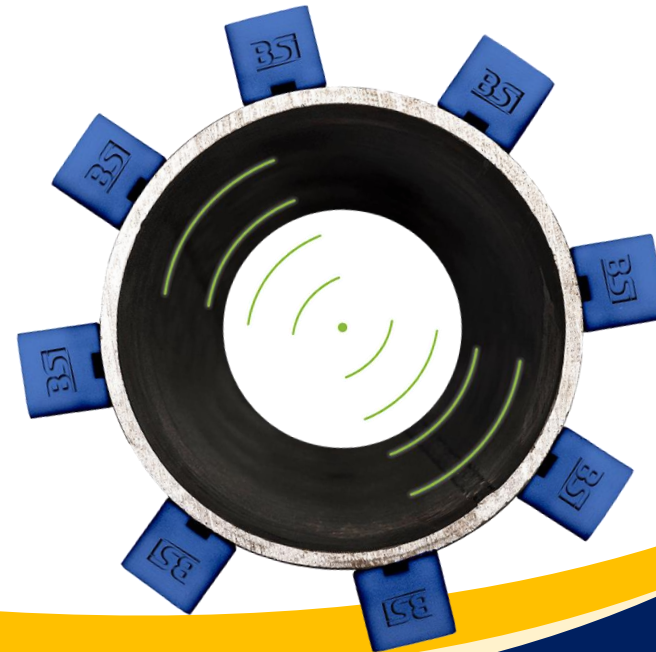
- An external data logger is required to energize the transducer and log the data



# Internal Corrosion Monitoring Methods

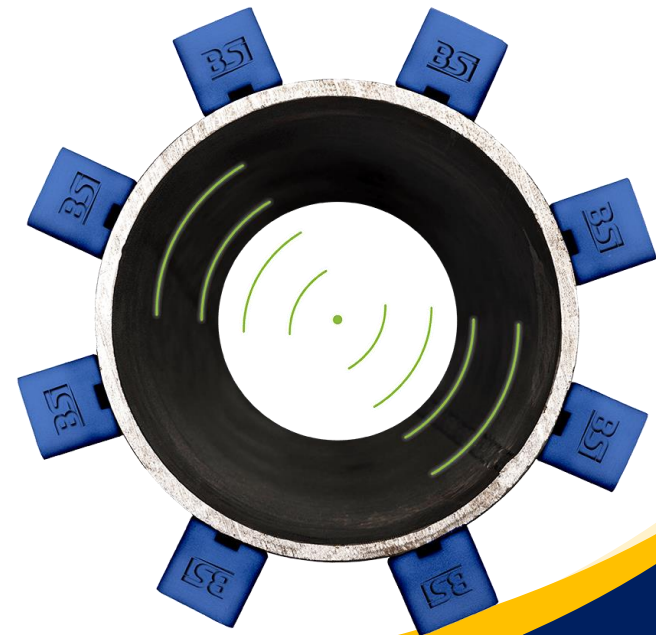
## ➤ Ultra Sonic Arrays

- A method referred to as “real time on-line” monitoring
- An array of ultrasonic sensors wrapped around pipes to map the wall thicknesses



# Internal Corrosion Monitoring Methods

- 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



# Internal Corrosion Monitoring Methods

## ➤ Smart Pig Imaging (Cont'd)

### 2) Ultrasonics (UT)

- measures ultrasonic sound wave echoes from the ID to determine pipe wall thickness



# Internal Corrosion Monitoring Methods

## ➤ Sampling of Process Fluids

- Bacteria (SRB, APB)
- Water (H<sub>2</sub>O)
- Oxygen (O<sub>2</sub>)
- Carbon Dioxide (CO<sub>2</sub>)
- Hydrogen Sulfide H<sub>2</sub>S
- Chlorides (Cl)
- Paraffin
- Iron (Fe)
- Chemical Residuals
- Corrosion (Aggressive)



# Internal Corrosion Monitoring Methods

## 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



# Internal Corrosion Monitoring Considerations

## 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

# Internal Corrosion Monitoring Methods

## Considerations (Cont'd)

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





# Internal Corrosion Monitoring Methods

## 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



# Internal Corrosion Monitoring Methods

## 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

# Internal Corrosion Monitoring Methods

## 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!