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

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Mott-Smith Consulting
1. VCI Background
2. Problem definition
3. Corrosion protection of storage tanks
4. Corrosion protection UST Sumps
5. Conclusions
What are VCIs?

- 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.
- These molecules will adsorb to the surface of steel and block other molecules from coming in contact with the steel.

- Can protect immersed surfaces
- Not a ‘coating’
- Does not change metallurgy
- Not permanent

- Can be painted/welded
- Non-toxic
- Can be designed for specific 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

- Thousands of machined parts must remain pristine during transport and storage.
- 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
Long Term Corrosion Protection

Shipping, Storage, Mothballing
Low Temperature Flanges

Flange Savers™

NTIC/Zerust uses a proprietary material impregnated with a Vapor Corrosion Inhibitor (VCI) to enclose the flanges, bolts and weld joints.
Corrosion cannot be eliminated, it’s mechanism can only be retarded
How can VCI be used in AST’s?
“ReCAST-SSB System provides environmental protection substantially equivalent to that provided by compliance with the requirements established in Rules 62-762.501(1)(f)4., 62-762.701(1)(b), F.A.C and may be used as a Cathodic protection system... Pursuant to Rule 62-762-851(2), F.A.C. ... is approved in the State of Florida as a corrosion inhibitor system that is applied to the soil filled area between the secondary containment system of an aboveground storage tank.”
Tank Bottom Geometries

 Aggregate Ring Wall

 Concrete or Asphalt Base

 with Reinforced Polymer Barrier

 Double Bottom

 Cone Up - Flat - Cone Down
Examples of Problems

Penetrations due to tank bottom corrosion

Are they from topside or bottomside?
How Do VCIs Work Under Tanks?

Tank Shell

Gap

Tank Floor

& Void

VCI Adsorb

Sand Base

VCI Molecules
Case Study – Double Bottom

Soil Side Bottom (SSB) Protection

Test

Control

VCI in Sand

Test Coupons

No VCI

A

B

C

D

E

F

G
Coupon Tests

Coupons were removed in 2007 and 2011 for corrosion rate evaluation according to ASTM G1-03.
# Surface Area Results

## Surface Area Affected by Corrosion - 2007 Specimens

<table>
<thead>
<tr>
<th>Specimen Type</th>
<th>Specimen ID</th>
<th>% Corroded Surface Area</th>
<th>Predominant Type of Corrosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Tank</td>
<td>B</td>
<td>86</td>
<td>Uniform / General</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>61</td>
<td></td>
</tr>
<tr>
<td></td>
<td>G</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>Control Tank</td>
<td>Control</td>
<td>22</td>
<td>Pitting</td>
</tr>
</tbody>
</table>
## Corrosion Rate Results

<table>
<thead>
<tr>
<th>Specimen Type</th>
<th>Specimen ID</th>
<th>Corrosion Rate (mm/year)</th>
<th>2007 Specimens</th>
<th>2011 Specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test Tank</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>--</td>
<td></td>
<td>0.0014</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.0041</td>
<td>0.0013</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0.023</td>
<td>0.010</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>0.042</td>
<td>0.026</td>
<td></td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>0.0075</td>
<td>0.0017</td>
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<td></td>
<td>F</td>
<td>0.0085</td>
<td>0.0041</td>
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</tr>
<tr>
<td></td>
<td>G</td>
<td>0.0050</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ALL (Avg)</td>
<td>0.015</td>
<td>0.0075</td>
<td></td>
</tr>
<tr>
<td><strong>Control Tank</strong></td>
<td>Control</td>
<td>0.059</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control P*</td>
<td>0.19</td>
<td>--</td>
<td></td>
</tr>
</tbody>
</table>

* Control P is the measured maximum pitting depth
Corrosion Rate vs. Time Exposed

Corrosion Rate (mm/yr)

- Control P: 0.20
- Control: 0.16
- A, B, C, D, E, F, G: 0.04

Legend:
- Blue: 9 months
- Red: 53 months

Notes:
- Pitting corrosion on Control coupon
- No pitting observed on test coupons
1. VCIs can work in conjunction with other forms of corrosion protection or stand-alone.

2. Can be installed under almost any tank pad design.

3. Tank pad design determines whether the original VCI installation can be accomplished while the tank is in service, or if it needs to be out-of-service.

4. VCI can be replenished as needed over time without taking the tank out-of-service, in any of the scenarios mentioned above.

5. Reduction in corrosion rates extend the life of the asset and the maintenance interval.
Tank Roofs
Floating Roof Legs
UST System Components

UST Sump
UST Vapor Space Chemistry

Ethanol Vapors + Water + Bacteria = Acetic Acid
No Inhibitor

No Inhibitor

December 5, 2013

February 20, 2014
UST Lab Test

- Inhibitor Packet
- Stand and Panels
- Jar and Lid
- Film Gasket
- Stand and Jar
UST Lab Test

0.05% Acetic Acid
- 10 ml
- 25 ml

Control 25 mg 50 mg 100 mg

0.1% Acetic Acid
- 10 ml
- 25 ml

Control 25 mg 50 mg 100 mg

mg of Inhibitor
UST Trial Components

Sample Sump

VCI Volatizes in Enclosure

Packet of VCI

Florida (e10)

Coupon
## UST Test Sites

Install Date: December 5, 2013

### Client Sites in South Florida

<table>
<thead>
<tr>
<th>Owner</th>
<th>Location</th>
<th>Sump Description</th>
<th>Coupon</th>
<th>VCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>A</td>
<td>RUL - South</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>#1</td>
<td>A</td>
<td>RUL - Middle</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>#1</td>
<td>A</td>
<td>RUL - North</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>#2</td>
<td>B</td>
<td>RUL - SE</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>#2</td>
<td>B</td>
<td>PUL - SW</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>#2</td>
<td>C</td>
<td>RUL - SW</td>
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<td>Yes</td>
</tr>
<tr>
<td>#2</td>
<td>C</td>
<td>PUL - Middle</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>#2</td>
<td>C</td>
<td>RUL - NE</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>#2</td>
<td>D</td>
<td>PUL - NW</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>#2</td>
<td>D</td>
<td>RUL - NE</td>
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<td>No</td>
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<td>#2</td>
<td>D</td>
<td>RUL - SE</td>
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<tr>
<td>#2</td>
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</tr>
<tr>
<td>#1</td>
<td>F</td>
<td>RUL</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Total** 18 10

* RUL Regular Unleaded

*PUL Premium Unleaded
Some Visible Surface Corrosion
UST Control Sump

Coupon Only

December 5, 2013
January 16, 2014

Significant Surface Corrosion
No Visible Corrosion
<table>
<thead>
<tr>
<th>Site</th>
<th>March 2014</th>
<th>April 2014</th>
<th>May 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Packet Only</td>
<td>Front Side Spray Only</td>
<td>Front Side &amp; Sump Spray</td>
</tr>
<tr>
<td>A</td>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>B</td>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>Site</td>
<td>March 2014</td>
<td>April 2014</td>
<td>May 2014</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------</td>
<td>---------------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td></td>
<td>Packet Only</td>
<td>Front Side Spray Only</td>
<td>Front Side &amp; Sump Spray</td>
</tr>
<tr>
<td>C</td>
<td>[Image]</td>
<td>[Image]</td>
<td>[Image]</td>
</tr>
<tr>
<td>D</td>
<td>[Image]</td>
<td>[Image]</td>
<td>[Image]</td>
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</table>
# UST Test Sump

<table>
<thead>
<tr>
<th>Site</th>
<th>March 2014</th>
<th>April 2014</th>
<th>May 2014</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Packet Only</td>
<td>Front Side Spray Only</td>
<td>Front Side &amp; Sump Spray</td>
</tr>
<tr>
<td>E</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
1. Acetic Acid can form in the sumps, due to Ethanol vapors, bacteria and moisture.

2. Absence of any of the three seems to result in a much lower corrosion rate.

3. Vapor Corrosion Inhibitors can reduce corrosion rates.

4. Sump condition is a factor in the effectiveness of the VCI.

5. Tests are on-going.
Thank you!
Questions?

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