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TRANSPORTATION RESEARCH BOARD

Steel your bridges – Preservation practices for steel bridge coatings

May 7, 2020
2:00-3:30 PM Eastern

@NASEMTRB
#TRBwebinar

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RCEP

REGISTERED CONTINUING EDUCATION PROGRAM

Learning Objectives

- Discuss coating and recoating methods
- Identify various specifications for coating systems
- Determine the difference between coating Quality Assurance and Quality Control, including who has responsibility for which
- Discuss current practices for the use of warranty contracts for bridge coatings

Domestic Scan 15-03:

Successful Preservation Practices for Steel Bridge Coatings

TRB Webinar

2:00 – 3:30 PM
May 7, 2020

Paul Vinik, P.E.
Scan Team 15-03 Chair
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First Some Background:

- This scan was conducted as a part of National Cooperative Highway Research Program (NCHRP) Project 20-68A, the U.S. Domestic Scan program

- The scan program was requested by the American Association of State Highway and Transportation Officials (AASHTO) and funded by the (NCHRP)

How Does the Domestic Scan Program Work?

- The D.S. Program conducts 3-4 scans/year.
- Scans are selected by AASHTO and the NCHRP 20-68A Project Panel.
- Scans address a technical topic of broad interest to state and local transportation agencies.
- Scan Purpose:
  - Facilitate information sharing and technology exchange.
  - identify best practices of common interest.

Who Is the Scan Team?

Paul Vinik, P.E., Chair

Cathodic Protections Services. Manager

Greenman Pedersen Inc.

Mike Todsen

Special projects engineer

Office of Bridges and Structures

Iowa DOT

Ray Bottenberg, P.E.

Bridge Preservation Managing Engineer

Bridge Engineering

Oregon DOT

Tom Schwerdt

Research Project Manager

Texas DOT Research and Technology

Justin Ocel, PhD, PE

Structural Steel Research Program Manager

Bridge and Foundation Engineering Team

FHWA: Turner-Fairbank Highway Research

Charlie Brown

Area engineer, structures coating division

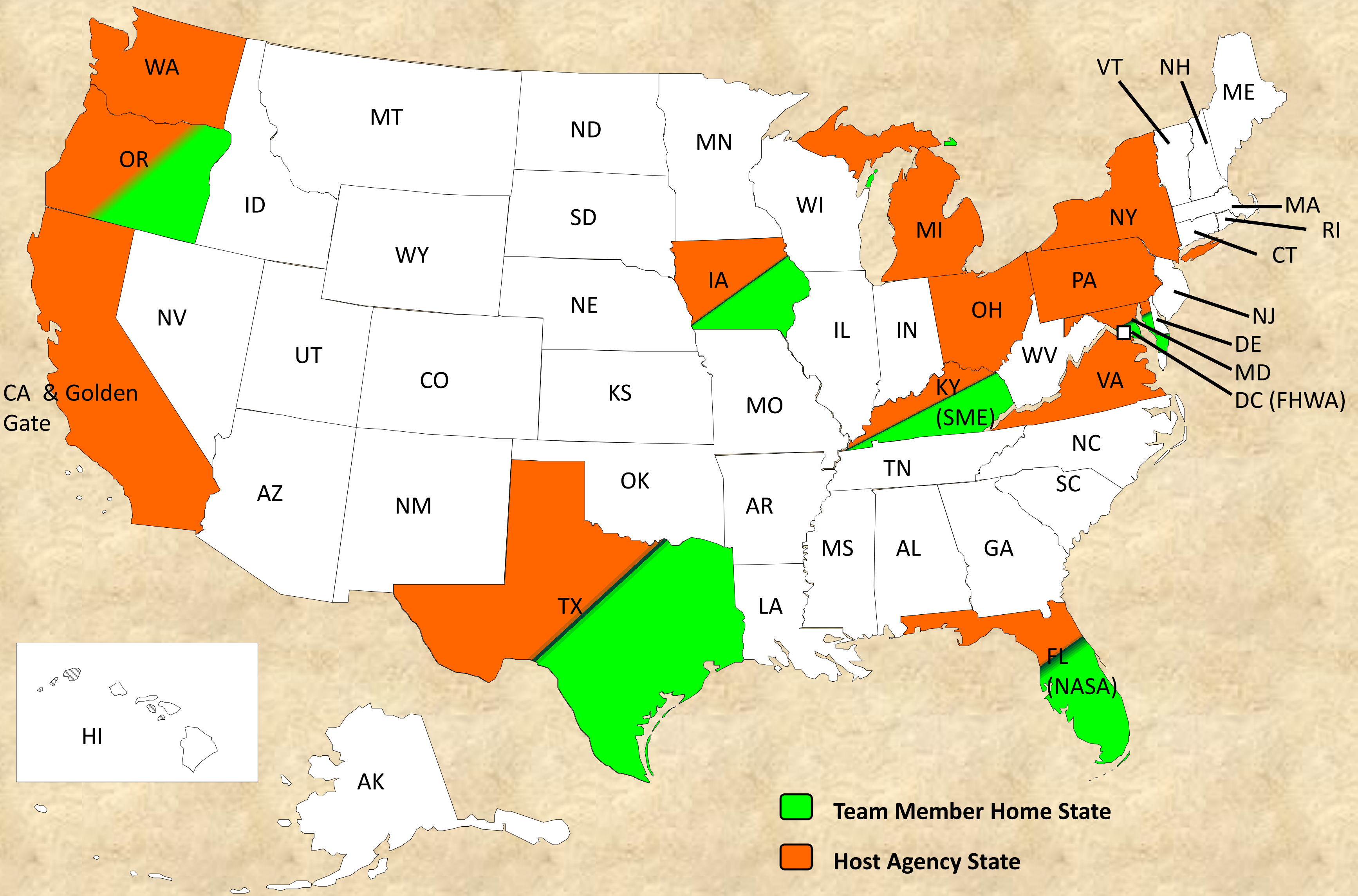
Greenman Pedersen Inc.

Sudhir Palle P.E., S.M.E

Senior Research Engineer

Kentucky Transportation Center

Scan 15-03: Geographically



AASHTO / NCHRP
U.S. Domestic Scan Program

Scan Team Topics:

- Coating option decision making
- Surface preparation
- Specifications for coating systems including :
  - Removal and replacement
  - Overcoating
  - Spot/zone coating
- Use of Performance-based contracts
- Evaluation practices for in situ coatings prior to recoating,
- Evaluation of performance of overcoat and replacement coatings
- Inspector qualifications
- Contractor qualifications
- Determination of Agency Funding Levels
- Agency commitment to supporting future preservation of coatings ”

Why are Structural Steel Coatings Important?

Structural Steel Coatings help reduce the cost of corrosion!

- Corrosion is estimated to cost the United States **$276 billion** per year.
- Organic coatings projects are estimated to cost between **$33.5 and $167.5 billion** each year.
- Corrosion of highways and bridges has an estimated cost of **$8.3 billion** per year.

How do Organic Coatings Work?

- Coatings encapsulate a metal substrate and isolate it from its environment
- Coatings provide a barrier that prevents diffusion (oxygen, salt)
- Coatings are pretty and provide an aesthetic appearance

What are the Most Important Aspects of a Coatings Project?

- A thorough specification/contract
- Surface Preparation:
  a) Pressure wash (solvent cleaning-remove salts)
  b) Abrasive blast (clean surface & provide profile)
- Coating Application: Spray, Roll, Brush
  How many coats:
  Prime/inter./tie/finish/clear/over
- Curing
- Quality Control (contractor inspection)
- Quality Assurance (owner verification)

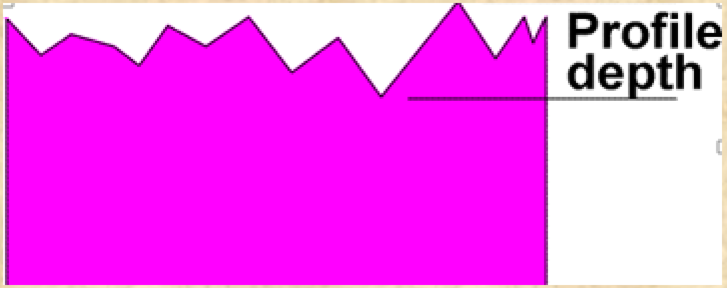
Pressure Washing (SP1)

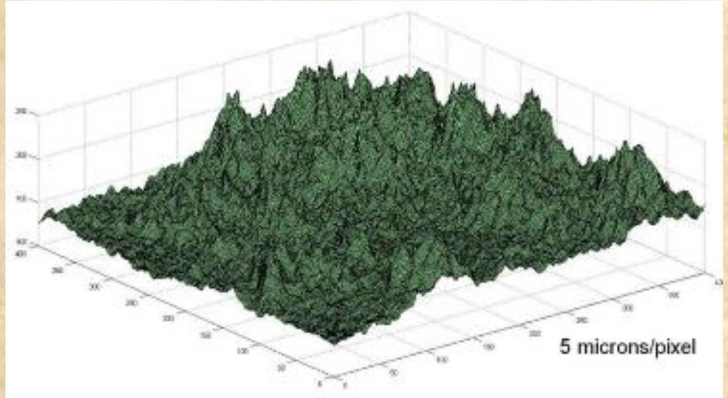
- Solvent cleaning is most frequently performed using pressurized potable water.

- This removes any salts that are water soluble as well as dirt and contaminants that can be removed by the mechanical force of the water stream.

Abrasive Blast (SP5,6,7,10, Vis1)

- Abrasive blast cleaning removes rust and other contaminants that were not removed by solvent cleaning.
- Abrasive blast cleaning removes steel and imparts a surface profile
- The ***proper*** surface profile promotes strong adhesion





Coating Application

- **Spray**: Fastest, most economical.
- **Roller**: Better penetration/wet in than spray. Appropriate for projects with limited surface area.
- **Brush**: Best penetration/wet in; hard to reach areas and irregular shapes (bolts, nuts, etc.)
- Most Projects require multiple methods.

Film Thickness: How Thick?

- Coatings are evaluated through extensive accelerated testing at their optimum film thickness. It is ***HIGHLY*** recommended that the film thickness used in testing be utilized in the field.
- Wet Film Thickness: Measured during application by the contractor.
- Dry Film Thickness: Measured after cure with magnetic gauge

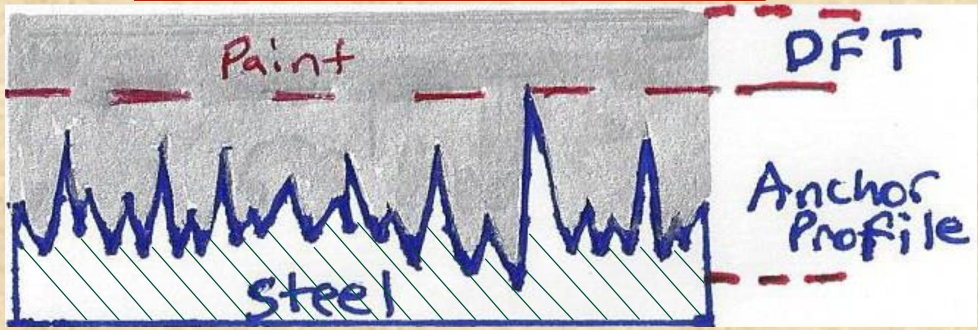
DFT = WFT * (% solids)

DFT = WFT * (%Solids/(100+%thinner))

DFT

WFT

DFT is the thickness above the profile

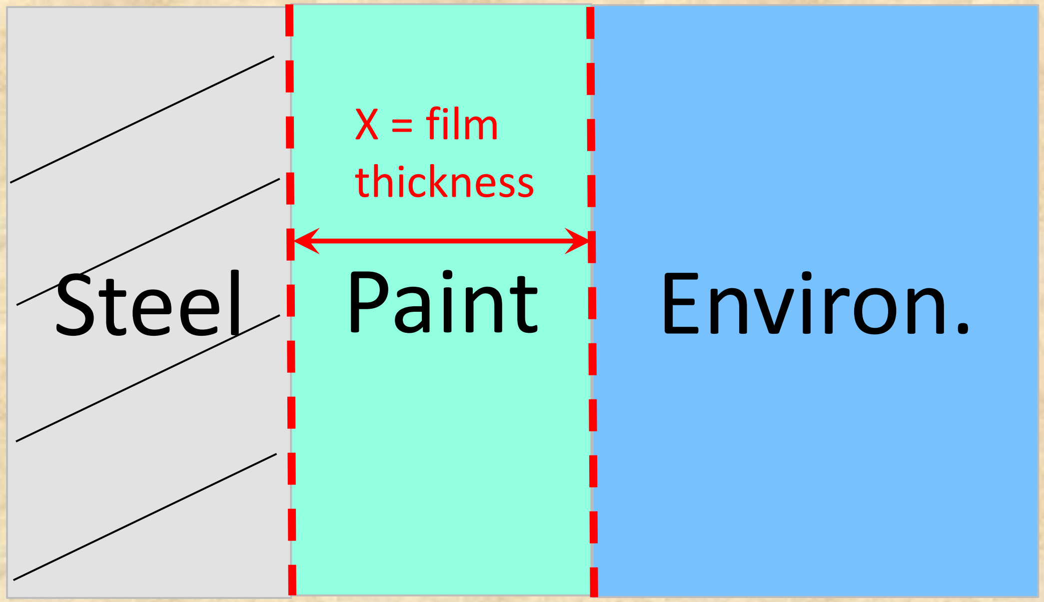


Diffusion Through Paint?

Fick's Law

$$J = Dp * \frac{\Delta C}{\Delta X}$$

$$\frac{J_1}{J_2} = \frac{D_{p1}}{D_{p2}} * \frac{(\frac{\Delta C_1}{\Delta X_1})}{(\frac{\Delta C2}{\Delta X_2})}$$



Dp1	Dp2
1.00E-08	1.00E-11

Assume X2 = X1

J1/J2 = 1000

If paint 1 is 3 times thicker than paint 2:

J1/J2=333

Assume X1 = 3*X2

J	**Flux**	**Mol/(m²·sec)**
Dp	**Diffusion Coef.**	**Mol/sec**
ΔC	**Conc. gradient**	**Mol/l**
X	**Film thickness**	

EPA – or – OSHA

- Environmental Protection Agency (EPA) – protecting human health and the environment.

- Occupational Health and Safety Administration (OSHA) – assure safe and healthful ***working conditions*** for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance.

I am going to call the EPA!

- Although this situation is obviously hazardous, calling the EPA would be a mistake.
- This is a workplace health hazard, not an environmental hazard. OSHA has jurisdiction over workplace safety.

Heavy Metals in Structures Maintenance

"There is no project that is 100% Compliant."

100% Compliance w/ Hazardous Materials

Heavy Metals in Structures Maintenance

OSHA:

TSP monitoring

PEL

Competent person

EPA:

Hazardous Waste – TCLP & RCRA Table 1

Let’s put common sense to it:

A typical 1 gallon can of lead (Pb) pigmented paint contained 5-10 lbs. of Pb.

$$5\ lbs. \cdot \text{Pb}\ x\ 453.6\ \frac{g}{lb} = 2{,}270\ g \cdot \text{Pb} = 2{,}270{,}000\ mg \cdot \text{Pb}$$

EPA Limit/Haz Waste

$$\frac{5\ mg\ Pb}{1\ kg\ Soil} = \frac{2{,}270{,}000\ mg\ Pb}{X\ kg\ Soil}$$

X = 440,000 kg of soil

= ~ 970,000 lbs. of soil

= ~485 tons of soil

1 can of paint = 24-48 dump trucks of soil

Thank You!

PAUL VINIK

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Thank You!

Purpose of Surface Preparation

- Remove Surface Contaminants
- Reduce Soluble Salt Levels
- Develop Angular Profile
- Pack Rust Removal

Domestic Scan 15-03

- All Agencies specified SSPC-SP 10 for full removal
- No consensus on surface preparation for spot prep/overcoating

Level of Cleanliness (OR DOT)

- New Steel
  - SSPC-SP10 Near White Metal Blast Cleaning

- Existing Steel
  - SSPC-SP10 Near White Metal Blast Cleaning
  - SSPC-WJ2 Watterjetting- Thorough Cleaning

- Rehabilitating Existing Coated Steel Structures
  - SSPC-SP15 Commercial Grade Power Tool Cleaning

SSPC SP10

- Joint Standard: NACE No. 2
- When viewed without magnification, shall be free of all visible oil, grease, dust, dirt, mill scale, rust, coating, oxides, corrosion products, and other foreign matter.
- No more than 5% staining

SSPC SP 10

Soluble Salts

- SSPC Technology Guide 15
  - Field Methods for Extraction and Analysis of Soluble Salts on Steel and Other Nonporous Substrates
- Pressure Washing
- Abrasive Blasting
- Soluble Salt Removal
  - Rust inhibitors
  - Chloride removers
  - Lead/chromate-treating abrasive additives

Domestic Scan 15-03

- Texas requires Waterjet Cleaning of Metals-Light Cleaning (SSPC SP WJ4) before mechanical surface prep

- New York requires hot pressure wash (180°F) at 3,000psi to remove surface contaminants

Soluble Salts (OR DOT)

- Soluble Salt Testing
  - 3 tests for the first 1,000 sq ft cleaned each day, minimum of 2 per shift
  - For areas cleaned with no salt removal:
    - Testing per SSPC TG 15 Section 4.1.1 (Soluble Salt Meter)
    - Max concentration 70 microsiemen per square centimeter
  - For areas cleaned with salt removal:
    - Testing per SSPC TG 15 Section 5.2.5.1 (Latex Sleeve Method)
    - Max concentration 5 micrograms per square centimeter

Cleaning Methods

- A stream of high-pressure air (Abrasive Blasting)
- A rotating centrifugal paddle wheel (Wheelabrator)
- A stream of high-pressure water (Waterjetting)

Cleaning Methods

Abrasives (OR DOT)

- Provide an abrasive that will produce a continual angular profile of 1-4 mils
- Measure profile according to ASTM D4417 using Replica Tape
- Keane-Tator Surface Profile Comparator ASTM D4417

Abrasives (OR DOT)

- Lead or Chromium?
  - Additive to render non-hazardous
- Abrasives that conform to SSPC-AB1
- Cleanliness ASTM D7393
- Conductivity ASTM D4940
  - Results shall not exceed 100 microsiemen/cm

Air

- Free of water, oil or any other material detrimental to the coating system
- Provide adequate separators or traps
- Test cleanliness daily according to ASTM D4285 (Blotter Test)

Water (for Waterjet Cleaning)

- Does not contain more than:
  - 75 milligrams per liter of chlorides

    or
  - 200 milligrams per liter of sulfates
- Filter, recycle and dispose of water when surface soluble salts cannot be consistently kept below 70 microsiemen per centimeter
- Use a rust inhibitor approved by the coating manufacturer
- Provide a test panel at least 14 calendar days before beginning work
  - Test panel must meet ODOT adhesion standards for coatings to be accepted

Cleaning

- Perform blasting or pressure washing as needed
- DO NOT BLAST CLEAN ADJACENT TO AREAS BEING COATED

Final Preparation

- Blow down/Sweeping/Brushing
- Last visual check
- Surfaces to be free of all residues per SSPC PA-1
- Repair damaged galvanizing per ASTM A780
- Obtain final approval from the engineer/engineer’s representative

Pack Rust Removal

- Fully remove pack rust using either of the following methods:
  - Mechanically, in combination with saturating the pack rust with water at 3,000 psi and heating to a minimum of 250 °F and a maximum of 400 °F
  - Blast with ultra-high pressure water jetting at 35,000 psi

Application of Coating

- Surface Condition: ensure surface cleanliness

- Application Method:
  - All application techniques shall conform to Section 7 in SSPC-PA 1 and the applicable sections of SSPC PA Guide No. 11
  - Use brushes to push the coating into complex areas

- Apply all subsequent coats of paint in sufficiently different shades
  - NEVER START WITH GRAY

Application of Coating

- Apply each coat in uniform layer, completely covering the preceding coat before moving onto the next coat

- Correct any deficiencies before moving on to the next coat

- One Wet Film Test first 15 minutes, one WFT per hour afterwards

Number of Coats and Film Thickness

- Apply all coats to the minimum thickness specified by the manufacturer (PDS)
- Apply the coating system in the number of coats specified in ODOT QPL
- On steel-to-steel contact surfaces, apply only zinc primer
- On steel-to-concrete contact surfaces, apply the full coating system so that it extends 1 inch into the contact surface
- Dry Film Thickness to min of 3 mils nor more than the manufacturer’s class “B certification allows

Stripe Coats

- Apply prime coat before full coat
  - Prime Stripe, Full Prime, Prime Intermediate, Full Intermediate, Top Coat
- Apply stripe coats by brush
  - Approximately 3 mils
- Different shades of color for each coat from the preceding coat

Stripe Coat

- SSPC PA Guide 11
- Hold Coats

Coating Thickness and Coverage

- Engineer will take DFT measurements after the application of each coat before the application of the succeeding coat
- Visual Inspections for complete coverage

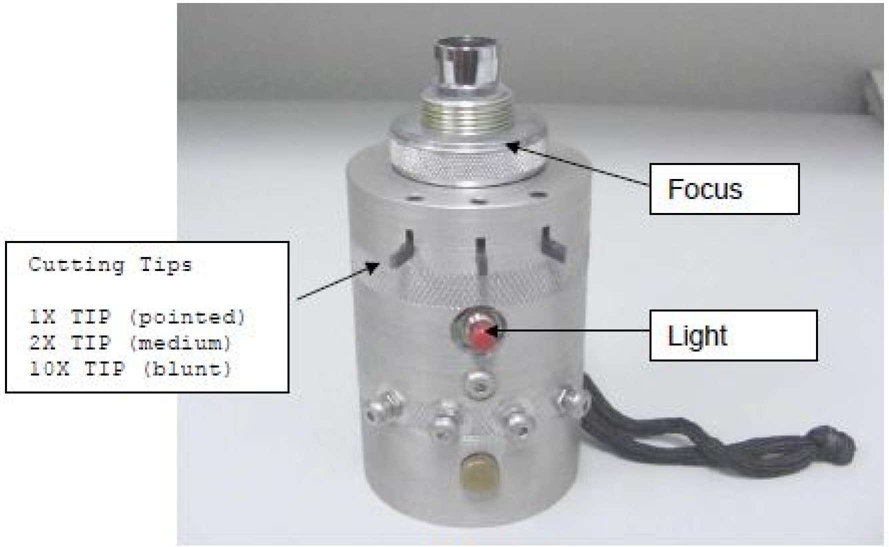
Coating Thickness and Coverage

- DFT measurements taken per SSPC-PA 2, modified as follows:
  - A single gauge reading will be taken for each 10 square feet of surface area
  - A spot measurement is only taken at locations where a gauge reading is less than 100 percent of the Project's specified minimum DFT
  - All spot measurements shall meet 100 percent of the Project's specified minimum DFT
  - Additional readings may be required to identify the limits of the non-compliant areas

Coating Thickness and Requirements

- Tooke Gauge
  - If not sufficient coating thickness, entire coating system to be replaced

- Additional Top Coat
  - If total thickness of prime and intermediate coats exceed the specified thickness, apply a top coat to at least the minimum required thickness



Tooke Gauge

Time of Application

- Unless otherwise approved by the Engineer, prime existing steel Structure surfaces according to one of the following methods:
  - Prime on the same Day that the surfaces are cleaned.
  - Apply an approved rust inhibitor to the entire surface on the same Day as cleaning, and prime within 48 hours after inhibitor application.
  - Reblast all surfaces prior to coating.
- Apply each coat as soon as possible
- Follow manufacturer’s recommendation for dry times and recoat windows

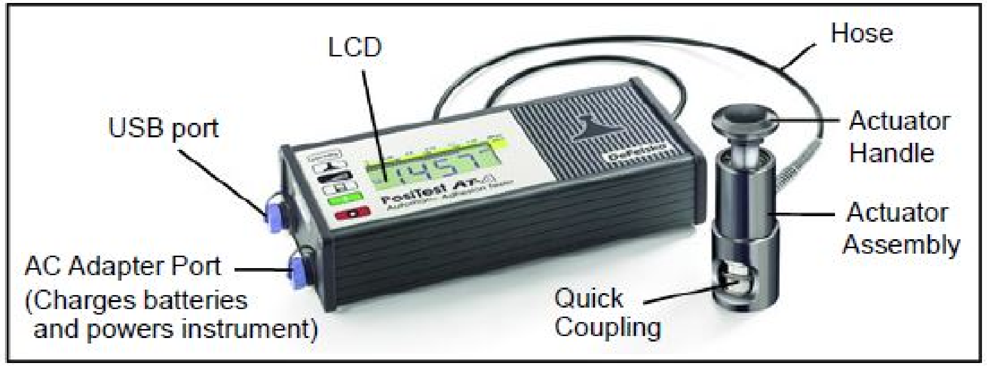
Caulking

- Apply caulk after complete application of the top coat. Fill and seal crevices and gaps between structural shapes and plates, around bolt heads and nuts, and similar areas that would retain moisture, with the following:
  - Caulk, if the crevice or gap cannot be filled with coating materials.
  - Backing material and caulk to fill the crevices and gaps that exceed 1/4 inch.
- Apply caulk over the backing material to form a watertight seal.
- In areas that collect or channel water, apply caulk even if coating fills the gap.
- ODOT QPL Product

Adhesion

- ASTM D4541 Test Method D, E or F
- Minimum Pull Off Values
  - OR DOT
    - 650 psi for zinc rich primer and tar based coatings
    - 1,000 psi for all other coatings
- Score coatings around test fixture that are more than 12 mils DFT

Positest AT-A **(ASTM D4541, Method E)**



Environmental Conditions (OR DOT)

- Test environmental conditions according to ASTM E337 and apply coating materials only during periods when:
  - Air temperature is above 45 °F
  - Steel surface temperature is:
  - Greater than 45 °F
  - Less than 115 °F
  - At least 5 °F above the dew point
  - Relative humidity is within the manufacturer's recommended range
- Do not apply coating materials if the Engineer determines that conditions are not favorable for proper application and performance of the coating

Environmental Conditions (OR DOT)

- If fresh coatings are damaged by the elements, replace or repair at no additional cost to the Agency.
- If a coating system allows application in environmental conditions different from those specified, submit a letter from the manufacturer stating the conditions under which the coatings can be applied. Application under conditions other than specified will not be allowed without the Engineer's written approval.
- Cover and protect the metal if coating is to be applied in adverse weather conditions.
- Heat the metal and surrounding air to the temperature specified in this subsection.
- Continue protecting the newly coated surfaces until the coating achieves proper cure.

Stenciling (OR DOT)

- Good idea for future planning, research, tracking
- Place in an easily accessible/visible area
- Place out of extreme weathering
- Stencil the month and year of application and the type of coating used in block letters 2 inches high at a location on each end of each span on the Structure being coated.
- Use flat black color stenciling unless otherwise directed.

Stenciling

Domestic Scan 15-03 Coating Option Decision Making

3-coat, zinc-rich is the workhorse

- Expect 15-30 years for total removal and replacement
- General satisfaction with these systems

Ultra-weatherable coating systems

- Siloxane, Polyurea, Flouropolymer
- Lack of data to justify cost, none submitted to AASHTO NTPEP

Metalizing

- New York and Ohio have multi-decade experience
- No rusting, though not aesthetic, cost

Product Selection

00594.10 – High Performance Coating

ODOT uses High Performance coating to protect New Steel Structures, Existing Steel Structures and Rehabilitating Coated Steel Structures.

Specifications:

- A 3-coat system with zinc rich primer from a single manufacture.
- Submit one unopened 1-quart container of each coating material, each component of multi-component coating material and each thinner sufficient for ODOT to be able to perform testing.

Product Selection

Tests	Test Method	Prime Limits	Limits
Density of Liquid Coatings, Inks, and Related Products	ASTM D 1475	22 to 26	10 to 16
Determination of Zinc in Dry Films of Paints and Coatings	ODOT TM 614	80% min	
Consistency of Paints Using the Stormer-Type Viscometer	ASTM D 562	80 to 110	80 to 110
Pigment Content of Solvent-type Paints	ASTM D 2371	55 to 85	35 to 65
Vehicle Solids (Ordinary Centrifuge)	FTMS 141, Method 4051	50 to 80	50 to 80

Product Selection

- ASTM D 4541 Adhesion
  - Minimum pull-off strength for zinc rich primers and tar based coatings of 650 psi.
  - Minimum pull-off strength for intermediate and top coats of 1,000 psi.
- ASTM D 523
  - 5,000 hours/15 cycles Minimum of 60 Gloss units measured at an angle of incidence of 20° or 60°.
- ASTM B 117 Salt Fog Resistance
  - 4,000 hours/12 cycles No Blister
- ASTM D 5894 Cyclic Weathering Resistance
  - 5,000 hours/15 cycles No Rust
  - 4,000 hours/12 cycles No Blister

Product Selection

- Slip-Critical Connections – The primer coat on steel-to-steel contact surfaces at all slip-critical structural bolted connections using high strength bolts shall conform to Class B (slip coefficient of 0.5) coating requirements in “Test Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints,” as adopted by the Research Council on Structural Connections.

Product Selection

To Apply:

- [ODOT Preliminary Information for Product Evaluation Form 734-5098]
- Submit the Product Data Sheet
- Submit the Safety Data Sheet
- Submit manufacturers' application recommendations for:
    - Substrates
    - Surface Preparation
    - Application Conditions
    - Application Equipment
    - Drying Schedule
    - Recommended Film Thickness

- Submit independent documentation sufficient for ODOT to be able to determine that your product meets the applicable specifications and is suitable for the application.

Access & Containment Issues

- Access controlled by contractor?
  - Controlled by engineer, enforced through hold points and specifications
  - Needs to be provided to do inspections
    - Scaffolding, man lifts, window washing platforms, etc.
- Containment Requirements are separate specification at ODOT
  - Section 00253
  - SSPC Guide 6
- Domestic Scan 15-03 found that all agencies utilized SSPC Guide 6

Containment

Containment

00253.00 Scope - This Work consists of designing, installing, maintaining, moving, and removing systems for:

- Temporary access to the work via work Bridges, platforms, scaffolding, and barges.
- Containment for all dust, debris and waste materials generated by the Work.
- Protection of work surfaces from weather.
- Heating and ventilating to maintain specified humidity, temperature, and air flow.

Containment

00253.01 General - Install all necessary work platforms and containment Structures before beginning Work in any area that requires them. Do not remove work platforms and containment Structures in an area until all Work in that area has been accepted by the Engineer.

Collect and dispose of accumulations of debris and waste before disassembling or moving a work platform or containment.

Containment

00253.03 Submittals - Submit all specified stamped drawings, specifications and design calculations for work platforms, scaffolding, work Bridges, barges, and containment, heating, and ventilating systems according to 00150.35 and at least 21 Calendar Days before the preconstruction conference.

00253.04 Design Services - Provide structural design services by a Civil or Structural Engineer licensed in the State of Oregon.

Provide heating and ventilating design services by a Mechanical Engineer licensed in the State of Oregon.

If barges will be used, provide marine design services by an engineer licensed in the State of Oregon to practice in the field of Naval Architecture and Marine Engineering or other Professional Engineer licensed in the State of Oregon with relevant naval architecture experience as accepted by the Engineer.

Containment

00253.05 Containment Requirements - Contain work debris that is generated from dry abrasive blasting, concrete chipping, and arc spray metallizing operations according to the Class 1A requirements of SSPC-Guide 6, with the following limits:

- Type A1 rigid containment material with Type C1 rigid support structure in locations adjacent to traffic.
- Type A1 rigid containment floor decking.
- Type A2 flexible containment materials are acceptable if rigid containment materials are not specified. Provide flexible containment materials that are air impenetrable and have tear strength of at least 200 pounds per foot and tensile strength of at least 300 pounds per foot.
- Type H1 instrument verification of air pressure in rigid containment, provide negative pressure at least 0.03 inch water column.
- Type H2 visual verification of air pressure in flexible containment.
- Type I1 minimum specified air movement 100 feet per minute cross draft or 80 feet per minute downdraft past work surfaces. Use portable fans as needed to provide air movement in stagnant areas.

Containment

- Type J1 exhaust air filtration with 99 percent cleaning efficiency for particulate diameters above 39 microinches and less than two grains of particulate per 1,000 cubic feet of exhaust air (or air recycled to the work area).
- Provide a muffler or pressure relief valve for air handling/cleaning system.
- Operate dust collection, air flow, and air movement Equipment during blowdown and vacuuming to prevent settling of dust on the Structure or within the containment Structure.

Oregon DOT (ODOT) References

- 2018 ODOT Standard Specifications
  https://www.oregon.gov/odot/Business/Documents/2018_STANDARD_SPECIFICATIONS.pdf
- ODOT Specification Boilerplate Templates
  https://www.oregon.gov/odot/Business/Pages/Boilerplate-SP-2018.aspx
- ODOT QPL
  https://www.oregon.gov/odot/Construction/Documents/qpl.pdf
- ODOT Coatings Criteria
  https://www.oregon.gov/odot/Construction/Doc_ProductReview/coating_high_perform.pdf

Contact

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NCHRP Domestic Scan 15-03

“Successful Preservation Practices For Steel Bridge Coatings”

Presented By Ray Bottenberg, Oregon DOT

Quality Control

- Quality Control (QC) - Contractor’s activities to ensure the work complies with the contract.

Quality Assurance

- Quality Assurance (QA) - Owner's activities to verify that the work complies with the contract.

Coating Inspection Requirements:

In-house Personnel QA Inspections

- 1 agency

Consultant Personnel QA Inspections

- 5 agencies

Blended In-house/Consultant QA Inspection

- 6 agencies

Minimum Consultant Certifications

- All at least NACE CIP Level 1 / SSPC BCI Level 1
- Some used NACE CIP Level 3 / SSPC BCI Level 2

Minimum In-House Certification

- Varied

Coating Inspection Requirements

Hold Points

- Maximize

100% QA inspection

- Verification leads to quality

Striping

- Tint the stripe
- Which coat varied by agency and coating

Inspector Qualifications

- All agencies required training before assigned a bridge project
- Primarily on-the-job training
- Industry-based (NACE or SSPC) training
- In-house instructor-led training

Contractor Qualifications

9 agencies required SSPC QP1 and QP2

3 agencies required SSPC QP 3 for shop painting

1 agency did not require SSPC QP certification

1 agency allowed SSPC QP 7 for new contractors

QP 1 = Prepare and apply coatings in field
QP 2 = Hazardous paint removal in field
QP 3 = Prepare and apply coatings in shop
QP 7 = Introductory program for contractor less than 6 months experience

Warranties

Maryland / Michigan

- 2 yr. / 25% total project value

Oregon

- 3 yr. / 90% of coating line items

Golden Gate

- 5 yr. (contracted labor and materials)

Virginia

- 1 yr.

Ohio

- 3 yr. in the past

Sweet Spot

- Leverage in-service inspection
- Not so long you forget
- If quality bad, it will appear in 2 yrs.
- Defining “failure” is tricky

ANY QUESTIONS

- http://www.domesticscan.org/15-03-successful-preservation-practices-for-steel-bridge-coatings
- raymond.d.bottenberg@odot.state.or.us

Today’s Panelists

- Paul Vinik, pvinik@gpinet.com
- Kevin Shearmire, Kevin.J.SHEARMIRE@odot.state.or.us
- Ray Bottenberg, Raymond.D.BOTTENBERG@odot.state.or.us

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  - Networking opportunities
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- For more information: www.mytrb.org
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