Fusion Bonded Epoxy Powders, Liquid Epoxy, and Repairs on Pipelines

Period 8

Pipeline Coatings Course
2017
Today’s Agenda

1. Fusion Bonded Epoxy Powders
   • Overview of FBE
   • FBE Factory Application
   • Field Applied FBE on Girthwelds
   • Specifications & Performance
   • Damage Resistant Systems

2. Liquid Epoxy
   • Powders vs. Liquids
   • Factory & Field Application
   • Application Methods
   • Quality Control of Liquid Epoxy
   • Keys for a Successful Application

3. Pipeline Repairs
   • The Need for Repairs
   • Repair Methods
   • Holiday Repair Methods

4. Summary
Fusion Bonded Epoxy Overview
Fusion Bonded Epoxy Powders are . . .

One part, heat-cured thermosetting epoxy coating designed for corrosion protection of metal and electrical insulation.

RM Categories:
Epoxy Resins
Catalysts
Pigments
Curatives
Fillers/Hardeners
Adhesion Promoters
Flexibility Agents
Others . . .
Fusion Bonded Epoxy: Features and Benefits

- Corrosion protection in Harsh Environments
- Productive Application – Fast Curing
- Won’t sag, cold flow or become soft in storage - allows for long term storage.
- Light weight - lowers shipping costs.
- Good chemical resistance
- Environmentally Friendly: No VOCs
- Resists Cathodic Disbondment
- High adhesion and toughness
- Easily Repaired
Fusion Bonded Epoxy: Advantages/Disadvantages

**Advantages**
- Excellent adhesion to steel
- Good chemical resistance
- Non-shielding to Cathodic Disbondment (CP)
- Resistant to biological, insect, termite, and root attack
- Installation friendly
- Good Abrasion, Gouge & Impact Resistance
- Good Flexibility

**Disadvantages**
- Damage during transportation can result in added costs
- Formulas w/ improved durability generally less flexible
- Higher Operating Temp products generally less Flexible
Pipeline Coating Selection

Operational LIFE
- Application
- Installation

Operational CONDITIONS
- Operational temperature
- Soil conditions
- Environmental conditions

Coating APPLICATION
- Storage & Handling
- Logistics, Transportation
- Quality Assurance

Location of INSTALLATION
- Terrain
- Backfill
- Soil Conditions
- Joint Repair Solution
FBE Factory Application
Types of Powder Applications

Factory Applied Powders:
- Line Pipe Applications
  - Semi-Automated, continuous process on 40' to 80' pipe lengths
  - Highly efficient on large projects
- Custom Coating Applications
  - Manual Application methods for parts or smaller volumes
  - Spray, Dip, or Electrostatic application to parts

Field Applied Powders:
- Typically Girthweld Coating
  - Applied at the right-of-way during pipe installation
  - Requires heat source and powder spray equipment in the field
Fusion Bonded Epoxy Application

Line Pipe Factory Application

Key Markets:
- Oil & Gas Industry
- Water, Wastewater & Utility Markets

- Single Layer
  - Standard corrosion protection
  - Elevated Operating Temperature

- Dual Layer
  - For abrasion Resistance & Gouging protection
  - Directional Drills & High Impact resistance.
Continuous Pipeline FBE Application Steps

1. Cleaning Process
   - Shot/Grit Blasting
   - Surface Pretreatments
   - Acid Washing

2. Heating Process
   - Source
   - Uniformity

3. Spray Booth
   - Electrostatics
   - Gun set-up
   - Dual Coat

4. Cure
   - Line Speed
   - Pipe W.T.
   - Data Sheet

5. Quench
   - Line Speed
   - Handling

6. Inspect / Repair
   - Coating Thickness
   - Holidays
   - Surface Defect
Fusion Bonded Epoxy Application

1. Abrasive Blast
2. Acid Wash
3. Hi-Pressure Rinse
4. Electrostatic Spray Booth (FBE Application)
5. Water Quench
6. Induction or Gas Fired Heaters
Cure Process Variables

Rate = Time / Distance

\[ t_1 = \text{Time to Gel (Sec)} \]

\[ t_2 = \text{Time to Quench (Sec)} \]

\[ d_1 = \text{Distance to First Touch (Gel Time)} \]

\[ d_2 = \text{Distance to Quench (Cure Time)} \]
Cut Back Requirements: Single Layer & Dual Layer Systems

- The end of every pipe is uncoated to facilitate welding in the field.
- Cut Backs typically vary from 2”-6”
- Cut Back is later Field Coated
- 3 Layer System are handled differently.
Fusion Bonded Epoxy Girthweld Coating

Blast

Heat

Apply

Completed

Inspect
Specifications & Performance Requirements
Specifications and Regulatory Agencies

- National & International Standards
  - National Association of Corrosion Engineers (NACE)
  - International Standards Organization (ISO)
  - Canadian Standards Organization (CSA)
  - French Standard (NFA)
  - German Standard (DIN)
  - Australian Standard (AUS)

- Many Pipeline Owners and Engineering Companies have their own specifications in addition to industry standards.

- Pipeline and Hazardous Materials Safety Administration (PHMSA)
  - Component of the Department Of Transportation (DOT)
  - USA requires PHMSA approval and auditing
  - Canada requires CSA compliance

- Typical standard for a project may require multiple test standard compliance.
  - Many standards introduce components from more than one standards group (e.g. NACE, CSA, ISO, ASTM, etc)
Product Performance Expectations

- **Toughness**
  - Penetration Resistance
  - Impact Resistance
  - Abrasion Resistance

- **Adhesion**
  - Cathodic Disbondment
  - Hot Water Adhesion

- **Flexibility**
Cathodic Protection & Coatings

Key Pipeline Protection Elements:
1. An Effective Coating System
2. Appropriate Cathodic Protection
3. Effective Pipeline Monitoring

Cathodic Protection Detail:
- The typical cathodic protection of a pipeline utilizes an impressed current type system or rectifier.
- In these systems, anodes are energized by an external DC power source.
- For pipeline cathodic protection systems, anodes (+) are installed in the electrolyte and are connected to the positive terminal of a DC power source and the pipeline (-) is connected to the negative terminal of that source.
- The rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), current that flows in only one direction.
- When employed, the anodes are typically tubular or solid rod shapes and are made of specialized materials such as hi Si cast iron, graphite, mixed metal oxides, platinum or niobium coated wire.
Damage Resistant Systems
Need for Damage Resistance

- **Where does Pipeline Damage Occur?**
  - General Pipeline Handling
  - Rocky Terrain
  - Arctic Projects
  - Backhoe Damage
  - Transportation Damage
  - Directional Drills / Bores

- **The Solution → Dual Layer Coatings / Abrasion Reistant Overcoats (ARO)**

- **What type of Coatings are used for ARO?**
  - Powder ARO – Coated In-Line with Base Layer Coatings
  - Liquid ARO – Applied after the initial Pipe Coating

- **Characteristics of ARO**
  - Highly filled, traditionally less flexible that base layer epoxy
  - Greater Impact & Gouge Resistance
  - Newer ARO versions offer greater flexibility, similar to base layer epoxy (3 deg/PD levels)
Dual Layer ARO Coating Process w/ In-Line Powders

Two coating Booth

Pipe direction

Guns for primary layer

guns for top coat)
Abrasion Resistant Overcoat

Directional Bore/High Impact Resistance

ARO
Basecoat Primer

Directional Boring  Transportation Damage  Backhoe Damage
Dual-Layer FBE (DFBE) ARO

Pilot Hole

Ream

Pullback

Directional Drilling

Rugged Terrain

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Steve Hall – 3M Infrastructure Protection Products
Testing
Quality Control Testing Areas

- DSC – Cure
- Adhesion
- Bend/Flexibility
- Impact
- Porosity
- Backside Contamination
- Cathodic Disbondment
- Hot-water soak (hot wet adhesion)
- Gouge Test
Testing of Applied Coating

- In plant quality control is dependent on the region, customer specification, and type of coating system. Common tests include:
  - Cathodic disbondment
    - 3% NaCl / 1.5 VDC – 3.5 VDC / 23°C to 150°C / 24 hours to 90 days
  - Hot water adhesion
    - Tap or Distilled water / 75°C – 95°C / 24 hours to 90 days
  - Impact
    - 1.5 - 3 Joules
  - Flexibility
    - Measured in degrees per pipe diameter
    - -30°C - 23°C
    - Mandrel bending (go/no go) / Four point bending (permanent strain)
  - Cure measured using Differential Scanning Calorimetry
    - Delta Tg and/or delta H
  - Porosity
    - Cross-sectional and interfacial
Common Reasons for Failure in the Field

- **Flexibility Failure**
  - Bend beyond product capability

- **Cure Failure**
  - Temperature not maintained during application

- **Steel Prep Failure**
  - Poor profile or contaminants
Epoxy: Powders vs. Liquids
Differences between liquid & powder epoxy

- **Powder Coatings**
  - Pipe is heated 425°F - 480°F (218°C - 249°C)
  - Dry powder material is sprayed on to hot pipe where it flows to form the coating
  - FBE must be melted to start cross-link

- **Liquid Coatings**
  - Pipe typically is at ambient temperature
  - Liquid material is sprayed, brushed or rolled on to the pipe to form coating
  - Two part liquid (Part A and Part B) must be mixed to start cross-link
Choosing Epoxy vs. Urethane

- **Epoxy**
  - Physical strength
  - Higher temperature resistance
  - Excellent adhesion
  - Chemical resistance

- **Urethane**
  - Flexibility
  - Cold weather cure
  - Faster cure speeds
  - Better UV resistance
  - Impact resistance
Liquid Epoxy: Factory vs. Field Application
Factory vs. Field: Liquid Epoxy Application

- Historically Liquid Epoxy was used in the Field for Girthwelds and Field damage.

- Today, Liquid Epoxy is widely Used in the Factory on . . .
  - Bent Pipe Sections
  - Elbows and Fittings
  - Parts with varied Geometry (difficult to Heat consistently)
  - Dual Layer Coatings over FBE
  - Repairs on Powder and Liquid Coatings

- Factory Application allows for good control of Application Parameters
Liquid Epoxy: Application Methods
Liquid Epoxy Application Methods

1. Manual Application (Brush & Roller)
2. Manual Cartridge Dispensing (Brush & Roller)
3. High Solids Spray Cartridge Application
4. Plural Component Application
Liquid Epoxy: Quality Control
Quality Control Measurements

Blast Profile:
- Testex Tape & Micrometer
- Profilometer

Film Thickness (Wet)
- Wet Film Thickness Gauge

Film Thickness (Dry)
- Elcometer or other Thickness Gauge

Hardness
- Durometer – measuring Shore D Hardness

Holiday Detection

Record all Pipe Data & Keep for your Records
Liquid Epoxy: Keys to Successful Application
Keys to a Successful Application

- Complete Operator Training – Application & Safety Training
- Follow all Safety Procedures
- Review Data Sheet & Application Guide
- Ensure Proper Surface Preparation of Steel; Record & Document
- Use Proper Equipment
- Follow Quality Control procedures
Why are Repairs needed with Epoxy Coatings?

**In the Factory** (In-Line Powder Application)
- Holidays (from Powder Coating Application)
- Steel Defects
- Contact points from stands when coating Liquid Epoxy

**Handing & Transportation Damage**
- Fork Damage from Handling
- Shipment damage – truck or rail over long distances

**Installation Damage**
- Backfill damage from rocks & equipment
Repair Methods
General Types of Coating Repairs

1. Holiday Repairs: < 10mm holidays
   - 2-Part Epoxy or Patch Sticks generally used
   - Follow the End User Specification & Manufacturer’s instructions

2. Smaller Repairs: < 25 cm² in size
   - 2-Part Epoxy generally Specified
   - Less than a full blast may be allowed for this repair
   - Follow the End User Specification & Manufacturer’s instructions

3. Larger Repairs: 25 cm² or >
   - 2-Part Epoxy Specified w/ full abrasive blasting
   - Follow the End User Specification & Manufacturer’s instructions
General Guidelines for Smaller & Larger Repairs

1. **Smaller Repairs**: < 25 cm² in size (pinholes)
   - Allows for surface abrasion with mechanical tool or sanding vs. Grit Blasting
   - Follow Manufacturer’s instructions & End User Specs

2. **Larger Repairs**: 25 cm² or larger
   - Requires full Grit Blasting of the surface to be coated
   - Follow Manufacturer’s instructions & End User Specs

*Follow all Manufacturer’s Guidelines for Repairs*
Holiday Repairs

2-Part Epoxys: Pin holes and larger voids

Patch Sticks: Pin holes only if specified

*Follow Pipeline Specs and Manufacturer’s Instructions for Holiday repair.*
1. What is the 226P Product?
   - Heat Bondable Polymeric coating in Stick form
   - Repair product for holidays, minor pinholes and abrasions
   - Used for Holidays up to 2mm in diameter (only)
   - This product should not be used for coating larger areas

2. General Application
   - Rough the surface of the defect with 80-120 grit sandpaper; Clean the surface
   - Heat the parent coating with a non contaminating heat source; avoid charring
   - When the patch stick begins to melt, apply in a circular motion
   - Apply to the thickness of the parent coating, approx 15 mils
   - Allow the product to cool and harden before handling
   - Always follow End User Specs and Manufacturer’s Guidelines for application
The Re-Coating Windows varies by Product & Application Conditions

Most Liquid Epoxy can be Re-Coated while they are still Tacky, but this could vary by Product.

The Standard Recoating window varies widely from 1-6 hours

Hot, Dry conditions reduce the Re-Coat Window; Lower temps and higher humidity increase the window.

After a product dries past its Re-Coat window, the surface of the Coating must be abraded prior to coating.

Follow all Manufacturer’s Instruction when Re-Coating.

<table>
<thead>
<tr>
<th>Air Temp Recoat Window*</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>60°F</td>
<td>4-6 hours</td>
</tr>
<tr>
<td>75°F</td>
<td>3-4 hours</td>
</tr>
<tr>
<td>85°F</td>
<td>2-3 hours</td>
</tr>
<tr>
<td>100°F</td>
<td>1-2 hours</td>
</tr>
</tbody>
</table>

*Variable by Product (example only)
Summary
In Summary

- **FBE Powder Coatings and Liquid Epoxies** have a long history of effective use in protecting Pipelines.
- **Epoxy Coatings, Cathodic Protection and Pipeline Monitoring** work together as a System to protect your pipeline.
- **Continuous FBE Powder Application** requires great attention to detail, but is efficient, low-cost, and green.
- **Dual Layer Systems** (powders & Liquids) provide excellent Pipe protection prior to Installation.
- Follow **End User Specification & Manufacturer’s Guidelines** when Coating your project, making Repairs, or Re-Coating.
Questions?
Liquid Epoxy: Quality Control