Corrosion Webinar Series

Protective Coatings 101

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Protective Coatings 101

Webinar Objectives

• Introduction to protective coatings
• Selecting the correct coating system for the service environment
• The importance of surface preparation
• Application methods and equipment
Introduction

Protective coatings: primary defense against corrosion
Annual corrosion cost: $451 billion (2.7% GDP)*

- **Purpose of Coatings**
  - Prevent significant metal loss
  - Prevent failures due to corrosion
  - Maintain aesthetics (public view)
  - Minimize future repairs and costs

- **Corrosion is an electrochemical process**

- **Components of Corrosion**
  - Anode, Cathode, Metallic pathway, and Electrolyte

*NACE International, IMPACT study, 2016
Extent of Damage at Shoshone PP

Catastrophic failure of entire infrastructure due to rupture of penstock uphill
Corrosion Control System (CCS)

A *coating* is the primary defense against corrosion.

*Cathodic protection* works with the coating to protect the structure at defects in the coating.

The most effective corrosion protection system for buried and submerged structures involves a *good bonded coating and cathodic protection*. 
Components of a Coatings Job

- Surface Preparation
- Coating Material
- Coating Application
Coating Life Cycle Costs

- Highest qualified coating should be applied
- Majority of the costs associated with a recoat job is in labor

Coatings with 30-, 20-, 15-, and 8-year service lifetimes shown to demonstrate frequency of recoat jobs as service lifetime decreases.
Costs Associated with Coatings Job

• Labor costs
  – Mobilization (scaffold, containment, transport equipment, etc.)
  – Blasting or coating removal
  – Handling and disposal
  – Application
  – Clean-up and demobilization

• Material costs
  – Abrasives
  – Handling and disposal
  – Coating product
  – or Metal wire feedstock
Coatings For Corrosion Protection

• Corrosion prevention by coatings
  – Initial driving force was during WWII, when steel was in high demand, expensive, and the need to protect investments from corrosion.

• Basic requirements
  – Strong adhesion to the substrate
  – Barrier to electrolyte
  – Dielectric strength
  – Resistant to exposure environment
    • weather, burial, immersion, chemicals, abrasion, impact, and age resistance
  – Compatible with cathodic protection
  – Ease of application
Types of Protective Coatings

- **Paint (coating)** = binder (polymer) + pigment & filler + solvent or diluent

- **Barrier coatings** are most common
  - High film build (coal tar enamel, polyurethane, epoxy)
  - Polymer chemistry and formulation
  - Flake pigments to make tortuous path for water (aluminum, glass, etc.)

- **Sacrificial** (zinc-rich, metallizing)

- **Inhibitive** (lead, chromate)

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Barrier Coatings

- Vinyl resin
- Coal tar enamel
- Aromatic polyurethanes and epoxy
- Coal tar epoxy
- Moisture cured urethanes

Some barrier coatings have flake-shaped pigments to increase tortuosity of the water and ions paths.
Sacrificial Coatings

- Organic Zinc-rich coatings
- Inorganic Zinc-rich coatings
- Galvanizing
- Metallizing (Zn, Al, Mg, and alloys)
Thermoplastic coatings have varying degrees of crystallinity, which controls the material’s permeability, among other properties.

**Key Features of Thermoplastics:**
- No chemical reaction/pre-polymerized
- Solvent evaporating or melted to form coating
- Flexibility

**Common Thermoplastic Coatings:**
- Solution vinyl resin
- Coal tar enamel
- Powder Coatings
  - Polypropylene/polyethylene
  - Teflon/Fluorinated
  - Nylon
  - PVC
Thermosets

Thermoset coatings have varying crosslink density, which controls the material’s permeability, among other properties.

Key Features of Thermosets:
• Chemical reaction
  • 2 or 3 component
  • Reacts with oxygen or moisture
• Crosslink density
• Can’t melt and reform

Common Thermoset Coatings:
• Epoxy Polyurethane
• Polyurea Polyaspartic
• Polysiloxane Silicates
• Alkyds Phenolic
• Vinyl ester Polyester
• Moisture cured urethane
Coating Selection – Modern Day

- **Epoxies & Coal Tar Epoxies**
  - Good for Immersion and Burial
  - Limitation - Not good in Atmospheric

- **Aliphatic Polyurethanes, Alkyds, Siloxanes, & Acrylics**
  - Good for Atmospheric
  - Limitation - Not good in Immersion

- **Zinc Rich Coatings**
  - Good for minimal water/humidity contact, Bridges, I-Beams
  - Limitation – Do not use with cathodic protection

- **Moisture Cured Polyurethanes and Siloxane**
  - Good for Immersion and Atmospheric
  - Limitation – Humidity must be within 30-100%
Coating Selection – Modern Day

• Fusion Bonded Epoxy
  – Good for Immersion and burial
  – Limitation – Only for small parts that can fit into industrial ovens, Not good in Atmospheric

• Nylon, PVDF, Teflon
  – Good for Immersion and Atmospheric
  – Limitation – Only for small parts that can fit into industrial ovens

• Polyureas, 100% Solids Epoxy, and Aromatic Polyurethanes
  – Requires specialized equipment (Plural Component)

• Vinyl Resin
  – Excellent for Immersion and Atmospheric
Case Histories

• Yellowtail Dam
  – Cavitation resistance – Enecon Flexiclad Duratough DL

• Elephant Butte and Durango Pumping Plant
  – Erosion resistance – 3M Thortex Ceramitech FG and Belzona Ceramic S Metal

• Zebra/Quagga Mussel resistant coatings
  – Silicone foul release coatings – 2008-present

• Denver Water 1995-present aromatic polyurethane
  – Madison Chemical Corropipe II PW

• Yellowtail Dam Radial Gates plus Cathodic Protection 1986-present.
  – Tnemec Potapox Series 20 solvent borne epoxy
Reintroducing Vinyl to Reclamation

- Long service life – historically used i.e. known service life expectations
- Low temperature applications
- No chemical reactions, i.e. no isocyanate sensitivity
- Easily repaired, solvent wipe with ketone solvent
- Indefinite overcoat window
- No proprietary chemicals, formulation driven specification
Impacted Immersion Coatings

• Definition
  - A high performance maintenance coating formulated and recommended for application on steel structures subject to immersion in turbulent, debris-laden water. These coatings are specifically resistant to high-energy impact damage caused by floating ice or debris.

• Coating Formulations
  - Corps of Engineers formulations
    • Zinc rich primer – VZ 108d
    • Vinyl resin intermediate/ topcoats – V-766e white or gray
    • Vinyl topcoats V-102e aluminum, V-103c black
Where and how to use Vinyl Coatings

• Coatings specifications have been developed for Impacted Immersion

• Items to be coated include:
  – Radial gates, trash racks, drum gates, turbine runners, penstocks, draft tubes, surge tanks, etc.

• Incompatibilities
  – Epoxy filler materials
  – Cathodic protection

• High solvent content
  – Flammability potential
  – Supplied air respirators
  • Especially in confined spaces
Coating Application

• Follow manufacturers’ technical data sheets for proper application procedures
  – Equipment, air pressures, gun type, mixing proportions, time between coats, surface cleanliness and surface profile, DFT per coat, dry to touch, pot life, etc.

• Material Safety Data Sheets
  – Document for potential hazards and safety precautions.

• Application Methods

• Shop Application vs. Field Application

• Environmental Effects

• Recoat window, down time, and cure time
**MACROPOXY® 646 FAST CURE EPOXY**

**Product Description**
High solids, high build, two part, epoxy resin for industrial applications. It is designed for high performance applications where good flexural strength, chemical resistance, and excellent adhesion are required. It is compatible with most Sherwin-Williams surface preparation systems.

**Product Information**

### Product Characteristics

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**Recommended Systems**

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<th>System</th>
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**Tinting**

- Tinting with low-solids tinting systems is recommended. Use tinting systems that are compatible with the epoxy system.

**Surface Preparation**

- The surface must be clean, dry, and free of contamination. Use the recommended surface preparation procedures.

- Recommended Surface Preparation:
  - Primer: SP-300 (S-300) or SP-301 (S-301)
  - Topcoat: SP-302 (S-302) or SP-303 (S-303)
  - Finish coat: SP-304 (S-304)

**Disclaimer**

- The information provided in this data sheet is based on tests conducted by Sherwin-Williams and is representative of the product.
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Material Safety Data Sheet

Section 1 - Chemical Product / Company Information

Product Name: RUSTBOND PART A
Identification Number: PLMSDS 0922A1NL
Product: Polymeric Epoxy Amine - FOR
Use/Class: INDUSTRIAL USE ONLY
Manufacturer: Carboline Company
350 Hanley Industrial Ct.
St. Louis, MO 63144
Revision Date: 08/01/2005
Preparer: Regulatory, Department
Supercedes: 06/17/2005

Section 2 - Composition / Information On Ingredients

Section 3 - Hazards Identification

Emergency Overview: Warning! May cause allergic skin reactions. May cause irritation.
Effects Of Overexposure - Eye Contact: May cause eye irritation.
Effects Of Overexposure - Skin Contact: May cause skin irritation. May cause allergic skin reaction.
Effects Of Overexposure - Inhalation: May cause nose and throat irritation.
Effects Of Overexposure - Ingestion: May be harmful if swallowed.
Effects Of Overexposure - Chronic Hazards: Under normal use conditions, this product is not expected to cause adverse health effects.
Primary Route(s) Of Entry: Skin Contact, Skin Absorption, Inhalation, Ingestion, Eye Contact
Medical Conditions Prone to Aggravation by Exposure: If sensitized to amines, epoxies, or other chemicals do not use. See a physician if a medical condition exists.

Section 4 - First Aid Measures

First Aid - Eye Contact: If material gets into eyes, flush with water immediately for 15 minutes. Consult a
Hazards During Coatings Application

- Surface Preparation
  - Abrasive blasting, Waterjetting, Powertools
  - High pressure equipment
  - Fall protection
  - Hearing protection

- Coatings Application
  - Isocyanates, Amines, Solvents
  - High pressure equipment
  - Flammable solvents and explosive limits
  - Fall protection
  - Hearing protection

- Confined Space Work
  - Cabin Creek Fire in Penstock
Basics - Adhesion

- **Mechanical**
  - Surface roughness/profile
  - Surface cleanliness

- **Chemical**
  - Covalent bonding
  - Hydrogen bonding

- **Wetting properties**
  - Ability to wet substrate
  - Film formation

- **Cohesion vs adhesion**
  - Adhesion between coats or substrate
  - Cohesion within coating itself

Corrosion Prevention by Protective Coatings, Munger, Charles, NACE
Surface Preparation

• Definition – The cleaning of metal to ensure the best possible bond between coating and the surface.

• Anchor Profile

• Degree of Cleanliness

• Coatings service life is directly related to surface preparation.

• Abrasive Blast Cleaning is the most effective and economical method of surface preparation.
Hand Tool and Powertool Cleaning
Water Jetting and Wet Abrasive Blast

- High Pressure Water Blasting 5,000 to 40,000 psi
- Water cleaning 15-5,000 psi
- Excellent for removing soluble salt contaminants
- A procedure for lead abatement
- Limitations
  - Flash rusting
    - Use of rust inhibitors or converters
  - Does not create surface profile

- Water jetting and dry abrasive blast cleaning combined
- Excellent for removing soluble salt contaminants
- Keeps dust to a minimum
- Creates a good mechanical profile
- Procedure for lead abatement
- Limitations
  - Flash rusting
    - Use of rust inhibitors or converters
Surface Cleanliness Standards
(Assessment and Removal of Dust)

- Dust will reduce the adhesion of applied coatings
- Dust can absorb moisture, which promotes corrosion
- ISO 8502-3:1992
  Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)
    - Parameters to assess:
      - Quantity of dust particles
      - Size of dust particles
- Removal of dust:
  - Blowdown using compressed air
  - Vacuum
Application Methods

- Brush
- Roller
- Pressure Roller
- Conventional Spray
- High Volume Low Pressure
- Airless
- Air Assisted Airless
- Electrostatic Spray
- Plural Component
- Cartridge Gun
Airless Spray Equipment
Plural Component
Cartridge Gun
Robotic Application
Coating Drying, Recoating, and Curing

- **Potlife** – Workable time before a mixing coating will setup prior to application (2 minutes to 2 hours)
- **Tack free** – When the coating surface cures to a point where it is not sticky (1-4 hours)
- **Dry to touch** – The coating is dry enough to lightly handle (2-5 hours)
- **Dry to handle** – The coating is cured sufficiently to be handled without causing damage (8-24 hours)
- **Recoat window** – the allowable time between applying a second or third coat
  - Depends upon environmental factors
  - Ambient temperature, humidity, substrate temperature
  - Minimum – 1 to 24 hour
  - Maximum – 15 to infinite
- If maximum time is exceeded, abrasive blasting is required to create a profile again (Sweep Blast)
Curing

- **Functional cure** – the curing has progressed for an item to be handled, transported, or stored
- **Full cure** – item can be put back into service (7 day cure at 70 F)
- Coating is more permeable if not fully cured.
- At lower temperatures a coating will take longer to cure
- Too thick of a coating can trap solvents
- Amine Blush
Renovated Coatings Lab
TSC-Sponsored Training

• Coating and Corrosion School
  – 3-days in Denver with lectures and hands-on training in Coatings and Corrosion Labs

• Corrosion Webinar Series
  – Twice per year, Feb-March and June-July
  – Email Jessica Torrey (jtorrey@usbr.gov) to receive email notices
  – 8 webinars now available:
    • Intro to Corrosion
    • Corrosivity Testing and Intro to Corrosion Mitigation
    • Testing Cathodic Protection Systems
    • Protective Coatings 101
    • Corrosion Mitigation for Gates
    • Coatings Maintenance Assessments
    • Cathodic Protection 101
    • CCS Construction Projects

• TSC Training Website
  – www.usbr.gov/tsc/training/training.html
  – Lists dates of upcoming TSC training and has links to slides and videos of all Corrosion Webinars
Thank you for your attention! Questions?

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