Specification for Application of Thermal Spray Coating Systems to Steel Bridges

S8.2-2017 / SSPC-PA 18

AASHTO/NSBA Steel Bridge Collaboration

PREFACE

This document is a standard developed by the AASHTO/NSBA Steel Bridge Collaboration and SSPC: The Society for Protective Coatings (SSPC). The primary goal of the Collaboration is to achieve steel bridge design and construction of the highest quality and value through standardization of the design, fabrication, and erection processes. Each document represents the consensus of a diverse group of professionals. The mission of SSPC is to inspire learning, advance knowledge, and elevate performance in the industry through training, certification, and education of the workforce, communication of advances in technology, and promotion of the use of protective coatings.

It is desired that Owners adopt and support Collaboration guidelines in their entirety to facilitate the achievement of standardization. It is understood, however, that local statutes or preferences may prevent full adoption of the guidelines recommended herein. In such cases, Owners may adopt these guidelines with the exceptions they feel are necessary.

DISCLAIMER

The information presented in this publication has been prepared in accordance with recognized engineering principles and is for general information only. While it is believed to be accurate, this information should not be used or relied upon for any specific application without competent professional examination and verification of its accuracy, suitability, and applicability by a licensed professional engineer, designer, or architect.

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Caution must be exercised when relying upon other specifications and codes developed by other bodies and incorporated by reference herein since such material may be modified or amended from time to time subsequent to the printing of this edition. The authors and publishers bear no responsibility for such material other than to refer to it and incorporate it by reference at the time of the initial publication of this edition.

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In 2017 the AASHTO–NSBA Steel Bridge Collaboration celebrated 20 years of providing high-quality technical documents related to the design, fabrication, erection, and inspection of steel bridges. What started as a small group of individuals working to "fill the gaps" with information not provided in other documents has grown to include over 100 people working within 10 task groups. Documents are continually updated and new ones added to a growing library to support the Collaboration's mission of improving quality and value of steel bridges through the standardization of design, fabrication, and erection.

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INTRODUCTION

SPECIFICATION

This specification represents a consensus on best practice for the application of metallic thermal sprayed coating (TSC), also known as metallizing, to steel bridges and other highway structures.

This document establishes and defines the functions, operations, requirements, and activities needed to achieve consistent quality in TSC application. It is based on a cooperative approach to achieving quality, where both the Owner's and Applicator's representatives work together with a clear understanding of their roles and responsibilities, resulting in metallizing of steel bridges and components completed in an efficient manner while meeting all contractual requirements. Its acceptance does not in any respect preclude anyone, whether adopting the standard or not, from manufacturing, marketing, purchasing, or using products or procedures not addressed in this standard.

Environmental, containment, and safety issues are outside the scope of this guide and should be addressed in other documents. Use of this document in no way relieves the Applicator of responsibilities to meet all federal, state, and local requirements.

COMMENTARY

The primary objective of this specification is to achieve quality and value in the application of metallic thermal sprayed coating (TSC) systems. The Collaboration's intent is for transportation authorities to adopt this specification by direct reference in their standard specifications. This will help standardize metallizing methods across the nation.

Historically, state Departments of Transportation (DOTs) have written their specifications based on industry standards, particularly SSPC-CS 23.00/AWS C2.23/ NACE No. 12, "Specification for the Application of Thermal Spray Coatings (Metallizing) of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection of Steel" (hereinafter referred to as the Joint Standard), and their own individual experiences. However, many agencies, Fabricators, and Applicators recognized that all would benefit from a common specification because:

- Variations among projects would be minimized because different practices, procedures, and operations would not be needed for each state, and minimizing variation improves quality and reduces errors.
- Economy in TSC would improve because Applicators would not have to change their methods and production variables from state to state.
- Expertise in TSC could be shared among states, resulting in a well-rounded, consistent application standard.
- Owners would be able to share their resources, minimizing the effort each would otherwise have to expend to maintain a TSC specification.

This specification was written by experienced representatives from a number of applicators and fabricators, state DOTs, consultants, and the Federal Highway Administration (FHWA). The work was based on existing state specifications, the Joint Standard, and other industry guides and documents.

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SECTION 1
GENERAL

1.1—GOVERNING SPECIFICATION

Application of TSC and all related activities (material selection, surface preparation, inspection, documentation, repairs, etc.) shall be in accordance with SSPC-CS 23.00/ AWS C2.23/NACE No. 12, "Specification for the Application of Thermal Spray Coatings (Metallizing) of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection of Steel" (hereinafter referred to as the Joint Standard), except as modified by this document, and in accordance with approved procedures (see Article 5.3.2). Specific Joint Standard section numbers are based on the 2016 edition; subsequent editions may modify section numbers or content.

C1.1

This document addresses aspects of TSC not covered by the Joint Standard, either because these aspects were considered to be outside the scope of that standard, or because stakeholders in the bridge coating industry felt that more was required.

Because this is a supplement to the Joint Standard, there are sections that include commentary but not specification language, because in those sections no additions are made to the Joint Standard.

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SECTION 2
DEFINITIONS AND RESPONSIBILITIES

Terms used in this standard are in accordance with SSPC-CS 23.00/AWS C2.23/NACE No. 12. Additional terms or terms used differently in this document are defined below.

2.1—APPLICATOR

"Applicator" refers to the facility or facilities performing surface preparation and application of TSC. "Applicator" also includes any agents of the Applicator, such as subcontractors. In some cases, the Applicator may also be the general contractor, but usually the Applicator is subcontracted by the Contractor. In this document, the term "Applicator" is used to describe roles usually performed by the Fabricator, but these could also be done by the Contractor.

2.2—APPROVED PROCEDURE

An "approved procedure" in this document means one approved by the Engineer.

2.3—CONTRACTOR

The Contractor is responsible for proper completion of all tasks required by the contract documents. Subcontractors, including fabricators, erectors, and field coating applicators, may be used by the Contractor, but the Contractor retains responsibility for material, operations, and the final product. The Contractor may permit direct subcontractor interaction with the Owner to expedite the project, but subcontractors must inform the Contractor of any proposed modifications to contract requirements accepted by the Owner. The Contractor may permit or reject the changes.

2.4—FACILITY

"Facility" refers to the shop, yard, or jobsite where TSC application is performed.

2.5—IMMERSION SERVICE

For the purpose of this document, "immersion service" refers to full or partial submersion of the coated product into liquid, regardless of duration or frequency.

C2.5

This definition is not intended to include precipitation or condensation in normal bridge environments, but otherwise is similar to Zone 2 and up as defined in Joint Standard Appendix C2.

2.6—OWNER

"Owner" refers to the entity paying the Contractor to fulfill the terms of the contract. The Owner encompasses both those preparing the contract documents, including the designer, and those representing the Owner during construction, including the inspector. These representatives may be employees either of the Owner or of professional firms contracted for the work.

2.7—ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ASTM	ASTM International
AWS	American Welding Society
BCI	Bridge Coating Inspector (SSPC)
CIP	Coating Inspector Program (NACE)
FHWA	Federal Highway Administration
Joint Standard	SSPC-CS 23.00/AWS C2.23/NACE No. 12, "Specification for the Application of Thermal Spray Coatings (Metallizing) of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection of Steel"
JRS	Job Reference Standard
NACE	NACE International
NSBA	National Steel Bridge Alliance
PCI	Protective Coatings Inspector (SSPC)
QC	Quality control
RCSC	Research Council on Structural Connections
SSPC	SSPC: The Society for Protective Coatings
TSC	Thermal sprayed coating

SECTION 3
REFERENCE STANDARDS

Unless otherwise noted in the contract, the latest edition of the following standards, and of standards incorporated by reference in these standards, in effect at the time of contract letting form a part of this document. A copy of applicable reference standards shall be available at the TSC facility.

- ASTM D4285, "Standard Test Method for Indicating Oil or Water in Compressed Air"
- ASTM D4417, "Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel"
- AWS C2.16/C2.16M, "Guide for Thermal Spray Operator Qualification"
- AWS C2.25/C2.25M, "Specification for Thermal Spray Feedstock—Wire and Rods"
- SSPC-CS 23.00/AWS C2.23/NACE No. 12, "Specification for the Application of Thermal Spray Coatings (Metallizing) of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection of Steel"
- SSPC-PA 17, "Procedure for Determining Conformance to Steel Profile/Surface Roughness/Peak Count Requirements"
- SSPC-SP 16, "Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals"

The following standards are referenced in the commentary to this document:

- AASHTO/NSBA Steel Bridge Collaboration S8.1/ SSPC-PA Guide 13, "Guide Specification for Application of Coating Systems with Zinc-Rich Primers to Steel Bridges"
- Research Council on Structural Connections (RCSC) *Specification for Structural Joints Using High-Strength Bolts*

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SECTION 4
PERSONNEL

4.1—APPLICATOR'S INSPECTION PERSONNEL

C4.1

This section addresses requirements for the Applicator's inspectors. It is recommended that the Owner's inspectors have, at a minimum, the same qualifications as the Applicator's inspectors.

4.1.1—Quality Control (QC) Supervisor

C4.1.1

The QC Supervisor is responsible for the quality of the TSC and the supervision and guidance of the QC Inspectors, and for ensuring that the QC Inspectors are competent to perform the tasks they are assigned.

The qualifications of the QC Supervisor shall include as a minimum:

- NACE CIP Level 3, SSPC PCI Level 3, or SSPC BCI Level 2.
- 24 months of cumulative experience over the last five years with inspection of TSC on steel structures.
- Five years of experience in corrosion control using coatings on steel structures.

The QC Supervisor may be in the role of overall "QC Manager" for the company, or may serve a function specific to TSC. It is not required that a qualified QC Supervisor be present on all shifts, but they need to be present to the extent required to monitor the performance of inspectors. This normally requires presence for most of the time work is performed. When a qualified QC Supervisor is not physically present, they should still be available to both Owner and Applicator personnel by phone in case unexpected situations arise. Typical QC Supervisor responsibilities include:

- Determining what inspections, tests, measurements, and documentation are required by the specification work items or are considered necessary to assure product conformance and compliance with contract specification requirements.
- Communication of contract requirements to inspection and production personnel.
- Development or review of project-specific inspection and testing plans.
- Maintenance and review of records required to document inspections and tests.
- Ensuring that correct and properly operating and calibrated equipment is used.
- Ensuring the specified consumables are properly stored and used.
- Supervision of QC inspectors.

4.1.2—QC Inspector

C4.1.2

QC Inspectors report to and are under the supervision of the QC Supervisor. The qualifications of QC Inspectors shall include, as a minimum:

- SSPC PCI Level 1, or SSPC BCI Level 1, or NACE CIP Level 1
- 12 months of cumulative experience over the last three years with application or inspection of TSC.
- 12 months of cumulative experience over the last three years with inspection of coatings on steel structures.

QC Inspector responsibilities typically include:

- Performing required inspection and testing.
- Verification of specification compliance.
- Verification that procedures are followed.
- Verification that specified materials are used.
- Verification of the calibration of quality control inspection equipment.
- Documentation of inspections, tests, and calibrations performed.

In place of prior TSC experience, the Applicator may use a documented on-the-job training program for QC Inspectors to provide them with the requisite knowledge.

- Communication of inspection and test results to production staff.

QC Inspectors without prior experience inspecting TSC should have closer supervision than more experienced inspectors.

The minimum Level 1 certifications required for QC Inspectors, as well as their more limited experience with TSC, may not be sufficient for conducting certain tasks, such as destructive testing. The QC Supervisor's responsibility includes assigning properly trained individuals to such tasks.

4.2—PRODUCTION PERSONNEL

4.2.1—Operator

The Applicator shall have a written plan to show how TSC operators are qualified. All training, testing, and demonstration of capability shall be documented.

Each TSC operator shall meet the following requirements:

- Spray specimens that meet project specifications for wire type and coating thickness and that pass the tests required by AWS C2.16/C2.16M TSOQT AS-1. Bend tests shall be performed in accordance with Joint Standard Appendix A, and adhesion tests shall be performed in accordance with Joint Standard Section 9.4.
- Demonstrate knowledge of how to verify the correct feedstock, load the TSC wire, and operate the TSC equipment and make adjustments.
- Demonstrate acceptable skill to test the compressed air cleanliness, the environmental conditions, the surface cleanliness (including dust), the surface profile, and the film thickness.
- Demonstrate knowledge of the blast cleaning process, applicable blast-cleaning standards, and surface profile requirements.
- Demonstrate proper and consistent spray techniques, standoff, hatch pattern, etc. for a time duration representative of production work.

C4.2.1

If the geometry of the workpieces will make them particularly difficult to coat, the TSC Supervisor or QC Supervisor may require additional test specimens reflecting the workpiece geometry.

AWS C2.16/C2.16M, particularly TSOQT JK-1 and AS-1, may be used as a resource for developing a qualification plan. The thermal spray equipment manufacturer may also be able to provide training.

4.2.2—Supervisors

Each TSC shift shall have at least one TSC Supervisor present on the facility who has passed the SSPC Thermal Spray Training course or equivalent, and has at least 12 months of cumulative experience with TSC application over the last three years. Each TSC Supervisor shall also demonstrate the skills and knowledge required for operators in Article 4.2.1.

C4.2.2

The SSPC Thermal Spray Training also has a certification component available by arrangement with SSPC. The TSC Supervisor may be the general foreman or may serve a function specific to TSC.

SECTION 5
PRE-PRODUCTION

5.1—COMMUNICATION

C5.1

Effective communication between the Owner, the Applicator, and any other relevant parties to the contract is essential to a successful project. Before work begins, these parties should establish the simplest, most direct lines of communication possible and make sure that all parties understand and use them. This is an important function of the pre-production meeting.

Important considerations:

- Establish lines of communication agreed to by all parties, including the Owner and Applicator.
- Keep the lines of communication as simple and direct as possible.
- Address problems and concerns as early as possible in the work.

On design-build jobs or other situations where the design is not complete when the Applicator is engaged, it is particularly useful for the designer and Applicator to discuss complex details as they are developed in the design Even on design-bid-build projects, the designer should consult with an applicator for advice on avoiding details that are difficult or impossible to metallize properly. See Section 14.

5.2—PRE-PRODUCTION MEETING

Before work begins, a pre-production meeting may be held at the discretion of the Owner or if requested by the Applicator or Contractor.

C5.2

A pre-production meeting may avert many of the problems that may complicate or delay coating. At the meeting:

- the Owner and Applicator should review the project and discuss specific concerns;
- the Applicator should describe the expected approach to the project, including milestones or specialized work;
- the Owner should point out any unusual requirements for the project and describe how their inspection will be accomplished;
- clear lines of communication should be established between all parties; and
- all parties should be given the opportunity to ask questions or express concerns.

The following aspects of the job should be reviewed:

- identification of key personnel
- personnel certification and qualification
- organizational structure and lead Applicator personnel
- appropriate lines of communication for submittals and approvals
- required submittals
- handling of material certifications
- application and repair procedures
- supply and sampling of materials, if applicable
- work and inspection schedule
- hold points and witnessing requirements, if applicable, for Owner's and for Applicator's inspectors
- availability and advance notification of Owner's inspectors
- project-specific areas of concern for application and inspection
- handling of nonconformance and repair issues;
- special requirements, especially any exceptions to this specification;
- project details, requirements, or processes that have caused prior difficulties; and
- loading and shipping.

It is not necessary to have a pre-production meeting before every project, especially if the Owner and Applicator work together on a regular basis.

All stakeholders in the TSC process should attend the pre-production meeting. Owner representatives will typically include representatives for engineering and inspection; Applicator representatives will typically include facility management and supervisory levels of production and inspection. Material or equipment suppliers might also attend.

Progress meetings can also be used to resolve disagreements over quality requirements, determine current status of completed and in-progress work, clarify unusual or altered contract requirements, discuss current or potential problems and their resolution, and monitor the anticipated production and completion schedule.

5.3—SUBMITTALS

5.3.1—Quality Plan

Submit a Quality Plan for approval to address how contract requirements will be met. The Quality Plan shall address, at a minimum, the following:

- Identification, qualifications, and responsibilities of key personnel (see Section 4)
- Inspection types and frequencies
- Materials to be used (type or brand; see Section 7)
- Procedures (see Article 5.3.2)

C5.3.1

Requirements may be addressed within the Quality Plan directly or through reference to other documents. For most jobs a standard Quality Plan should suffice, but some projects may require a job-specific plan or addendum.

5.3.2—Procedures

Submit written procedures for approval for the following:

- JRS (Job Reference Standard) configuration, preparation, and testing (see Article 5.4)
- Qualification of TSC operators (see Article 4.2.1)
- Surface preparation (including blast media, edge treatment, and applicable SSPC-SP standard; see Section 8)
- TSC application (see Section 9), incorporating equipment manufacturer's recommendations
- Provisions for use of companion coupons, if permitted (see Article 12.2)
- Provisions for inaccessible areas (see Section 14)
- Sealing and topcoating (if applicable; see Article 7.2 and Section 10), incorporating manufacturer's recommendations
- Typical repairs for surface preparation and coatings, including repair of adhesion test sites (see Section 11)
- Air handling and dust removal
- Storage and handling, both of completed product and in process

The procedures shall detail the equipment; production methods; in-process and final inspection methods and frequencies; Applicator and Owner hold points, if any; and required records. Procedures may be standalone or incorporated into the Quality Plan.

C5.3.2

Procedures are intended to facilitate understanding between the Owner and the Applicator about how various aspects of the work will progress. Having these procedures helps the Applicator's employees understand requirements, and providing copies for review by the Owner helps minimize conflicts once the work has begun. Most procedures reflect the Applicator's standard practices, so they should not need to be resubmitted for routine jobs for the same Owner unless a specific aspect of work needs particular attention. Written procedures provide more specific guidance than specifications do, but the Owner should not use written procedures to introduce requirements beyond the intent of the specifications. For repairs, the Applicator and Owner should reach an understanding about testing, scheduling, and the advance notice needed to coordinate inspections.

For sealer application, the manufacturer's technical representative may need to provide instructions for sealer thinning that are not reflected in normal coating documentation (product data sheets).

5.3.3—Material Documentation

Submit for approval safety data sheets, certificates of conformance, and manufacturer's product data sheets to contract requirements for the following:

- TSC wire
- Any liquid-applied coatings (sealers and topcoats)
- Blast media

C5.3.3

See Section 7 for more detail about material documentation.

5.4—JOB REFERENCE STANDARD (JRS)

Prepare, test, and present a JRS for approval. Witnessing of testing shall be as stated in project specifications or as agreed between Owner and Applicator.

C5.4

The Joint Standard requires the JRS to be "made with the actual field equipment and the process parameters and procedures (surface preparation and thermal spraying) to be used for the contracted work." Any changes to the TSC procedure will require a new JRS; the JRS procedure should define which parameter changes would require a new JRS. Multiple JRSs may be needed for complex projects if key parameters vary for different portions of the work. The Joint Standard also allows for a requirement to tailor the shape of JRSs to reflect geometry challenges in the work.

5.5—COMMENCEMENT OF WORK

Provide a written advance notice to the Owner a minimum of two weeks before coating begins.

C5.5

When the Applicator provides the Owner with an anticipated work schedule, this allows planning and preparation for inspection. The earlier notification is provided to the Owner the better, so Applicators should provide schedule information as soon as possible and not simply follow the prescribed minimum lead times. The Applicator can initially provide a general estimate to the Owner and then provide more precise details as the commencement date approaches.

SECTION 6
EQUIPMENT

6.1—THERMAL SPRAY EQUIPMENT

Set up and operate thermal spray equipment per the manufacturer's instructions and technical manuals. Set spray parameters for the specified feedstock material and selected wire size.

C6.1

Thermal spray equipment setup may be validated using the bend test. Bend test coupons should be prepared and sprayed in the same manner and requirements for the production spraying as described in the Joint Standard. Any failures of the bend test coupon could be an indication of improper surface preparation or incorrect spray parameters.

6.2—DUST COLLECTION

Implement a dust collection and removal system in the TSC application work area, in accordance with approved procedures.

C6.2

Dust from the TSC process settling on the substrate surface between coatings is an issue and can lead to adhesion loss.

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SECTION 7
MATERIALS

7.1—TSC WIRE

7.1.1—Composition and Size

All TSC wire shall be of the nominal composition specified (aluminum, zinc, or 85 percent/15 percent zinc/aluminum alloy) and meet the compositional requirements stated in Table 2 of AWS C2.25/C2.25M, classification W-Zn-2, W-Zn-1, W-ZnAl-2, W-Al-1350, or W-Al-1100.

C7.1.1

Various sizes of wire are available for use in thermal spray coatings. The selection of wire size is dependent on the equipment used, the desired production rate, and the geometry of the substrate. Wire size is a factor in pass thickness, which can affect adhesion strength.

Zinc, aluminum, and zinc/aluminum alloys are the most common materials used in TSC. The best choice of material depends on many variables, including atmospheric conditions, proximity to salt and sea water, pH of surrounding medium (for immersion service), and the amount of pollution (SO_2) in the air.

Zinc and Zinc Alloys

Zinc has a much lower corrosion rate than steel in atmospheric environments. One reason for this slower rate is that zinc passivates over time by forming a protective barrier layer of carbonates and oxides on the surface. Formation of this barrier layer will be interrupted by high levels of salt and wetness, as in a marine environment. Without a barrier layer, the corrosion rate will be higher.

In neutral or alkaline water (pH 7 to 12), zinc does not corrode significantly. Zinc is particularly known for "throwing power," or high cathodic reach from the coated area to an unprotected area, which means a higher tolerance for damage to the coating.

Alloying zinc with aluminum, up to 15 percent aluminum by mass, generates a higher corrosion resistance in chloride-contaminated environments compared to pure zinc. This higher corrosion resistance is achieved by combining the aluminum's oxidative passivation mechanism with the cathodic protection properties of the zinc. Zinc/aluminum alloys provide high corrosion resistance in most environments, including a low acid medium (pH 5 to 7) and chloride and SO_2-containing atmospheres. It is suitable for immersion in service in salt water when properly sealed, and retains some of zinc's cathodic reach.

Aluminum and Aluminum Alloys

Similar to zinc, aluminum will passivate and form an atomically bonded barrier layer of aluminum oxide, which regenerates upon damage. Unlike zinc, this process is relatively straightforward and rapid. Aluminum forms an aluminum oxide layer which acts as a barrier protection system. It is highly resistant to corrosion in environments with a pH between 4 and 9, and is much more resistant to

corrosion than other common TSC options. It is particularly applicable for steel structures in industrial and marine atmospheres. It is suitable for immersion in salt water.

Aluminum TSC may have an unfavorable reaction with concrete and should be kept from direct contact through masking or use of alternative coatings or isolators in areas to be encased in concrete.

7.1.2—Documentation

Provide certification of wire composition to the specified AWS C2.25/C2.25M classification and indicating chemical composition, wire diameter, lot number, manufacturing date, and any other applicable data.

7.1.3—Storage

Keep TSC wire clean and dry.

7.2—SEALER AND TOPCOAT (WHEN SPECIFIED)

C7.2

The purpose of a seal coat is to provide a degree of barrier protection before the metal oxides are able to form and fill the void space in the TSC film. This is generally necessary if a topcoat is used that cannot be applied over a porous surface, such as typical urethanes. Polyurethane and epoxy sealers are commonly used but other types of sealers are available. For instance, aluminum-pigmented silicone is an example of a sealer recommended for aluminum TSC. Sealers are thinned or formulated for low viscosity in order to penetrate the pores in the TSC. Topcoats and sealers can be added for aesthetics and to extend the durability of the coating system.

When sealer is required for service rather than aesthetic reasons, topcoat may or may not be needed. The addition of a suitable topcoat will provide aesthetics and UV protection (see Article 7.2.2). Many commonly used sealers, including most epoxies, are not stable under exposure to UV light.

Any choice of sealer or topcoat should be evaluated for the anticipated service conditions. See Appendix C1 of the Joint Standard for more discussion of sealers.

7.2.1—Sealer Selection

- Sealer shall be a type recommended by the sealing supplier for use on the particular TSC used for the project and with the topcoat, if one is specified.
- A sealer shall be required whenever a topcoat is specified that is not formulated for application directly over unsealed TSC.

7.2.2—Topcoat Selection

- The topcoat shall be compatible with the sealer and the TSC
- The color shall be as specified by the owner.
- Sealer and topcoat shall be from the same manufacturer
- Sealers that are not UV-resistant shall be topcoated with a UV-resistant coating if the sealer will be exposed to UV light.

7.2.3—Documentation

- Provide manufacturer's certificate of conformance confirming that a particular batch of product was produced in accordance with the manufacturer's standard.
- Provide documentation of manufacturer's recommendation for compatibility of coatings with each other and with the TSC.

7.2.4—Storage

Store liquid-applied coatings and thinners in accordance with the manufacturer's instructions.

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SECTION 8
SURFACE PREPARATION

8.1—GENERAL

C8.1

The blast profile is important in achieving adhesion. However, profiles outside the range required by the Joint Standard could be evaluated to be acceptable if adhesion test results support the outlier blast profiles.

Correction of excess profile depth is very difficult; removal of the peaks can affect adhesion of the coating. It is therefore very important to develop abrasive selection and proper blasting methods during the JRS preparation phase and make adjustments during JRS development to the abrasive blend as needed to maintain specified profile requirements. Different types of blast media may be necessary to provide the necessary angular profile and cleanness to achieve the contract specified bond strengths.

8.2—EDGE PROFILE

Before the abrasive blasting process, remove the hardened surface along thermal-cut edges by grinding or machining this surface to a depth that will allow for conventional grit blasting to produce the required surface profile for application of the TSC.

Flame-cut or sheared edges must also have the corners “broken” to remove sharp or irregular edges. A radius is not required. The Applicator is to break corners by providing at least a $^{1}/_{16}$" chamfer or radius. See Figure C8.2 for chamfer illustration. Rolled edges do not need to be broken or ground unless they are sharp or irregular.

C8.2

Thermal-cut surfaces may have been affected by the cutting process; there may be striations or marks that interfere with the use of replica tape or have a condition (such as increased hardness) which inhibits the blast medium from producing the same surface profile as uncut surfaces. Determination of adequate profile on thermal-cut edges is best performed visually with magnification and a profile comparator.

Normal blasting practices will typically allow the formation of anchor profile adequate for paint, but the hardness of thermal-cut edges may be too much to allow the formation of the deeper and more angular profile required for TSC. Grinding or machining should remove sufficient material to eliminate the hardened surface (typically no more than ⅛ in.), but not enough to reduce the width of the plate beyond allowable tolerances.

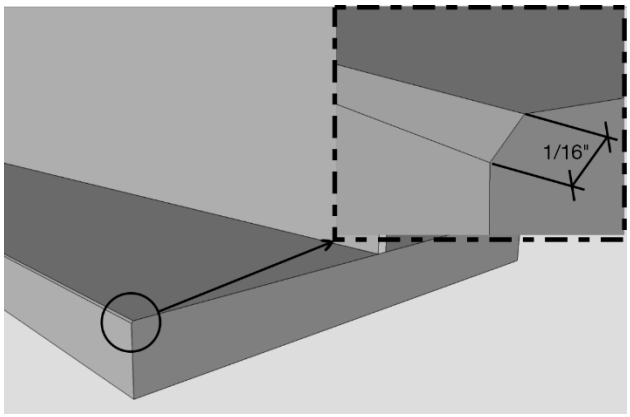

Figure C8.2—Chamfer Illustration

8.3—STRUCTURAL FASTENERS

If galvanized fasteners are installed before application of TSC, it is not necessary to restore the surfaces of the fasteners to bare metal. Galvanizing may remain on the surfaces of the fasteners. Remove lubricant and other surface contaminants.

C8.3

Galvanizing presents a good surface for TSC adhesion and provides additional cathodic and barrier protection.

If connections must be bolted before TSC application, the connections may require particular attention in order to achieve proper surface preparation. The fastener surfaces will be coated in oil or wax, and there may be lubricant in the area surrounding the fasteners. In addition, hardened bolts, nuts, and washers may not be able to achieve the required profile depth, and access to all sides of the fasteners may not be available. Even with good access, bolts may need to be addressed by similar alternative measures as for inaccessible areas (see Section 14). If galvanized bolts are used for connections that are later coated with TSC, it is best to avoid blasting off the galvanizing during surface preparation of the surrounding area, and retain as much galvanizing as possible.

8.4—MAINTENANCE OF SURFACE CONDITIONS

Reinspect the surface for rust bloom or insufficient blasting immediately before applying TSC. Substrates shall be in compliance with surface preparation requirements at the time thermal spraying begins, for each portion of the surface. If surface cleanliness has degraded to an unacceptable level at the time of spraying, restore the surface condition by blasting before TSC is applied. If surface cleanliness degrades to an unacceptable level during the course of TSC application, stop TSC operations and restore the surface condition.

C8.4

The surface to be coated should be protected from environmental exposure between blasting and coating. This will be more difficult if the workpiece must be transported from blasting area to a separate TSC application area.

The size of the area to be coated and the number of TSC operators working simultaneously will determine the total time needed to complete the TSC application process. Long durations between blasting and completion of the application, either because of delays between blasting and the start of TSC application, or because too large an area was selected for work, could lead to flash rusting prior to completion. Therefore, the surface condition should be monitored during the application process.

SECTION 9
APPLICATION OF THERMAL SPRAY COATING

9.1—GENERAL

C9.1

Recommendations for application:

- Spray angle should be within about 30° from perpendicular to the surface.
- The gun should be held at such a distance from the work surfaces that the metal is still molten on impact, but not so close so as to create excessive rebounding of the molten material. If the configuration of the surface being coated does not allow for a proper gun-to-workpiece standoff distance, this should be considered an inaccessible area and addressed accordingly. See Section 14.
- The application should be done in overlapping passes to ensure uniform coverage.

9.2—TSC THICKNESS

Apply at least 8 mils of TSC, unless otherwise specified.

C9.2

See Article C9.5 for considerations for faying surfaces.

9.3—BEFORE APPLICATION

- Verify that surface condition is in accordance with requirements. See Article 8.4.
- Blow dust off with clean dry air in accordance with ASTM D4285 for initial application or when applying additional TSC to previously coated surfaces.
- If applying additional TSC to previously TSC-coated surfaces with visible TSC oxidation, brush-off blast the oxidized surface with non-metallic grit in accordance with SSPC-SP 16 and blow off loose dust before the application of the additional TSC.

C9.3

TSC should be applied as soon as possible after surface preparation.

Visible oxidation of TSC depends on environmental conditions. Reapplication of TSC over TSC is most likely to occur in the context of a repair or to address insufficient thickness; deliberate use of a partial-thickness “hold coat” followed by later buildup to required thickness is not recommended.

9.4—DURING APPLICATION

- Maintain surface condition and monitor for flash rust or dust. See Article 8.4.
- Apply TSC as a uniform film, firmly adherent, free from thin spots, misses, or lumps.

C9.4

TSC creates heavy dust particles that may not be adequately collected with conventional air handling equipment. Modifications to the process may be needed if contamination issues arise.

9.5—FAYING SURFACES

For slip-critical faying surfaces, ensure that the required slip coefficient is provided.

C9.5

Connections in which both faying surfaces are coated with unsealed TSC of either 100 percent zinc or 85 percent/15 percent Zn/Al with a thickness of 16 mils or less on each element meet the requirements for a Class B slip coefficient. See FHWA report FHWA-HRT-14-083, "Slip and Creep of Thermal Spray Coatings." For other TSC systems, the slip coefficient must be demonstrated through testing in accordance with the Research Council on Structural Connections *Specification for Structural Joints Using High-Strength Bolts*, Appendix A, or else the required slip coefficient can be achieved through masking or alternative coatings.

SECTION 10
SEALER AND TOPCOAT

10.1—GENERAL

Blow down the TSC surface with clean dry air in accordance with ASTM D4285 before sealer application.

C10.1

See Article C7.2 for discussion of sealer and topcoat selection.

The TSC surface must be in proper condition for application of the sealer; otherwise oxides will be trapped by the sealer. Applying the sealer as soon as possible after TSC application is complete is the best way to ensure the TSC surface is suitable. However, TSC application is a time-consuming process, and large parts like big bridge girders can take many hours to coat. The best overall coating is achieved through complete coverage by TSC and then complete sealer application, rather than accomplishing these steps in stages. Therefore, for large components, it is prudent to adopt a practice of completing the TSC application and then properly preserving the condition of the TSC surface until the sealer is applied. TSC surface condition is best preserved through control of the environment in which the piece is stored. If the TSC condition has deteriorated (visible oxidation, rust spots, contamination), brush-blasting with nonmetallic grit in accordance with SSPC-SP 16 to remove visible TSC oxidation may be acceptable to restore the TSC surface condition. In some situations, such as where there is a risk of salt contamination of the unsealed TSC, which could result in salt entrapment between the TSC and the sealer, it may be necessary to apply only as much TSC as can be sealed in the same shift. Care should be taken in scheduling so as to allow enough time for inspection of the TSC before sealing.

AASHTO/NSBA Steel Bridge Collaboration S8.1/ SSPC-PA Guide 13 contains information that is likely to be relevant for topcoat application.

10.2—CONNECTIONS

See Article 9.5 for requirements for slip-critical bolted connections. If connection areas are masked from sealing in order to achieve slip coefficient, seal exposed portions of those areas after the connections have been completed.

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SECTION 11
REPAIRS

11.1—GENERAL

Perform repairs in accordance with approved procedures. For situations that are not covered by preapproved procedures or that may affect the performance or appearance of the coating system, submit a nonconformance report with remediation proposal for approval.

C11.1

See Appendix A for common problems and suggested remedies that could be used as a starting point for repair procedures for unsealed TSC.

When assessing repair solutions, consider the impact of the repair on the performance of the coating (for example, see Article C8.1 regarding excess profile depth). For cosmetic repairs (nonconforming coating that has unacceptable appearance but is expected to perform adequately for corrosion protection), consider how the aesthetics of the repair will look compared to the original coating. Cosmetic repairs may not need remediation if they will not be exposed.

If the repair is not due to an adhesion failure, potentially destructive adhesion testing of the repair is not recommended.

Procedures for repair of repeated or severe nonconformances should include evaluation and remediation of root cause. A new JRS would be required if application parameters are changed. See Article 5.4.

Repairs to TSC that has already been sealed or that has been reduced in thickness in the course of repair to sealer or topcoat will involve a certain degree of TSC applied over sealer, but with proper feathering of the repair area in accordance with the Joint Standard, the presence of sealer in the TSC application area should be minimal and not affect the performance of the TSC.

Where a repair procedure requires complete removal of the TSC, the impact of the repair on the performance of the coating should be considered. For example, attempting to remove all TSC from the profile could result in excess profile depth (see Article C8.1). Depending on the root cause of the nonconformance, well-adhered TSC remaining in the profile could be acceptable. Good adherence of TSC for this purpose can be verified by an aggressive blow down with clean high pressure (at least 100 psi) compressed air.

11.2—ADHESION FAILURES

If a companion coupon (see Article 12.2) fails an adhesion test, test the workpiece. Test areas adjacent to any failed tests on the workpiece to determine the full extent of the area of concern. Adjust application technique, surface preparation, or other parameters to prevent recurrences, then blast to required surface preparation and reapply TSC. Perform adhesion testing on the repaired area.

C11.2

If sealer is specified and the Applicator elects to apply the sealer “at risk” around previously applied adhesion dollies before they are pulled, adhesion failure repair may be needed on sealed TSC, and this case should be addressed in the Applicator’s repair procedures.

11.3—REPAIR OF SEALER OR TOPCOAT

If removal of coatings is required to address deficiencies, brush-blast or sand the area as needed to remove the unsatisfactory coating. If removal of the coating reduces TSC thickness below acceptable limits, reapply TSC to restore required thickness before reapplying other coatings. If repair involves removal of topcoat, reapply sealer before replacing topcoat.

C11.3

Because TSC thickness may be reduced in the process of removing sealer or topcoat, the repair procedures should address the case of applying new TSC to previously sealed TSC.

Information about repair of paints can also be found in AASHTO/NSBA Steel Bridge Collaboration S8.1/ SSPC-PA Guide 13.

SECTION 12
INSPECTION AND TESTING

12.1—FREQUENCY OF PROFILE MEASUREMENT

Take measurements for blast profile every 200 sq. ft. for manual blast and every 2,000 sq. ft. for automated blast. Record readings or affix replica tape to inspection records.

C12.1

This is a stricter frequency requirement than that of SSPC-PA 17, referenced by the Joint Standard. SSPC-PA 17 also uses ASTM D4417 to determine the number of readings required to define a location average; that requirement remains unmodified. Test locations (edges, vertical vs. horizontal surfaces, etc.) should be varied so as to represent the entire cross section.

12.2—COMPANION COUPONS

Use of companion coupons in lieu of destructive testing on the workpiece shall be at the Owner's discretion.

C12.2

Use of coupons is an effective means of testing adhesion without damaging the coating on the actual work. However, there are sometimes concerns about how well coupons represent the work. One approach is to test both workpiece and coupons in parallel early in production until confidence in the coupons is established, and then use only companion coupons or reduced production testing once the consistency of the production process has been established.

When companion coupons are not or cannot be used, damage to TSC can be avoided in some cases if pull tests are discontinued when a passing strength result is achieved and not pulled to TSC failure. However, considering that adhesion tests results are the average of three pulls, not each of which is required to have a passing value; and that sometimes the specimen may pull away shortly after a passing result is achieved, this is not a foolproof method to avoid damage to healthy TSC.

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SECTION 13
HANDLING

13.1—SOFTENERS

Avoid damaging the TSC when handling coated product. Use soft, clean, and dry material between coated product and support blocks or metal appurtenances such as hooks, chains, or wire rope.

C13.1

Using precautions that are typically applied for painted product will minimize damage to TSC in shipping and handling. Carpet, rubber padding, and plastic angles are examples of suitably soft materials for handling. Reusing the same pick points is a helpful strategy for minimizing damage. Even with softeners, hooks can "flatten" the TSC, and this flattening is more noticeable after sealing. However, the flattening does not affect the integrity of the coating.

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SECTION 14
GEOMETRY AND INACCESSIBLE AREAS

14.1—PROCEDURES FOR INACCESSIBLE AREAS

If the geometry of the piece prevents proper surface preparation or TSC application in certain areas, address those areas in accordance with approved procedures.

These procedures shall be demonstrated when the JRS is sprayed at the onset of the TSC application.

C14.1

Possible locations for inaccessible areas and irregular geometric shapes include, but are not limited to:

- where blasting material cannot properly prepare the surface, and
- where area can be blasted, but cannot be properly metallized.

Bolts, nuts, corners, edges, limited access, surfaces containing crevices and any surface which may not be sprayed at 90 degrees to the surface are likely to be above or below the specified thickness. In some cases, the surface may not receive any coating.

Bolts installed prior to TSC application present a problem not only for access to the back sides of the nuts and bolt heads, but for surface profile. See Article C8.1.

The designer should be informed about any inaccessible areas, as feedback for the improvement of future designs.

Inaccessible areas need to be prepared and coated by alternative methods. Coating selected should be appropriate for the achievable surface condition. Caulking may also be an acceptable method.

It may be difficult to apply TSC to small and irregular attachment members, such as cross-frames. Consider the use of hot-dipped galvanizing or other means of corrosion protection in lieu of TSC for cross-frames and similar members.

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SECTION 15
FIELD APPLICATION

15.1—PROCEDURES FOR FIELD APPLICATION

All requirements of this document apply equally to shop and field application, unless otherwise approved. Procedures for application of TSC in the field shall address any particular concerns for the job site.

C15.1

Concerns for field application are similar to those for painting, and include the following:

- environmental conditions, such as wind and precipitation, are more difficult to control
- dust collection systems are more difficult to set up in areas with limited access and working space
- surfaces of existing structures are more likely to be contaminated with soluble salts or other contaminants; the Owner should specify appropriate testing and acceptance criteria for the environment and history of the structure
- work schedules, which can affect time between surface preparation and coating or time between TSC application and sealing, may be more difficult to control because of constraints on roadway or navigable water closures

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NONMANDATORY APPENDIX A
COMMON TSC DEFECTS AND RECOMMENDED REPAIRS FOR UNSEALED TSC

Condition	Cause	Remedy
Excessive TSC	Improper application technique	Conduct adhesion testing on a companion coupon to determine whether the excess thickness is detrimental. If the companion coupon fails the adhesion test, proceed in accordance with Article 11.2. See Joint Standard Section 9.3; also see Article 9.5 for requirements for faying surfaces.
Insufficient TSC	Improper application technique	Apply additional coating to specified film thickness. See Joint Standard Section 9.3.
Contaminants IN the TSC	Poor application conditions	Remove contaminated TSC by blast-cleaning to the required surface conditions and reapply TSC.
Contaminants ON the TSC (could include rust-contaminated dust from nearby blasting)	Poor storage conditions	Clean surface using solvent, hand tools, or other methods.
Rust under the TSC (may be discovered through adhesion testing)	Poor surface preparation	Remove TSC, reprepare surface to required conditions, and reapply TSC.
Rust in the TSC	Improper application technique or storage, or insufficient TSC thickness	Brush-blast the area with non-metallic grit to remove surface oxides and restore TSC to required thickness. See Joint Standard Section 8.5.

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