Pipeline Research Council International

Vapor Corrosion Inhibitors for Corrosion Control of Aboveground Storage Tank Bottoms

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LEADING PIPELINE RESEARCH

Our Mission

To collaboratively deliver relevant and innovative applied research to continually improve the global energy pipeline systems.

Background

Challenges of Cathodic protection (CP) systems under tank bottoms

- Operators are experiencing numerous instances of corrosion even with fully operating CP systems that achieve/exceed NACE criteria for corrosion control.
- Anode failures under ASTs is not uncommon.
- Anodes above single bottom tank dielectric containment liners or within the interstitial space of double bottom tanks cannot be replaced without floor removal.
- Current distribution issues are concerning with double bottom tank CP systems.
- Long-term deactivation of CP system on surrounding tanks during terminal tank repair projects leads to long-term loss of corrosion control.

Breakout Tanks are covered by 49 CFR §195

- §195.565: installation of CP system for as per API recommended practice 651
- §195.573: monitoring of external corrosion control
- §195.402: procedural manual for operations, maintenance, and emergencies

Motivation

- Experimentation with Vapor Corrosion Inhibitors (VCIs) for tank floor corrosion control began in late 1990's.
- VCI applications below aboveground storage tanks (AST) floors have grown substantially over the last two decades.
- Operators of AST have continually experienced numerous soil-side corrosion control challenges on cathodically protected tank floors.
- PRCI led research to independently evaluate VCIs for AST bottom corrosion control to establish effective new tools to mitigate and monitor soil-side corrosion.

Research Objectives

- **Independently evaluate the effectiveness of VCIs**
- **Developing a user-friendly best practices guidance**
  - Applicability—Determine conditions where VCIs are appropriate and where they are not (e.g., whether VCIs are compatible with CP)
  - Installation—VCI preparation and installation procedures, containment (e.g., effectively sealing “chime” along the perimeter of an AST)
  - Monitoring—Type and extent of equipment to be used, measurement frequency, and related factors
  - Effectiveness Analysis—Relative corrosion-control effectiveness of VCIs (e.g., reduction in corrosion rate or extension of service life) as a primary method or as a retrofit in the event CP is deemed ineffective, and in situations where both VCI and CP are functional

Research Objectives

- Compare CP and VCI treated tanks
- Monitoring of in-situ localized corrosion (UT-based mass-loss coupons)
- VCIs effectiveness in extreme conditions:
  high levels of chloride and bacteria concentrations
- Evaluation of VCI delivery systems/methods including migration of VCIs

Project Scope

- **ASTs with sand pads (both single and double bottoms)**
  - Floor inspection data in API 653 reports, concurrent CP data
  - Approximately 100 ASTs, few treated with VCIs
- **Two commercially available VCIs, vendor provided chemistries**
- **Field testing using mass-loss coupons**
- **Field sand for laboratory testing was from below ASTs experiencing severe corrosion**

Key Findings

- **Two commercially available VCIs provide high-level of corrosion mitigation at recommended dosage levels, pitting corrosion tendencies are mitigated with VCIs' application**
- **Electrical Resistance (ER) probes are appropriate to monitor effectiveness of the VCIs by corrosion rate monitoring in the sand electrolyte. ER probes were able to detect VCI effect by corrosion rate measurement**
- **VCIs were found to be compatible with impressed current CP, no detrimental effect of the impressed current CP system and its ability to deliver CP current to AST bottom plates**
- **Extensive field testing and included both bonded and unbonded mass-loss coupons**
  - Corrosivity of sand electrolyte is an important factor
  - Unresolved questions about extensive corrosion of bonded coupons in a few CP protected tanks

Conclusions

- **AST operators continue to experience soil-side corrosion of the bottoms; seeking additional tools and technologies to control the soil-side corrosion of AST floors.**
- **PRCI Phase 1 and Phase 2 research projects provide independent evaluation of VCI efficacy for AST floor soil-side corrosion control.**
- **Emerging tools include:**
  - VCI technology
  - Undertank corrosion monitoring technologies used to evaluate the effectiveness of active corrosion control systems
- **AMPP (NACE) is developing standard providing guidance for VCI application and corrosion monitoring for ASTs.**

Key Gaps and Research Opportunities

- Need to develop VCI monitoring protocols similar to potential measurements for CP
- Understanding of distribution/migration rates of VCIs, limited data will be available through PRCI research

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