Use of Vapour phase Corrosion Inhibitors for Control of Corrosion Under Insulation (CUI)

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Agenda

1. What are Vapour Phase Corrosion Inhibitors (VpCIs)?
2. Corrosion Under Insulation (CUI)
3. VpCI products for CUI control
4. Cold/hot cyclic corrosion testing of VpCIs
5. Application in practice
6. Conclusions
Cortec Corporation

• Based in St Paul, Minnesota, USA

• Specialise in Vapour Phase Corrosion Inhibitors
  – Synthesis
  – Application

• Corrosion Control Solutions
  – Specification development & implementation
What Are VpClIs?

- **VpCl = Vapour phase Corrosion Inhibitor**
  - Chemical description: an amine carboxylate
  - Protects in three phases: vapour, liquid and interface of vapour & liquid
  - Inhibits the electrochemical reaction on the metal surface.
  - Forms a stable bond at the interface of the metal, preventing penetration of corrosive species to metal surfaces
Corrosion Under Insulation

- CUI is any type of corrosion that occurs due to moisture present on the external surface of insulated equipment.
- The damage/attack can be caused by one of multiple factors
  - Occurs in equipment operating at ambient, low, and heated services; pipelines with repetitive cooling and warming of the insulated pipes.
  - Occurs in equipment that is in service, out of service, or in cyclic service.
Water Ingress

- Infiltration of water under insulation (rain, process liquids, fire water, etc.)
- Condensation water
- Damaged casing or end caps
- Water follows gravity and pools in horizontal pipe runs
Corrosion Under Insulation Risk

- General temperature ranges in which risk of CUI is present:
  - Carbon steel pipe: -4°C to +175°C: Risk of CUI (highest risk area: +60°C to +120°C)
  - Stainless steel pipe: +50°C to +175°C
- Insulation of process equipment is normally implemented when the outer steel temperature exceeds 50°C (due to the risk of work-related injuries as well as heat loss).
- Contributes to production declines, extended plant shutdowns and pipe leakage.
CUI Insulation

- Common insulating materials include foam rubber, polyurethane, calcium silicate, and fiberglass.
- Insulating materials with high porosity are likely to have high adsorption properties for water and acidic chemicals.
- The insulation material may also contribute to CUI:
  - Creates a crevice for water retention
  - May absorb water
  - May leach contaminants that increase corrosion rate
VAPOUR PHASE CORROSION INHIBITOR PRODUCTS & METHODOLOGIES:

- **CorroLogic® CUI Inhibitor = VpCl®-658**
  Solvent-based, vapour phase Corrosion Inhibitor for injecting into insulation on low temperature pipes <170 °C

- **CorroLogic® CUI High-Temp Inhibitor = VpCl®-619**
  Water-based corrosion inhibitor for application on new insulation on high temperature pipes <=600 °C
CorroLogic® CUI Inhibitor = VpCl®-658

WHERE & HOW TO USE:

- Use on carbon steel, copper, brass
- Temps up to 338°F (170°C)
- Inject beneath the insulation at 3 to 6 m intervals depending on pipe diameter
- Dose rate 1 L/m³ of insulation volume
CorroLogic® CUI Inhibitor = VpCl®-658

FEATURES:

- Vapour phase Corrosion Inhibitors migrate throughout insulation to protect insulated metal surfaces from corrosion
- Protects in wet and dry cycles
- Solvent based liquid
- Long lasting
CorroLogic® CUI Inhibitor = VpCl®-619

WHERE & HOW TO USE:

- Use for carbon steel or cast iron pipes up to 1100°F (600 °C)
- Spray on new insulation before wrapping around clean pipe or apply direct to pipe
- Protect piping or exhaust manifolds in
  - Power Plants
  - Refineries
  - Ships
  - Offshore Rigs
  - Other Industrial Facilities
CorroLogic® CUI High-Temp Inhibitor = VpCl®-619

FEATURES:

- High temperature resistance up to 1100°F (600 °C)
- Water based so non-flammable, safe
- Protects in wet and dry cycles
- Long lasting
- Application rate 3.7 to 3.9 m² per L - 250 to 270 μm wet
BENEFITS OF VpCIs:

- Inhibit CUI on pipes and other insulated metal surfaces
- Reduce frequency of maintenance and repair related to CUI
- Increase overall plant safety by reducing dangerous corrosion-related failures
- Immediate control of CUI once discovered without need to remove insulation (VpCI-658)
Cold/Hot cyclic corrosion tests

- API 5L X65 mild steel pipe
- 200 ppm sodium chloride solution was injected by tube into the pipe/insulation interfaces every 48 hours.
- Hot dry air (120-140 °C) was blown through the pipes (inner diameter) for two hours per day and held at ambient temperature for twenty-two hours.
- The samples (one with inhibitor, 1 without) were disassembled every 720 hours (30 days) to evaluate their surface condition and document the extent of corrosion damage at pipe/insulation interfaces.

Reference: Bavarian et al NACE Corrosion 2015
Laboratory Testing

Test rig components

INSULATION

PROBE

CAP

WIRE

PIPE

Aluminum & Copper Sensors
Laboratory Testing

Test Assembly
Laboratory Testing

Assembled Test Rig
Hot/Cold Cycles Test

Comparison of insulation/pipe interfaces after 242 days (5,800 hours): CorroLogic VpCl®-658 treated pipe shows no corrosion attack, while the control sample shows red rust formation.

NOTE: Testing performed at California State University, Northridge
ER Probe Data – CorroLogic VpCI-658

- Comparison of corrosion rate from the ER probes.
  - Control sample (no inhibitor) measured about 24 μm per year and as high as 56 μm per year at 110 hours of testing
  - CorroLogic VpCI®-658 treated sample with a corrosion rate in the range of 0.76 to 1 μm per year.

NOTE: Testing performed at California State University, Northridge.
CorroLogic® CUI High-Temp Inhibitor = VpCl®-619

- Insulated pipes after 240 hours of CUI condition testing at 176°F (80°C).
  - Control sample the insulation reveals localized corrosion and red rust.

- No corrosion seen on sample treated with VpCl®-619.

NOTE: Testing performed at California State University, Northridge
CUI - ER Probe Monitoring

Why use ER Probe Monitoring
- Difficulty of detection due to the corrosion occurring beneath the insulation.
- Required complete removal of insulation to thoroughly inspect the materials is time consuming and expensive.

Benefits
- Provides an early warning that damaging process conditions exist which may result in a corrosion-induced failure.
- Potential savings in inspection and associated repair costs.
- Does not require removal of insulation.
- Provides management information relating to maintenance requirements.
Application in practice: Corrective Action Phase - Apply VpCI

- Obtain ER probe real-time corrosion rate data.
- Apply liquid VpCI per specified dosage.

VpCI migrates all directions from injection ports
ER probe located between VpCI injection ports
Maintenance Phase
Monitor & Replenish

- Monitor ER probe corrosion rate data.
- Replenish VpCI per ER probe data or per schedule eg 12 monthly.

VpCI in equilibrium through the entire insulated space

ER probe located between VpCI injection ports
Assessment Phase
Corrosion Rate Monitoring

- ER Probe identifies real-time rate of corrosion at the pipe surface.
- Data from ER probe is described in μm per year metal loss.
- Probe tip is shielded from direct contact with the pipe surface.
- Corrosion rate data obtained by unscrewing the cap & connecting a meter cable to the probe.
Conclusion

- Vapour phase corrosion inhibitors (VpCI) are an alternative protection method that is effective at controlling corrosion and cost effective.
- Does not require removal and replacement of the existing pipe insulation.
- Application of proven multi-phase VpCI chemistry is incorporated for in-service piping systems to mitigate CUI.
- Real-time corrosion rate monitoring is incorporated to evaluate the corrosiveness of the insulated pipe environment and evaluate the effectiveness of the corrosion inhibitor.
- Long-term control of CUI is engineered into the program through easy and economical replenishment of VpCI as needed at any time in the future.
Thank You

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