How VCI’s Can Prevent Corrosion for AST and UST System Components

Presented by David Durling, Zerust Oil & Gas
Efim Lyublinski, Monique Posner, Terry Natale,
Yefim Vaks, Ronnie Singh, Kelly Baker, Gautam Ramdas
Northern Technologies International Corporation, USA

Marcelo Schultz
Petrobras, Brazil

Marshall Mott-Smith
Mott-Smith Consulting
AGENDA

• Introduction
• What are VCIs
• Industry Applications
• Delivery Systems Document
• Tank Floors – Several Options
• Tank Roofs
• Pipelines
• Intro to Ethanol Corrosion
• Questions
Definition - VCI

Vapor Corrosion Inhibitors

Also referred to as Volatile Corrosion Inhibitors

- A class of corrosion inhibiting compounds which have vapor pressures higher than that of air.
- This results in the release of vapor molecules of inhibitor into the air.
Different Mechanisms for Different Purposes

Passivators
- Anodic inhibitors that shift the metal potential in the positive direction
  - Direct – anions react with the metal surface and become part of the passive film (chromates, nitrites)
  - Indirect – improve adsorption of the dissolved oxygen on the metal surface to enable oxygen to passivate the metal surface (phosphates, silicates)

Barriers
- Act as a barrier layer between the metal and the environment, adsorption can be either physical (electrostatic) or chemical (sharing electrons)
  - Organic – coat the surface with an oily layer
  - Inorganic – inhibitor reacts with the environment to precipitate insoluble products (phosphates, silicates, bicarboantes)

Scavengers
- Eliminate dissolved oxygen from a closed system (neutral or alkaline pH) (sulfite)
- Inhibitor reacts with acidic gases in air space (ReCast-R1)

Neutralizer
- Reduces the concentration of H⁺ ion in solution
Definition Con’t

VCI molecules fill space and deposit on all surfaces.

• Can work for immersed surfaces
• Not a ‘coating’
• Does not change the metallurgy
• Not permanent
• Can be painted/welded
• Non-toxic
• Can be designed for the service exposure
Many forms of VCI

What’s the difference?

1. **Self-fogging Flash Corrosion Inhibitor (FCI™) technology**
   - High vapor pressure, low vapor density
   - Fast acting flash corrosion inhibitor
   - Fills vapor spaces immediately
   - Highest volume of protection per weight of active ingredient
   - Navigates complex systems

2. **Long-term Vapor Corrosion Inhibitor (VCI) protection**
   - Slower evolving, long-term vapor corrosion inhibitor

3. **Long-term Soluble Corrosion Inhibitor (SCI) protection**
   - Contact corrosion inhibitors activated when water present
   - Chloride “neutralizer”
Automotive industry – 30+ years

Not “NEW” Technology

Clean, environmentally friendly
Requires no cleaning prior to assembly
VCIs have been sold through major retailers for years

Several ‘consumer market’ products you can try:

- Lowes
- Cabellas
- Flambeau
- Kobalt
- ...others
Some consumers are more demanding than others ...

US Navy SEALS

VCI capsules in the engine housing

US Marines in Iraq

VCI gun sleeves
Managing Corrosion

Corrosion cannot be eliminated, it’s mechanism can only be slowed
Immersion Test

Concentration & Formulation Matter

Test Conditions:

• Immersion
• Solution pH 5
• NaCl 100mg/L
• Age 13 days @ 50°C
FVS formulation will evolve the VCI at a faster rate.
Applications!

How can VCI be used in Oil & Gas?
Low Temperature Flanges.

- Proprietary dual layer plastic film
- Impregnated with a VCI to enclose flanges, bolts and weld joints
- Average 2+ year life.
Long Term Corrosion Protection
Vapor Capsules

Numerous applications

Protection of Electrical & Electronic Control Panels and Safety Switch Boxes
Applications!

Tank Floors!
Underside
## Floor Configurations

**New/Existing – In Service/Out of Service**

<table>
<thead>
<tr>
<th></th>
<th>Cathodic Protection</th>
<th>VCI/SCI</th>
<th>Liquid VCI</th>
<th>Powder VCI</th>
<th>Suggested VCI / SCI System</th>
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<tbody>
<tr>
<td><strong>Sand Base w/ Liner</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>- Ring-Wall Injection System</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Dry Underside Tube System</td>
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<td>- Internal Flood System</td>
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<td>- Wet External Ring System</td>
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<td>- Wet External Ring System</td>
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<tr>
<td><strong>Double Bottom w/Liner</strong></td>
<td>Effectiveness determined by sand depth</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td><strong>Double-Bottom w/o Liner</strong></td>
<td>Effectiveness determined by sand depth</td>
<td>If original floor has no penetrations (?)</td>
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<td>Yes</td>
<td>- Dry Underside Tube System</td>
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<td>- Internal Flood System?</td>
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VCI Effect Under Tank Floors
External Ring System

- CHIME / TUBE SEAL
- INHIBITOR TUBE REFILL PORTS
- PERFORATED INHIBITOR TUBE
- CONCRETE or ASPHALT PAD
BERM AREA

Riser to inject liquid inhibitor slurry

PERFORATED INHIBITOR TUBE

CHIME / TUBE SEAL

CONCRETE or ASPHALT BASE

BERM AREA
SSB New Floor Trench System

- ER Probe / Coupon Ports
- Concrete Trench
- PVC Sleeve
- PVC Cap

Approx. 7.5’ (open for discussion)

Concrete Ring wall / pad
2” x 2” troughs
Parallel Tubes
Injection Options

Ring Wall OR Floor Plate

- 2" PVC Pipe (furnished by owner) install prior to wall concrete placement (see plan for location)
- Concrete Ring Wall
- Attach HDPE liner to foundation per Gundle Lining Systems, Inc. System "C" or approved equal
- Concrete Pile Cap
- #9 Dowels @ 11" O.C., place radially 60°, 9°
- 60 mil HDPE liner fusion welded at seams to create leak proof membrane
- Slot HDPE pipe (furnished in 20° joints by owner, installation by contractor)

Pile Beyond

Steel Shell (by others)

Asphalt Impregnated Felt (by others)

(9) #9 bars (typ.)

NOTE: Maintain wall levelness with API 650 to steel tank code.
Video of Under Floor Tube System

Corrosion Prevention for Soil Side Bottom (SSB) of Aboveground Storage Tanks (ASTs)

**Zerust ReCAST-SSB “Permanent Inhibitor Delivery System (PIDS)”**

(For new tanks or old tanks undergoing full bottom replacements)
Concrete ring wall, sand/soil foundation and a leak prevention liner
& Double bottom tanks with sand/soil fill and a leak prevention liner
Pipes Installed
SSB Double Bottom System

NEW TANK FLOOR

EXISTING TANK FLOOR

INHIBITOR STRIPS

SAND BASE

INHIBITOR SLURRY

MONITORING PORTS
Double Bottom Injection
Applications!

Tank Roofs!
Cone roof supports!

Continuity of coatings?

Tank roof and support beam

Coatings do not effectively cover all surfaces
Cone roof plates

Welded on top-side, and flex.

Steel roof plates

Flexing of roof plates

Allows for crevice corrosion
Examples of AST Roof corrosion

Internal acid gas vapors cause underside corrosion
Mitigate roof underside corrosion

The delivery system!

Inhibitor levels can be monitored and replenished while the tank is "In-Service".

Molecular vapor pressure disperses the inhibitor from cannisters installed during a tank shutdown.
Dispenser Placement

- 22.1m = 72.5ft Diameter
- Expected avg. cycling of 1 time per week
- Total Recommended Dispensers = 13

- 55m = 180ft Diameter
- Expected avg. cycling of 1 time per week
- Total Recommended Dispensers = 51
Roof System

1. Liquid VCI volatizes into a vapor.
2. Vapor pressure forces the VCI molecules down through the nozzle into the tank vapor space.
Mono-Molecular Barrier

VCI takes preference on steel surface
Applications!

Other Applications!
Pipe Casings

Long Term Corrosion Protection

Vent Pipe

Surface structure
i.e.: road, rail, etc.

Casing Seal
UST System Components

UST Sump
UST Vapor Space Chemistry

Ethanol Vapors + Water + Bacteria = Acetic Acid
No Inhibitor

December 5, 2013

February 20, 2014
Current Test Locations in Texas
Current Test Locations in Texas
Current Test Locations in Texas
Current Test Locations in Texas
Current Test Locations in Texas
After 1 Month at Test Site in Texas
One other site in Texas 
(this store is around 3 yrs old!)
One other site in Texas
(this store is around 3 yrs old!)

After 5 weeks!
One other site in Texas
(this store is around 3 yrs old!)

After 5 weeks!
Some Visible Surface Corrosion
Significant Surface Corrosion
<table>
<thead>
<tr>
<th>Site</th>
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<th>May 2014</th>
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<td>Packet Only</td>
<td>Front Side Spray Only</td>
<td>Front Side &amp; Sump Spray</td>
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## UST Test Sump

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<tr>
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<td>[Image]</td>
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<tr>
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<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
</tr>
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</table>
Beta Test

• Relatively Clean Surface & Tightened Fittings

Annual Application

Monthly Application
Thank you!
Questions?

David Durling
ddurling@ntic.com
832-482-8781