From the Sublime to the Ridiculous: Life in the Fast Coatings Lane

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MARTS meeting 4th Oct, 2016
Sublime – Ridiculous Agenda

- Faster, Faster, Faster?
- Sublime to the Ridiculous
- Problems
- Solutions

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Why Line Tanks?

Corrosion protection
• Crude oil tanks: bottom and ≈ 1 meter up the side
• Corrosive chemicals (e.g. aqueous): Whole tank

Protection of product purity
• Finished products: Line whole tank to prevent contamination with e.g. rust particles

Materials Integrity
• Some chemicals e.g. ethanol, may cause stress corrosion cracking of welds → line whole tank
Cargo Storage Temperatures

- Epoxy
- Phenolic epoxy
- Novolac epoxy

Thin film systems

Thick film systems
Chemical Resistance - Lining History

- Epoxy
- Phenolic Epoxy
- Novolac Epoxy
- Polycyclamine cured Novolac Epoxy
- Vinyl Ester
- Novolac Vinyl Ester
- Novolac Epoxy
- Phenolic Epoxy
- Epoxy

Big Innovations

Chemical Resistance

Technology
Faster, Faster, Faster: Solvent-Free Epoxy Advantages

- Quick return to service
- Usually a one-coat lining system
- Can be applied at high film builds
- No risk of solvent entrapment
- No inter coat adhesion issues
- Can save a great deal of time and labour
- Excellent adhesion to prepared steel substrate
Sublime to Ridiculous - Solvent-Free Epoxy Advantages

- Minimal OH&S issues
- No worker exposure or solvent LEL concerns
- Seen as being environmentally friendly
- Edge Retention
Solvent-Free Epoxy Disadvantages

- Higher viscosities of one or both components
- Difficulty in mixing
- Shorter pot life
- More complicated equipment: paint heaters, proportioning pumps, static mixers, etc.
- Not for use in vessels with complex geometry
- Lower chemical resistance
“The more complicated the equipment and the shorter the pot life, the greater the chance that things will go wrong with Solvent-Free Epoxies in the field”

Mark Dromgool, KTA Tator Australia
Application Equipment: Plural Spray
A good rate of success of some facility owners with Solvent-Free Epoxy linings, does not always translate well to other regions, contractors or owners.
Always be ready for any surprises in life...
Value of Stripe Coating and Possible Issues

- Very important for tank and vessel linings
- SFE materials are not very tolerant to stripe coating
- Film thickness control
- Too viscous to mix properly and apply correctly
- Elevating the temperature shortens the pot life
- Mix ratio errors are magnified
AHA – Perhaps Solvents are Really Good?
We all love solvents
Chemistry - Solvent

- The absence of solvent denies the coating of lubricity
- Solvent provides many advantages during the mixing, induction, application, reaction, drying and curing phases
- Solvents lower the surface tension of the coating which means better wetting of the substrate
- Slower gelling times often lead to higher wet and dry adhesion
Coating cure is not simple and uniform as often depicted. Rather, it is nucleated and autocatalytic.

Like a crossword puzzle, having something makes it easier to fill-in.
Solvent-Based Epoxy Features

- Easier to mix and have a longer and more usable pot life
- Can accept some site-added solvent to help make the coating system adjust for different climatic or substrate conditions and to suit the available application equipment
- Usually result in more uniform film build and less chances of overbuild
- Can achieve higher crosslink densities and more complete cure due to the lower viscosity, more lubricity and hence better molecular mobility of the reactive species
- Are much more easily handled by coating application contractors with a variety of skill levels
Solvent-Based Epoxy Features

- Have a slower gel time after application which aids flow into the surface profile and assists release of air from the film
- Quite tolerant of a variety of weather, substrate and other application conditions
- Multiple coats minimise the chances of concurrent pinholes or defects
- Have superior wetting due to the lower surface tension that the solvent brings to the resin binder
- Apply well as stripe coats without the compromises to their chemistry and integrity due to variations in the effective induction time
Solvent-Based Epoxy Disadvantages

- Relatively low volume solids
- Multiple coats usually required.
- Ventilation mandatory
- Hazardous solvents - an OSHA issue, etc.,
- Danger of solvent entrapment
- Longer cure times
- Poor productivity
Where Do We Go Now?
Shift to New Technology Solvent-Free Epoxy Technology

The Tour De Force Solutions
Next technology Solvent-Free Epoxy Lining

Solvent-Borne Epoxy

- Multiple coats (2-3)
- Longer cure time
- Low film build

New Technology Solvent-Free Coating

+ Low Viscosity
+ Long Pot Life
+ Fast cure
+ Single Coat
+ Film build 15-35 mils
+ No Blushing
+ High Performance
+ High Heat resistance
+ Excellent wetting
+ Single Leg Equipment

Traditional: Solvent-Free Coating

- High viscosity
- Poor wetting
- Short pot life
- Plural Equipment

...the Best of Solvent-Free and Solvent-Borne in 1 easy to use Lining
Balancing Act – Judicious Lining Selection
**Next Generation Lining Technology**

Single Leg Airless or Plural Component spray applied
- No thinning required
- No heating required
- Pot life of 70 minutes @ 77°F/25°C

Single Coat application
- Typical 10-14 mils DFT
- Flexible Lining
- No Amine Blush

Services Excellent
- FDA Approved
- Benzyl Alcohol and BPA Free
- High Temp Crude Oil

Fast Cure
- Holiday test 5 hours @ 77°F/25°C
- Bake Schedule @150°F is 2 hours

High solids, Ultra Low VOC
- 96% ±2% Volume solids
- 0.37lb / gal (45 g./Litre)
3rd Party Independent Laboratory Testing

300 °F

250 psi
<table>
<thead>
<tr>
<th>Coatings</th>
<th>Sample ID</th>
<th>Testing Phase</th>
<th>Pre-Test</th>
<th>Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Thickness (mils)</td>
<td>Adhesion*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gas</td>
<td>24.1 - 24.8</td>
<td>A</td>
</tr>
<tr>
<td>E - 1</td>
<td></td>
<td>Hydrocarbon</td>
<td>26.0 - 27.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>24.7 - 26.1</td>
<td></td>
</tr>
<tr>
<td>International Paint Environline 2405</td>
<td>E - 2</td>
<td>Gas</td>
<td>20.4 - 20.9</td>
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<tr>
<td></td>
<td></td>
<td>Hydrocarbon</td>
<td>20.6 - 22.2</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Water</td>
<td>23.0 - 23.5</td>
<td></td>
</tr>
</tbody>
</table>

*Pre-test adhesion and EIS was conducted on the un-tested reference panels.

Note: After test, the pH of the water solution was about 6.0.

Rating Key:

<table>
<thead>
<tr>
<th>Blistering</th>
<th>Rated as per ASTM D714</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>Density</td>
</tr>
<tr>
<td>#2 #4 #6 #8</td>
<td>Medium (M)</td>
</tr>
<tr>
<td>Large.....Small</td>
<td>Medium-Dense (MD)</td>
</tr>
<tr>
<td>Dense (D)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Adhesion</th>
<th>Rated as per parallel scribe</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Coating may shear within itself but does not release from substrate</td>
</tr>
<tr>
<td>B</td>
<td>Some metal is visible but more than 50% of the coating remains adhered</td>
</tr>
<tr>
<td>C</td>
<td>More than 50% of the coating is removed</td>
</tr>
<tr>
<td>D</td>
<td>All coating releases between scribes but remains firmly adhered adjacent to cuts</td>
</tr>
<tr>
<td>E</td>
<td>No bond exists between coating and substrate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Colour Change</th>
<th>None (N)</th>
<th>Slight (S)</th>
<th>Moderate (M)</th>
<th>Severe (SE)</th>
</tr>
</thead>
</table>

**Date:** Jan 13 – Feb 12, 2014
**Duration:** 30 Days
**Tested by:** J. Cortes, S. Rao
**Pressure at Normal Temp.:** 145±15 psi @ 120±3°C
**Pressure at Spike Temp.:** 210±15 psi @ 146±3°C
**Gas Phase:** 50% H$_2$S and 50% CO$_2$
**Hydrocarbon Phase:** Toluene Kerosene @ 1:1 by Volume
**Water Phase:** 75 ppm Cl in Water with pH of 3.5
Laboratory Testing
Deionized Water Immersion for 12 Months @ 212F/100C

Pre Test Adhesion:
1522 psi/10.5 MPa

Post Test Adhesion:
1261 psi/8.7 MPa
Laboratory Immersion Testing
High Temperature Crude Oil for 6 Months

RESULTS:
Performed as a liner for crude oil and water. Absolutely no corrosion.

Crude Oil Phase

Water Phase

Crude + 3% NaCl @ 203°F/95°C

Crude + 3% NaCl @ 203°F/95°C

Established Product Comparison
## Chemical Resistance

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Test Method</th>
<th>Specification Details</th>
<th>Typical Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immersion</td>
<td>ISO 2812 Part 2 – “Resistance to Corn Syrup @ 80C”</td>
<td>1×300µm/500µm dft applied directly to Sa2½ blasted steel.</td>
<td>No film defects following 3 months exposure.</td>
</tr>
<tr>
<td>Immersion</td>
<td>ISO 2812 Part 2 – “Resistance to Molasses @ 60C”</td>
<td>1×300µm/500µm dft applied directly to Sa2½ blasted steel.</td>
<td>No film defects following 3 months exposure.</td>
</tr>
<tr>
<td>Immersion</td>
<td>ISO 2812 Part 2 – “Resistance to Vegetable Oil @ 60C”</td>
<td>1×300µm/500µm dft applied directly to Sa2½ blasted steel.</td>
<td>No film defects following 3 months exposure.</td>
</tr>
<tr>
<td>Immersion</td>
<td>ISO 2812 Part 2 – “Resistance to Lard @ 60C”</td>
<td>1×300µm/500µm dft applied directly to Sa2½ blasted steel.</td>
<td>No film defects following 3 months exposure.</td>
</tr>
<tr>
<td>Immersion</td>
<td>ISO 2812 Part 2 – “Resistance to PP and HDPE Plastic Pellets @ 60C”</td>
<td>1×300µm/500µm dft applied directly to Sa2½ blasted steel.</td>
<td>No film defects following 3 months exposure.</td>
</tr>
<tr>
<td>Immersion</td>
<td>ISO 2812 Part 2 – “Resistance to Dry Flour, Sugar, Starch @ 60C”</td>
<td>1×300µm/500µm dft applied directly to Sa2½ blasted steel.</td>
<td>No film defects following 3 months exposure.</td>
</tr>
<tr>
<td>Immersion</td>
<td>ISO 2812 Part 2 – “Resistance to 5% Beers @ 60C”</td>
<td>1×300µm/500µm dft applied directly to Sa2½ blasted steel.</td>
<td>No film defects following 3 months exposure.</td>
</tr>
<tr>
<td>Immersion</td>
<td>ISO 2812 Part 2 – “Resistance to 5% Vodka @ 60C”</td>
<td>1×300µm/500µm dft applied directly to Sa2½ blasted steel.</td>
<td>No film defects following 3 months exposure.</td>
</tr>
</tbody>
</table>
Easy Maintenance Use – Complex Geometry

Applicators Comments: “One of the easiest 100% solids material I have sprayed, it has a great pot life for brushing out the welds and hard to coat areas.”
The End