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# **Pipeline Assets and Vapor Corrosion Inhibitors**

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Zerust Oil & Gas (NTI)



Appalachian Underground Corrosion Short Course

# Agenda

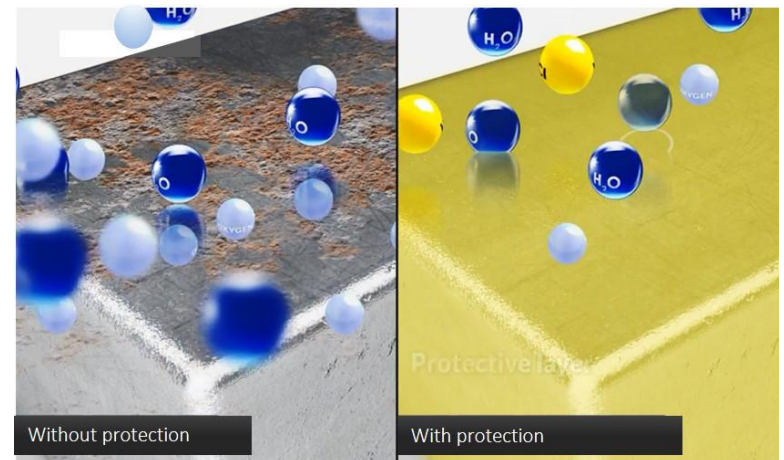
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- What is VCI & how does it work
- Pipelines
- Pipe Casings
- Tanks
- CUI
- Summary



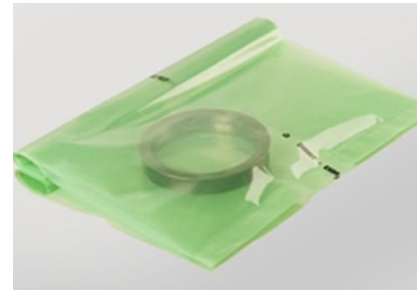
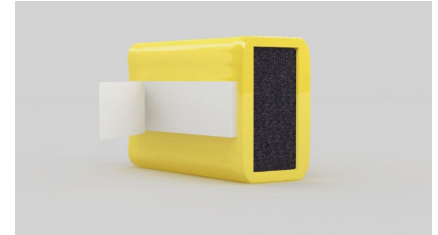
# Intro to VCI

- Chemistry – Amine Carboxylate
- Powder or liquid
- Vapor partial pressure
- Adsorbs
- Blocks



# Quick History

- Formulated – Shell 1948
- Human safe version – mid-70's
- Packaging – Equipment preservation
- Oil & Gas ~ 2005
- Tanks
- Pipe Casings
- Pipeline (OOS)



# Out-of-Service Pipelines

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## When is VCI an Option?

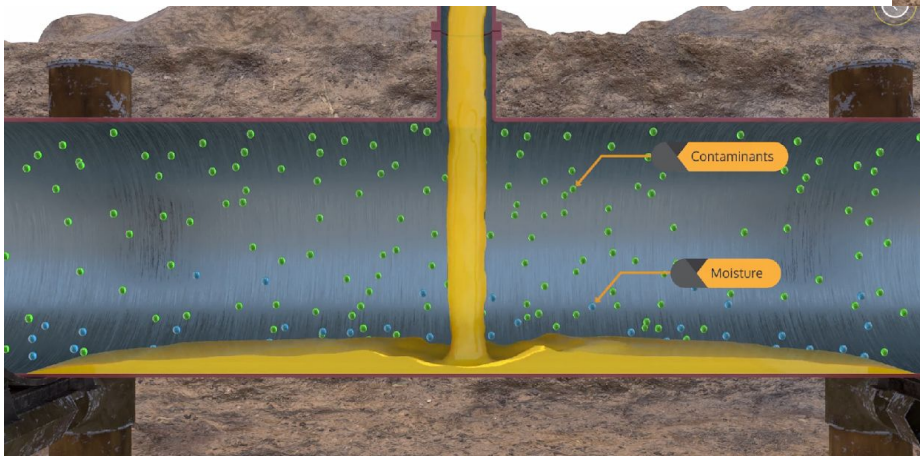
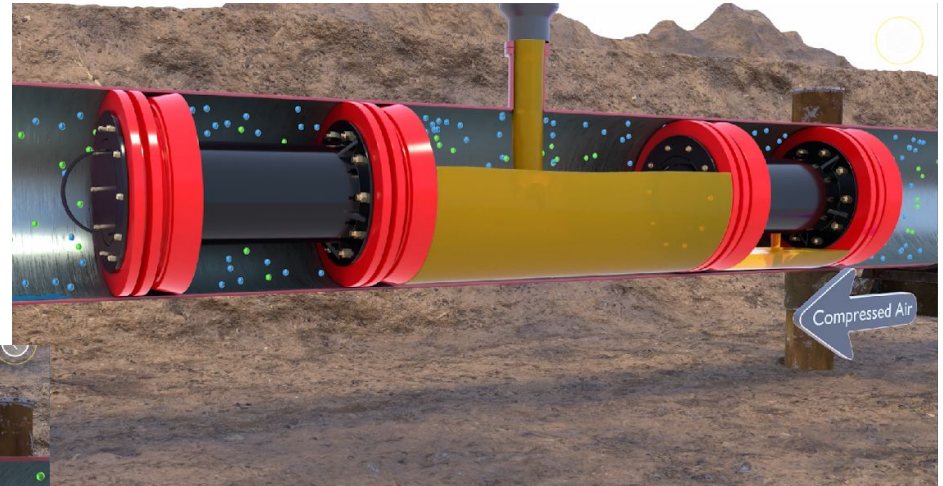
- Post hydrotest
  - Treats residual hydrotest water
  - Drying of the pipe is not required
  - Nitrogen blanket is not required
- Mothballing / Layup
  - Remove as much product as practical
  - Non-piggable, nitrogen blanket is not required





# Out-of-Service Pipelines

- What Type of Pipe Design?
  - Piggable
  - Non-piggable



# Regulatory – OOS Pipelines

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## Pipeline

- AMPP SP21472 (TG 440), “Hydrotesting and Long-Term Wet Storage of Pipelines, Risers, and Subsea Equipment” – New document



# Other Applications

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Hydrotesting

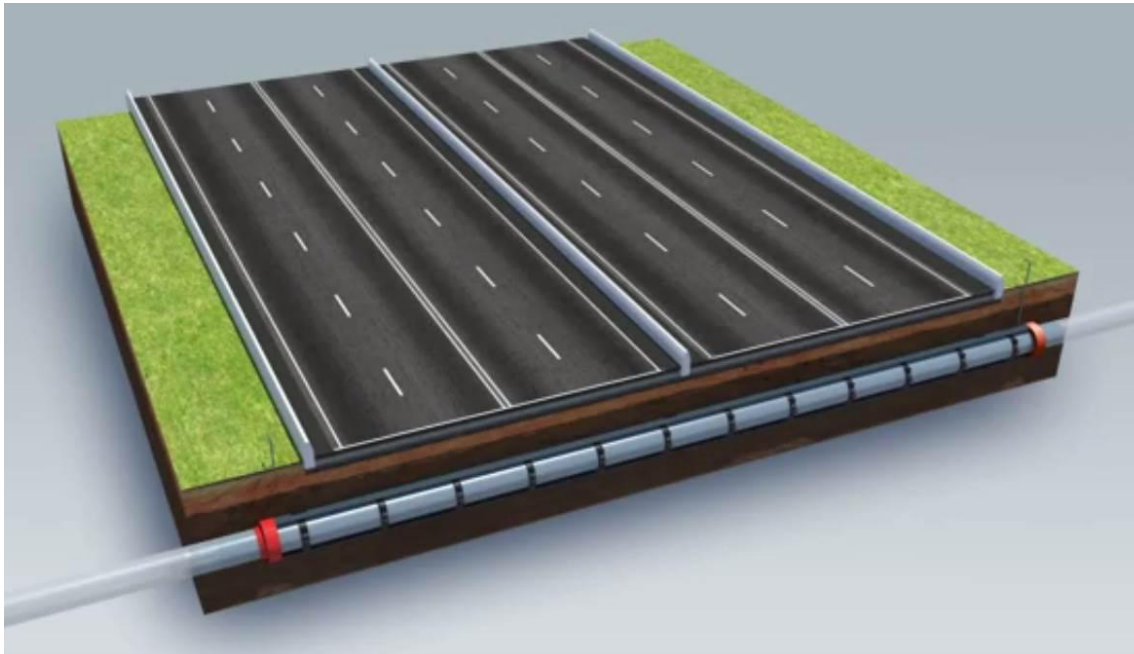


Preservation of Pipe Lengths



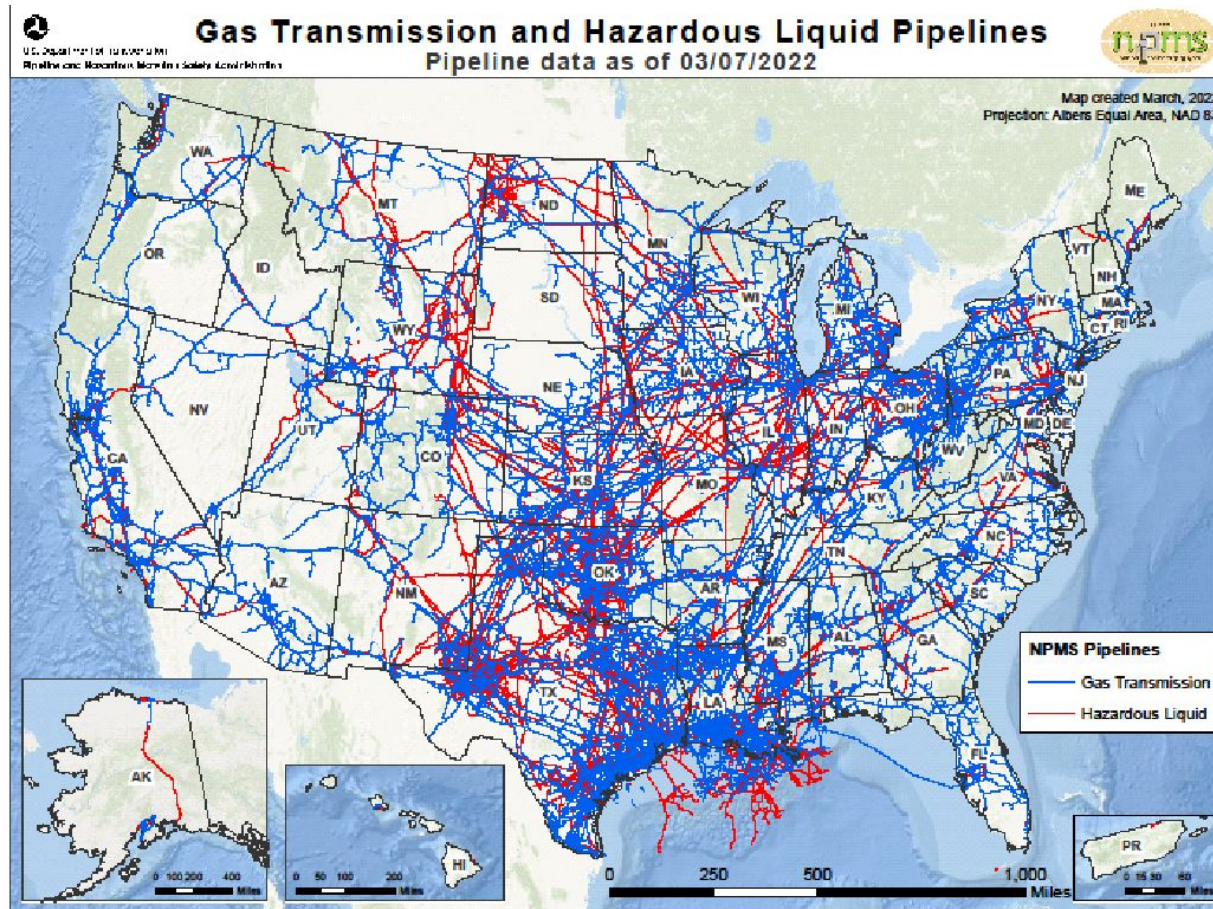
# Pipe Casings

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- Carrier pipe inside a structural support pipe
- Spacers isolate the carrier from contact with casing
- Carrier inside casing is isolated from Cathodic Protection (CP)
- Metallic Short
- Electrolytic Couple

# National Pipeline Mapping System

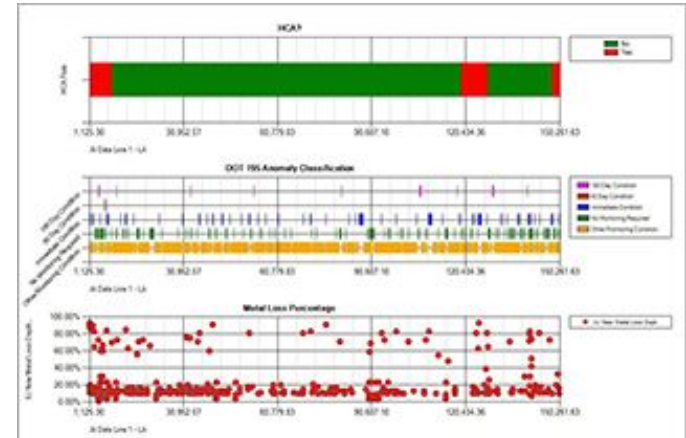


# In-Line Inspection

ILI tools can identify anomalies on the carrier pipe inside a casing

Corrosion depth measurements on the carrier determine priority

PHMSA Mega-Rule is expanding the inspection requirements

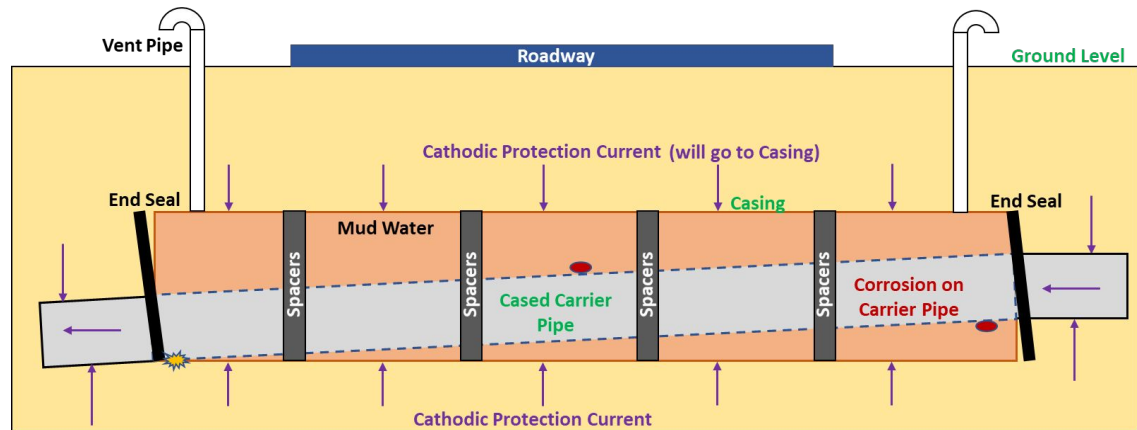




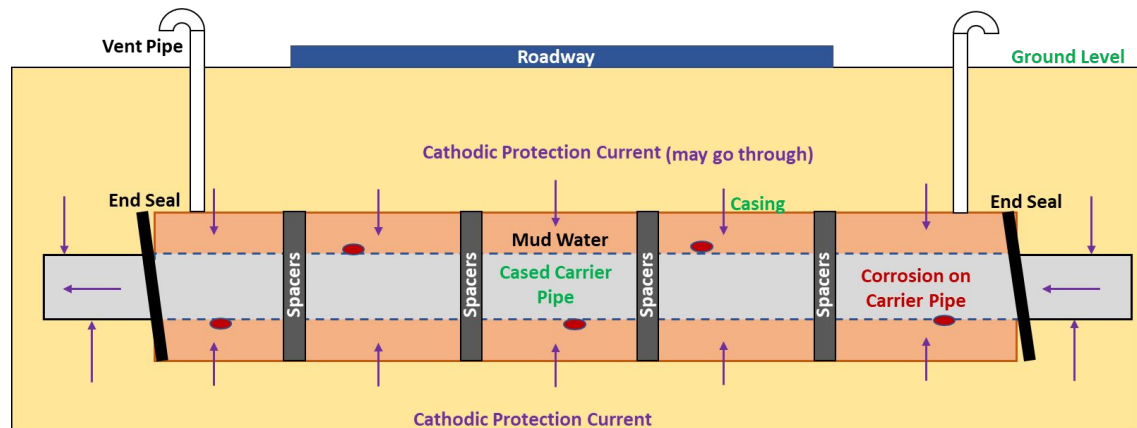
# Shorts

- Ground settling
- End-seal failure
- Spacer degradation
- Ingress of water or other contaminants
- Other

## Metallic Short



## Electrolytic Couple



# Regulatory - Casings

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## Pipe Casing

- AMPP SP0200-2023 - Steel-Cased Pipeline Practices

## Section A3 Treating the Casing Annulus with Corrosion-Inhibiting Products

- A3.2 There are two fundamental options available to accomplish this method of corrosion mitigation inside casings:
- A3.3 Option 1: Fill the Casing with Corrosion-Inhibiting Gel Filler
- A3.4 Option 2: Leave the Casing Annulus Unfilled and Apply a Multiphase Vapor Corrosion Inhibitor System





# Regulatory – Recent Rulings

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Enstar – March 11, 2019

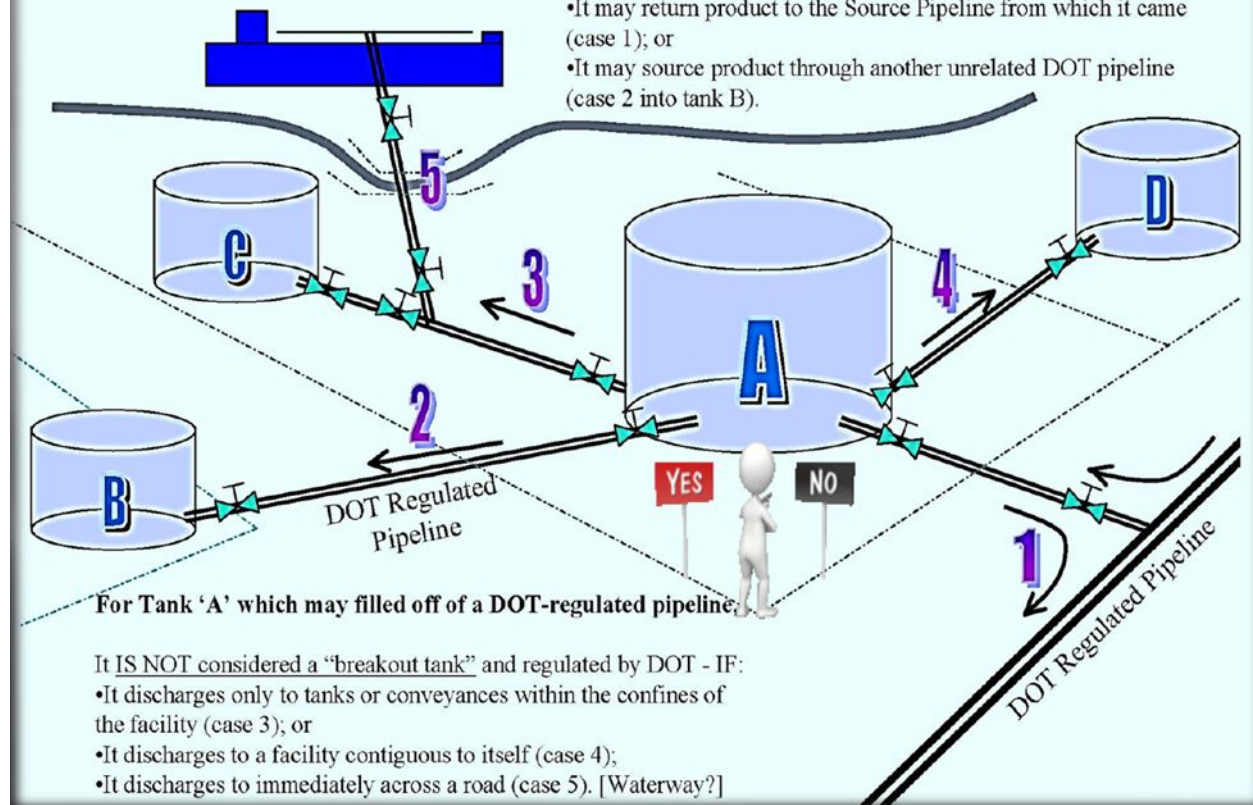
- Requested Annual Inspection of a leaking pipeline
- PHMSA response – clear the short, if practical
  1. Fill casing w/wax or corrosion inhibitor
  2. Monitor with ILI
  3. Or, utilize leak detection monitoring
  4. Implement remedial measures to maintain carrier pipe MAOP
  5. Apply for Special Permit



# Regulatory - Tanks

- Tanks
  - Part of the Pipeline

## Classification as “Breakout Tank” per 49 CFR 195.2



# Regulatory - Tanks

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- API 2610 - Design, Construction, Operation, Maintenance, and Inspection of Terminal and Tank Facilities
- API 651 - Cathodic Protection of Aboveground Petroleum Storage Tanks
- API 655 TR - Vapor Corrosion Inhibitors for Storage Tanks
- AMPP SP21474 - Standard for External Corrosion Control of On-Grade Carbon Steel Storage Tank Bottoms



# Regulatory – API RP651

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Cathodic Protection Does NOT Work	Cathodic Protection MAY Not Work
<ul style="list-style-type: none"><li>• Concrete pad tank foundations</li></ul>	<ul style="list-style-type: none"><li>• High resistivity soil or rock aggregate pads</li></ul>
<ul style="list-style-type: none"><li>• Asphalt/Bitumen or Oil Sand Layer foundation</li></ul>	<ul style="list-style-type: none"><li>• Double bottoms with sand layer &lt;12"</li></ul>
<ul style="list-style-type: none"><li>• Geomembrane or HDPE layer between CP and bottom</li></ul>	<ul style="list-style-type: none"><li>• Stray current environments</li></ul>
<ul style="list-style-type: none"><li>• When bottom plates are not in contact with soil</li></ul>	

# Regulatory – Tanks - PHMSA

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- CP is required for Breakout Tanks
- VCI alone, not approved
- VCI in conjunction with CP is approved

## PHMSA previous testing w/PRCI

- Vapor Corrosion Inhibitors Effectiveness for Tank Bottom Plate Corrosion Control
  - Published: May 4, 2018
- Vapor Corrosion Inhibitors Effectiveness for Tank Bottom Plate Corrosion Control —Phase 2
  - Published: July 20, 2022





# Regulatory – Tanks - PHMSA

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*TRANSPORTATION, HOUSING AND URBAN DEVELOPMENT,  
AND RELATED AGENCIES APPROPRIATIONS ACT, 2021*

## *Aboveground storage tanks*

The agreement directs PHMSA to conduct a review of current and new corrosion control techniques that may be used to improve leak prevention of regulated aboveground storage tanks. PHMSA is directed to submit a report within 1 year of enactment of this Act to the House and Senate Committees on Appropriations, the House Committee on Transportation and Infrastructure, and the Senate Committee on Commerce, Science and Transportation detailing the findings on supplementary or alternative techniques to cathodic protection systems and the application of such techniques to aboveground storage tanks.



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# Regulatory – Tanks - PHMSA

## PHMSA current testing w/PRCI

### EC-6-5B & EC-6-5C

1. Evaluation of CP effectiveness for AST application
2. Undertank corrosion monitoring: monitoring electrolyte to predict
3. Tank bottom corrosion
4. Characterize migration of VCI within tank pads
5. Determine VCIs performance in presence of high chloride levels
6. Determine VCIs performance in presence of bacteria



Report to Congress  
Aboveground Storage Tanks  
Review of Current and New  
Corrosion Control Techniques

Published – December 2021



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# Regulatory – Tanks - PHMSA

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## PHMSA testing w/PRCI planned

### Research Announcement #693JK323RA0001

Knowledge Development – Standardize the Application of Vapor Corrosion Inhibitors (VCIs)

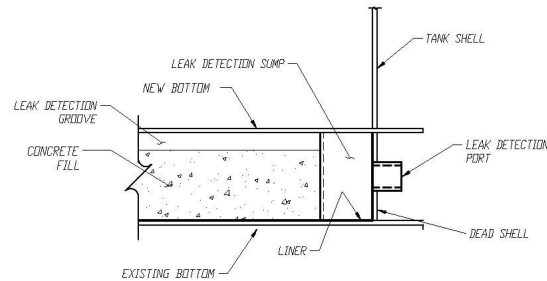
- Consider methods of VCI application under primary tank bottoms, between bottoms in tanks with multiple bottoms, and under original tank bottoms;
- Establish a method to evaluate the performance of VCIs compared to a functioning CP system and qualify their effectiveness for use in breakout tank applications;
- Establish best practices for VCI application and monitoring in breakout tank application; and
- Deliver reported results in 24 months, with a total project cost of up to \$500,000.



# Foundation Design



Sand Pad – w/Liner  
Sand Pad – w/o Liner



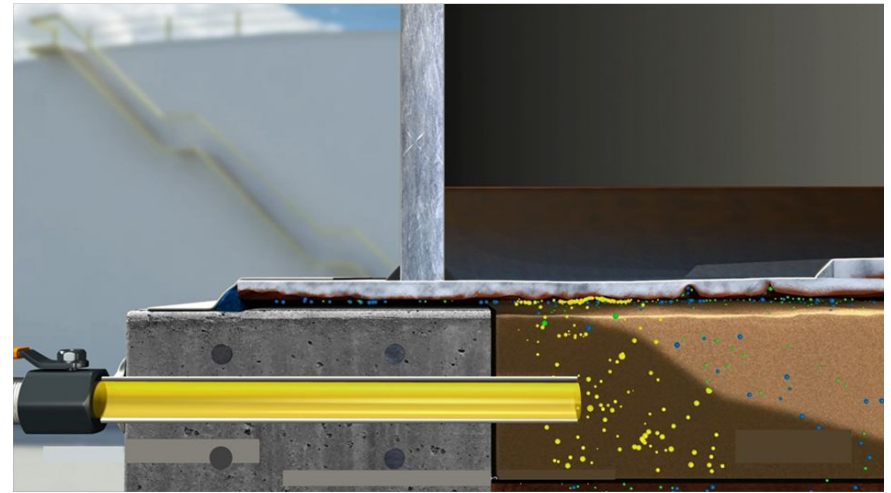
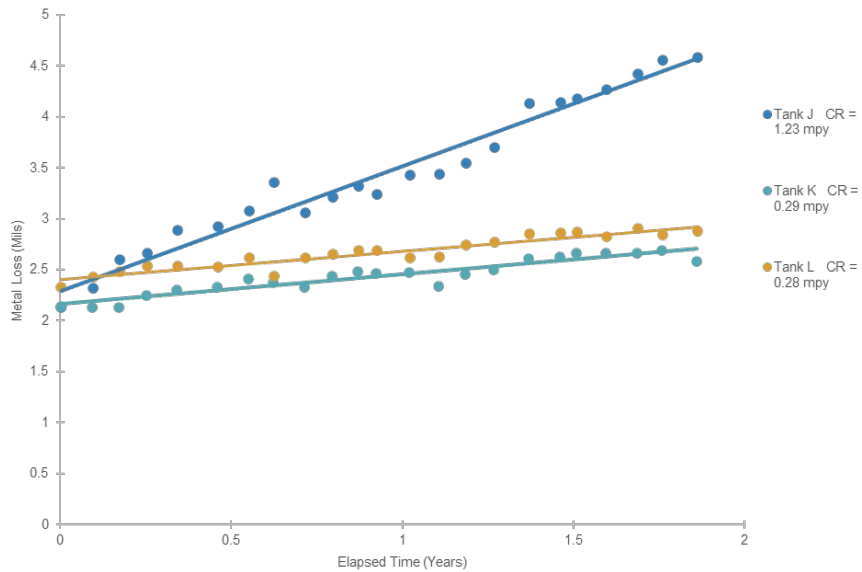
Double Bottom – Sand  
Double Bottom - Concrete



Concrete or  
Asphalt Pad

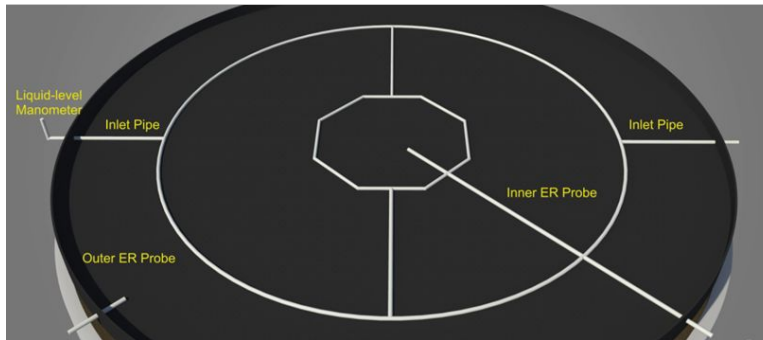
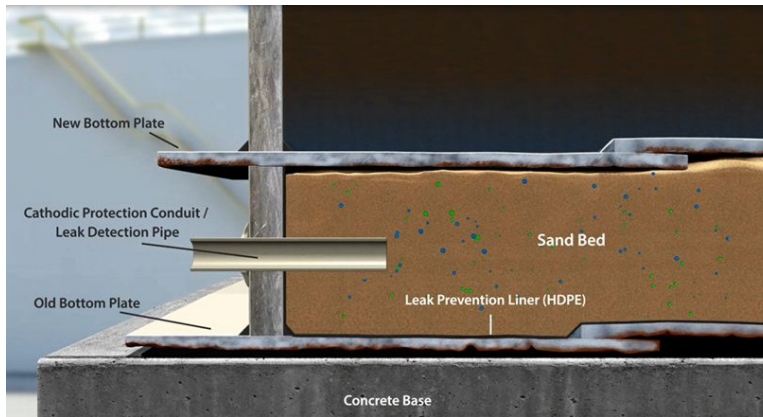
# Single Bottom

Underside Injection - Average Corrosion Rate Data

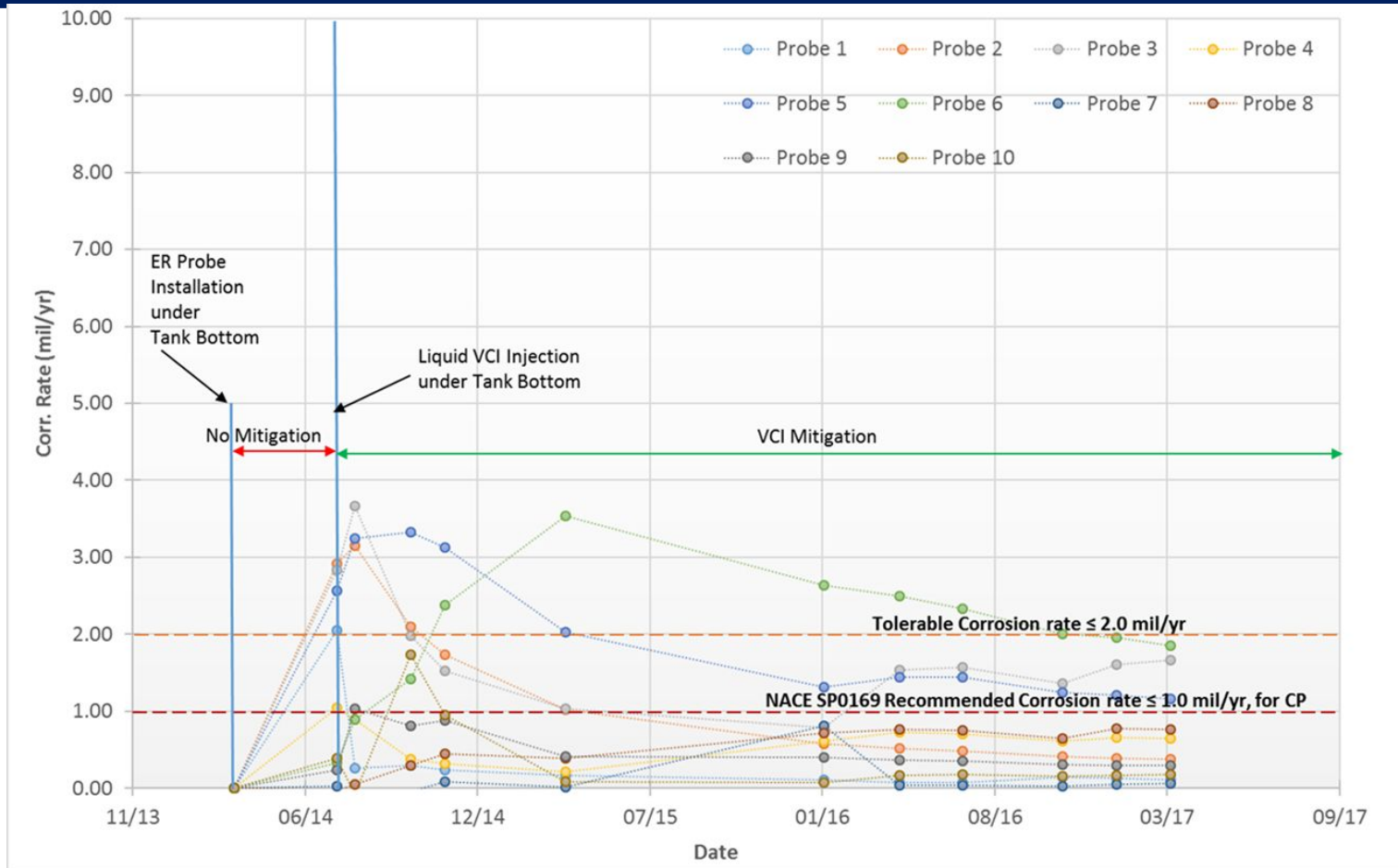




# Double Bottom



# Probe Data



# CUI

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Contact inhibitor in Silicone





# CUI Trial Results

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Conducted: November 2018

Inspected: October 2019

Duration: 11 months

Live Line: Ambient to 100C



# Summary

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- VCI's have been around a long time
- Effectiveness is well documented
- API & AMPP documents
- PHMSA Approvals & Trials
- Many applications
- Another “Tool in the kit”





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**tions?**

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