Innovative Coatings and Linings Technology for Rail Cars

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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

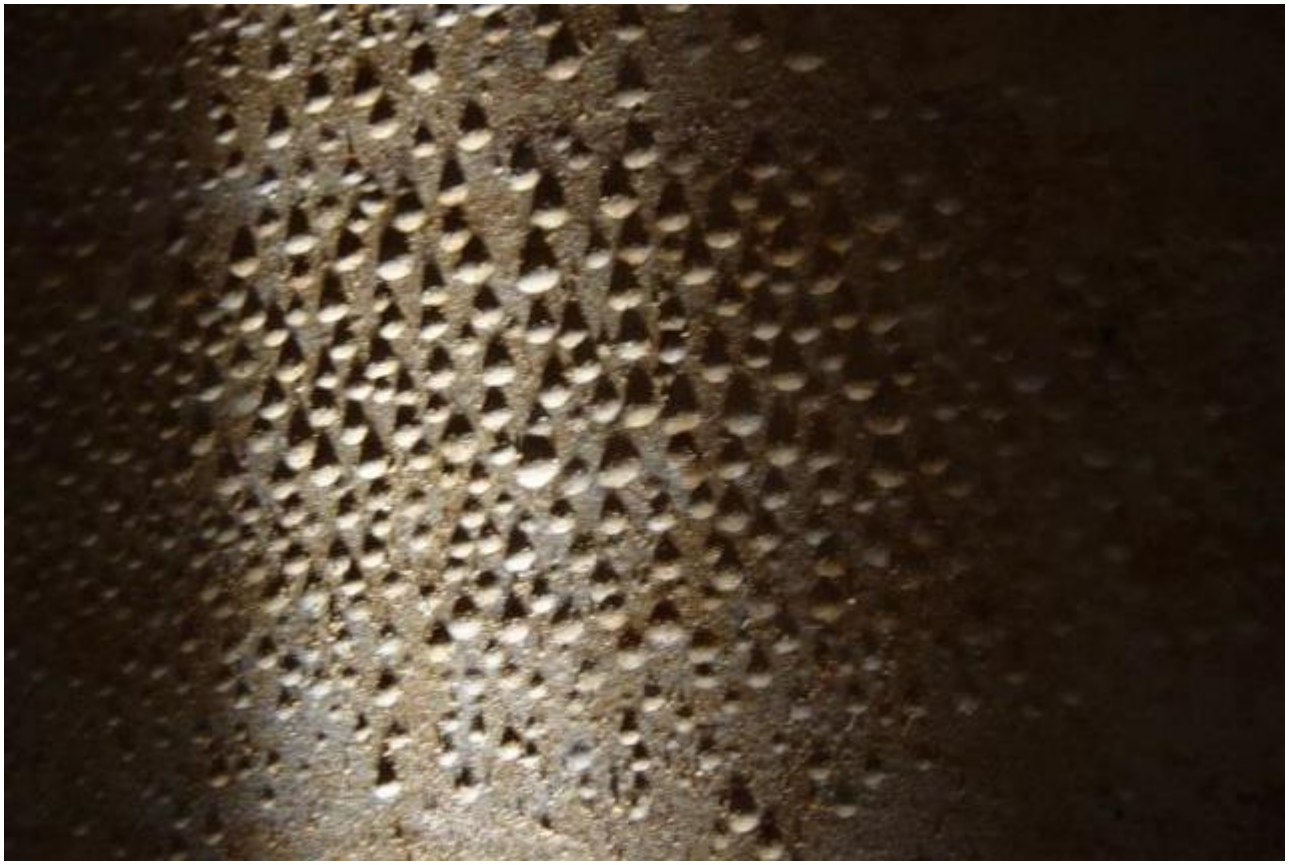
- Tar Sand
- Eagle Ford
- Bakken Crude
- Many others
- All Vary in Composition

Bakken Crude Oil

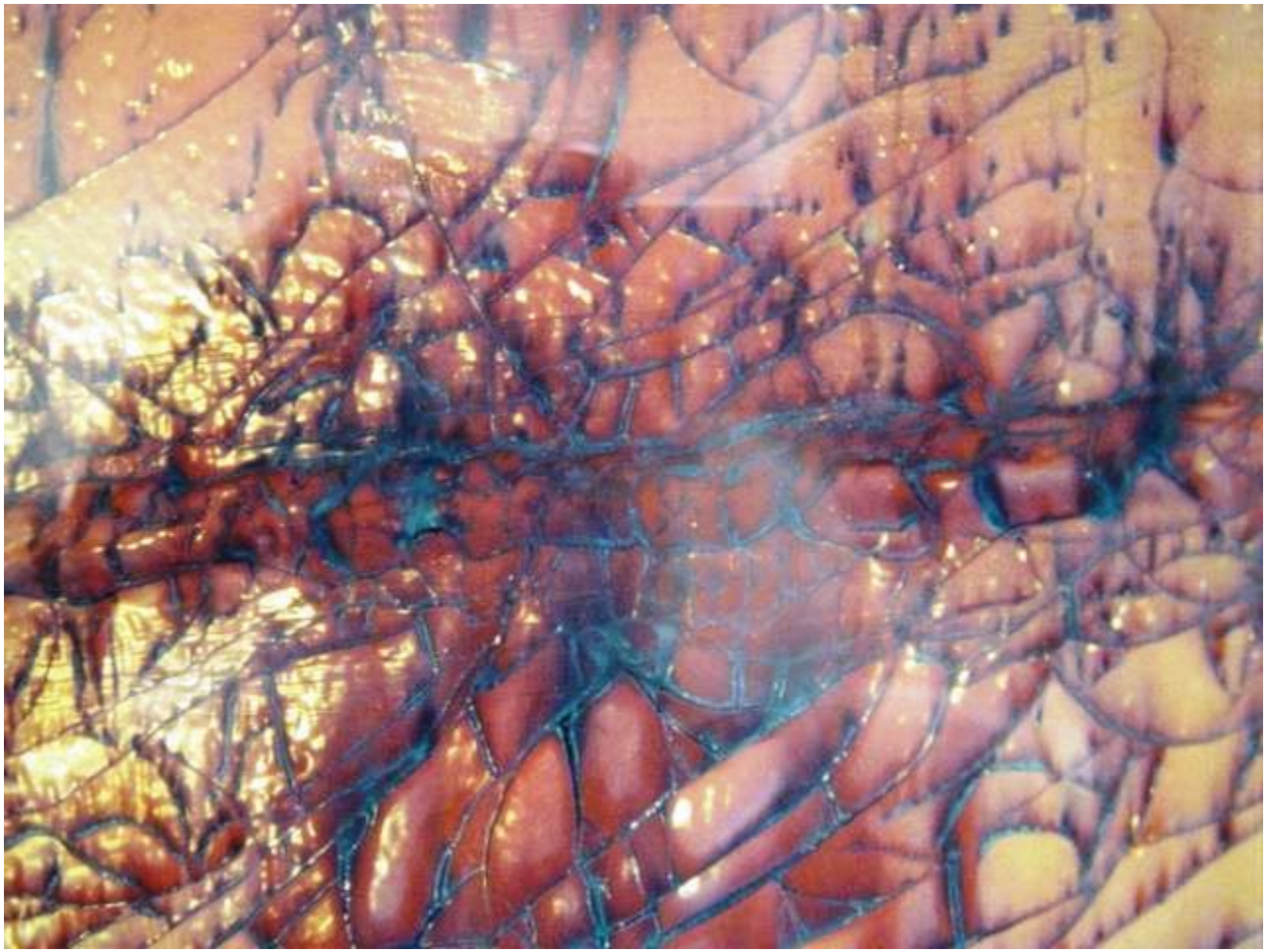
- Higher Levels of light-ends and Combustible gases
- High Vapor Pressure - 13.9 PSI vs 6 PSI
- Higher the Vapor pressure more Volatility

Always be ready for any surprises in life...

Blistering



Cracking



Trends in Internal Coatings

Why Line Rail Cars

Corrosion protection

- Crude Oil with water
- Corrosive chemicals

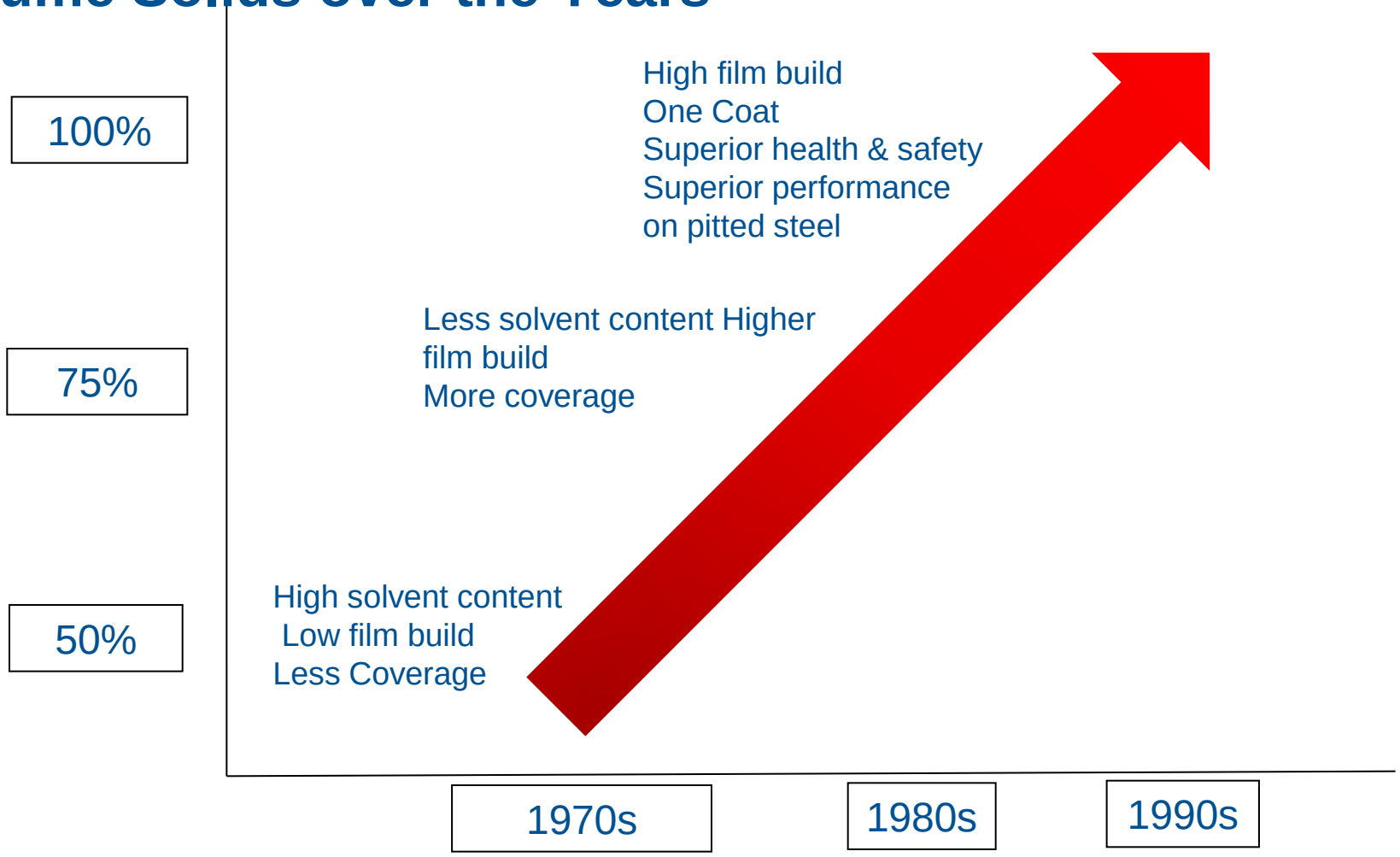
Protection of product purity

- Finished products: Line whole Tank Car to prevent contamination with e.g. rust particles

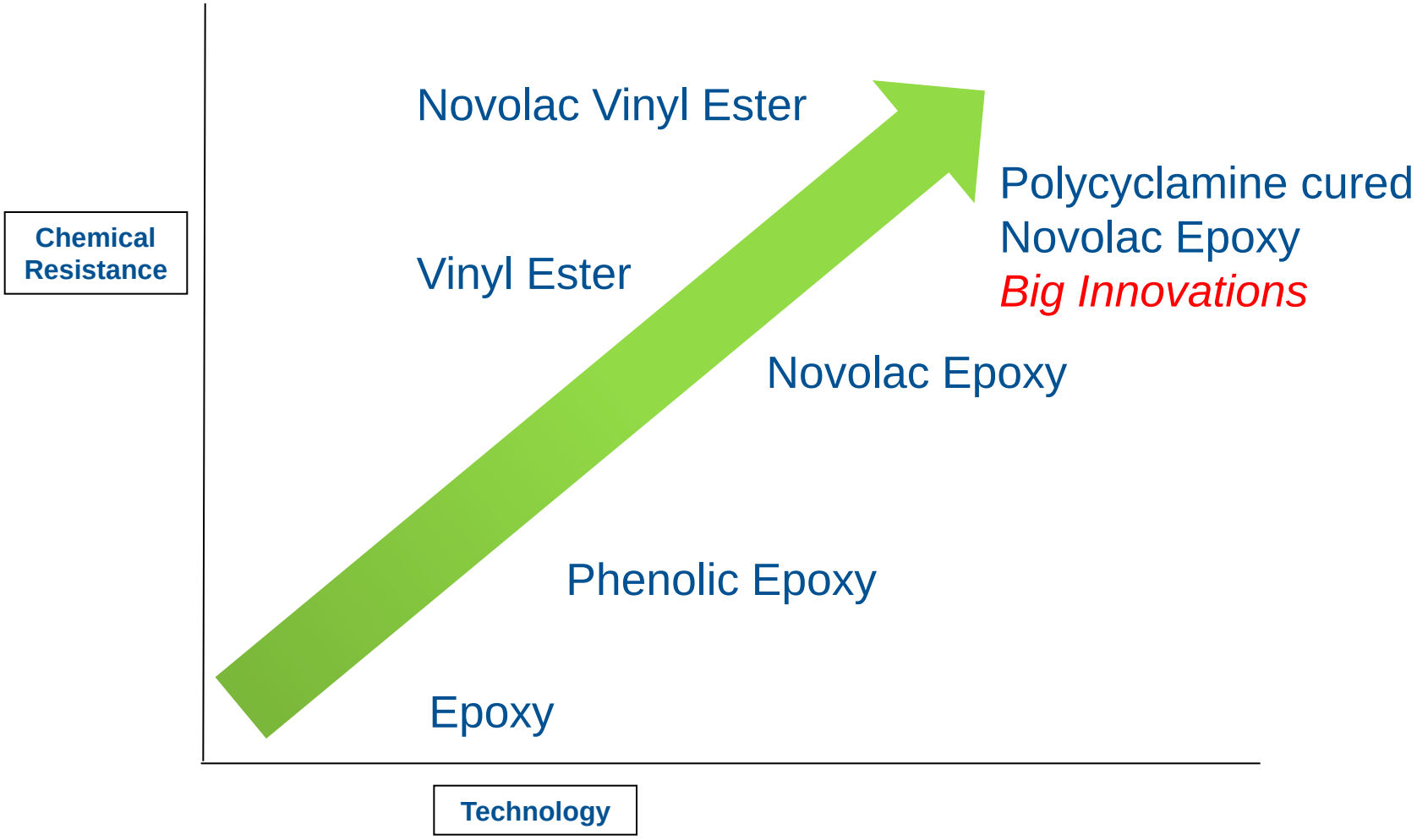
Materials Integrity

- Some chemicals e.g. ethanol, may cause stress corrosion cracking of welds → line whole tank car

Volume Solids over the Years



Chemical Resistance - Lining History



Generic Examples - Where to use Linings

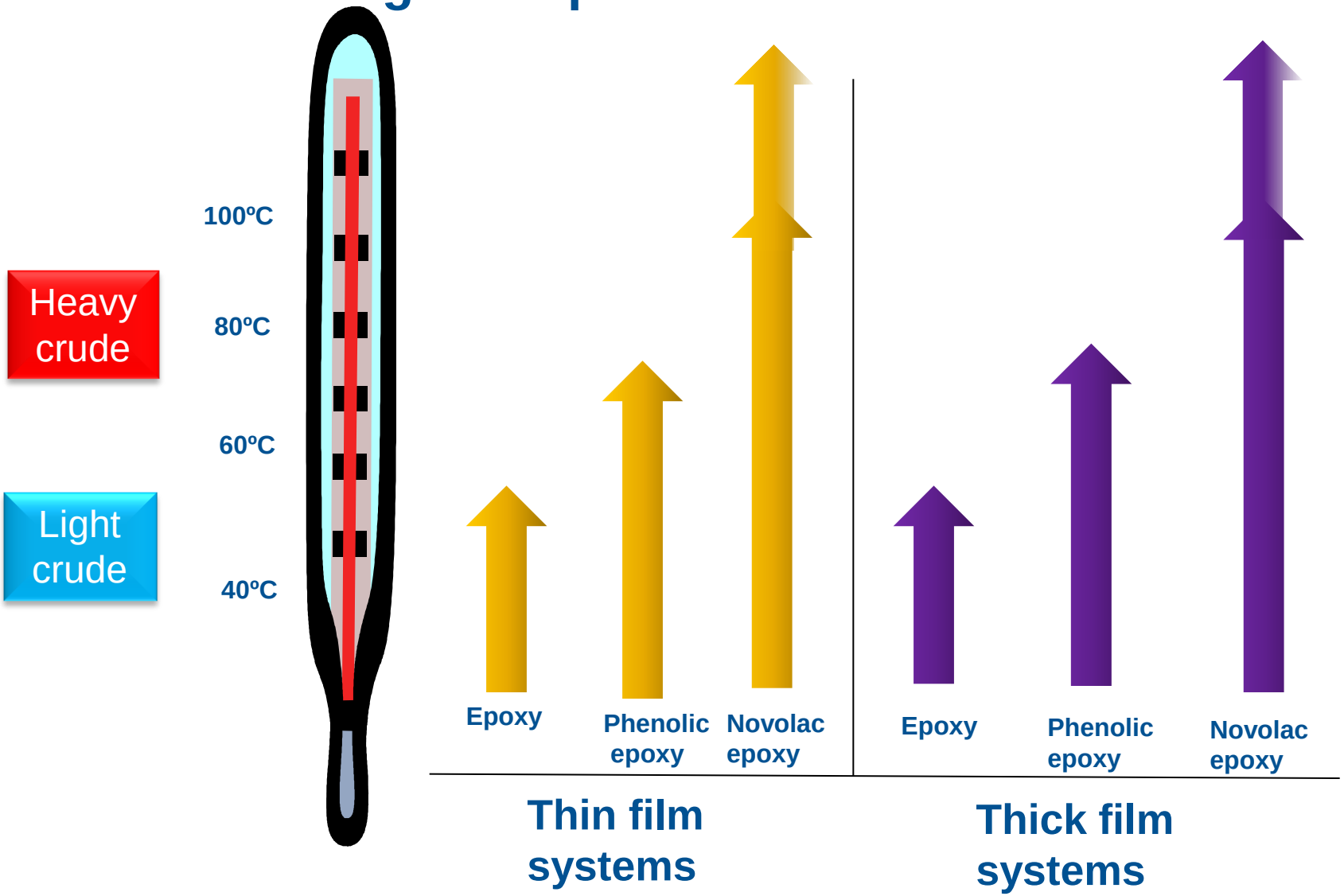
	Water/ waste water	Solvents	Caustics	Mineral acids	Organic acids	Vegetable oils/fatty acids
Epoxy	✓	±	✓	X	X	X
Phenolic Epoxy	✓	±	✓	±	X	±
Novolac epoxy	✓	✓	✓	±	±	✓
Polycyclamine cured Novolac	✓	✓	✓	✓	±	✓
Vinyl ester	✓	±	±	✓	✓	✓

✓ = generally suitable

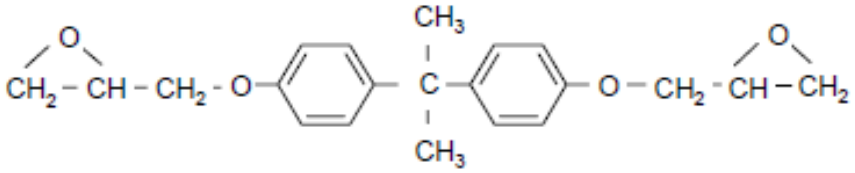
± = sometimes suitable

X = generally unsuitable

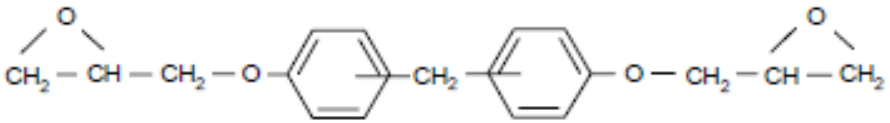
Crude Oil Storage Temperatures



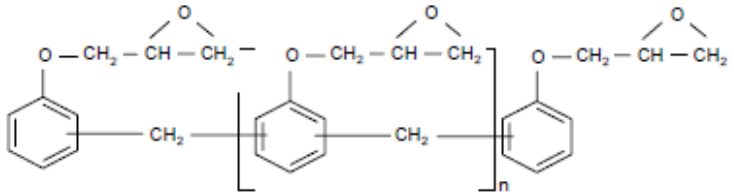
Epoxy or polyepoxide is a thermosetting polymer formed from reaction of an epoxide "resin" with polyamine "hardener".



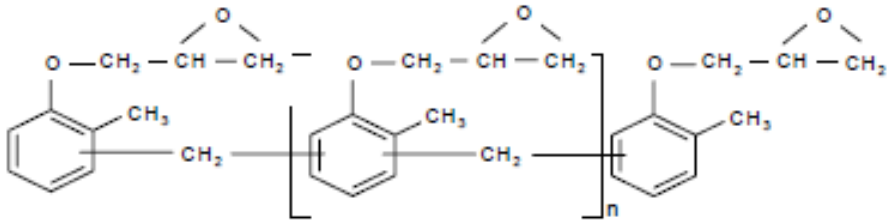
Bisphenol A type epoxy



Bisphenol F type epoxy



Epoxy phenol novolac



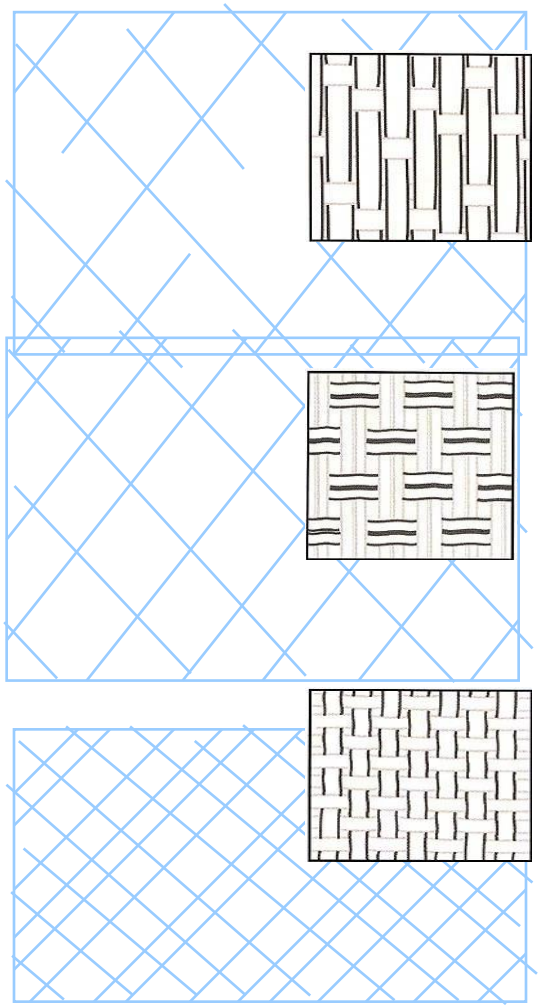
Epoxy cresol novolac

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 Recoat 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

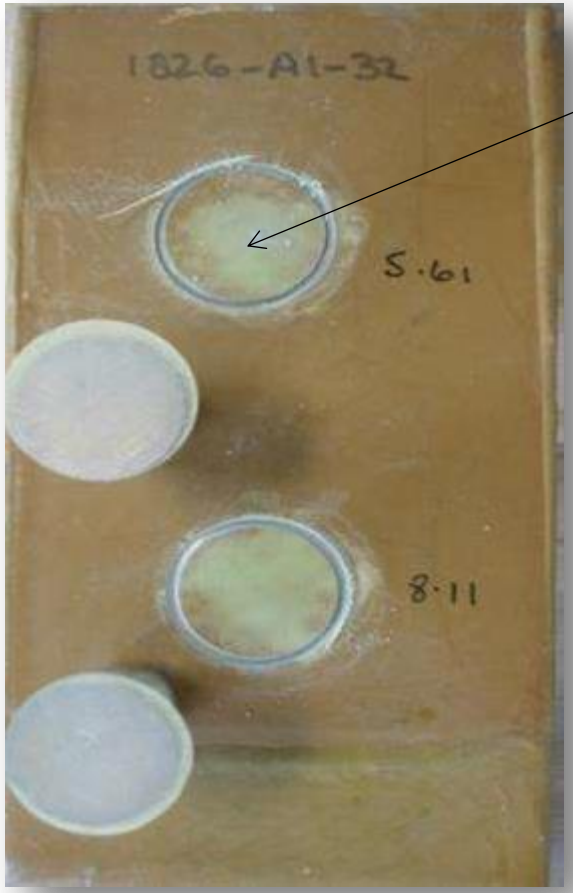
Autoclave Testing

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

Laboratory Immersion Testing
High Temperature Crude Oil for 6 Months

Crude Oil Phase

Water Phase

Established Product Comparison

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

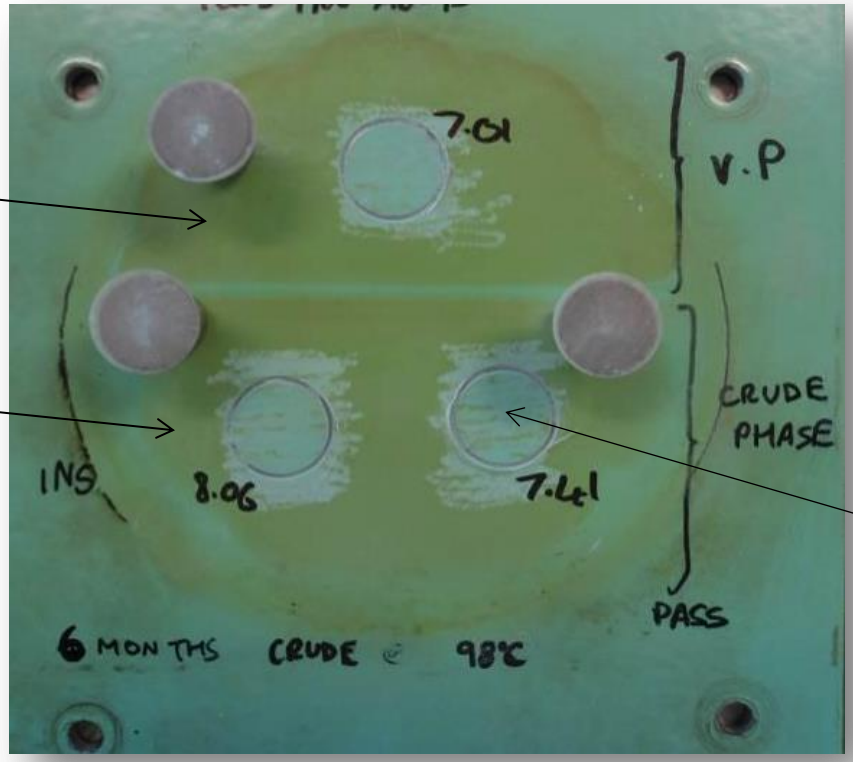
Crude + 3% NaCl @ 203ºF/95ºC

Crude + 3% NaCl @ 203ºF/95ºC

Laboratory Immersion Testing
High Temperature Crude Oil for 6 Months

Water Vapor Phase

Crude Oil Phase



Dolly Glue Failure

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

6 Months (Insulated)
Crude + 3% NaCl
@ 203ºF/95ºC

ISO 2812 – ISO Immersion in “Shale Oil” @ 221ºF/105ºC

- 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: 365ºF/185ºC

Pressure: 165 psi / 11 bar

Water: 3 % Sodium Chloride Solution

Gas: Super Heated Steam

Duration: 6 months

Decompression: None

Cool Down: From 365ºF/185ºC to 70ºF/21ºC in 16-24 hours

High Temperature Cathodic Disbondment

Independent Testing Done at Charter Coating Service

Volts:	**-1.45 to -1.55**
Temperature:	**200ºF/93ºC**
Initial Holiday:	**3.2 mm**
Test Duration:	**28 days**

Sample:

Samples:	**2405 applied in one coat @ 30 mils DFT**
Cured:	**7 days at 77ºF/25ºC**
Method of application:	**Single Leg no heating**

(CSA Z245.20-10 @ 200ºF/93ºC)

Shop Application and Field Repair

Shop Application:

- **Any Tank Lining**

Field Application**:**

- **Solvent free coating**
  - Kit packs for field repairs

Trends in External Linings

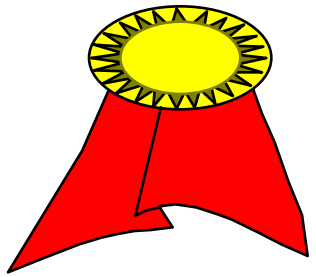
Zinc Rich Primers

Cathodic Protection and Barrier Protection

Zinc-Rich Coatings – A Major Advantage

"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

Primer (Cathodic Protection & Barrier)	Zinc Rich Epoxy @ 2.5 - 3 mils DFT
Optional Mid Coat: (Barrier Coat)	High build Epoxy @ 4 - 6 mils DFT
Finish Coat: (Gloss and Colour)	Urethane Polyaspartic, or Polysiloxane @ 2-3 mils DFT

Polyurethanes

Gloss and Color Retention

The Enemy: Free Radicals and UV

Polyaspartics

Gloss and Color Retention

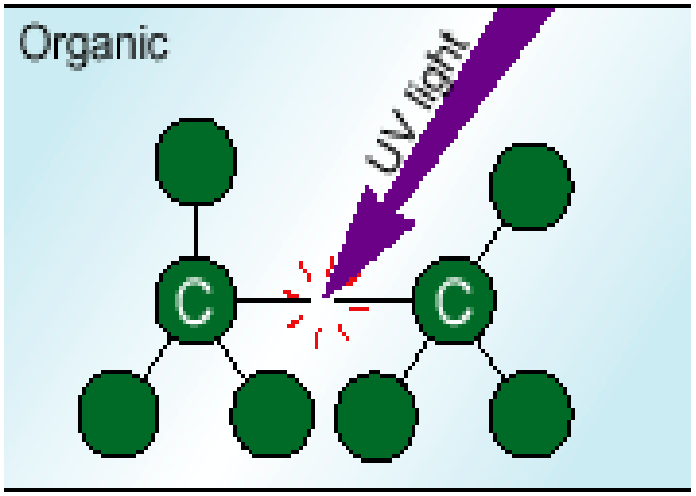
Polyurethane vs. Polyaspartic – Courtesy Bayer

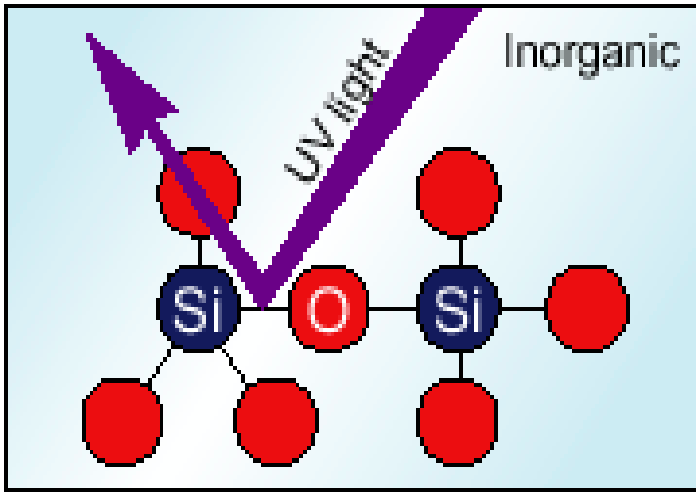
	Conventional Polyurethane	Polyaspartic Urethane
Potlife	~ 4 hours	~3 hours
Film Build	2-4 mils	6-9 mils
Edge Retention	40-50%	70-80%
Color and Gloss Retention	SSPC Paint 36 Level III	SSPC Paint 39 Level III
Dry Hard times	6-12 hours	1-3 hours
Application	Spray, Brush, Roll	Spray, Brush, Roll

Polysiloxanes

Gloss and Color Retention

Polysiloxane Technology





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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