Innovative Coatings and Linings Technology for Rail Cars
Vijay Datta MS, International Paint LLC and Mike O Donoghue, PhD
Overview

➢ Introduction

➢ Technology Trends for Interior Tank linings

➢ Technology Trends For Exterior Tank coatings

➢ Questions?
Corrosion Cost Comparison

Annual Cost of Corrosion:  > $990 Billion
Annual Cost of Natural Disasters:  > $19 Billion

Corrosion costs the US Economy

> 50 times

as much as all the natural disasters

Source: Pierre Crevolin, NACE 2005 Western Regional Conference and G2MT Laboratories 2014
Corrosive Components In Crude Oil

- Brackish Water (Chlorides)
- Carbon Dioxide
- Organic Chlorides—Phantom Chlorides
- Organic Acids
- Sulfur
- Bacteria
Various Kinds Of Crude Oil

- Tar Sand
- Eagle Ford
- Bakken Crude
- Many others
- All Vary in Composition
Bakken Crude Oil

- Higher Levels of light-ends and Combustible gases
- High Vapor Pressure - 13.9 PSI vs 6 PSI
- Higher the Vapor pressure more Volatility
Always be ready for any surprises in life...
Blistering
Cracking
Why Line Rail Cars

**Corrosion protection**
- Crude Oil with water
- Corrosive chemicals

**Protection of product purity**
- Finished products: Line whole Tank Car 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 car
**Volume Solids over the Years**

- **100%**
  - High film build
  - One Coat
  - Superior health & safety
  - Superior performance on pitted steel

- **75%**
  - Less solvent content
  - Higher film build
  - More coverage

- **50%**
  - High solvent content
  - Low film build
  - Less Coverage

- **1970s**
- **1980s**
- **1990s**

- **Volume Solids over the Years**

- **100%**
  - High film build
  - One Coat
  - Superior health & safety
  - Superior performance on pitted steel

- **75%**
  - Less solvent content
  - Higher film build
  - More coverage

- **50%**
  - High solvent content
  - Low film build
  - Less Coverage
Chemical Resistance - Lining History

- Epoxy
- Phenolic Epoxy
- Novolac Epoxy
- Polycyclamine cured Novolac Epoxy
- Vinyl Ester
- Novolac Vinyl Ester
- Big Innovations
- Phenolic Epoxy
- Novolac Epoxy
- Epoxy
## Generic Examples - Where to use Linings

<table>
<thead>
<tr>
<th></th>
<th>Water/waste water</th>
<th>Solvents</th>
<th>Caustics</th>
<th>Mineral acids</th>
<th>Organic acids</th>
<th>Vegetable oils/fatty acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epoxy</td>
<td>✓</td>
<td>±</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Phenolic Epoxy</td>
<td>✓</td>
<td>±</td>
<td>✓</td>
<td>±</td>
<td>✓</td>
<td>±</td>
</tr>
<tr>
<td>Novolac epoxy</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>±</td>
<td>±</td>
<td>✓</td>
</tr>
<tr>
<td>Polycyclamine cured Novolac</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>±</td>
<td>✓</td>
</tr>
<tr>
<td>Vinyl ester</td>
<td>✓</td>
<td>±</td>
<td>±</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

✓ = generally suitable  ± = sometimes suitable  X = generally unsuitable
Crude Oil Storage Temperatures

- **Thin film systems**
  - Epoxy
  - Phenolic epoxy
  - Novolac epoxy

- **Thick film systems**
  - Epoxy
  - Phenolic epoxy
  - Novolac epoxy

**Light crude**

**Heavy crude**

Temperatures:
- 40°C
- 60°C
- 80°C
- 100°C
Epoxy or polyepoxide is a **thermosetting polymer** formed from reaction of an **epoxide** "resin" with **polyamine** "hardener".

- **Bisphenol A type epoxy**
- **Bisphenol F type epoxy**
- **Epoxy phenol novolac**
- **Epoxy cresol novolac**
Epoxy Cross - Link Density

Traditional Bis A Epoxy

Low viscosity Bis F Epoxy

Higher Viscosity Epoxy Novolac
Polycylamine Cured Hybrid Epoxy

- Volume Solids: (96% ±2%)
- VOC Compliant: (45 g/L EPA Method 24)
- Easy Mix Ratio: (2:1 by Volume)
- Great Pot Life: (1 hour @ 77°F/25°C)
- No heating required: (spray at ambient temperatures)
- Rapid Curing: (Dries Hard in 6 hours @ 77°F/25°C)
- Great Maximum Reccoat Window: (7 Days @ 104°F/40°C)
- Rapid return to service: (48 hours @ 72°F/22°C)

- Lower Temperature Application:
  -(minimum Temperature: 50°F/10°C)
- ALL this with simple single leg airless spray application!
  –Yes it can be sprayed via plural component without heat
Extensive Laboratory Testing

- Autoclave Testing
- Atlas Cell Testing
- Immersion Testing
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

Dolly Glue Failure
Laboratory Immersion Testing
High Temperature Crude Oil for 6 Months

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

Crude + 3% NaCl @ 203°F/95°C

Crude + 3% NaCl @ 203°F/95°C
Laboratory Immersion Testing
High Temperature Crude Oil for 6 Months

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

6 Months (Insulated)
Crude + 3% NaCl
@ 203°F/95°C

Water Vapor Phase
Crude Oil Phase
Dolly Glue Failure
ISO 2812 – ISO Immersion in “Shale Oil” @ 221°F/105°C

- Panels are 2/3rds immersed in the Shale Oil for 6 months
Laboratory Testing
Autoclave Test

The high pressure vessel was partly filled with the following test solution, brought to the appropriate temperature with an external heating jacket.

Test Method: NACE TM 185 Procedure
Temperature: 365°F/185°C
Pressure: 165 psi / 11 bar
Water: 3% Sodium Chloride Solution
Gas: Super Heated Steam
Duration: 6 months
Decompression: None
Cool Down: From 365°F/185°C to 70°F/21°C in 16-24 hours
High Temperature Cathodic Disbondment

Independent Testing Done at Charter Coating Service

Volts: -1.45 to -1.55
Temperature: 200°F/93°C
Initial Holiday: 3.2 mm
Test Duration: 28 days

Sample:
Samples: 2405 applied in one coat @ 30 mils DFT
Cured: 7 days at 77°F/25°C
Method of application: Single Leg no heating

(CSA Z245.20-10 @ 200°F/93°C)
Shop Application and Field Repair

Shop Application:
• Any Tank Lining

Field Application:
• Solvent free coating
  – Kit packs for field repairs
Trends in External Linings
Zinc Rich Primers

Cathodic Protection and Barrier Protection
“Only zinc-rich coatings can eliminate pitting corrosion at voids, pinholes, scratches and abrasions. This protective capability makes zinc-rich coatings so unique.”

Ken Tator, KTA Tator Inc.
# New Construction Systems

<table>
<thead>
<tr>
<th>Description</th>
<th>Material</th>
<th>DFT Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primer</strong></td>
<td>Zinc Rich Epoxy</td>
<td>2.5 - 3 mils</td>
</tr>
<tr>
<td>(Cathodic Protection &amp; Barrier)</td>
<td></td>
<td>DFT</td>
</tr>
<tr>
<td><strong>Optional Mid Coat:</strong></td>
<td>High build Epoxy</td>
<td>4 - 6 mils</td>
</tr>
<tr>
<td>(Barrier Coat)</td>
<td></td>
<td>DFT</td>
</tr>
<tr>
<td><strong>Finish Coat:</strong></td>
<td>Urethane, Polyaspartic, or</td>
<td>2-3 mils</td>
</tr>
<tr>
<td>(Gloss and Colour)</td>
<td>Polysiloxane</td>
<td>DFT</td>
</tr>
<tr>
<td></td>
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</tbody>
</table>
Polyurethanes

Gloss and Color Retention
The Enemy: Free Radicals and UV
Gloss and Color Retention
## Polyurethane vs. Polyaspartic – Courtesy Bayer

<table>
<thead>
<tr>
<th></th>
<th>Conventional Polyurethane</th>
<th>Polyaspartic Urethane</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Potlife</strong></td>
<td>~ 4 hours</td>
<td>~3 hours</td>
</tr>
<tr>
<td><strong>Film Build</strong></td>
<td>2-4 mils</td>
<td>6-9 mils</td>
</tr>
<tr>
<td><strong>Edge Retention</strong></td>
<td>40-50%</td>
<td>70-80%</td>
</tr>
<tr>
<td><strong>Color and Gloss Retention</strong></td>
<td>SSPC Paint 36 Level III</td>
<td>SSPC Paint 39 Level III</td>
</tr>
<tr>
<td><strong>Dry Hard times</strong></td>
<td>6-12 hours</td>
<td>1-3 hours</td>
</tr>
<tr>
<td><strong>Application</strong></td>
<td>Spray, Brush, Roll</td>
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Polysiloxanes

Gloss and Color Retention
Polysiloxane coatings form a more impenetrable layer against the forces of nature and are much more able to resist the degrading properties present within sunlight.
Single Pak Polysiloxane Finish
Single Package Polysiloxane

Based on siloxane inorganic chemistry which allows for stronger chemical bonds

These bonds are already oxidized which means that there is much more resistance to degradation by:

• Thermal Oxidation

• Photo-initiated Oxidation

• Chemical Effects
Features and Benefits

Extended Durability
- Exceptional gloss retention
- Excellent color retention
- Resistance to dirt pick up
- Easy washability with water/detergent
- Very Flexible
Thank You - Any Questions?

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Mike.odonoghue@akzonobel.com