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Preliminary Assessment of Procedures for Coating Steel Components on Virginia Bridges

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16. Abstract:

The purpose of this study was to conduct a preliminary assessment of the Virginia Department of Transportation's (VDOT's) bridge coating practices to identify areas where process improvements and/or cost savings could be realized. The assessment included reviewing VDOT's coating procedures, coating performance, and costs associated with bridge coating work, including containment systems, surface preparation techniques, and coating systems. In addition, information on bridge coating products and programs from bridge coating industries and organizations was gathered.

The study found that the predominant methods VDOT uses to prepare and coat steel bridge components are adequate and are consistent with industry and compliance standards. These methods include dry abrasive blasting and the use of power tool cleaning for surface preparation; conventional full containment that achieves minimal emissions; and use of a three-coat zinc-based coating system. However, enacting changes in some of the preliminary work for a bridge coating project could improve VDOT's coating process and potentially reduce costs. These changes include providing additional guidance for coating treatment decisions and preventive maintenance; providing contractors more project scope details in the bid and contract documents; and requiring discussion of job-specific tasks in the preconstruction meeting.

Combining the data from Site Manager and the Pontis Structure Inventory appears to be an efficient means of evaluating expenditures and trends. Analyzing costs for recoating work (VDOT's most common coating method) can be expedited by using "bridge deck area" (a field in the Pontis Structure Inventory) rather than "steel tonnage" (which must be drawn from individual contracts).

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FINAL REPORT

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ABSTRACT

The purpose of this study was to conduct a preliminary assessment of the Virginia Department of Transportation's (VDOT's) bridge coating practices to identify areas where process improvements and/or cost savings could be realized. The assessment included reviewing VDOT's coating procedures, coating performance, and costs associated with bridge coating work, including containment systems, surface preparation techniques, and coating systems. In addition, information on bridge coating products and programs from bridge coating industries and organizations was gathered.

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INTRODUCTION

The environmental conditions at bridge sites can promote the corrosive attack of steel and greatly reduce the functional life of steel bridge components. Some atmospherically exposed steel in bridges is subjected to very mild environments, whereas other steel is exposed to very harsh environments and has a higher risk of corroding. The application of polymer coatings is one of the most common ways of mitigating corrosion of atmospherically exposed steel in structures. This corrosion mitigation technique provides additional service life to the steel, but periodic maintenance of the coatings is required given its exposure to the surrounding environment (Figure 1).

Bridge coating systems can be complex. The composition of coating liquids can differ depending on the type of solvent, resin, and pigment used. Further, bridge coating systems are typically composed of different layers, each serving a particular function. Therefore, care must be taken during the selection of the appropriate coating for a new structure. With existing structures, however, determining the best approach for maintaining the coating system and protecting the structural steel becomes even more complex. First, the condition of the existing coating must be evaluated, including factors such as coating type, percentage of coating failure on the structure, adherence of the existing coating (Figures 2 and 3), coating thickness, and coating age. It is also important to assess the condition of the steel substrate. Depending on when the structure was put into service, the steel may contain mill scale or have an existing profile.

Figure 1. Deterioration of Protective Coating Leading to Corrosion of Underlying Structural Steel

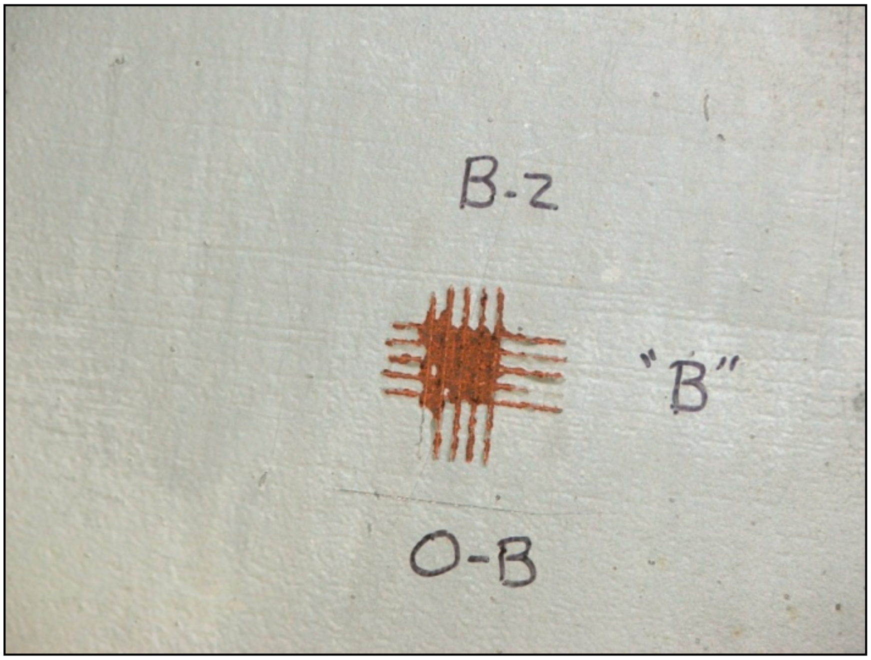

Figure 2. Illustration Showing Outcome of Adhesion Test

Figure 3. Photograph Showing Loss of Coating Adhesion on Exterior Beam

Based on the evaluation, a determination is made as to whether the structure should be spot coated (i.e., localized or isolated coating repair); zone coated (i.e., selective coating of a steel area that requires additional protection from corrosion); overcoated (i.e., application of a new coating over an existing coated surface); or recoated (i.e., removal of old coating and application of new coating). If any coating is to be removed, the proper means of preparing the surfaces and the type of surface preparation must be determined. When done correctly, the final result is a properly prepared surface that is ready to be coated (Figure 4).

Surface preparation techniques include dry abrasive blasting (i.e., blasting with dry media); wet abrasive blasting (i.e., blasting with water, which can contain abrasive media); and power tool cleaning (i.e., using mechanical tools). Further, coating work in the field requires that measures be taken to ensure environmental compliance through proper containment (of waste, emissions, and debris), waste storage, and disposal (Figure 5). Without an effective containment system, paint debris and emissions from surface preparation work can contaminate the surrounding air, soil, and water. This challenge is exacerbated when coatings on existing structures contain lead-pigmented coatings (generally bridges coated prior to 1984), which require additional environmental and worker safety compliance measures.

The Virginia Department of Transportation (VDOT) spends approximately $105 million per year on bridge maintenance statewide, with bridge coating maintenance accounting for approximately 10% of this annual cost (Milton, 2013). These costs are associated with mobilization, traffic control, environmental and worker protection, surface preparation, painting, and the disposal of waste. Most VDOT bridge coating maintenance projects include preparing steel surfaces or components by dry abrasive blasting to bare metal and coating the surface with a three-coat system that includes a zinc-rich primer. Given VDOT's annual expenditures for its bridge coating program, it would be beneficial to evaluate VDOT's bridge coating practices and to investigate whether alternative processes and products have the potential to improve the coating program and reduce costs. To do so, more information is needed on VDOT's current coating procedures (with regard to surface preparation, coating systems, and environmental compliance measures) and alternative technologies and processes not currently used by VDOT.

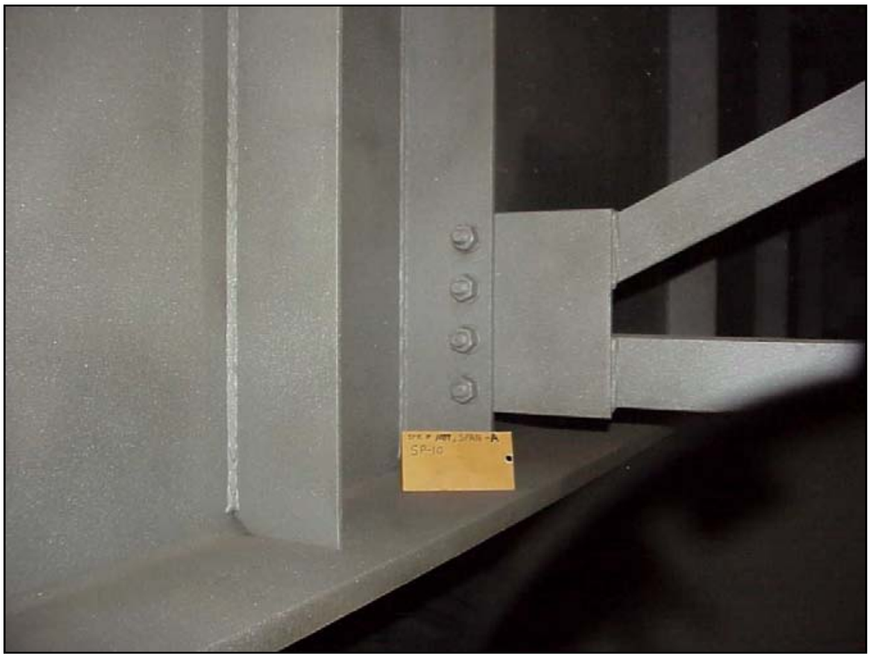

Figure 4. Properly Prepared Surface

Figure 5. Example Showing Considerable Size of Some Full Containment Systems

PURPOSE AND SCOPE

The purpose of this study was to conduct a preliminary assessment of VDOT's bridge coating practices and investigate whether alternative processes and products have the potential to improve the coating program and reduce costs. The objectives of the study were as follows:

1. Review VDOT's practices for bridge coatings including maintenance and environmental practices; coating performance; and costs associated with bridge coating work, including containment systems, surface preparation techniques, and coating systems.
2. Gather information on bridge coating products and programs from bridge coating industries and organizations.

The study included an internal review of current VDOT bridge coating practices, including inventories of VDOT bridge management databases and VDOT road and bridge specifications (VDOT, 2007). The study also included an external review of bridge coating practices currently used by industry and other state departments of transportation (DOTs).

METHODS

Seven tasks were conducted to achieve the study objectives.

1. Review VDOT's current maintenance practices for bridge coating projects.
2. Review VDOT's current environmental practices for bridge coating projects.
3. Review VDOT's bridge inventory records to assess the performance of existing zinc-based coating systems.
4. Conduct a preliminary review of costs associated with VDOT's bridge coating practices.
5. Obtain feedback regarding VDOT's bridge coating practices from painting contractors and consultant inspectors who often conduct VDOT bridge coating work.
6. Review the current activities of the National Cooperative Highway Research Program (NCHRP) and the American Association of State Highway and Transportation Officials (AASHTO) related to bridge coating.
7. Identify alternative bridge coating technologies and high-potential future research efforts, including those used by other state DOTs.

Review of VDOT's Current Maintenance Practices for Bridge Coating Projects

VDOT's *Road and Bridge Specifications* (Section 411) describes the requirements for protective coating applications on metal structures (VDOT, 2007). These requirements were reviewed and compared with current industry standards by the Society for Protective Coatings (SSPC) and the National Association of Corrosion Engineers International (NACE).

Field observations of VDOT bridge coating projects were made by some members of the research team over the course of conducting routine field work. This practice of identifying where and how improvements can be made by studying field work can provide insight that could otherwise be overlooked.

Review of VDOT's Current Environmental Practices for Bridge Coating Projects

In order to comply with federal and state environmental and health standards, VDOT has three primary requirements for surface preparation and coating operations: (1) containment of emissions and debris, (2) perimeter air monitoring, and (3) proper waste management. The project champion had a particular interest in containment, given its substantial cost. A primary focus of the study, therefore, was reviewing VDOT's containment specifications (VDOT, 2007); gathering information on the types of containment measures constructed for VDOT coating projects; and determining whether less costly containment methods could be used.

SSPC Technology Guide No. 6 (*Guide for Containing Surface Preparation Debris Generated During Paint Removal Operations)* (SSPC, 2012a) was reviewed for national environmental standards (particularly those associated with containment) for coating projects.

In addition to a review of VDOT containment and other environmental specifications (i.e., emissions control and waste management) (VDOT, 2007), environmental plans required for bridge coating projects were collected from VDOT's district environmental engineers and environmental specialists. These plans were reviewed to determine the method of containment constructed for surface preparation and coating operations.

Review of VDOT's Bridge Inventory Records to Assess Performance of VDOT's Existing Coating Systems

After an initial review of VDOT's bridge inventory records in the Pontis Structure Inventory database (hereinafter Pontis database) by the research team, work was contracted to the University of Virginia to determine changes in the coating condition of VDOT bridges over time. Inspection data in the Pontis database were searched to identify bridges that received a dry abrasive blast surface treatment followed by a coating with a zinc-based primer system. As described previously, these are the predominant maintenance methods currently used for VDOT bridges. The coating condition rating was evaluated over time to determine trends in coating degradation.

The bridges evaluated had steel beams/girders and concrete decks; were active and not posted (i.e., had no weight restrictions); and were maintained by VDOT. They were located throughout Virginia in all VDOT districts.

Four groups of bridges were investigated:

1. simply supported bridges built after 1983 (dataset contained 326 bridges)

2. continuous bridges built after 1983 (dataset contained 284 bridges)

3. simply supported bridges built before 1984 and repainted after 1984 (dataset contained 381 bridges)

4. continuous bridges built before 1984 and repainted after 1984 (dataset contained 82 bridges).

The bridges were divided into these groups to investigate possible differences in performance between structures that had been shop coated (Groups 1 and 2) and structures that had been field coated (Groups 3 and 4).

The dates selected for these groups reflected the fact that although zinc-rich prime coats were available beginning in the late 1970s, lead-pigmented alkyds were the standard coating used by VDOT until approximately 1984. Two VDOT special provisions released in 1984 (VDOT, 1984) required the use of zinc-based coating systems. It is important to note that coated steel structures built before 1978 may contain mill scale (the VDOT specifications were revised in 1978 [VDOT, 1978] to require shop blasting of steel prior to application of the primer coat); the residual mill scale may affect coating adhesion, which could also influence the data.

Preliminary Review of Costs Associated with VDOT Bridge Coating Projects

Cost allocations for tasks associated with bridge maintenance coating projects were evaluated. Cost information was gathered primarily from the Site Manager database. Structure data for the cost evaluation were obtained from the Pontis database. Data on steel tonnage, which were not included in the databases, were obtained from contracts for bridge coating work submitted to VDOT between 2005 and 2012. Database information was linked using district, county, structure, and contract order number designations. Although the Site Manager database contains contract item codes for numerous tasks related to structure maintenance, data in this study were limited to the following contract item codes relevant to bridge coating operations in Virginia:

- 68455: Prepare and Spot Coat Existing Structure
- 68470: Prepare and Overcoat Existing Structure
- 68472: Recoat Existing Structure
- 68474: Environmental Protection and Health and Safety
- 68476: Environmental and Worker Protection

- 68490: Disposal of Material
- 68492: Material Disposal.

During the process of evaluating cost information in the databases and contracts, it became apparent that there were specific means of improving the efficiency and accuracy of conducting cost assessments for bridge coating projects. These included determining whether a correlation exists between steel tonnage data, which are included in the contract documents, and other bridge attributes that are not available in the contract documents but are available in the bridge inventory database and therefore more readily accessible to VDOT.

Gathering of Feedback Regarding VDOT Bridge Coating Practices From Painting Contractors and Consultant Inspectors

A feedback form was sent to 14 painting contractors and 9 individuals with 4 consultant inspection firms. Contractors and consultant inspectors were chosen because of their first-hand involvement with bridge coating work. Recipients were limited to those who regularly performed coating work for VDOT. The feedback form was designed to provide contractors an opportunity to communicate observations, concerns, or suggestions about coating work for VDOT; the researchers planned to use the contractor responses to identify discussion topics for subsequent group meetings.

The Internet-based program SurveyMonkey was used to create and circulate the feedback form (provided in Appendix A). SurveyMonkey was chosen because it ensures the anonymity of respondents, a feature that may encourage candid responses. Individuals and firms were requested to respond within 6 weeks, and a reminder was sent 4 weeks after the feedback form was sent.

After receiving the results, VDOT invited the recipients to an in-person meeting with the VDOT coating research group, which was held January 23, 2013, at VDOT's Materials Division. A total of three individuals, all contractors from two painting contracting companies, were available to participate in the meeting. An email containing a series of topics and questions was sent to the contractors prior to the meeting and then discussed during the meeting. The email, provided in Appendix B, included topics related to surface preparation, coating options, and containment.

Review of Current Activities of NCHRP and AASHTO Related to Bridge Coating

NCHRP and AASHTO are conducting several efforts related to bridge coating standards and practices. A member of the research team monitored these efforts throughout the study period by attending relevant NCHRP and AASHTO meetings.

Identification of Alternative Bridge Coating Technologies and High-Potential Future Research Efforts

Several sources were used to obtain information on coating technologies with the potential to reduce VDOT bridge coating maintenance costs. In addition, three guest speakers were invited to speak to the research team and technical review panel for this study about relevant coating research or applications. This generated insightful discussions between the speakers and meeting attendees. The topics included nondestructive evaluation of coatings, software for coatings management, comparisons of different coating systems, and future research ideas.

Questions regarding alternative coating technologies were also included in the online feedback form (Appendix A) and in-person meeting with contractors (Appendix B) discussed previously.

Information was also gathered from other state transportation agencies to evaluate whether and how cost savings could be realized from adopting alternative containment measures and coating procedures. A request for information regarding cost-saving containment systems and bridge coating techniques with minimal waste generation was sent to the TRANLIB listserv via an email (provided in Appendix C). TRANLIB is an international email discussion forum with nearly 250 members (library and information professionals) that represent state and federal DOTs, academic institutions, and transportation associations. It was expected that the recipients would forward the message to the most appropriate professionals in their organization. Containment and other environmental compliance information was also gathered from the feedback from contractors and consultant inspectors.

RESULTS AND DISCUSSION

VDOT's Current Maintenance Practices for Bridge Coating Projects

As stated previously, VDOT's *Road and Bridge Specifications* (Section 411) describes the requirements for protective coating applications on metal structures (VDOT, 2007). Coatings are approved for use through the National Transportation Product Evaluation Program, and the specific approved coating systems are shown in lists maintained by VDOT's Materials Division (VDOT, 2013a). Certain guidance in Section 411 is similar to that provided by international organizations such as SSPC and the National Association of Corrosion Engineers International (NACE), as discussed further in the following sections.

As described previously, older VDOT structures (prior to 1984) were originally coated with lead-pigmented coatings, whereas since 1984, a zinc-rich primer has been used to coat new structures and to recoat existing structures. Therefore, for the past 29 years, new fabricated steel has received a zinc-rich prime coat applied in the shop. The intermediate and finish coats have been either an epoxy and urethane (respectively) or two coats of acrylic.

Surface Preparation

Surface preparation for protective coating work for metal in structures is described in Section 411.04 of VDOT's *Road and Bridge Specifications* (VDOT, 2007). This specification reflects the importance of coating adherance to the metal surface; coating cannot sufficiently adhere to surfaces with contaminants or an improper surface profile. Proper preparation of the metal surface is therefore a critical step in creating an adequate surface finish. SSPC and NACE (SSPC, 2012b) provide guidance on surface preparation and coating. Table 1 lists the standards relevant to VDOT's coating practices for surface finish and shows the range of surface preparation options.

Several techniques are available for preparing a steel surface for coating. For larger areas, traditional dry abrasive blasting is predominantly used. This method of surface preparation produces the greatest air emissions and therefore requires the most sophisticated (and costliest) form of containment. Wet abrasive blasting, which is not commonly used on VDOT bridges, produces fewer emissions, but there is a greater risk of embedding residual particles into the finished coating. This occurs when wet blast medium attaches to the containment curtains; when the medium dries on a moving curtain, it detaches from the surface and can embed in the wet coating (K. Timber, personal communication). Power tool cleaning and hand tool cleaning techniques are other options for surface preparation but are better suited for preparing smaller surface areas and as a preventive maintenance technique. Typically, surfaces are required to be prepared using Method 5 when blasting and Method 4 when using power tools (VDOT, 2007).

Table 1. List of SSPC and NACE Standards and VDOT Specifications for Surface Finish

Subject	SSPC/NACE Standard[a]	VDOT Specification[b]
Solvent cleaning	SSPC-SP 1	Method 1
Hand tool cleaning	SSPC-SP 2	Method 2
Power tool cleaning	SSPC-SP 3	Method 3
White metal blast cleaning	SSPC-SP 5 / NACE No. 1	N/A
Commercial blast cleaning	SSPC-SP 6 / NACE No. 3	N/A
Brush-off blast cleaning	SSPC-SP 7 / NACE No. 4	Method 6
Near-white blast cleaning	SSPC-SP 10 / NACE No. 2	Method 5
Tool cleaning to bare metal	SSPC-SP-11	Method 4
Industrial blast cleaning	SSPC-SP 14 / NACE No. 8	N/A
Commercial grade power tool cleaning	SSPC-SP 15	N/A
Low-pressure water cleaning	N/A	Method 7

SSPC = Society for Protective Coatings; NACE = National Association of Corrosion Engineers International; VDOT = Virginia Department of Transportation; N/A = not applicable.
[a] Society for Protective Coatings (2012b).
[b] Virginia Department of Transportation (2007).

Field Coating Options

VDOT specifications for protective coating work for metal in structures are provided in Section 411 of the *Road and Bridge Specifications* (VDOT, 2007). Requirements for coating existing and new structures are provided in Sections 411.05 and 411.06, respectively. As described previously, VDOT coating repair work generally falls into one of four categories: recoating, spot coating, zone coating, and overcoating.

Field Observations

As previously described, field observations were noted over the course of routine bridge maintenance work. An example of such an observation is depicted in Figure 6, whereby the two ends of a bridge have been coated and the center has not, demonstrating that bridges are not always coated in the same project and under one contract. This requires multiple project mobilization events (i.e., equipment setup and containment construction), which adds to project costs. Although conducting coating work in multiple stages is often justifiable because of the nature of the project, guidance for bridge coating maintenance decisions may reduce the frequency of this approach and thereby reduce costs.

Figure 6. Norris Bridge Showing Newly Applied Coatings on Deck Truss (ends of bridge, light color) With Existing Coatings on Through Truss (center of bridge, dark color)

VDOT's Current Environmental Practices for Bridge Coating Projects

Prior to surface preparation, containment systems are constructed to reduce potential environmental hazards by minimizing or eliminating emissions and containing waste material. To ensure that emissions from blasting operations are sufficiently contained, VDOT requires perimeter air monitoring with the use of high-volume air samplers equipped for the collection of total suspended particulate samples (VDOT, 2007).

SSPC Technology Guide No. 6 (SSPC, 2012a) classifies containment systems according to the degree to which the containment design controls emissions of dust and debris into the environment. Class 1 containment involves the use of more elaborate containment components and provides the greatest degree of emissions control. Class 4 containment provides the least control of emissions (Table 2).

Table 2. Description of SSPC Containment Classes and Requirements for Abrasive Blast Surface Preparation

Containment Class[a]	Level of Emissions Control	Requirements
1A	Highest	Air-impenetrable walls, ceilings, and floors, with rigid or flexible framing; fully sealed joints; airlock or resealable entryways; negative air pressure; exhaust air filtration
2A	High	Air-impenetrable walls, ceilings, and floors, with rigid or flexible framing; fully sealed joints; partially sealed entryways; negative air pressure; exhaust air filtration
3A	Moderate	Air-penetrable walls, ceilings, and floors, with rigid or flexible framing; partially sealed joints; partially sealed entryways; exhaust air filtration
4A	Minimal	Air-penetrable walls, ceilings, and floors, with flexible framing; open seams; open entryways; natural air flow

SSPC = Society for Protective Coatings.
[a] Class designations are in accordance with those specified in SPPC Technology Guide No. 6 (SSPC, 2012a). "A" designates dry abrasive blast surface preparation, the predominant surface preparation technique used for VDOT bridges.

VDOT's *Road and Bridge Specifications* (VDOT, 2007) do not require specific types of containment measures or a particular class of containment as categorized in SSPC Technology Guide No. 6 (SSPC, 2012a). Instead, the specifications are performance based; they specify the degree to which emissions are or are not permitted. When surface preparation entails the use of properly operated vacuum-assisted power tools, minimal visible emissions are allowed outside the containment system provided the equipment is properly functioning and a secondary means is employed to capture any large debris. "No visible emissions" are permitted outside the containment system for other surface preparation measures (VDOT, 2007). The specifications also require contractors conducting bridge coating work to comply with applicable state and federal regulations, including those of the U.S. Environmental Protection Agency, U.S. DOT, Virginia Department of Environmental Quality, and Virginia Department of Labor and Industry. Contractors must also submit a site-specific environmental protection plan for surface preparation operations, which must include the controls for capture, containment, collection, storage, and transportation of waste material generated by the work. The contractor must also use the "most effective method possible" for containment and must perform continuous visual inspections and perimeter air monitoring to detect emissions outside the containment system (VDOT, 2007).

Although VDOT specifications do not require a particular SSPC class of containment, contractors often refer to an SSPC containment class when describing their containment plans for VDOT bridge coating work. In a review of 16 environmental plans (VDOT Environmental Division, unpublished data) submitted by contractors for bridge coating projects in VDOT's Fredericksburg, Hampton Roads, and Salem districts, all indicated the use of Class 2A containment for the coating projects, which corresponds with a "high" level of emissions control (SSPC, 2012a).

Other states vary with regard to the manner in which they specify their containment requirements. Some state DOT specifications, including those of California, Illinois, New Jersey, and Washington State, specify containment according to SSPC containment classes; the containment requirement for these states is Class 1 or Class 2 (Kowalski, 2012; Najem, 2012;

Rogers, 2012; Wilson, 2012; K. Trimber, personal communication). Other states describe the containment efficiency (i.e., the containment should fully protect the environment [Appleman, 1992]) or establish different levels of containment depending on the environmental sensitivity of the area (Appleman, 1992; Vogel, 2012).

Regardless of the means in which containment requirements are specified among DOTs, the degree to which emissions and debris are controlled by the containment measure must comply with national environmental and worker safety standards, including hazardous waste standards codified in the Resource Conservation and Recovery Act of 1976 (40 CFR Parts 260-299), National Ambient Air Quality Standards (40 CFR Part 50), and Occupational Safety and Health Standards (29 CFR 1910.1025; 29 CFR 1926.62).

Performance of VDOT's Existing Coating Systems

The work performed by the University of Virginia to analyze the performance of zinc-based coating systems produced data that illustrate (1) the average condition state for coated open steel girders and stringers versus the age of the coating (Figure 7) and (2) the average superstructure general condition rating versus the age of the coating (Figure 8). This evaluation will be described in detail in an upcoming report from the Virginia Center for Transportation Innovation and Research (VCTIR) (Johnston and Chase, 2013).

Element level inspection focuses on the condition of individual components of a bridge. For example, Element 107 in Figure 7 designates open steel girders and stringers. Figure 7 illustrates the condition of Element 107 in terms of its level of corrosion, as described by its condition state. Condition states are a standardized national ranking that ranges on a scale of 1 (no evidence of corrosion) to 5 (advanced corrosion). Condition State 3, the intermediate state, indicates that rust is prevalent but there is no measured section loss from active corrosion.

General condition ratings (Figure 8) are used to describe the condition of the existing in-place bridge as compared to its original condition. The evaluation is based on the condition of the materials associated with the deck, superstructure, and substructure elements in a bridge. General condition ratings are intended to provide an overall characterization of the general condition of the entire component being rated. General condition ratings are standardized national rankings that range from 0 (a failed condition) to 9 (excellent condition).

The bridges represented in Figures 7 and 8 have an average coating age of 28 years. The average values are based on 6-year moving averages, which were used to smooth fluctuations and reveal long-term trends more clearly. Based on the data used to create Figure 7, the average condition state for Element 107 for bridges prepared and coated in the shop ranged from 1.2 to 1.4 and the average condition state for Element 107 for bridges prepared and coated in the field ranged from 1.7 to 1.9. Since Condition State 1 is defined as no active corrosion and Condition State 2 is defined as little or no active corrosion, these data indicate good performance of the coating systems.

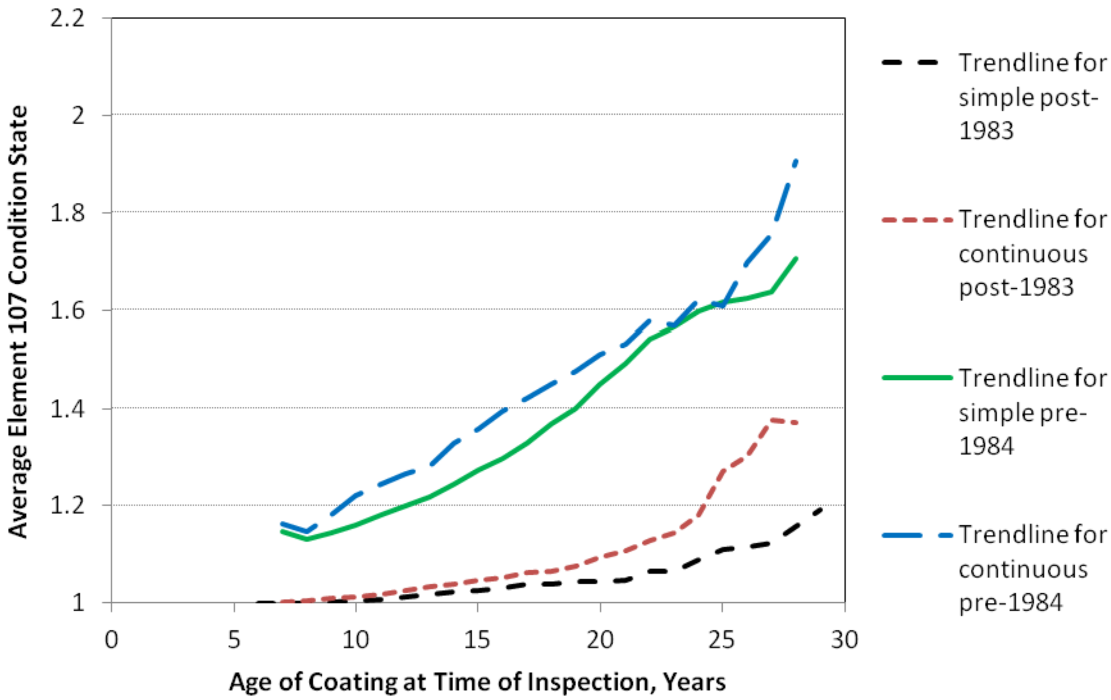

Figure 7. Trendline of Condition State Versus Age of Coating. Data are based on 6-year moving average (Johnston and Chase, 2013). Element 107 = open steel girders and stringers; simple post-1983 = simple spans coated after 1983; continuous post-1983 = continuous spans coated after 1983; simple pre-1984 = simple spans coated before 1984; continuous pre-1984 = continuous spans coated before 1984.

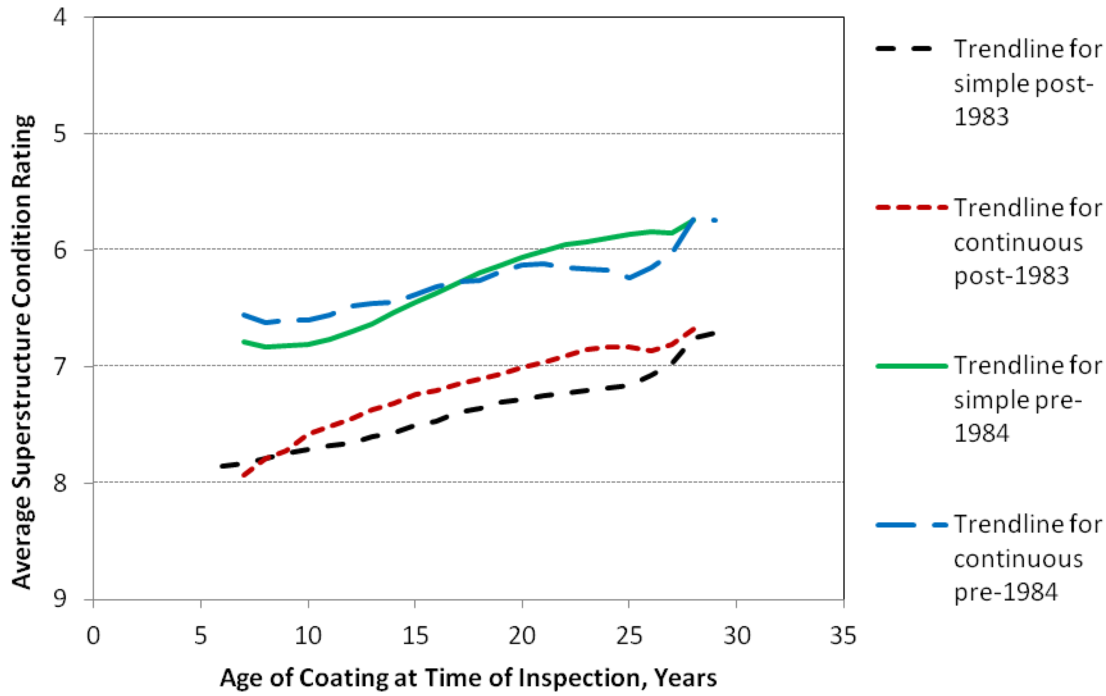

Figure 8. Trendline of General Condition Rating Versus Age of Coating. Data are based on 6-year moving average (Johnston and Chase, 2013). Simple post-1983 = simple spans coated after 1983; continuous post-1983 = continuous spans coated after 1983; simple pre-1984 = simple spans coated before 1984; continuous pre-1984 = continuous spans coated before 1984.

Based on the data used to create Figure 8, the average superstructure general condition rating for bridges prepared and coated in the shop was 7.2 and the average superstructure general condition rating for bridges prepared and coated in the field was 5.8. Since a general condition rating of 7 is defined as good condition and a general condition rating of 6 is defined as satisfactory condition, these data indicate good to satisfactory performance of the coating systems.

Finally, the evaluation indicated that the condition of the shop-coated bridges indicated superior performance over that of the field-coated bridges. The researchers believe that this can be attributed to the more controlled conditions available in a shop environment.

Costs Associated with VDOT's Bridge Coating Projects

A comparison of historical spot coating and recoating costs showed that the largest proportion of coating work is for recoating projects (Figure 9). A comparison of the breakdown in costs for spot coating and recoating (Table 3) indicated similarities regarding the allocation of costs (i.e., the coating operation itself was the largest contributor to the overall cost and disposal was relatively small, approximately 3% in both cases).

Evaluation of the overcoating cost showed different allocations, but it is important to note that this evaluation was based on only one contract.

The average costs to VDOT for spot coating, recoating, and overcoating are provided in Table 3. The average cost per ton for recoating was unexpectedly lower than for overcoating, but again, the overcoating value was based on one contract.

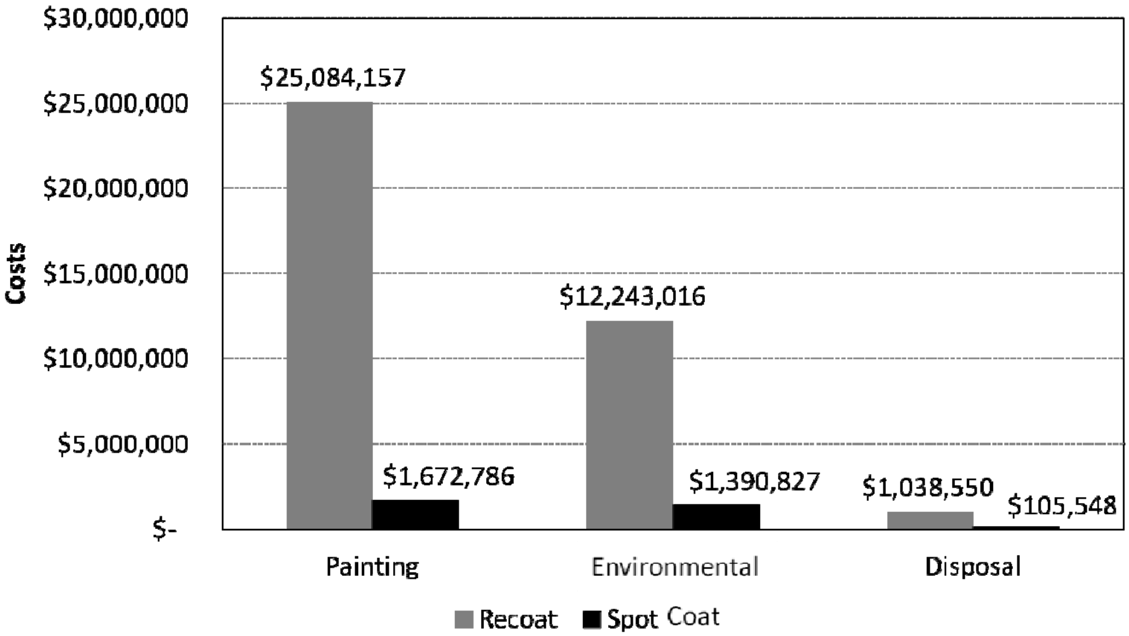

Figure 9. Costs for Recoating vs. Spot Coating (data based on 35 recoating contracts and 31 spot coating contracts in 2012 dataset)

Table 3. Total Coating Cost Breakdown for VDOT Projects Based on 2012 Dataset

Description	Costs (% of Total)			Average Price	No. Contracts Evaluated
	Painting	Environmental	Disposal		
Spot coat	53	44	3	$65/square foot	31 for spot cost costs; 15 for average price[a]
Recoat	65	32	3	$1,485/ton	35
Overcoat	27	73[b]		$2,186/ton	1

[a] Spot coat costs were based on 31 contracts and average price was based on 15 contracts, with the reduction in contracts evaluated being attributable to less data available than required for the average price calculation.
[b] Environmental and disposal costs are combined in the cost data.

Costs of recoating projects involving removal of lead-pigmented coatings were compared with those involving removal of zinc-rich (non-lead) coatings. Because few bridge recoating projects have been conducted on bridges with zinc-rich coatings, only one case study was available for comparison (Table 4). The single zinc-rich coating project was 27% lower in total cost as compared to the average total costs for the lead-pigmented coating systems. The costs associated with environmental work (i.e., containment and air monitoring) for the bridges with a lead-pigmented coating system represented 33% of the total project cost and for the bridge with a zinc-rich system represented 19% of the total project cost. The smaller cost difference between the lead-pigmented and zinc-rich coating system was attributed to waste disposal (3% vs. 1%, respectively). This example, although based on only one contract, suggested that VDOT costs may be reduced as coating projects increasingly involve zinc-rich coating removal.

The Site Manager database was used to evaluate the costs of bridge coating projects. The Pontis database was used to obtain physical attributes (i.e., bridge deck measurements) that are not included in the Site Manager database in order to associate bridge coating costs and their physical attributes. During this process, the fact that particular data elements are not included in the Site Manager database made it difficult to evaluate certain bridge coating costs. First, tonnage or square foot data for painting projects are not included. These data are important for evaluating relationships between costs and bridge size and for assessing any changes over time. Although the steel tonnage data can be manually entered into the database for cost analysis, this information must first be extracted from the contracts or bridge plans. This process is labor-intensive, as it typically requires human interaction to extract the correct information and manually enter it in the database. Once the tonnage data are entered into the database, they can be converted into an estimated value of the surface area to be painted. To determine whether a more efficient analysis of coating costs is possible, bridge deck area (which is included in the Pontis database) was evaluated to determine whether it would serve as an accurate replacement for using steel tonnage or steel surface area to evaluate costs. This was based on the researchers' assumption that a relationship should exist between deck surface area and the amount of structural steel supporting the deck.

Table 4. Comparison of Recoating Costs: Existing Zinc-Rich vs. Lead-Pigmented Systems

Task	Zinc-Rich Percentage of Total (n = 1)	Lead-Pigmented Percentage of Total (n = 34)
Disposal	1	3
Environmental	19	33
Recoating with zinc-rich coatings	80	64
Total	100	100

This approach was evaluated for bridge recoating projects. The correlation between pricing and deck area (R^2 = 0.70) for recoating operations was similar to the correlation between pricing and steel tonnage (R^2 = 0.77; Figure 10). This indicates that the use of deck area rather than steel tonnage may be a viable means of evaluating recoating costs, thereby expediting this type of cost analysis.

It was also apparent during these cost evaluations that data in the Pontis and Site Manager databases would be easier to merge if federal structure numbers were associated with each row of data in the Site Manager database. Because there are currently no federal structure numbers included in this database, additional steps must be taken to associate a structure with its maintenance costs. Requiring the Site Manager software to include a field for structure number (that uniquely identifies each bridge) would allow easier merging of data in the two databases and enable a more efficient means of conducting maintenance cost assessments of DOT assets.

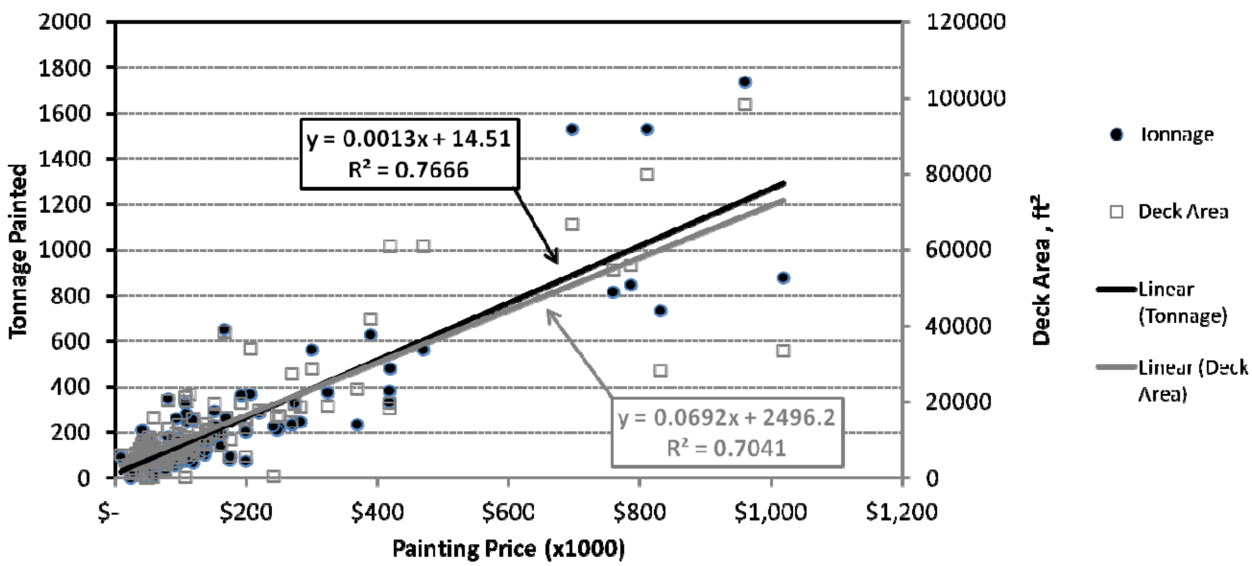

Figure 10. Relationships Between Price and (1) Tonnage Painted and (2) Deck Area

Feedback on VDOT Bridge Coating Practices From Painting Contractors and Consultant Inspectors

Results from Feedback Form

Five contractors or consultant inspectors provided anonymous feedback from the online feedback form (Appendix A). The responses are provided in Appendix D. A summary of key responses, organized by topic, is as follows:

- *Preliminary project work.* Clearer guidance and training are needed, particularly for containment, air monitoring, and waste management.

- *Surface preparation*

  — Dry abrasive blasting is the most common method of surface preparation.
  — Innovative alternatives are not currently available.

- *Coating.* Timing of coating maintenance is important; therefore, VDOT should be more proactive with coating maintenance rather than wait until a structure requires complete recoating.

  — For bridges with a small number of beams (i.e., five or fewer), zone coating is not cost-efficient, given that the equipment and project setup are the same regardless of the number of beams. A full recoat is recommended in these scenarios.

  — The three-coat zinc-based system used by VDOT performs well, conforms to industry standards, and is the most commonly used coating system.

  — States are becoming more interested in metalizing (i.e., applying metallic coating to a steel structure) followed by a seal coat and finish. This method is expected to be more common in the future as a good long-term coating alternative.

  — Overcoating should be considered for bridges with zinc-based primers.

Responses at Follow-Up Meeting

As discussed previously, a follow-up group discussion with three painting contractors was held after VDOT received feedback on the online feedback forms to foster a better understanding of the contractors' perspectives. This discussion provided additional insight regarding potential areas of improvement in VDOT's bridge coating practices. The questions emailed to the contractors prior to the meeting (Appendix B) were read aloud and discussed during an in-person meeting with painting contractors. Appendix E provides the responses and discussion points and the possible outcome if VDOT were to implement the contractors' suggestions. Selected responses, organized by topic and determined by the research group as the most relevant to the objectives of this study, are provided here.

- *Preliminary project work*

  — VDOT should provide guidance for determining when preventive maintenance (i.e., spot cleaning) is necessary and how to determine the most appropriate treatment for existing bridges (i.e., recoating, overcoating, spot/zone coating) in Chapter 32 of the *Manual of the Structure and Bridge Division* (VDOT, 2013b).

  — VDOT should improve the project scoping process by providing more project details before the projects are bid. This includes determining the feasibility of recycling equipment placement (i.e., whether large jobs would qualify for expendable abrasive approvals; waste storage limitations; identification of traffic controls; and identification of all zones to be recoated to allow the contractor to predetermine the extent of containment).

— VDOT should provide more structure details (i.e., square footage of steel, areas requiring coating) in the contract documents and specific plans for equipment placement and waste storage on-site and off-site.

— VDOT should include critical discussion points and job-specific tasks regarding coating work in the preconstruction meeting.

- *Containment of structures.* The use of less costly containment measures than what is currently used (i.e., SSPC Class 2A) would not comply with federal and state environmental requirements and worker safety and health standards.

- *Waste management.* Further study is needed on having the consultant inspectors rather than the contractor manage the wastes. This might increase the efficiency of the waste disposal process.

- *Additional suggestions*

— Further study is needed on paying the consultant inspectors on a lump sum basis rather than hourly, which might reduce costs for VDOT.

— Further study is needed on whether the paint manufacturers should be asked to provide an opinion regarding the optimal surface preparation method for their coating.

— Further study is needed on whether the paint manufacturers should be asked to require extended warranties.

— VDOT should remove the current VDOT option for a certified industrial hygienist to certify the environmental plan. Such personnel are not used by contractors.

As reflected in these contractor comments, many of the suggestions were associated with the preliminary work for bridge coating projects. This included providing VDOT guidance for preventive maintenance and coating treatment decisions; providing contractors more project scope details in the bid and contract documents; and discussing job-specific tasks in the preconstruction meeting. Contractors suggested that implementing these measures would provide them with a more efficient bidding and coating process and reduce costs to VDOT.

Current Activities of NCHRP and AASHTO Related to Bridge Coatings

Current NCHRP and AASHTO activities related to bridge coatings include the following:

- NCHRP Project 14-30: Extending the Life of Highway Bridge Coating Systems Through the Use of Spot Painting with Minimal Surface Preparation
- work by the T-9 AASHTO Technical Committee for Bridge Preservation
- work by the Southeast Bridge Preservation Partnership's Paint Working Group in AASHTO's Transportation System Preservation Technical Services Program
- work by the Bridges Technical Working Group of AASHTO's Subcommittee on Maintenance.

NCHRP Project 14-30: Extending the Life of Highway Bridge Coating Systems Through the Use of Spot Painting with Minimal Surface Preparation

The objective of NCHRP Project 14-30 is to develop guidelines for the selection and use of a broad spectrum of protective materials for spot treatment of failed coatings on steel highway bridges. Materials and application guidelines should be suitable for implementation as an effective maintenance program by state DOTs. Proposals have been received in response to the request for proposals, and the selected contractor will have 30 months to conduct the project (Transportation Research Board, 2013).

T-9 AASHTO Technical Committee for Bridge Preservation

The T-9 AASHTO Technical Committee for Bridge Preservation has several objectives: to document lessons learned with regard to failing paint systems; to discuss key components of specifications and hold an SSPC coating specification course; to create training requirements and roles and responsibilities for coating project team members; and to monitor research on surface preparation techniques.

Southeast Bridge Preservation Partnership's Paint Working Group in AASHTO's Transportation System Preservation Technical Services Program

The objective of the Southeast Bridge Preservation Partnership's Paint Working Group is to develop a guidance document and life-cycle cost tool to provide practitioners in the southeastern states a reliable way to determine best practices for evaluating, planning and executing a steel bridge maintenance painting project. It also includes guidance for selecting an appropriate coating method (AASHTO, 2013).

Bridges Technical Working Group of AASHTO's Subcommittee on Maintenance

The Bridges Technical Working Group of AASHTO's Subcommittee on Maintenance recently submitted a research needs statement for the development of a method for identifying the location and distribution of chlorides on steel surfaces. The research should also investigate effective chloride remediation methods

Alternative Bridge Coating Technologies and High-Potential Future Research Efforts

Technologies Presented by Guest Speakers

Seung-Kung Lee, a corrosion expert formerly with the Federal Highway Administration, spoke to the research group about his research comparing coating systems (Yao et al., 2011). The work compared several one-coat systems and two control coating systems (i.e., a three-coat system and a two-coat system). The three-coat system demonstrated the best performance, followed by a high-ratio calcium sulfonate alkyd coating.

Steven B. Chase, a research professor of civil engineering at the University of Virginia, spoke to the research group about an infrared-based coating assessment tool. This tool can be used to provide a nondestructive condition assessment of a bridge coating (unpublished data).

Kenneth A. Trimber, president of KTA-Tator, Inc., a coating and corrosion consulting firm, spoke to the research group about KTA-Tator's Coating Assessment and Painting Priority (CAPP) system. The CAPP system is a coating maintenance assessment and strategy program that evolved out of a need for a more consistent method for assessing coating systems. The program uses coating life-cycle curves to aid in making coating maintenance decisions. A recent publication discussed the application of CAPP to power industry assets (SanJuan and Wissmar, 2013). Trimber indicated that CAPP can also be applied to bridges and allows for coating maintenance comparisons between bridges.

Workshop Presentation

At the 46th Mid-Atlantic Quality Assurance Workshop, held in Williamsburg, Virginia, February 5-7, 2013, Joseph A. Bracken, an engineer at the Pennsylvania Department of Transportation, made a presentation entitled "Galvanizing Versus Metalizing of Structural Steel" (unpublished data). Bracken stated that the thickness of the coating desired was 15 mils but that the DOT is willing to accept a coating thickness up to 25 mils to ensure the metalized surface is sealed. He also recommended the use of a top protective coat over the metalized surface, with additional masking of selected regions to maximize the functional life of the coating. He cautioned that edges can be an issue, especially if flame-cut (because of the hardening effects), so it is important to obtain an SSPS-SP 5 finish (near white blast, Table 1) after the surface is prepared for metalizing. The estimated cost for metalizing was $\$6/ft^2$ and for a top coating was $\$2/ft^2$, for a total cost of $\$8/ft^2$.

Information Provided Via TRANLIB Listserv Request for Information

In addition to soliciting information on containment practices, the TRANLIB listserv requested information (Appendix C) regarding surface preparation techniques that minimize or treat waste. Eight responses were received from eight DOTs. One of the state respondents discussed the use of Blastox by the state DOT. This product is an abrasive blast additive used to stabilize lead paint during sand blasting applications and render it nonhazardous. The respondent stated that the use of Blastox may reduce costs for lead testing and hazardous waste disposal.

The disposal cost difference between hazardous and non-hazardous waste is relatively small in Virginia (Appendix E). In addition, as reflected in Table 3, waste disposal represents only 3% of project costs. Requiring contractors to use this product is therefore not expected to achieve significant cost savings.

Discussions Among Research Team and Technical Review Panel Members

Several ideas concerning bridge coating practices were generated from discussions among the research team and members of the technical review panel. The ideas that show great promise and should be considered as research efforts in the future include the following:

- Determine the difference in coating quality when certified inspectors are routinely present on-site during the coating operation versus when they are rarely on-site during the coating operation.

- Investigate the available concrete coatings materials, and determine their relative performance.

- Develop a side-by-side pilot project where superstructure and substructure elements are protected with various candidate materials. This project should be conducted on a structure with actively leaking joints.

CONCLUSIONS

- *The predominant methods VDOT uses to prepare and coat steel bridge components are adequate and are consistent with industry and compliance standards. These methods include the following:*

  — *Dry abrasive blasting and the use of power tool cleaning for surface preparation.* The latter is particularly good for cleaning small areas and for preventive maintenance. Wet abrasive blasting, which is not currently used by VDOT, presents an increased risk of contaminants adhering to the new coating surface (when dried contaminants detach from containment curtains and are carried by the wind).

  — *Conventional full containment that achieves minimal emissions.* Because the use of less costly containment measures can result in emissions and waste that would violate federal and state environmental and worker safety and health standards, VDOT cannot incur significant cost savings with regard to containment. VDOT's current specifications are achieving the intended result of maintaining compliance with environmental and worker health regulations.

  — *A three-coat zinc-based coating system.* This system performs well and conforms to industry standards.

  Revisions to specifications with regard to these measures are currently not required

- *Enacting changes in some of the preliminary work for a bridge coating project can improve VDOT's coating process and potentially reduce costs*. These changes include the following:

  — *providing additional guidance for coating treatment decisions and preventive maintenance*

  — *providing contractors more project scope details in the bid and contract documents*

  — *requiring discussion of job-specific tasks in the preconstruction meeting.*

- *Combining the data from the Site Manager and Pontis databases appears to be an efficient means of evaluating expenditures and trends.* Analyzing costs for recoating work (VDOT's most common coating method) can be expedited by using "bridge deck area" (a field in the Pontis database) rather than "steel tonnage" (which must be drawn from individual contracts).

RECOMMENDATIONS

1. *VDOT's Structure and Bridge Division should pursue the following:*

   - *Modify bid documents to provide more project scope details, such as specific areas requiring coating (for zone coating projects), surface area of steel to be coated, lane closure restrictions, and plans for equipment placement and waste storage on-site and off-site*.

   - *Conduct a pilot project applying the CAPP system to a select group of VDOT bridges to facilitate the development of a bridge coating maintenance strategy.*

   - *Develop guidance for the maintenance of bridge coatings.* The information provided should allow engineers to make timely and cost-effective decisions with respect to coating treatments. These guidelines should be based on actual performance data and the results of the pilot study referenced in Recommendation 3. The guidance should provide recommended schedules for coating maintenance and should consider variables such as climate, environment, and potential exposure to contaminants. Guidance for bridge coating maintenance should be included in Chapter 32 of the *Manual of the Structure and Bridge Division* (VDOT, 2013b).

   - *Address coatings in the vicinity of deck joints.* VDOT is emphasizing the elimination of bridge deck joints, but in many cases it is not economically feasible to do so. In these cases, a strategy is required in order to protect superstructure and substructure elements that will be exposed to moisture and road salts. In order to provide a coherent and useful policy for these conditions, VDOT's Structure and Bridge Division in conjunction with VCTIR should develop a pilot project to evaluate the feasibility and cost of metallizing structural steel.

- *Validate the infrared-based coating assessment tool described by Chase (personal communication) by providing access to a bridge structure and determining its success.*

2. *For future VDOT bridge coating cost assessments, VDOT's Structure and Bridge Division should consider the following*:

    - *Add the federal structure number to the Site Manager database to allow easier merging with the Pontis database.*

    - *Use deck surface area instead of steel tonnage for evaluating recoating costs.*

3. *VDOT's Structure and Bridge Division should coordinate with VDOT's Materials Division and Construction Division to create a checklist of job-specific tasks to be discussed at the bridge coating project preconstruction meeting or pre-activity meeting for bridge coating.* The checklist should address items to be inspected, material to be tested, level of workmanship, results expected, and actions taken if results are not acceptable.

4. *In an effort to improve the efficiency and oversight of waste management activities for bridge coating projects, VDOT's Environmental Division and Structure and Bridge Division should investigate whether the consultant inspectors rather than the contractors should oversee waste management.* The South Carolina DOT, Wisconsin DOT, and VDOT district hazardous materials staff should be consulted to discuss their experience with this method.

ACKNOWLEDGMENTS

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APPENDIX A

ONLINE FEEDBACK FORM FOR CONTRACTORS AND CONSULTANT INSPECTORS

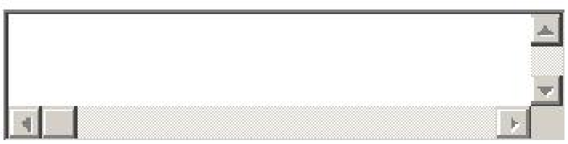
VDOT bridge coating survey

The Virginia Department of Transportation is seeking your input as part of an overall review of our bridge maintenance painting program. Specifically, we would like for you to share your preferences, experiences and suggestions on various coating topics. Please provide comments on each topic in the space provided. We hope that this survey will inform us and direct our painting program toward implementation of the best available methods and technologies.

All responses will remain anonymous. If you prefer to have someone from the Department contact you personally, please provide your telephone number in a reply to the email in which you received the link to this survey.

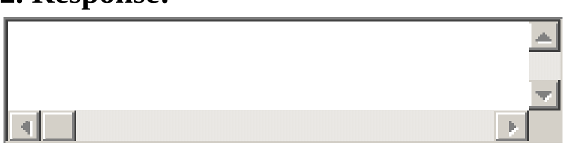
1) Scope of Work
• Recoating
• Over coating
• Zone and Spot Coating

1. Response:



2) Containment of Structures
• Conventional full containment structures for dry abrasive blasting
• Containment for waterjetting
• Containment for chemical stripping
• Levels of Containment
• Perimeter Air Monitoring
• Waste Management
• Other innovative containment systems

2. Response:



3) Surface Preparation
• Dry abrasive blasting
• Waterjetting with or without abrasives
• Power tool cleaning
• Vacuum shrouded power tool cleaning

• Chemical Stripping
• Other innovative surface preparation methods

3. Response:

4) Coating Systems
• Conventional three coat zinc primer based systems
• Single coat inorganic zinc systems
• Conversion coatings
• Systems for beam end painting that require minimal surface preparation
• Other innovative coating systems

4. Response:

Thank you for taking the time complete this survey.

If you would be willing to participate in a listening session that we would provide, please let us know in the following response box.

Please add any additional thoughts in the space below.

5. Additional thoughts...

APPENDIX B

EMAIL SENT TO CONTRACTORS PRIOR TO THE SMALL GROUP DISCUSSION

The Virginia Department of Transportation (VDOT) appreciates your recent response to our survey and would like to invite you to attend a forum on bridge coating to be held in Richmond.

In June of 2012 VDOT issued a survey to solicit industry expertise on the subject of bridge painting. The intention of the survey was to receive input from contractors and consultants in assessing whether the best methods and practices are being utilized by the Department when maintaining coated structures.

After reviewing the survey responses, VDOT decided to conduct a forum on the subject to allow a free exchange of information. We would like to invite you, along with a select group of other painting contractor to participate in our forum, where we will discuss whether we are utilizing the best available methods and practices. Please find below a series of categories, comments and questions for discussion.

Scope of Work

Comment: Over-coating is a good option as long as the bridge is assessed well in advance and there is limited surface prep.

When considering over-coating, what is considered limited surface preparation of over-all square footage? Obviously, less preparation is better but what is the point at which time and labor costs becomes no longer cost effective in preparing surfaces?

SSPC TU-3 states that once 15 to 20% of a leaded (Type B) structure's coating is in need of preparation, total removal is the most viable option.

When considering a non-lead (Type A) structure, is 15 to 20% of the structure's surface area needing preparation an accurate limit from a labor cost standpoint, when considering over-coating versus total recoating?

Comment: The Department should re-coat small structures and zone coat large structures providing there is substantial square footage.

What is the square footage needed for zone coating large structures to be comparable to re-coat cost per foot?

Is zone coating underutilized?

Containment of Structures

Do you follow SSPC Guide 6 in containing structures? If so, which class do you typically use (1A,2A, etc)?

Do you vary the type or Class of containment you use based on the job, particularly with regard to whether the bridge has lead paint, or do you generally use the same containment for each project (because of familiarity with that method, satisfaction with its performance, etc)?

Are containment requirements too restrictive and potentially adding unnecessary expense?

Are there alternative containment options that you would like VDOT to consider allowing in lieu of the current requirements.

Are there other environmental/waste management procedures that could be utilized to reduce the scale and still provide adequate environmental protection and waste management?

Do you have experience with or have you considered evaluating wet abrasive blasting and if so, do you see this as a viable alternative to dry abrasive blasting?

Do you think more guidance is needed from VDOT regarding Perimeter Monitoring or do you feel when it is required it is appropriate?

Are there issues meeting the waste storage and disposal requirements in the spec? If so, please provide reasons and comments for possible improvement.

Surface Preparation

Would you consider water induced (Wet Abrasive Blasting) with expendable abrasives if containment requirements are less restrictive and labor hours were reduced?

What are your thoughts regarding cost comparisons of using recycled versus expendable abrasives?

What savings could be attained if the Department specified SP-6 surface preparation as opposed to SP-10 preparation?

Coating Systems

In your estimate what savings could be attained if the Department offered more two coat painting systems for use?

Do you have experience with field metalizing structural steel?

What are your recommendations regarding coating systems that can be applied over surfaces prepared to SP-3 for spot and zone coating?

APPENDIX C

EMAIL REQUEST FOR INFORMATION SENT TO TRANLIB MEMBERS

From: Winter, Kenneth A. (VDOT) [mailto:Ken.Winter@VDOT.Virginia.gov]
Sent: Tuesday, November 06, 2012 5:20 AM
To: TRANLIB
Cc: Winter, Kenneth A. (VDOT)
Subject: [tranlib] VDOT Research Seeks Consultations: Steel Bridge Containment Costs

Dear TRANLIB-

I work with a research team investigating bridge coatings/containment issues at VDOT.

They have asked me to forward to the following to TRANLIB in the hopes that TRANLIB members could forward this to the appropriate colleagues at your organizations. Here's what they asked me to post. We would be most grateful if you could forward this message on to the appropriate counterparts at your organizations for direct response back to them:

> We are evaluating VDOT's procedures for coating steel bridge components in an effort to find ways to increase efficiency and reduce costs. Containment procedures are a significant portion of these costs, perhaps in part because our specifications require complete containment of any emissions and total capture of waste.
>
> We have come across an example of a state DOT that coordinated with their environmental regulatory agency to classify bridges regarding the environmental sensitivity of the area, and then base the containment requirements on that classification. The containment requirements for non-sensitive areas can therefore be less strict (and less costly) than sensitive areas.
>
> We are also investigating whether certain coating systems and surface preparation techniques minimize or treat the waste that is generated, thereby requiring less costly containment and disposal measures.
>
> Our question is whether you (1) know of or have been involved in creating a process that classifies containment measures based on environmental sensitivity (such as the use of SSPC TECHNOLOGY GUIDE NO. 6 - Guide for Containing Surface Preparation Debris Generated During Paint Removal Operations) or (2) know of coating systems or surface preparation techniques that minimizes or treats waste such that the containment and disposal requirements are less costly?

If the answer is yes, can you provide us with any documentation (published or internal research or case studies) you might have to help us learn from your experience?

Responses can be directed to:

Bridget M. Donaldson
Senior Research Scientist
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Thank you!

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APPENDIX D: ONLINE FEEDBACK RESPONSES FROM PAINTING CONTRACTORS AND CONSULTANT INSPECTORS (N = 5)

1) Scope of Coating Work
• Recoating
• Over coating
• Zone and Spot Coating

Responses:

- The states appear to be getting away from overcoating. Since a containment is required for spot blast cleaning anyway, they decide that it makes sense to go ahead and remove all of the coating. This way they don't have to deal with lead in the future or assume the risk of disbonding of the old coating. They will do some zone painting of expansions, though. This is typically the expansions and 5 or 10 feet out in both directions.

- Recoating is being performed after total failure resulting in damage to structural steel. Often steel repairs are required. Over coating is being performed by un trained personnel with no oversite. Coating often fails as some as applied. Zone and Spot Coating is under utilized.

- I have not seen appreciable cost savings using the last 2 over recoating due the labor involved.

- Would like to have an optional alternative paint system with a Zinc Primer, Acrylic Intermediate and Acrylic Topcoat like that of NCDOT. The Acrylic intermediate and topcoat are a dry fall paint and can be painted without containment and on some structures this can be advantageous and expedite certain projects, especially rapid deployment overpass bridges. Over coating is a good option as long as the existing bridge is assessed well in advance to determine that the structure only has limited need for surface preparation. This option minimizes lead waste generation, decreases recoating costs and extends the coating life an additional 10-15 years. However if the bridge is in pretty bad shape the time necessary to prepare the surface adequately where the contractor feels comfortable painting over the existing coating can be prohibitive and a deterrant. Zone and Spot coating: IF there is substantial squarefootage on the structure in the beams, (16 or more beams) we see this as a viable option. But when we see zone coating projects for bridges with only 4 or 5 beams it just doesn't really make sense to us as contractors. With all the same equipment and similar setup as though it was a full recoat it seems as though the additional cost to make a zone coat and spot coat project with 4-12 beams into a full recoat would be advantageous to the department and the marginal cost increase would be greatly diminished.

- I think the administration does a good job identifying areas on drawings and does not leave it up for interpretation

2) Containment of Structures
• Conventional full containment structures for dry abrasive blasting
• Containment for waterjetting
• Containment for chemical stripping
• Levels of Containment
• Perimeter Air Monitoring
• Waste Management
• Other innovative containment systems

Responses:

- Containments for abrasive blast cleaning have become commonplace and most bridge contractors are now comfortable with it. With the exception of firms that specialize in waterjetting, contractors are typically not familiar with this type of removal/containment method. Containment for wet abrasive blast cleaning is similar to dry blasting, but contractors seem to struggle with getting all of the corners properly blast cleaned. The damp abrasive packs into corners preventing cleaning, so it takes time to properly prepare those areas. The other problem is that the damp abrasive/dust sticks to the tarps. When it dries, the wind flexes the containment causing it to become airborne, landing on the steel/wet paint. We see little chemical striping on bridges, execept for localized lead removal, so the containment isn't a problem, but if you're going to paint the surface, you have to follow it with mechanical cleaning to remove rust and mill scale and to create a surface profile. This puts you into vacuum-shrouded tools, or a containment if you open blast (in which case, you've negated the benefit of using the stripper). We still see the use of high volume ambient air monitoring, with the locations selected in accordance with SSPC-TU7. This is to determine if the public is exposed, and is a good idea. Typically the TSP monitors are used, rather than PM-10. We see little use of the personal pumps around containment to establish the regulated area. It is established more from experience. The exception is when there's a sidewalk in the area. Occassionally we'll see area pumps with the personal cassettes in these cases. The lead waste is handled as hazardous, or the states allow the use of abrasive that is preblended with an additive (e.g., Blastox). Need to make sure the state accepts the use of an additive. Note that you still want to put the waste in an industrial landfill (not domestic), but again, confirm with the state.

- Conventional full is adaquite, havent seen waterjetting, chemical stripping. Levels of containment dont exist due to lack of training. Air monitoring is not always done due to lack of training. Waste Management needs to be given clear direction. Waste often sits on side of roadway for months after project is done. Unless a full blown containment is done for abrasive blast containment is a issue due to lack of training.

- Method 1 says salt shall be removed "in accordance with the requirements of SSPC-SP-1, but salt is not specifically addressed in that standard. Moreover, contractors have stated in the past that since SP 1 allows for many methods of solvent cleaning that they can use hand wiping with solvent (water) and rags in lieu of pressure washing (and collecting water). This will not remove embedded salts that will likely contribute to early coating failure. Salt testing is the only reliable way to determine the presence of soluble salts, and the specification should include this.

- Class Ia or IIa containment is easly achievable on most structures. No issue with Waste management or perimeter air monitoring. Not a big fan of chemical stripping.

- Air monitoring is very veg. It varies from job to job and who you have as your onsite inspector. VDOT needs to be specific as to what it wants that way every bidder is at a equal playing field.

3) Surface Preparation
• Dry abrasive blasting
• Waterjetting with or without abrasives
• Power tool cleaning
• Vacuum shrouded power tool cleaning
• Chemical Stripping
• Other innovative surface preparation methods

Responses:

- By far and away, dry abrasive blast cleaning is the most common method of cleaning. You see both expendable abrasives or recyclable. Both do a good job of preparation. We see little water jetting on bridges, and limited use of wet abrasive blast cleaning. Vacuum shrouded power tool cleaning is very common for touch up (damage, containment connection points, etc.) on on occassion for zone painting, but that's rare. It's very labor intensive. Chemical stripping is typically confined to the cleaning of lead paint from localized areas before cutting, but not for wholesale paint removal. There really isn't a lot of inovative methods (e.g., lasers) used for bridges right now.

- Surface prep is a issue when untrained personnel is writting the contracts and do not understand required surface prep needed.

- Blast profile requirements need to be revisited. The current 1-3 mil requirement is seldom achieved, and is most often extended to 4 mils. The contractors need to demonstrate their ability to provide profiles as specified, perhaps including a requirement of a written plan detailing how blast profiles will be managed. In addition, the requirement might be expanded to include manufacturer's recommendations. This problem is ongoing, and involves a lot of time and discussion on every project. There should be concrete discussions at every pre-construction meeting with this regard.

- Looking into abrasive blasting with expendable media such as coal slag with a water collar ring to reduct emissions in lieu of full containment as an option on a case by case basis.

- no comment

4) Coating Systems
• Conventional three coat zinc primer based systems
• Single coat inorganic zinc systems
• Conversion coatings
• Systems for beam end painting that require minimal surface preparation
• Other innovative coating systems

Responses:

- The most common system remains zinc/epoxy/urethane. Some users substitute polysiloxane as the finish on occassion. We don't see much in the way of single coat zinc or "conversion" coatings. Best bet is to search the AASHTO NTPEP site for a listing of all of the systems tested and the results. KTA is the testing lab for the AASHTO coatings program and the most commonly submitted systems are zinc/epoxy/urethane, which is consistent with our field work showing it to be the primary bridge system. We're seeing more interest in metallizing, typically 85/15, with a seal coat and finish. I expect to see more use of it in the future as a good long term coating alternative. For minimal surf prep, the most common systems involve the use of epoxy mastic.

- Coating systems in VA are good by industry standards and new coatings are incouraged to be presented to Elko for review.

- No comment.

- Look at an option for a Zinc/acrylic/acrylic 3 coat system similar to NCDOT*

- We like using the 2 coat system and would wish there were more options. The only system that is approved is SW and we understand Carboline and International have a two coat system that allows a longer re-coat window. Could VDOT explore that?

Additional Thoughts

- If you have additional questions, feel free to contact me: Ken Trimber KTA-Tator, Inc. 412-788-1300, x204 ktrimber@kta.com

- Specifications need to be reviewed and updated with industry, VDOT materials, Bridge, and Environmental personnel involved.

- Significant coating failures have been found in some states that were caused by soluble salts found between coats that was evidently deposited during over-winter work lapses. Salt testing would have prevented this.

- Traffic control requirements as updated in the 2011 WAPM make if very difficult for a contract to propose alternate means of traffic control that may be safer and also lead to a more expeditious project for VDOT. VDOT traffic engineering should be responsible for PE stamping traffic control designs, NOT the contractor. It is absolutely ridiculous in some instances the hoops and barrels a contractor has to jump through to propose alternate restrictions or traffic control options (like temporary barrier). It is usually at an increased cost to the contractor and when the contractor is trying to make for a safer and more expeditious project at an increased cost to themselves and STILL butting heads over repeated roadblocks for no logical reason, it doesn't make sense. TRAFFIC ENGINEERING needs to have their PE at every pre-con meeting, they need to understand the work we are doing and the implications it has to the public and the workers.

APPENDIX E

RESPONSES FROM IN-PERSON CONTRACTOR MEETING (N = 3)

This is a summary of the discussion points and responses to the questions provided in Appendix C from the contractor meeting held on January 23, 2013.

Contactor Comments/Suggestions	Possible Action Items	Possible Outcome
Project Specifications and Payment		
VDOT does not provide enough project-specific information in the bid specs, including lane closure restrictions.	VDOT should provide lane closure restriction information in bid specs for each site.	Create more informed bidding among contractors.
VDOT does not provide enough project-specific information in the bid specs, including areas to be painted for zone coating projects.	VDOT should provide areas to be painted in bid specs for each site.	Create more informed bidding among contractors.
Consider paying coating contractor per square foot versus lump sum.	VDOT should consider paying coating contractors by the square foot instead of lump sum.	Improve quality control.
Consider lump sum for inspectors versus hourly for inspectors.	VDOT should consider conducting a cost analysis on inspectors' time vs. square foot of steel coated to determine if it cost savings could be realized without loss of coating quality	Improve coating turnaround time.
Containment of Structures		
Although not specified in VDOT's *Road and Bridge Specifications*, contractors comply with the SSPC Class 2A containment standards as standard practice (in order to comply with national air quality and worker safety standards) and often use SSPC 1A over reservoirs or sensitive areas.	VDOT should review its containment specifications and determine if they should be revised to specify a minimum of Class 2A in SSPC standards.	Improve clarity and consistency with regard to containment requirements.
Contractors routinely perform air perimeter monitoring regardless of whether required in specs.	N/A (no change needed in VDOT specs with regard to air monitoring).	Contractor must comply with federal air quality and worker health/safety standards.
Delaware Department of Transportation (DelDOT) and Maryland (MDOT) Department of Transportation use third party monitors for air perimeter monitoring.	VDOT should discuss with DelDOT and MDOT their experience with third party air perimeter monitoring.	Improved expertise.
Preblast air monitoring samples are valuable for comparison purposes,	VDOT should require preblast air monitoring samples.	Verify adequacy of containment.
Air monitoring results can be provided to VDOT in at least 7 workdays.	VDOT should require contractors to provide air monitoring results within 2 weeks of monitoring date.	Improve turnaround time for air sampling results.

Consider preventive maintenance, such as spot-cleaning with vacuum-assisted power tools, to reduce containment requirements.	VDOT should investigate where vacuum-assisted power tools could be used to reduce costs.	Reduce costs.
If bridge damage extends over traffic lanes, it is more cost-efficient to contain and repair the entire structure. If damage is limited to abutment region, containment could be minimized.	VDOT should factor in location of damage relative to traffic lanes in the coating maintenance decision process and bid specs.	Reduce costs.
Waste Management		
With South Carolina DOT and Wisconsin DOT, consultant inspectors are responsible for waste management activities.	VDOT should discuss with South Carolina and Wisconsin their experience with using inspectors to manage waste.	Improves oversight of waste management.
VDOT should develop site-specific plans for equipment placement and acceptable waste storage locations on-site and off-site.	VDOT should develop site-specific plans for equipment placement and acceptable waste storage locations on-site and off-site.	Improve project efficiency and environmental compliance.
Small cost difference in disposal costs between hazardous and non-hazardous waste.	VDOT should maintain current approach to waste disposal requirements with regard to lead-pigmented coatings.	N/A
Surface Preparation		
The paint suppliers for coating projects should review initial surface prep. Paint supplier and VDOT maintenance staff should be part of the final inspection.	VDOT should require contractors to have paint supplier on-site to verify that the surface preparation is acceptable prior to coating and should require maintenance staff to be present at final inspection.	Improve quality control.
Products that remove soluble salts, such as CHLOR*RID, are effective.	VDOT should employ soluble salt wash solutions.	Improve work quality.
Wet abrasives are slow and messy. The Florida DOT discontinued their use.	VDOT should abstain from using wet abrasives.	Minimize regret.
VDOT should consider including expendable abrasive in the specs as an alternate bid item, and contactors can decide based on site limitations.	VDOT should consider including expendable abrasive in the specs as an alternate bid item.	Expendable abrasives may be cost-efficient at certain sites.
VDOT will not reduce coating costs by specifying a SP6 vs. SP10 finish.	VDOT should not revise its current specs on surface finish.	Minimize regret.
VDOT should consider conducting a test blast area, photograph the acceptable surface finish, and then distribute photographs to contractor and inspector.	VDOT should require contractors to create a test blast area for determining the acceptable level of surface preparation.	Improve quality control.

Coating		
Bridge size is an important factor in the decision to recoat vs. overcoat. For large bridges, consider overcoating when damage is less than 15%.	VDOT should add guidance to Chapter 32 of the *Manual of the Structure and Bridge Division* with regard to bridge size considerations in coating decisions.	Improve cost-efficiency.
VDOT should recoat small structures and zone coat large structures, providing there is substantial square footage.	VDOT should add guidance to Chapter 32 of the *Manual of the Structure and Bridge Division* with regard to bridge size considerations in coating decisions.	Improve cost-efficiency.
VDOT should consider including both 2- and 3-coat painting systems in specs.	VDOT should include both 2- and 3-coat painting systems in specs	
Connecticut DOT is using a 2-coat system on beam ends	VDOT should discuss Connecticut's experience with using a 2-coat system on beam ends.	
Additional Suggestions		
The certified industrial hygienist requirement is no longer relevant so it should be removed from the VDOT specification	VDOT should remove the requirement from the specification	Clarify spec.
Preconstruction meeting should include sufficient time to discuss project-specific coating issues and consultant and contractor duties.	VDOT should create a checklist for preconstruction meeting of critical discussion points and job specific tasks.	Improve work quality and efficiency.
Quality of coating work suffers because of VDOT's low bid practice.	VDOT should investigate a method other than awarding the contract to the lowest bid.	Improve work quality.
Requiring warranty and bonding of work would improve work quality.	VDOT should investigate feasibility of requiring warranty and bonding of work.	Improve work quality.