Bridge Maintenance Painting in the Land of 10,000 Lakes

MnDOT's Approach to Improving Bridge Maintenance Painting Operations

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Introduction

2013: MnDOT and KTA-Tator, Inc.
Conducted a One-Day
Bridge Maintenance Painting Workshop

One Outcome :
MnDOT Would Benefit from

1. A More Uniform Method To Rate Coating Systems

2. A Process To Select And Prioritize Maintenance Painting Strategies

Four Objective Approach Was Developed

1. Conduct a Transportation Research Synthesis (TRS)
2. Identify Best Maintenance Painting Practices
3. Prepare a MnDOT Bridge Maintenance Painting Manual
4. Develop Additional Information to Aid MnDOT Personnel

Objective 1:
Conduct a Transportation Research Synthesis

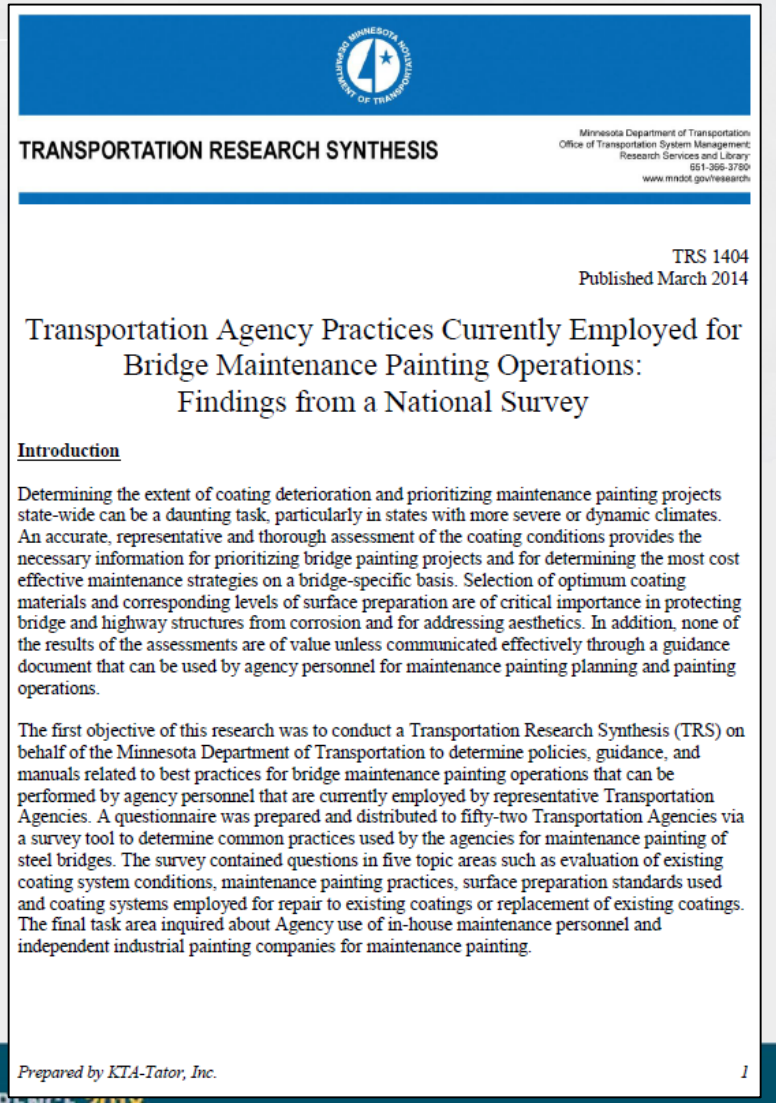
NATIONAL SURVEY

Current Maintenance Painting Practices Employed By Transportation Agencies Across The US On Steel Bridges

- The Survey Process:
- **52 Agencies** Contacted
- **42 Respondents** –

(**81%** Response Rate)

www.dot.state.mn.us/research/TRS/2014/TRS1404.pdf



TRANSPORTATION RESEARCH SYNTHESIS

Minnesota Department of Transportation
Office of Transportation System Management
Research Services and Library
651-366-3780
www.mndot.gov/research

TRS 1404
Published March 2014

Transportation Agency Practices Currently Employed for Bridge Maintenance Painting Operations: Findings from a National Survey

Introduction

Determining the extent of coating deterioration and prioritizing maintenance painting projects state-wide can be a daunting task, particularly in states with more severe or dynamic climates. An accurate, representative and thorough assessment of the coating conditions provides the necessary information for prioritizing bridge painting projects and for determining the most cost effective maintenance strategies on a bridge-specific basis. Selection of optimum coating materials and corresponding levels of surface preparation are of critical importance in protecting bridge and highway structures from corrosion and for addressing aesthetics. In addition, none of the results of the assessments are of value unless communicated effectively through a guidance document that can be used by agency personnel for maintenance painting planning and painting operations.

The first objective of this research was to conduct a Transportation Research Synthesis (TRS) on behalf of the Minnesota Department of Transportation to determine policies, guidance, and manuals related to best practices for bridge maintenance painting operations that can be performed by agency personnel that are currently employed by representative Transportation Agencies. A questionnaire was prepared and distributed to fifty-two Transportation Agencies via a survey tool to determine common practices used by the agencies for maintenance painting of steel bridges. The survey contained questions in five topic areas such as evaluation of existing coating system conditions, maintenance painting practices, surface preparation standards used and coating systems employed for repair to existing coatings or replacement of existing coatings. The final task area inquired about Agency use of in-house maintenance personnel and independent industrial painting companies for maintenance painting.

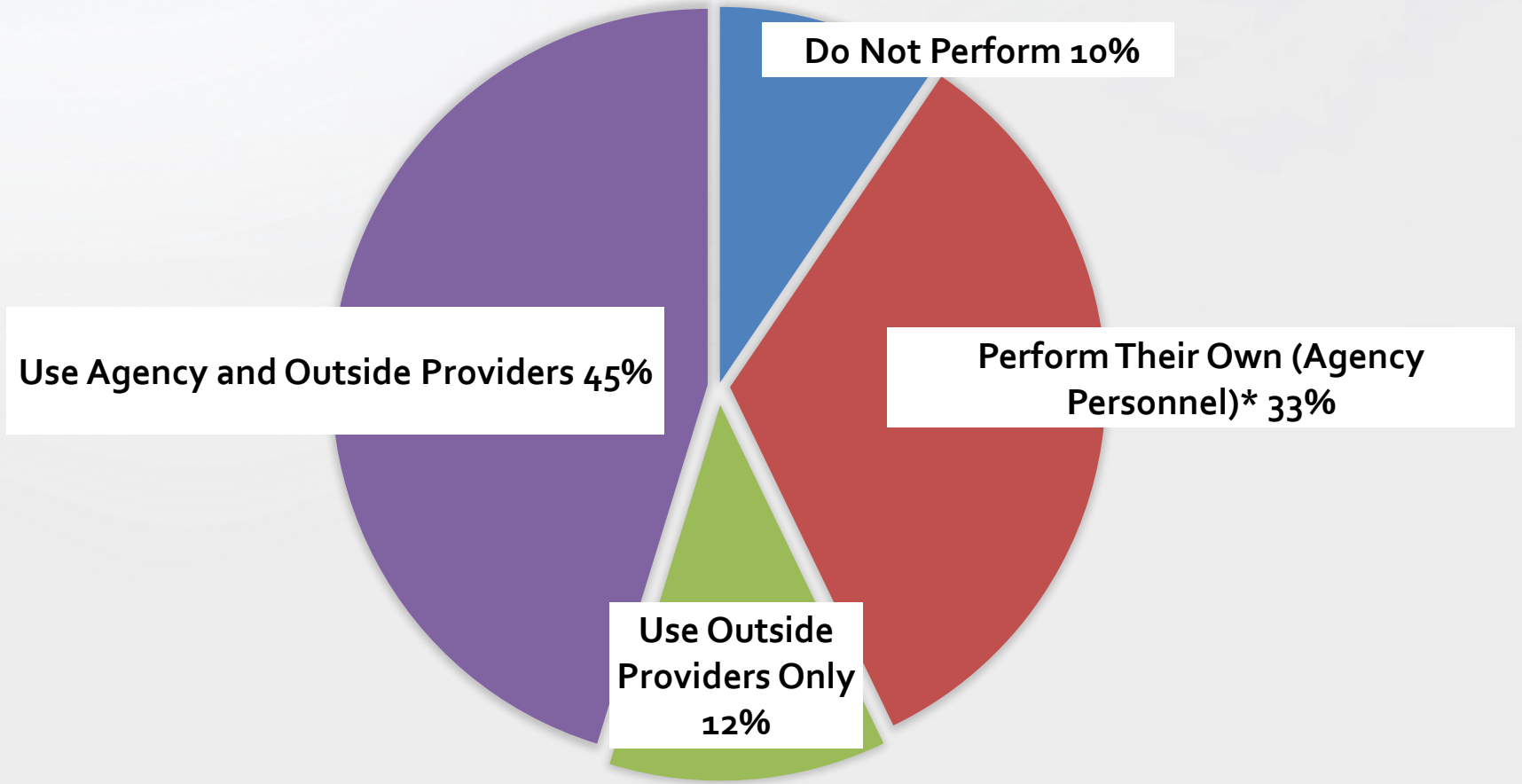
Prepared by KTA-Tator, Inc. *1*

Transportation Research Synthesis (TRS)
Five Topic Areas

1. Coating Condition Assessments
2. Bridge Maintenance Painting Strategies
3. Surface Preparation Methods
4. Coating Systems
5. Use of In-House Painting Forces versus Contractors

Topic Area 1: Coating Condition Assessments

WHO DOES COATING CONDITION ASSESSMENTS?



Note: * Indicates MnDOT current practice through-out

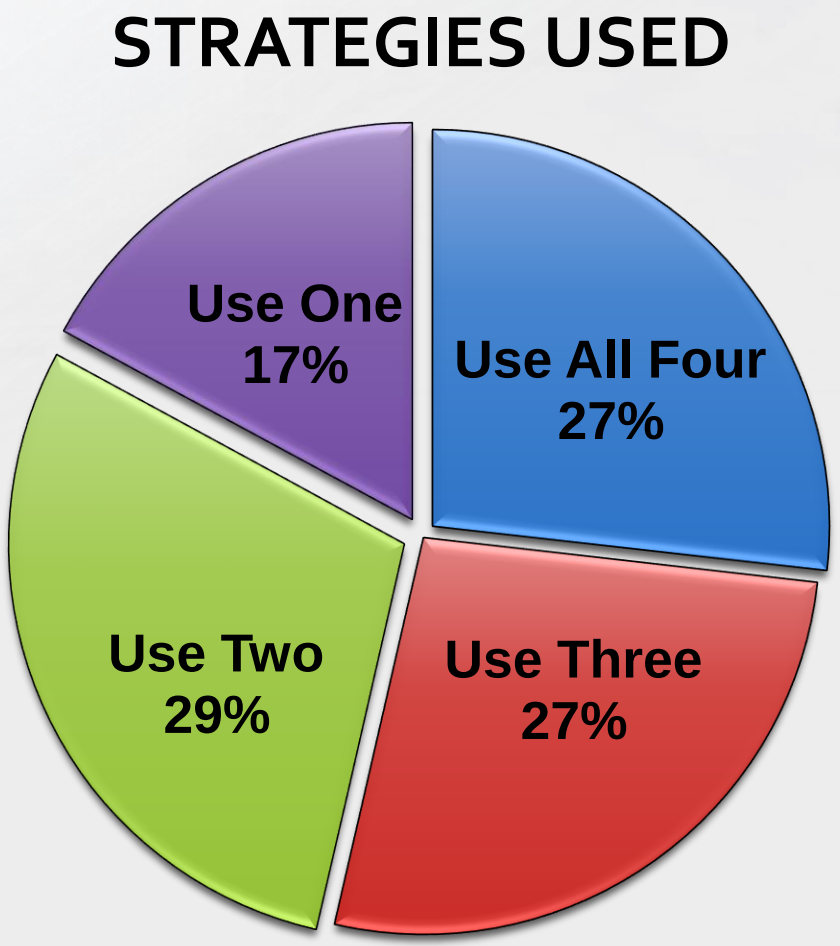
Topic Area 2:
Bridge Maintenance Painting Strategies

- Do Nothing (DN)
- Spot Repair (SR)
- Zone Painting (ZP)*
- Spot Repair & Overcoat (SRO)
- Remove & Replace (RR)*

The most significant factors for determining a coating strategy are the visual and physical condition of the coating system.

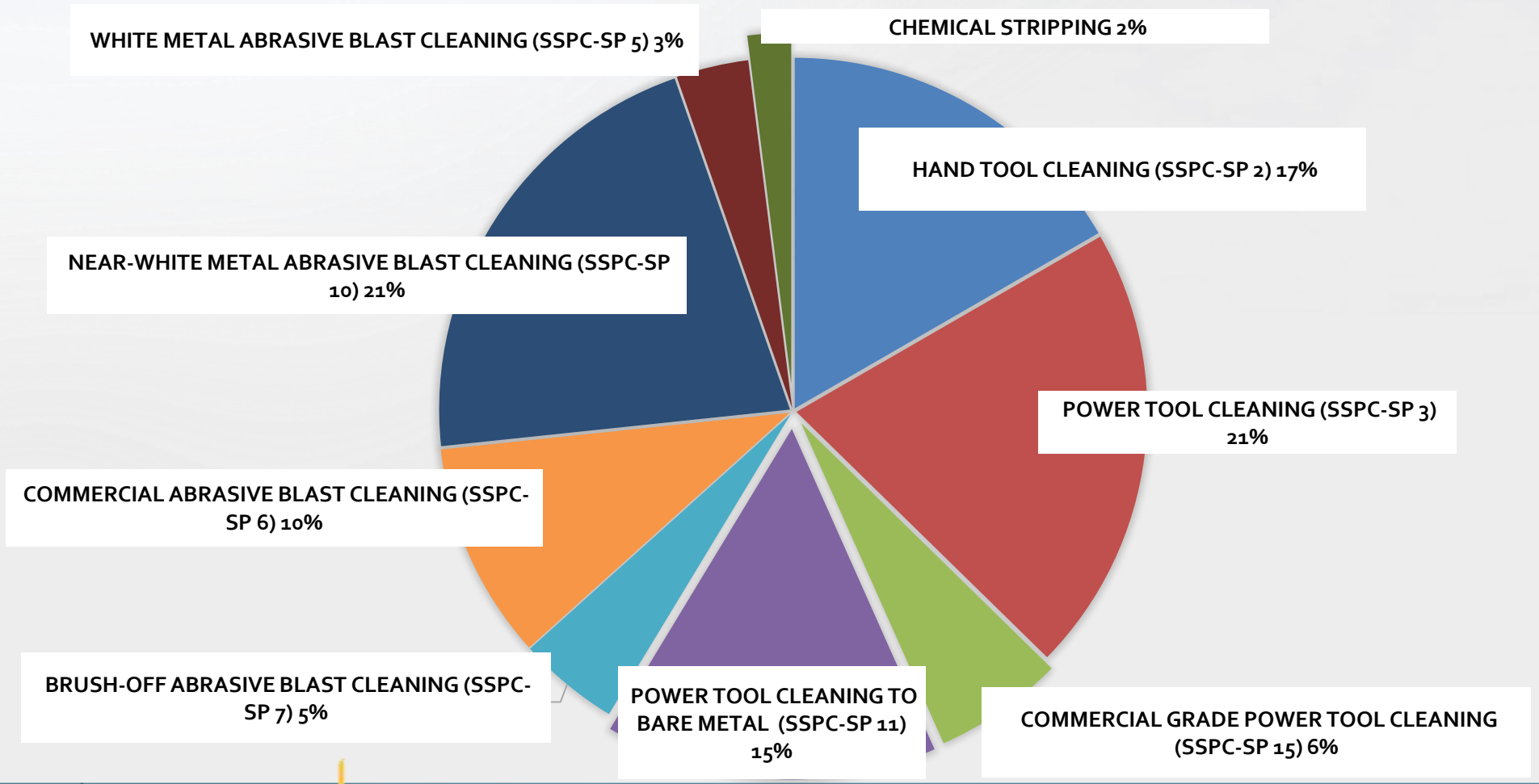
Topic Area 2:
Bridge Maintenance Painting Strategies Employed

Spot Repair
54.8%
Zone Painting
66.7%
Spot Repair & Overcoat
50%
Remove and Replace
90.5%



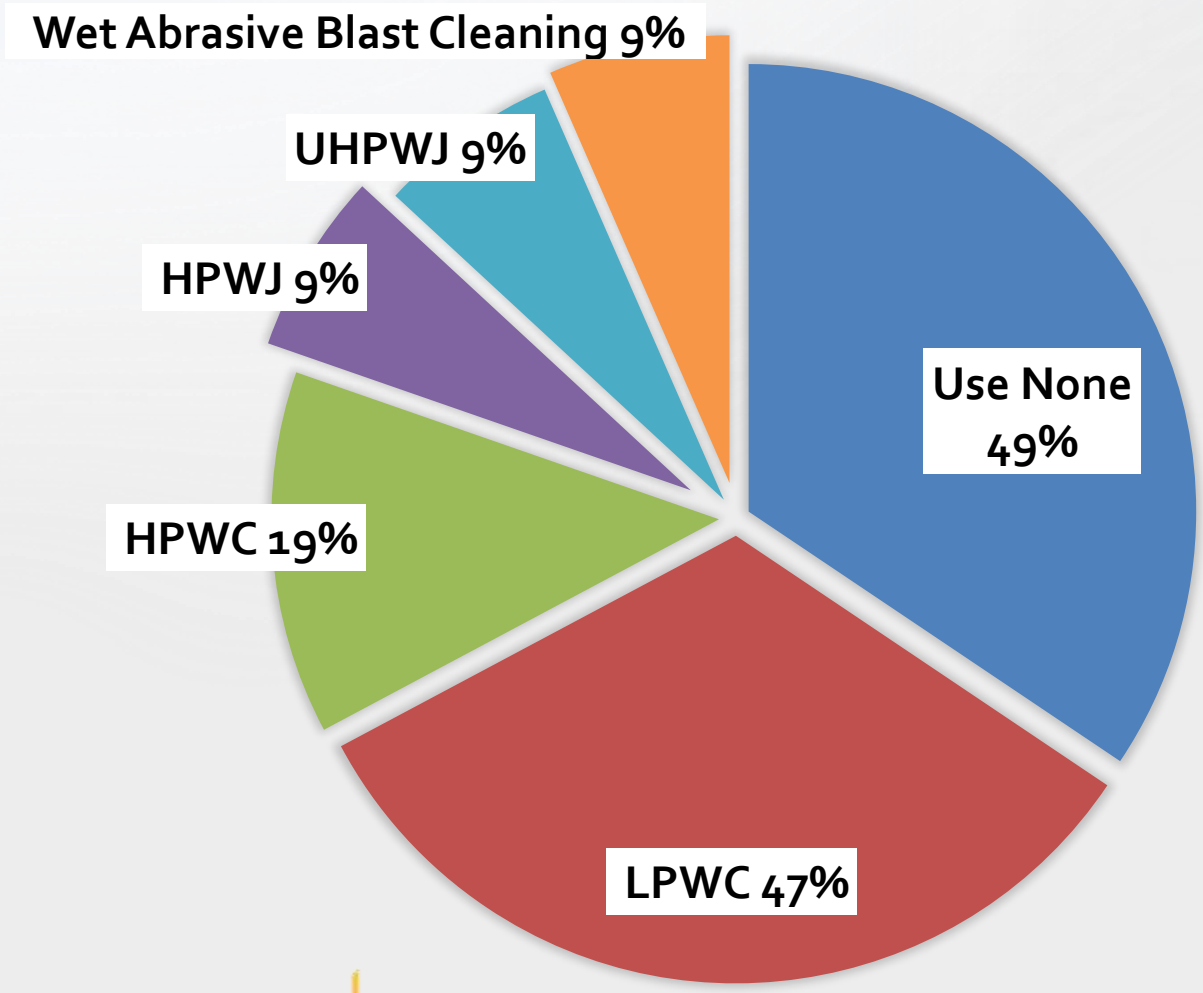
Topic Area 3: Surface Preparation Methods

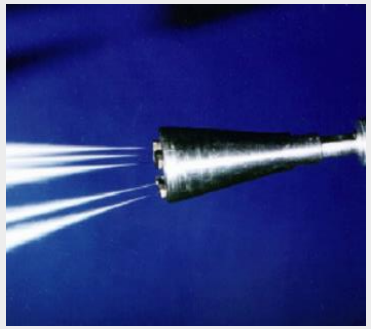
DRY METHODS (MOST FREQUENTLY USED)

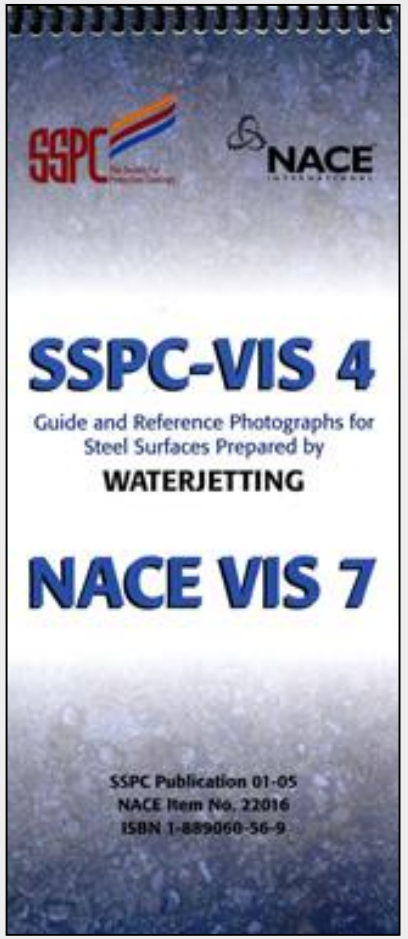


Topic Area 3: Surface Preparation Methods

WET METHODS



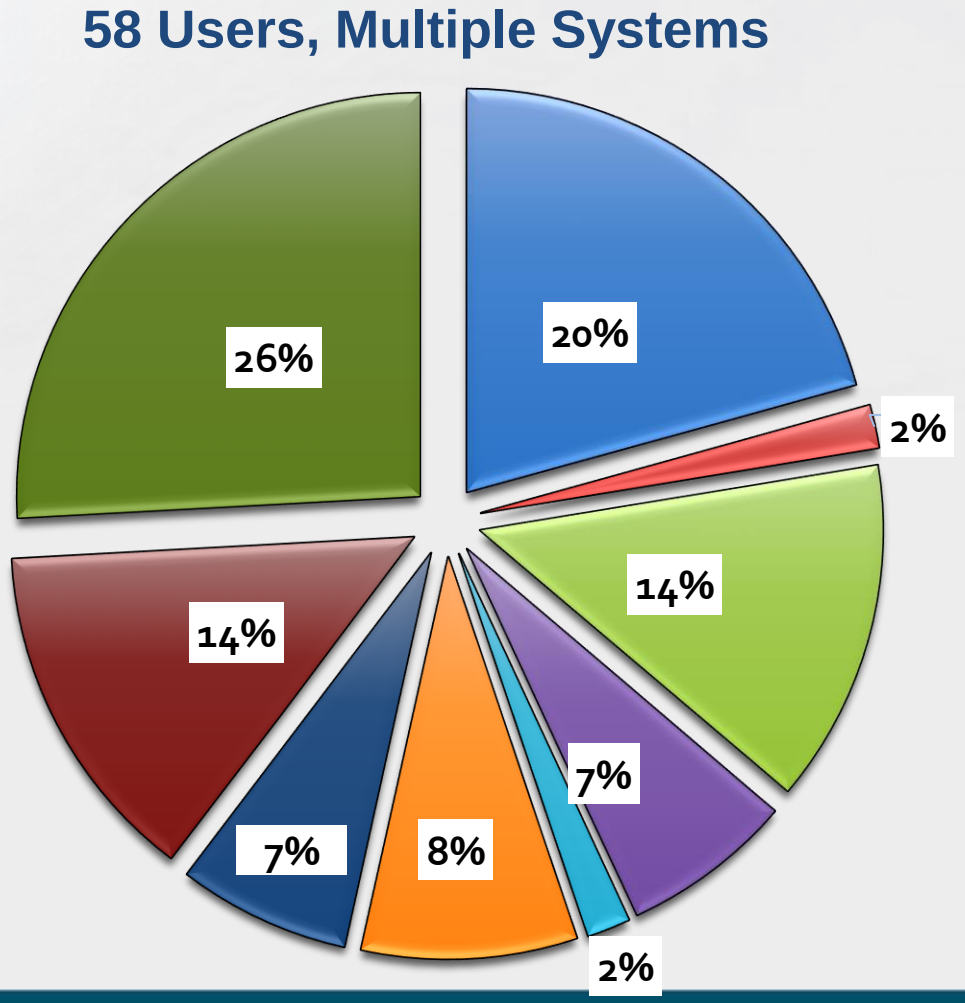




Topic Area 4: Coating Systems

Maintenance Coating Systems Used

- EM/ Polyurethane
- EM/ Acrylic
- EPS/ EM/ Polyurethane
- EPS/ EM/ Acrylic
- EPS /EM /Polysiloxane
- Calcium Sulfonate (Alkyd)
- Alkyd
- Acrylic (WB)
- Moisture Cure Urethane



Topic Area 4: Coating Systems

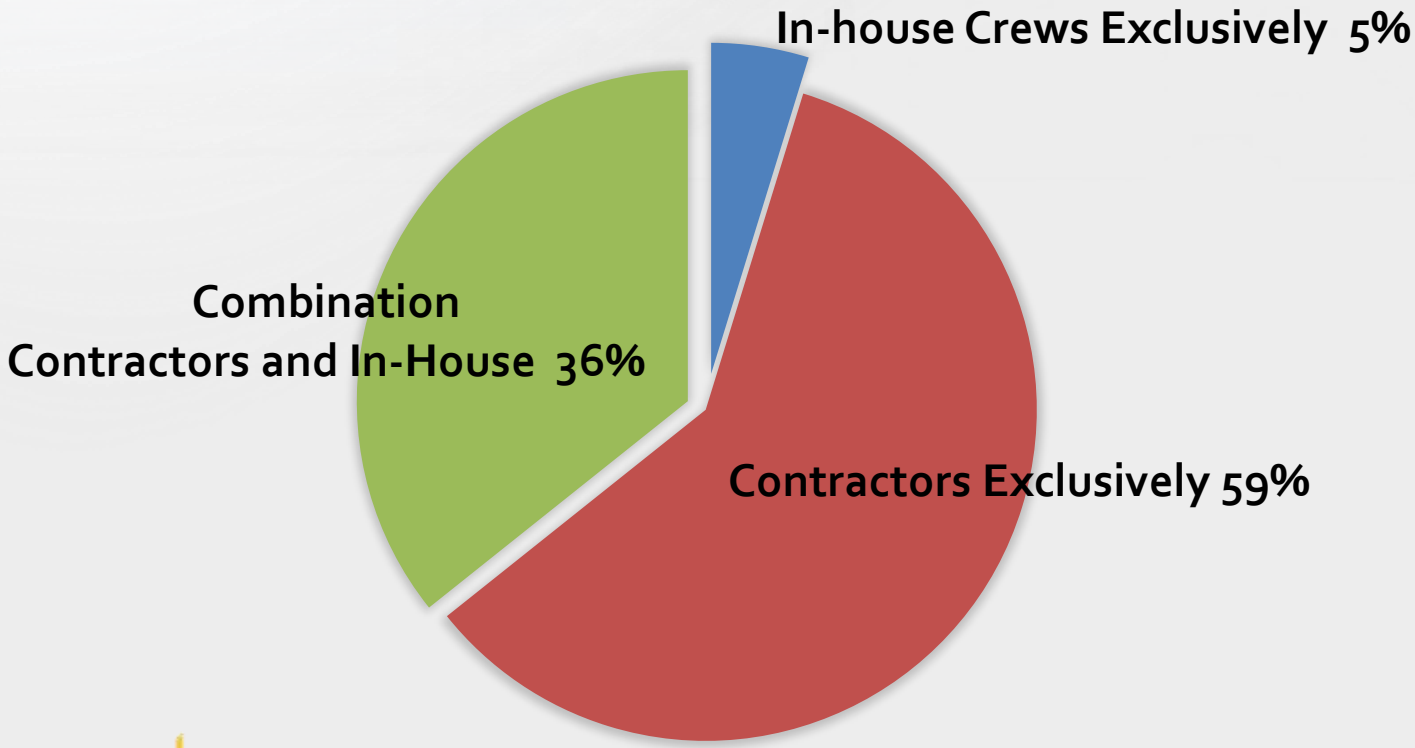
Full Replacement System Distribution

System Type	IOZ	EZR	Other	Alkyd	MET (Unsealed)	MET (Sealed)
Single System	23.8%	47.6%	28.6%			
Two Systems	16.7%	61.1%	16.7%	5.6%		
Three Systems	27.3%	42.4%	6.1%		3.0%	21.2%

IOZ = Inorganic Zinc; EZR = Epoxy Zinc Rich; MET=Metallizing

Topic Area 5:
Use of In-House Painting Forces vs. Contractors

WHO PERFORMS THE MAINTENANCE PAINTING?



Objective 2: Identifying Best Practices
For Inclusion in a Maintenance Paining Manual

- **Best Practices**
  - Appropriate For MnDOT
  - Derived from the Results of the Transportation Research Synthesis

Best Practices

Coating Condition Assessments

- **Develop Condition Assessment Rating System**
  - Painted Steel, Galvanized and Weathering Steel
  - Uncoated Galvanized and Weathering Steel
- **Develop Resources and Guidance**
  - Coating Condition Assessment Guide
  - Additional Testing Requirements if Overcoating

Best Practices

Surface Preparation

- Select Surface Preparation Method based on Maintenance Painting Strategy

Strategy	Recommended Surface Preparation Methods
Spot Repair OR Spot Repair and Overcoat	Methods may include: Pressure washing, degreasing per SP 1, chloride testing and hand or power tool cleaning. Commercial grade power tool cleaning may be needed if heavy rust, pitting or pack rust is present.
Remove and Replace	Methods may include: Degreasing per SP 1, chloride testing, pressure washing if needed and abrasive blast cleaning per SP 10.

Best Practices

Coating Systems

- Select Coating Systems based on Maintenance Painting Strategy

Strategy	Recommended Coating Systems
Spot Repair OR Spot Repair and Overcoat	Epoxy Mastic and Polyurethane finish coat either with or without an epoxy penetrating sealer
Remove and Replace	1. Organic (epoxy) zinc primer and epoxy mid-coat with a polyurethane or polysiloxane finish coat 2. Moisture cure urethane (MCU) zinc primer with two coats of MCU finish

Objective 3:
Prepare a Bridge Maintenance Painting Manual

Chapter 8 - MnDOT Bridge Maintenance Manual

- **8.1:** Overview
- **8.2:** Coating Condition Assessment
- **8.3:** Selecting Maintenance Painting Strategies
- **8.4:** Establishing Priorities
- **8.5:** Planning the Work
- **8.6:** Maintenance Painting Procedures
- **8.7:** Maintenance of Weathering Steel

Coating Condition Assessments

Rating System	Condition States (CS)			
	1	2	3	4
	GOOD	FAIR	POOR	SEVERE
Steel Protective Coatings • General Paint System Deterioration • General Galvanizing System Deterioration • Galvanized and Painted (Duplex) Deterioration • Unpainted Weathering Steel Patina Condition				
Steel Superstructure Elements Corrosion, Distortion, Cracking, Alignment, Connection				
Section Loss				

DIAGRAM A:

Examine Steel Protective Coating

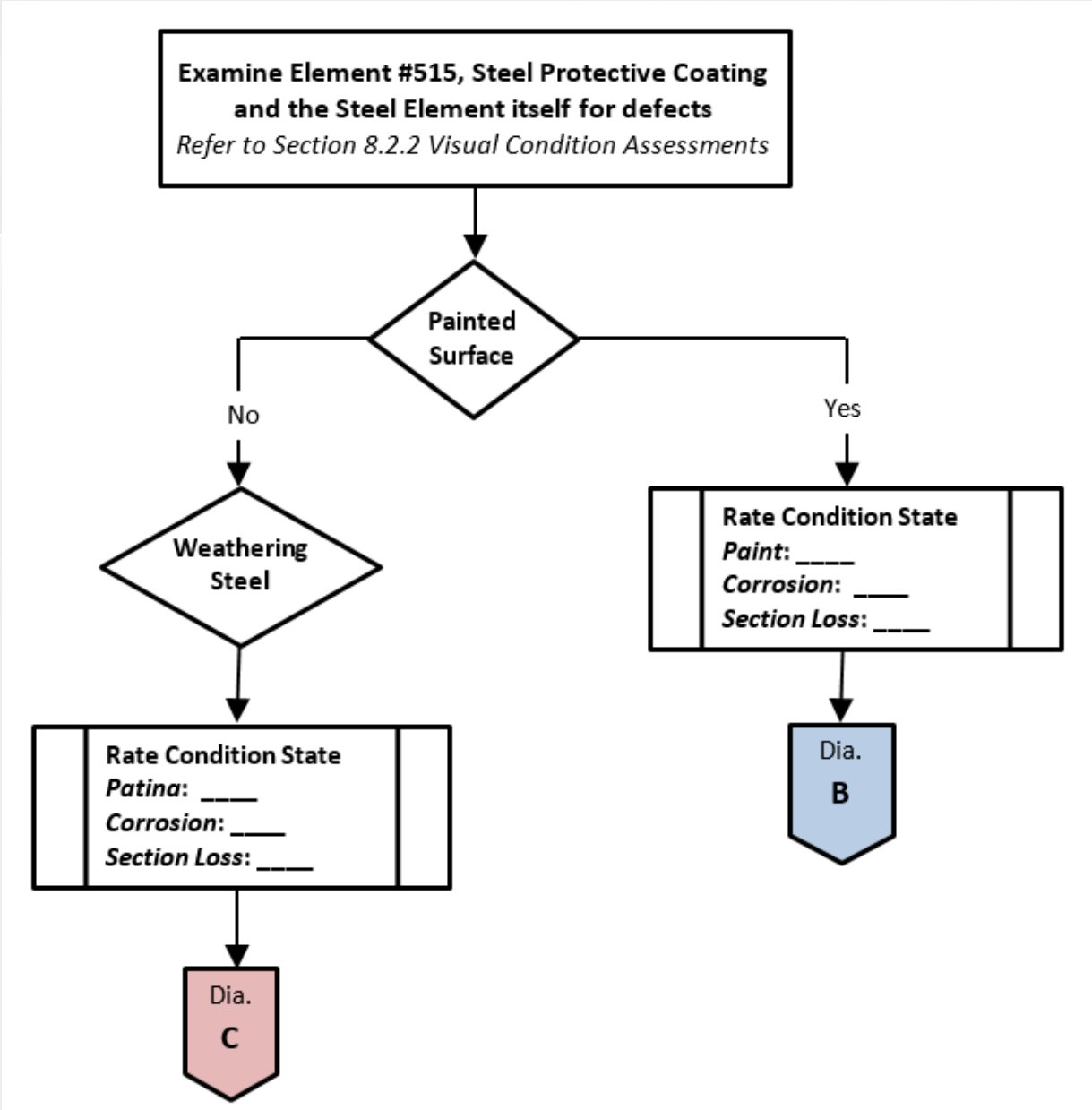


DIAGRAM B:

Determine Maintenance Painting Strategy for Painted Steel Elements

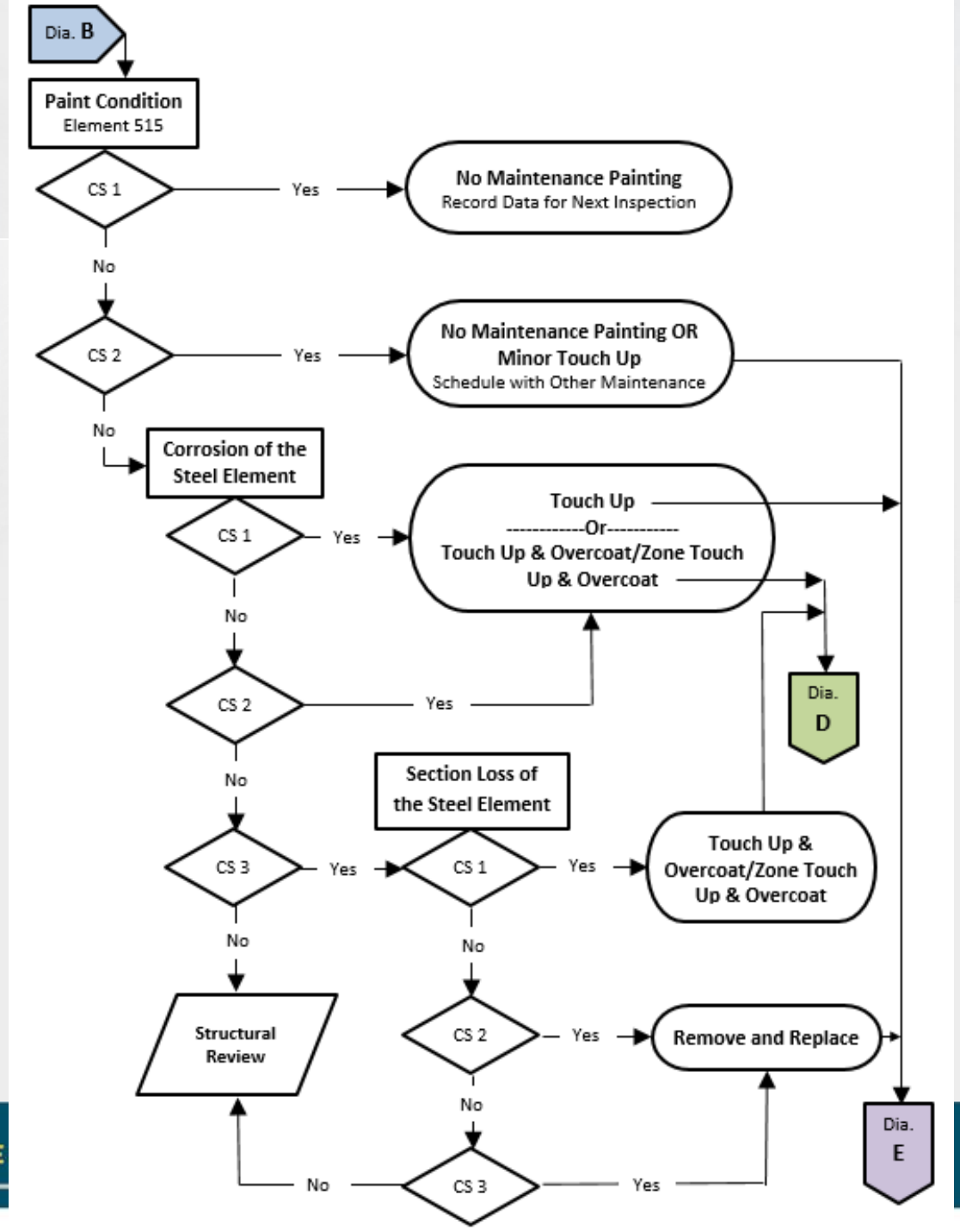


DIAGRAM C:

Determine Maintenance Strategy for Weathering Steel Elements

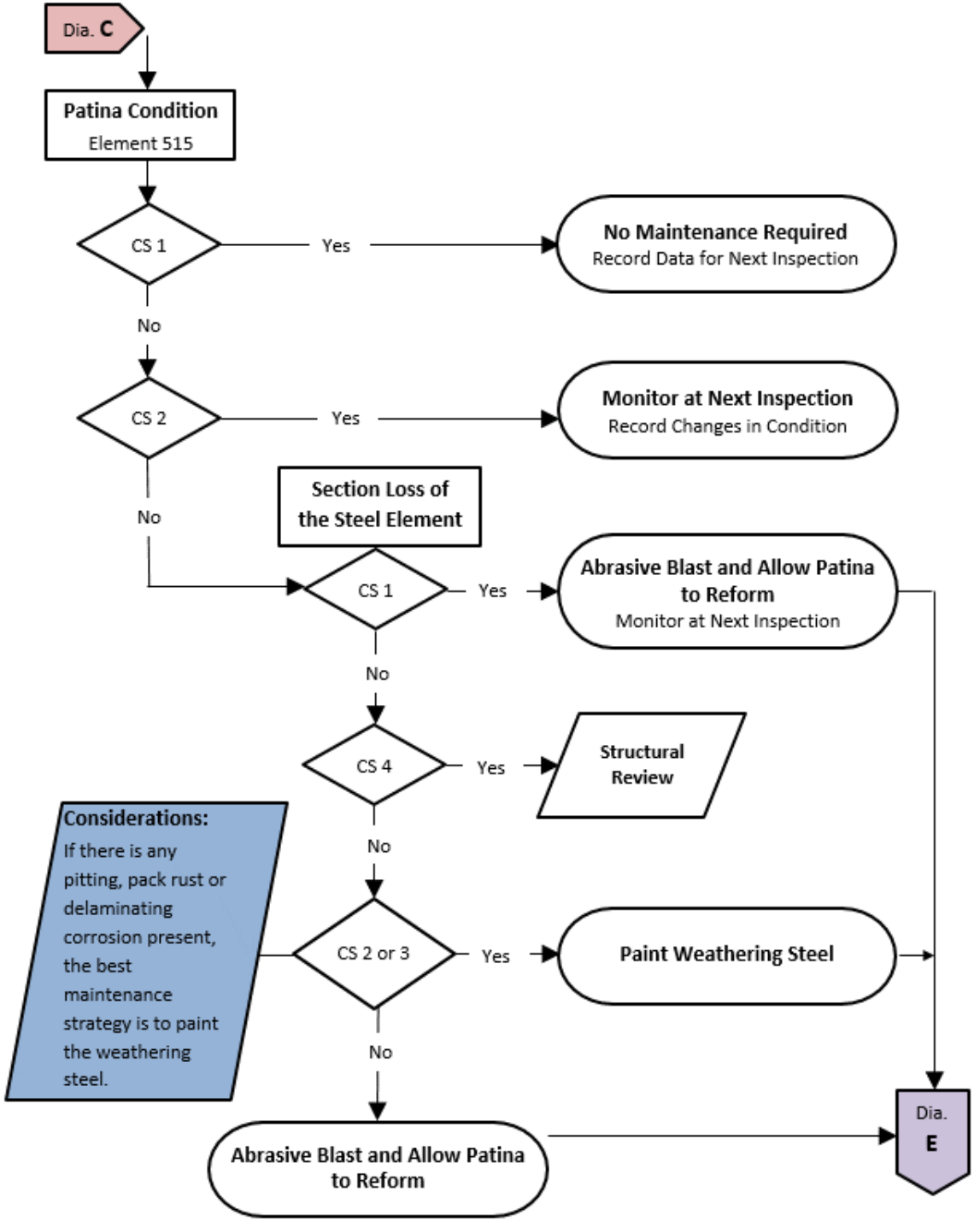
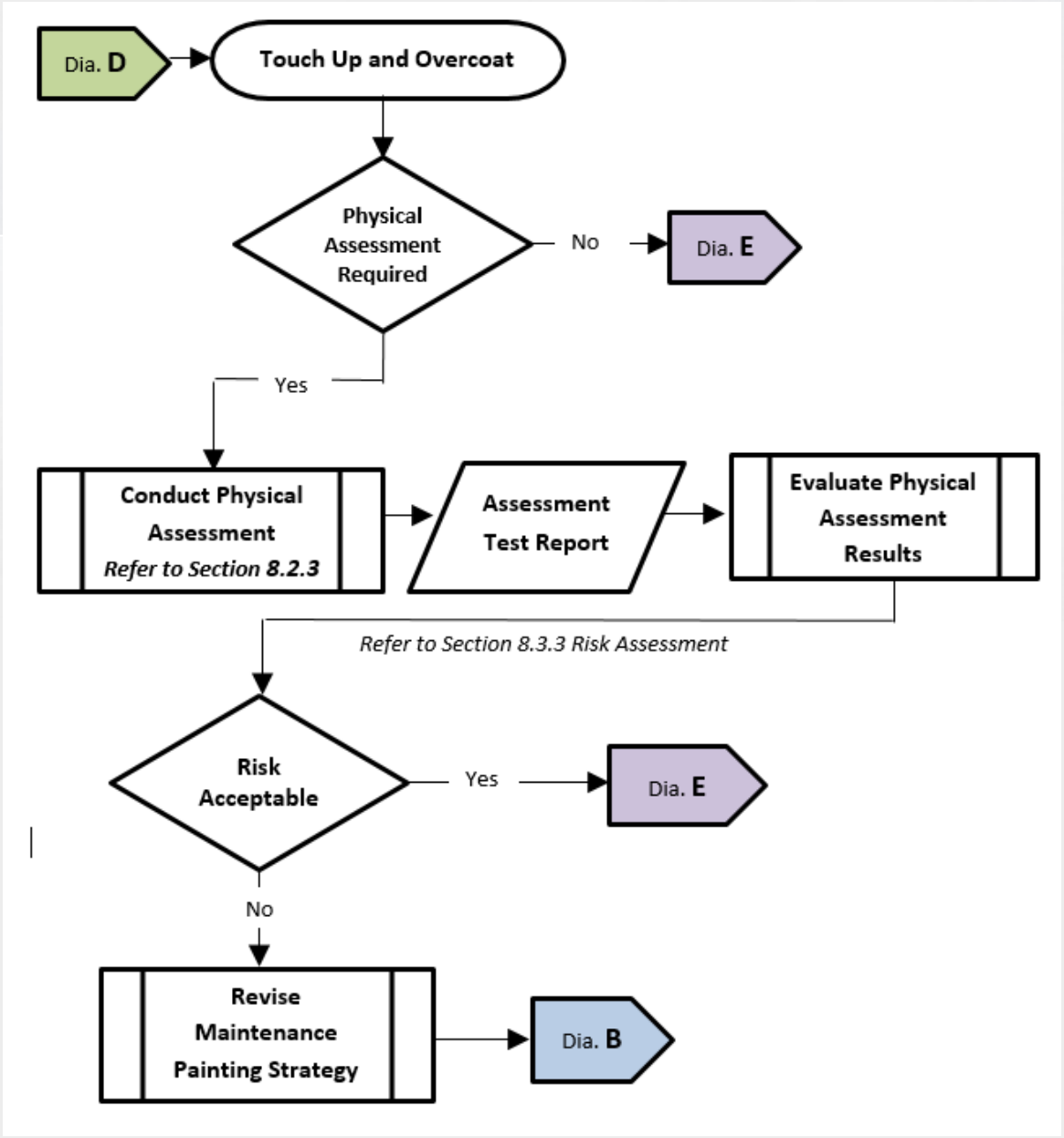


DIAGRAM D:

Risk Assessment for Overcoating

If Overcoating is selected as the preferred strategy, a Physical Assessment is required to assess the risk.



Risk Assessment for Overcoating
Based on Physical Properties

Coating Repair Risk	Coating Deterioration	Adhesion Tape Test	Adhesion, Pull-Off	Coating Thickness (mils)	Substrate Condition
MINIMAL (Nil)	**1-3%**	**>3A >3B**	**>500**	**< 10**	**Clean profile**
LOW- Repair Likely	**3-10%**	**3A 3B**	**>400-500psi**	**>10 to 20**	**Clean & profiled**
MODERATE- Repair Possible	**10-20%**	**2A 2B**	**200-400psi**	**20 to 30**	**No Active Rust**
HIGH- Repair Unlikely	**>20%**	**≤1A ≤0B**	**<200psi**	**>30**	**Rust, Flaking Mill Scale**

Diagram E:

Determine Who Will Perform the Work

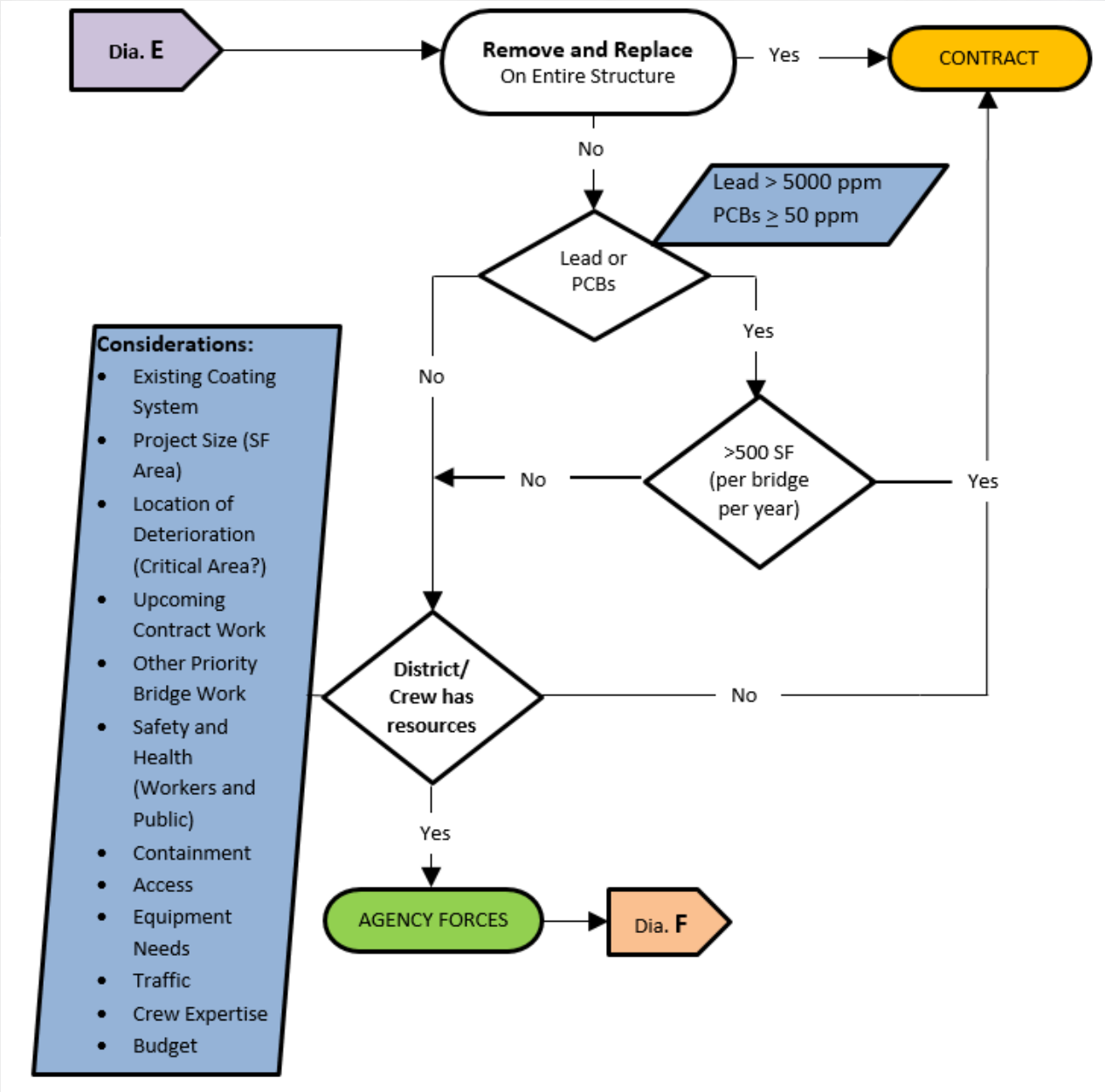
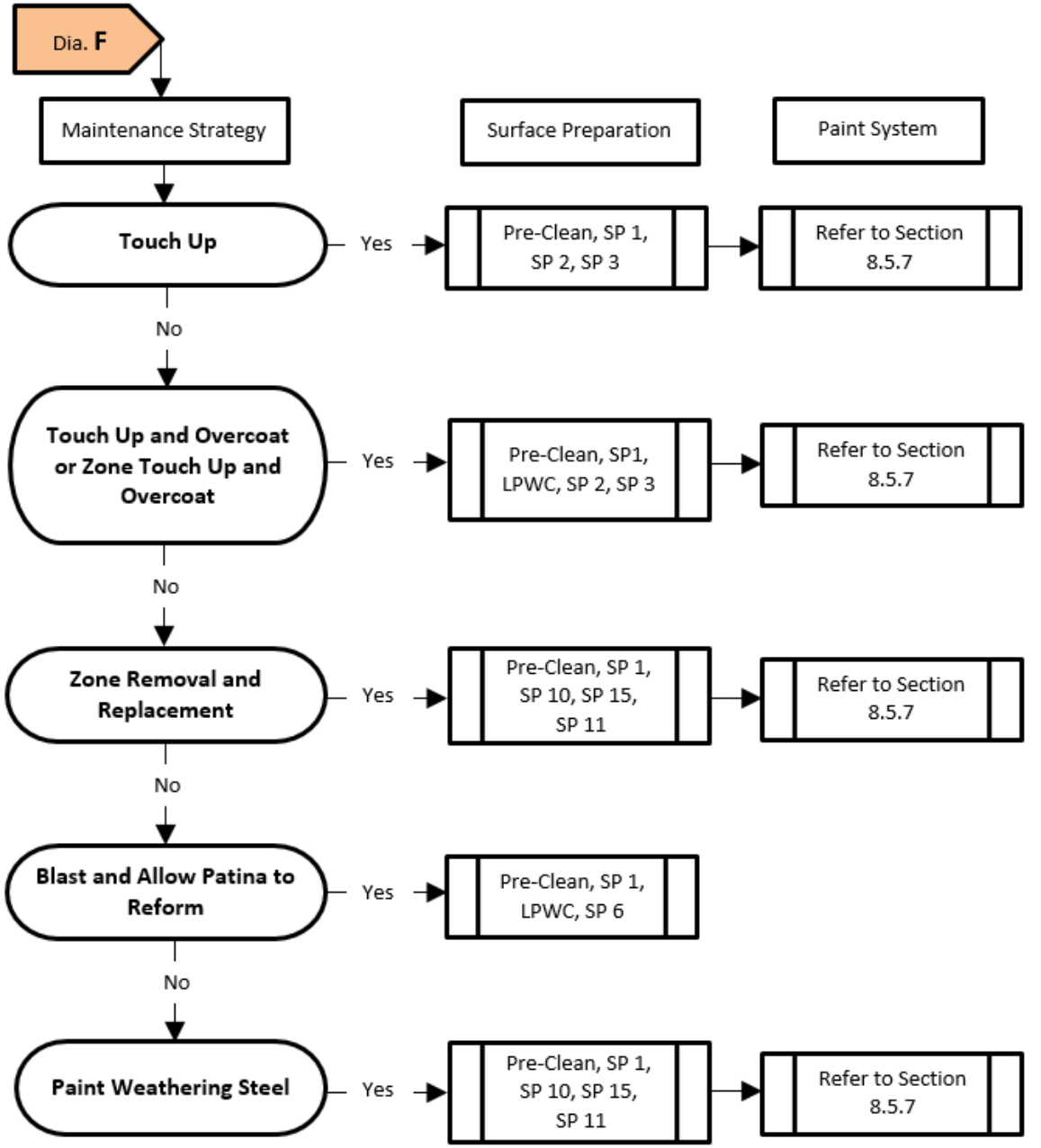


DIAGRAM F:

Surface Preparation and Paint System



Section 8.5.7:

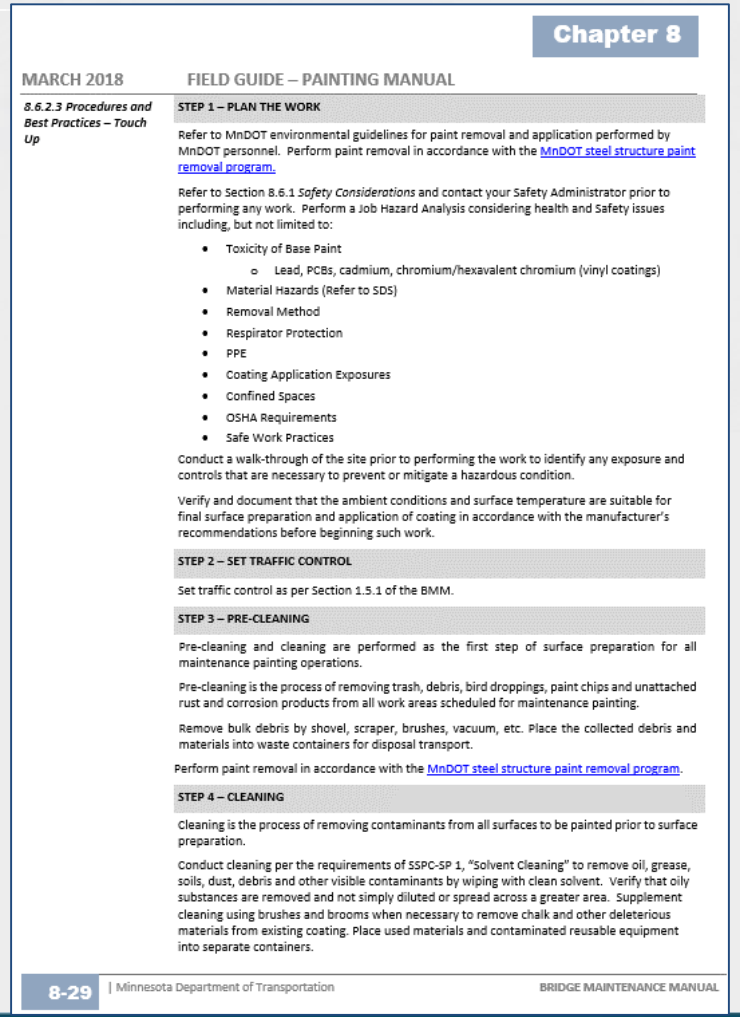
Coating System Options

Remove and Replace (APL):
http://www.dot.state.mn.us/products/paint/bridgestructuralsteelcoating.html

Maintenance Painting Strategy	Substrate Condition	1ST Coat (Primer)	2ND Coat	3RD Coat	Finish Coat Option
Touch Up	Pack Rust and Crevice Corrosion Remains	EPS	Epoxy Aluminum	Polyurethane	Acrylic, Waterborne
	Tightly adhered rust, paint and mill scale	Epoxy Aluminum	Polyurethane		Acrylic, Waterborne
Touch Up and Overcoat or Zone Touch Up and Overcoat	Pack Rust and Crevice Corrosion	EPS	Epoxy Aluminum	Polyurethane	Acrylic, Waterborne
	Tightly adhered rust and mill scale	Epoxy Aluminum	Polyurethane		Acrylic, Waterborne
	Adhered existing coating	Compatible tie-coat	Polyurethane		Acrylic, Waterborne
Zone Removal and Replacement*	Near white abrasive blast cleaned	Epoxy Zinc Rich	Epoxy	Polyurethane	Acrylic, Waterborne
		Zinc Rich MCU	MIO MCU	Polyurethane	Acrylic, Waterborne
	Tie-in to Existing Coating	Compatible tie-coat	Epoxy	Polyurethane	Acrylic, Waterborne
			MIO MCU	Polyurethane	Acrylic, Waterborne or MCU
Paint Weathering Steel	Initial Painting, Commercial Blast Cleaned	Corrosion inhibitive epoxy	Epoxy	Polyurethane	Acrylic, Waterborne or MCU
		MIO MCU	MIO MCU	Polyurethane	Acrylic, Waterborne or MCU

Maintenance Painting Procedures for MnDOT Personnel

- Safety Considerations
- Procedures and Best Practices
  - Touch Up, Overcoat, Zone Removal and Replacement, Weathering Steel
    - Introduction
    - Criteria and Frequency
    - Equipment and Materials
    - Procedures and Best Practices



Chapter 8

MARCH 2018 FIELD GUIDE – PAINTING MANUAL

8.6.2.3 Procedures and Best Practices – Touch Up

STEP 1 – PLAN THE WORK

Refer to MnDOT environmental guidelines for paint removal and application performed by MnDOT personnel. Perform paint removal in accordance with the MnDOT steel structure paint removal program.

Refer to Section 8.6.1 *Safety Considerations* and contact your Safety Administrator prior to performing any work. Perform a Job Hazard Analysis considering health and Safety issues including, but not limited to:

- Toxicity of Base Paint
  - Lead, PCBs, cadmium, chromium/hexavalent chromium (vinyl coatings)
- Material Hazards (Refer to SDS)
- Removal Method
- Respirator Protection
- PPE
- Coating Application Exposures
- Confined Spaces
- OSHA Requirements
- Safe Work Practices

Conduct a walk-through of the site prior to performing the work to identify any exposure and controls that are necessary to prevent or mitigate a hazardous condition.

Verify and document that the ambient conditions and surface temperature are suitable for final surface preparation and application of coating in accordance with the manufacturer's recommendations before beginning such work.

STEP 2 – SET TRAFFIC CONTROL

Set traffic control as per Section 1.5.1 of the BMM.

STEP 3 – PRE-CLEANING

Pre-cleaning and cleaning are performed as the first step of surface preparation for all maintenance painting operations.

Pre-cleaning is the process of removing trash, debris, bird droppings, paint chips and unattached rust and corrosion products from all work areas scheduled for maintenance painting.

Remove bulk debris by shovel, scraper, brushes, vacuum, etc. Place the collected debris and materials into waste containers for disposal transport.

Perform paint removal in accordance with the MnDOT steel structure paint removal program.

STEP 4 – CLEANING

Cleaning is the process of removing contaminants from all surfaces to be painted prior to surface preparation.

Conduct cleaning per the requirements of SSPC-SP 1, "Solvent Cleaning" to remove oil, grease, soils, dust, debris and other visible contaminants by wiping with clean solvent. Verify that oily substances are removed and not simply diluted or spread across a greater area. Supplement cleaning using brushes and brooms when necessary to remove chalk and other deleterious materials from existing coating. Place used materials and contaminated reusable equipment into separate containers.

8-29 | Minnesota Department of Transportation BRIDGE MAINTENANCE MANUAL

Objective 4: Develop Additional Information to Aid MnDOT Personnel

1. Coating Condition Assessment Field Guide
2. Training
3. Maintenance Painting Test Site

Objective 4-1:

MnDOT Coating Condition Assessment Field Guide

- Images of various bridge elements in condition states "**Good**", "**Fair**", "**Poor**" and "**Severe**" to assist bridge inspectors

- **Elements:** Beam Ends, Fascia Beams, Interior Girders Expansions, Piling, Pin and Hanger, Hinges, Trusses, Railings, Weathering Steel

- Guide finalized January 2015

MnDOT Coating Condition Assessment Field Guide

Condition States: This guide contains photos of various steel elements in the condition states described below. Use these reference photos to assist with consistently rating the condition of the protective coating (Element 515). A directory of the reference photos is shown on the following page (ix).

Painted Surfaces		Duplex (Galvanized and Painted) Surfaces		Unpainted Weathering Steel Patina	
(1) GOOD: No or very minor deterioration (≤0.01% to 0.3% corrosion or defects)	**(2) FAIR** (Touch-up): Minor paint deterioration; Chalking and fading of finish coat. >0.3% to 3% corrosion or defects	**(1) GOOD:** No or very minor deterioration (≤0.01% to 0.3% corrosion or defects)	**(2) FAIR** (Touch-up): Minor paint deterioration; Chalking and fading of finish coat. >0.3% to 3% corrosion or defects	**(1) GOOD:** Protective oxide coating is uniform and tightly adhered. Steel is yellow, orange or chocolate- brown	**(2) FAIR** Protective oxide coating has minor deterioration. Steel is chocolate-brown to purple in color; surface may be dusty or granular
(3) POOR (overcoat): Moderate paint deterioration; Finish coat failure (cracking, bubbling, or peeling) - prime coat remains mostly intact. >3% to 16% corrosion or defects	**(4) SEVERE** (remove & replace): Paint system failure Prime coat cracked, bubbling or peeling (steel exposed); >16% corrosion or defects	**(3) POOR** (overcoat): Finish coat failure (cracking, bubbling, or peeling) – underlying galvanizing remains mostly intact. > 3% to 16% corrosion or defects	**(4) SEVERE** (remove & replace): Duplex system failure (steel exposed); >16% corrosion or defects	**(3) POOR** (re-blast or paint): Protective oxide coating has moderate deterioration (small flakes, less than ½"). Steel is black in color	**(4) SEVERE** (re-blast or paint): Protective oxide coating has failed. Large areas of the surface layer may be flaking off

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MnDOT Coating Condition Assessment Field Guide

Element: Fascia Beams (View A)
Condition State: 3 (Poor) *>3 – 16% corrosion/defects*

Element: Fascia Beams (View B)
Condition State: 3 (Poor) *>3 – 16% corrosion/defects*

Element: Fascia Beams (View A)
Condition State: 4 (Severe) *>16% corrosion/defects*

Element: Fascia Beams (View B)
Condition State: 4 (Severe) *>16% corrosion/defects*

Objective 4-2:

Bridge Maintenance Painting Workshop, April 2015

- Introduce Bridge Maintenance Painting Manual Revisions
- Introduce MnDOT Customized Coating Assessment Guide
- Facilitate Workshop – Maintenance Painting Scenarios
  - Performing Coating Condition Assessments
  - Selecting Maintenance Painting Strategies

Workshop Scenarios

MNDOT MAINTENANCE PAINTING MANUAL WORKSHOP
SCENARIO 1

Photograph No. 33
Localized corrosion at floor beam stringer connection.

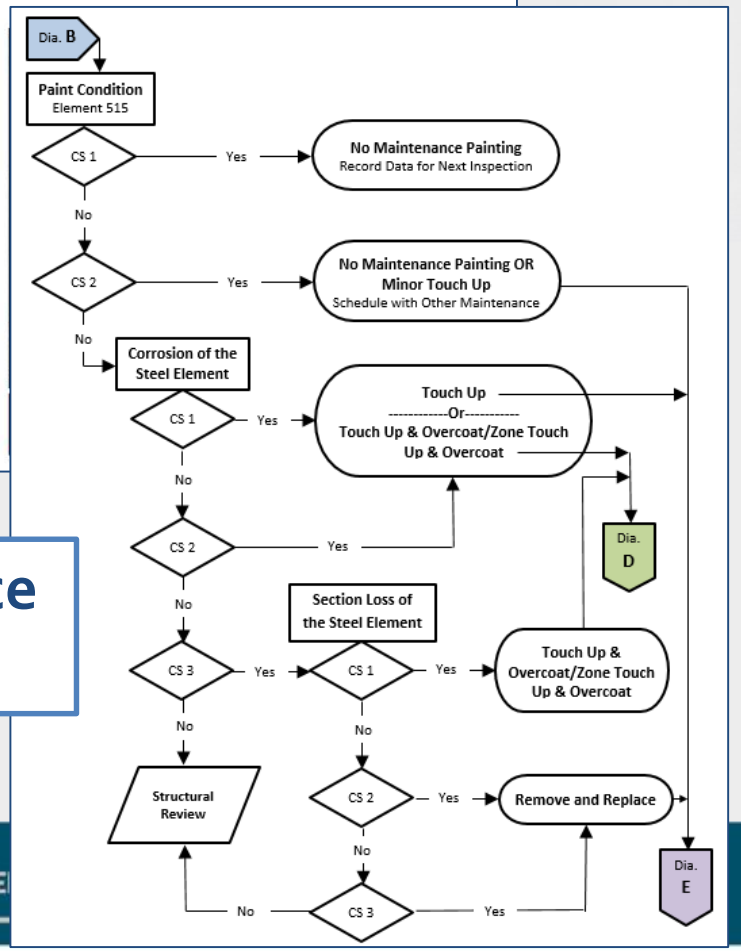
1. Perform Coating Condition Assessments

Element: Fascia Beams (View A)
Condition State: 3 (Poor) *>3 – 16% corrosion/defects*

Element: Fascia Beams (View B)
Condition State: 3 (Poor) *>3 – 16% corrosion/defects*

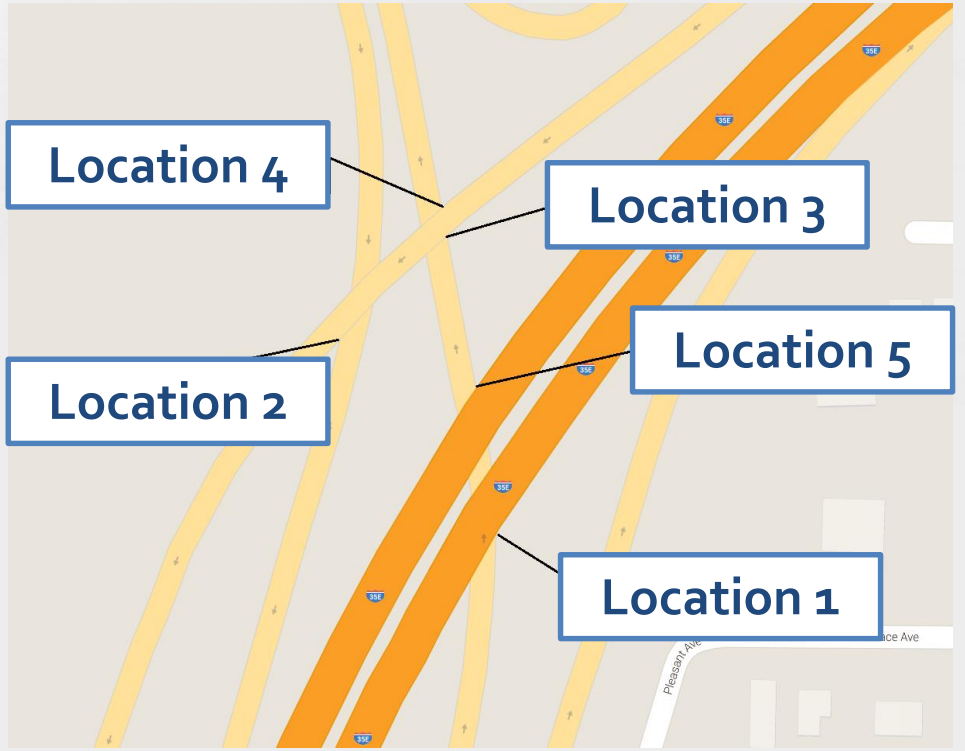
Element: Fascia Beams (View A)
Condition State: 4 (Severe) *>16% corrosion/defects*

2. Select Maintenance Painting Strategies



Objective 4-3:
Bridge Maintenance Painting Test Site

1. **Select** a test site
2. **Apply** various combinations of surface preparation methods and coating systems using in-house crews
3. **Evaluate** over a three year period



Project Test Site: I-35E over Ayd Mill Road, St. Paul, MN

Objective 4-3:
Bridge Maintenance Painting Test Site

4. **Identify** best practices for MN
   - Surface Preparation
   - Coating Systems
5. **Develop** Maintenance Coatings Approved Products List (APL)

Objective 4-3:
Bridge Maintenance Painting Test Site

Surface Preparation and Coating Application Summary							
Test Location	Coat	Generic Coating Type	Degree of Rusting (ASTM D-610)	Surface Preparation	Specified DFT	Total Specified DFT	Total Field DFT
1	Primer	Epoxy Mastic	Top Flange = 6	SP1/SP2/SP3	7-10		11.5
	Finish	Aliphatic Acrylic-Polyester Polyurethane	Web = 5 Bottom Flange = 1		3-5	10-15	17.0
2	Primer	Polyamide Epoxy	Top Flange = 7	SP1/SP2/SP3	3-8		7.4
	Finish	Acrylic Aliphatic Polyurethane	Web = 5 Bottom Flange = 1		2-5	5-13	9.0
3	Primer	Aluminum Filled Polyamine Epoxy	Top Flange = 6	SP1/SP3	4-6		5.2
	Finish	Polyaspartic Urethane	Web = 5 Bottom Flange = 0		6-9	10-15	11.3
4	Primer	Aluminum and Micaceous Iron Oxide Filled Urethane	Top Flange = 6	SP1/SP3	2-3		2.8
	Finish	Polyaspartic Urethane	Web = 5 Bottom Flange = 0		6-9	8-12	8.1
5	Primer	Mastic Waterborne Acrylic	Top Flange = 6	SP1/SP2/SP3	6-8		9.7
	Finish	HDP Acrylic Polymer	Web = 6 Bottom Flange = 2		2-3	8-11	10.2

Objective 4-3:
Bridge Maintenance Painting Test Site

- Field Evaluation
  - Pre-existing Conditions
  - Application (August 2015)
  - Coating Performance (3-years)
    - Adhesion
    - Rusting
    - Blistering
    - Pitting

Test Location 2

Objective 4-3:
Bridge Maintenance Painting Test Site

Coating Performance Evaluation Criteria

Standard	ASTM	Severe	Poor	Fair	Good
Adhesion	D 3359	0	1	2	3 to 4
Rusting	D 610	4	5	6 to 7	8 to 9
Blistering	D 714	Dense	Medium Dense	Medium	Few
Pitting	G-46	5	4	3	1 to 2

Objective 4-3:
Bridge Maintenance Painting Test Site

Existing Condition

2015

2016

2017

Test Location 1: Epoxy Mastic/Aliphatic Acrylic-Polyester Polyurethane

Objective 4-3:
Bridge Maintenance Painting Test Site

Existing Condition

2015

2016

2017

Test Location 2: Polyamide Epoxy/Acrylic Aliphatic Polyurethane

Objective 4-3:
Bridge Maintenance Painting Test Site

Existing Condition

2015

2016

2017

Test Location 5: Mastic Waterborne Acrylic/HDP Acrylic Polymer

Objective 4-3:
Bridge Maintenance Painting Test Site

Existing Condition (Anti-Graffiti Coating)

2015

2016

2017

Test Location 3: Epoxy Mastic/Aliphatic Acrylic-Polyester Polyurethane

Objective 4-3:
Bridge Maintenance Painting Test Site

Additional Testing (September 2016)

- Eliminate variability due to existing conditions
- Minimize surface preparation (SP1 only) and single prime coat

Test Location	Generic Coating Type	Surface Preparation	Specified DFT
A	Epoxy Mastic	SP1/ Spot SP2	7-10
B	Aluminum Filled Polyamine Epoxy	SP1/Spot SP2	4-6
C	Polyamide Epoxy	SP1/Spot SP2	3-8
D	Mastic Waterborne Acrylic	SP1/ Spot SP2	6-8

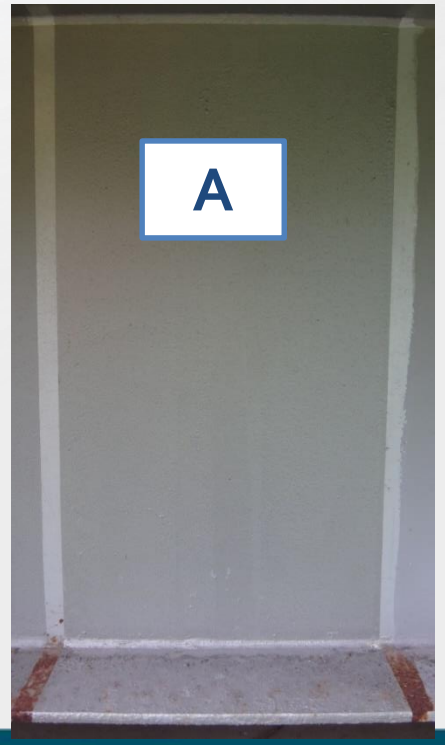
Objective 4-3:
Bridge Maintenance Painting Test Site

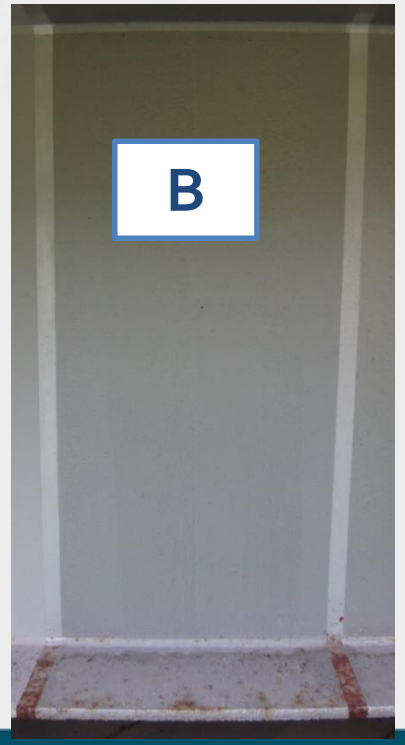
Additional Test Patches at Test Location 1

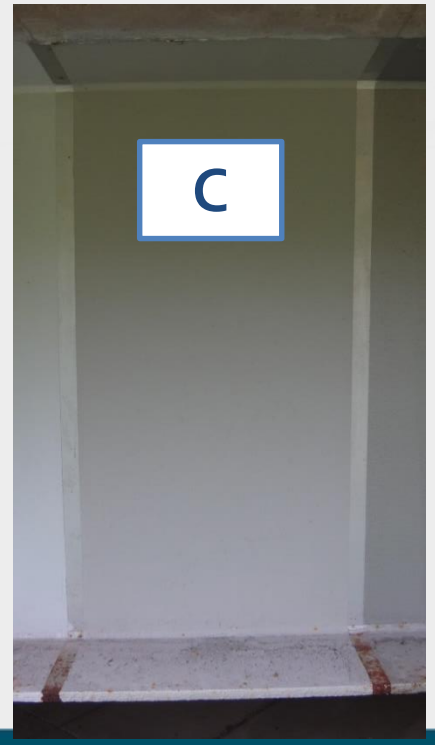
Objective 4-3:
Bridge Maintenance Painting Test Site

Existing Condition

Condition of Test Patches at Test Location 1 (2017)







Objective 4-3:
Bridge Maintenance Painting Test Site

Next Steps

- 3 Year Field Evaluation
  - August 2018
- Final Report
  - November 2018
- Update Bridge Maintenance Painting Manual
- 4 Year Field Evaluation (by MnDOT)
  - August 2019
- Bridge Maintenance Coatings APL

MnDOT's Approach to Improving Bridge Maintenance Painting Operations

QUESTIONS?

THANK YOU!