product focus

SPECIFYING VALUE

A properly installed coating system adds not only protection to fabricated structural steel, but also value.

BY WILLIAM D. CORBETT

ON THE SURFACE (pun intended), applying a protective coating to structural steel may seem like a pretty simple procedure.

In reality, a properly applied coating system encompasses quite a bit: surface and edge preparation; abrasive blast cleaning to SSPC-SP10/NACE No. 2, *Near-White Metal Blast Cleaning* and the associated indirect requirements, including abrasive cleanliness and compressed air cleanliness as well as solvent cleaning per SSPC-SP 1; coating materials and associated thinners; mixing and application of sophisticated, multi-component, multi-layer coatings; masking of connections; dry film thickness consistency; cure times and handling; and time allowances for owner quality assurance inspection.

Sophisticated Coating

Given everything involved in the application of a sophisticated paint system, how can you ensure it's done properly? In 2010, AISC and SSPC published AISC-420-10/SSPC-QP 3—*Certification Standard for Shop Application of Complex Protective Coating Systems*. By specifying AISC-420-10/SSPC-QP 3 as a bid requisite, facility owners can have confidence that the corrosion protection system they are paying for is being installed by a shop that has proven its capabilities to an outside auditor.

I've heard people ask, "Why go to the trouble and expense of writing a coating specification when all the information needed is on the manufacturer's product data sheets?" It's important to remember that these sheets contain *recommendations*; they are not intended to act as a specification. Product data sheets often contain multiple surface preparation and coating thickness recommendations based on the intended service environment. They are not prepared for entire coating systems (just single products) and they do not contractually invoke inspection (quality control) check points or the frequency in which these tests must be performed. It is best to think of a product data sheet as simply an "instruction manual" for a coating. It tells us how to mix the product, what to reduce it with, what equipment can be used to apply the product and under what conditions the product can be applied and cured. While relying on manufacturer product sheets to convey the contractual requirements of a sophisticated paint system is cheaper up front, it can become very expensive when poor quality is the end result.

Verifying Quality

Acknowledging that specifying (and verifying) quality will greatly reduce the opportunity for coating problems after the steel is erected, the question then becomes: Which specific quality control checkpoints should be invoked by specification, and how is quality to be verified?

First and foremost, a fabrication shop that applies a sophisticated paint system should have and implement a written quality control program. The written program should incorporate management responsibilities related to quality, technical capabilities of the shop, training of shop personnel, implementation of process controls, internal auditing, purchasing procedures, evaluation of subcontractors and suppliers, calibration and use of inspection equipment and quality control inspection procedures. The program should also contain standard forms for documenting these items as well as the results of project-specific quality inspections. If the shop is AISC-420-10/SSPC-QP 3 certified, they have all of the above. Specifications may also require the shop to prepare and submit a project-specific work plan and quality control plan, based on the corporate plan.

Below are some common in-process quality control check points that can be specified and subsequently verified in the shop, as well as some of the more modern inspection instrumentation that a shop can use to streamline quality control inspections and documentation practices.

Measuring ambient conditions and surface temperature. The prevailing conditions of air temperature, relative humidity (the ratio of moisture in the air relative to total saturation), dew point temperature (the temperature at which moisture condenses on a surface) and the temperature of the steel surface are all important attributes and must be measured and recorded (in the area where the coatings will be applied) prior to mixing the coating and throughout the application process. Most coating manufacturers indicate, on the product data sheets, the acceptable air and surface temperature ranges—a minimum, maximum or acceptable range for relative humidity—and that the surface temperature should be a minimum of 5 °F higher than the dew point temperature to preclude condensation. Specifying a *minimum* amount of moisture in the air is an important

William D. Corbett (bcorbett@kta.com) is a vice president and group manager–Professional Services with KTA-Tator, Inc.

consideration for coatings that use moisture to cure (e.g., ethyl silicate inorganic zinc primers and moisture cure urethane products). Specifying a *maximum* amount of moisture in the air is an important consideration for coatings that are adversely impacted by excessive humidity during application and cure (e.g., epoxy and polyurethane). While a manufacturer may indicate that a minimum of 40% relative humidity is acceptable, a coating specification can require a minimum of 50% humidity to attain proper cure of a moisture cure product. Similarly, a product data sheet may indicate that up to 90% relative humidity is acceptable; however, the coating specification can invoke a maximum of 85% relative humidity. Ambient conditions and surface temperature can be measured and auto-logged using electronic (digital) psychrometers (Figure 1).

Pre-Blast Ceaning Inspections

Pre-blast cleaning inspection check points include verifying that the abrasive is clean, the compressed air is clean and dry and the grease, oil and other lubricants used during the fabrication process are removed. Note that each of these checkpoints is automatically invoked when an SSPC surface cleanliness standard, such as near-white, is specified (i.e, these are "indirect" requirements of the SSPC *Surface Cleanliness Standards*). These inspections are described below.

Abrasive cleanliness. There are two primary concerns related to contamination of the abrasive media: oil and elevated conductivity caused by soluble salt contamination. The transfer of either of these contaminants onto the steel during cleaning can adversely impact the performance of the coating system; testing is particularly important when the abrasive is recycled. The procedure described in ASTM D7393, *Standard Practice for Indicating Oil in Abrasives* can be specified to verify that the abrasive is not contaminated with oil (Figure 2).

The procedure described in ASTM D4940, *Standard Test Method for Conductimetric Analysis of Water Soluble Ionic Contamination of Blasting Abrasives* can be specified to verify that the abrasive does not contain elevated levels of ionic contamination (Figure 3).

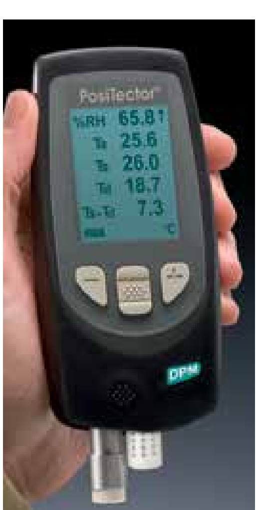
Compressed air cleanliness: Anytime compressed air is used to propel the abrasive during blast cleaning, perform a blow-down to remove surface dust or atomize a coating (e.g., conventional/pressure pot spray), its cleanliness must be verified—i.e., do not assume that the moisture and oil extractors are providing adequate air cleanliness. The procedure described in ASTM D4285, *Standard Test Method for Indicating Oil or Water in Compressed Air* can be specified to verify that the compressed air does not contain water and oil contamination (Figure 4).

Grease/oil removal: Prior to mechanical methods of surface preparation (e.g., abrasive blast cleaning), surfaces must be visually inspected to verify that there is no visible grease, oil lubricants or cutting compounds on the steel surfaces that may contaminate abrasive media or be spread across adjacent surfaces. SSPC-SP 1, *Solvent Cleaning* is an indirect requirement of the SSPC Surface Cleanliness Standards (Figure 5). Inspection of surfaces can be performed visually, by wiping the surfaces with a cotton cloth, using black light florescence or using a water break test. There are no ASTM standards governing this type of inspection; however, it is nonetheless a critical inspection checkpoint.

Post-Blast Cleaning Inspections

After surface preparation is completed, there are two primary inspections that must be performed prior to primer application: an inspection for surface cleanliness and surface profile and a visual inspection of the prepared surfaces for residual dust and abrasives. These inspections are described below.

Fig. 1



Courtesy of DeFelsko Corporation

Fig. 2


Courtesy of KTA-Tator, Inc.

Fig. 3 (above) and Fig. 4 (below)


Courtesy of KTA-Tator, Inc.


Courtesy of KTA-Tator, Inc.

Fig. 5

Assessing surface cleanliness. SSPC and NACE International have jointly published surface cleanliness standards. The two most commonly specified for shop steel include SSPC-SP 6/NACE No. 3, *Commercial Blast Cleaning* and SSPC-SP 10/NACE No. 2, *Near-White Metal Blast Cleaning*. Both of these standards require 100% removal of all mill scale and rust (and paint, if present). SSPC-SP 6 allows up to 33% staining to remain on each 9 sq. in of prepared steel, while SSPC-SP 10 allows up to 5% staining to remain on each 9 sq. in of prepared steel. Verifying either of these levels of surface cleanliness can be challenging, so SSPC created a visual guide (SSPC-VIS 1; Figure 6) containing color photographs of seven initial conditions (rust grades) of steel (four uncoated and three coated) and various degrees of surface cleanliness for each of the initial rust grades, including SSPC-SP 6 and SSPC-SP 10. The visual guides are used to "calibrate the eye" before evaluating surface cleanliness. While the written standard is the governing document, the specifier can invoke the use of SSPC-VIS 1 for the inspection of the prepared surfaces.

Measuring surface profile. Surface profile "anchors" the coating system to the steel, and the depth of the surface profile must be compatible with the coating system. A surface profile that is too shallow can result in loss of adhesion, while excessive surface profile can result in pinpoint rusting of rogue peaks or the consumption of more paint to fill the profile in order to prevent pinpoint rusting. To this end, a minimum and maximum surface profile must be specified; the specifier may also elect to specify the shape of the surface profile (e.g., "angular"). The size of the abrasive media should not be specified; rather it is the responsibility of the shop to determine the proper abrasive size in order to achieve the required surface profile depth.

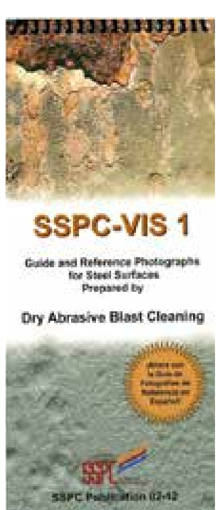
There are two standards for the specifier to consider. ASTM D4417, *Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel* and SSPC-PA 17, *Procedure for Determining Conformance to Steel Profile/Surface Roughness/Peak Count Requirements* are designed to be used in conjunction with one another. ASTM D4417 describes how to acquire measurements while SSPC-PA 17 contains requirements for frequency and location of instrument readings and evaluation criteria to ensure that the profile over the entire prepared surface complies with the project specification (Figures 7, 8 and 9).

Assessing residual surface dust/abrasive. Residual dust and abrasive media that remain on steel surfaces after abrasive blast cleaning is performed must be removed prior to primer application (typically by blowing-down with clean, dry compressed air; vacuuming can also be effective) to prevent loss of adhesion as well as coating defects (pinholes). Oftentimes specifications will require a "dust-free" surface, which is essentially impossible to achieve (or for that matter, verify). The most common method of assessing surface dust is not covered by a standard and involves wiping a lint-free clean cloth across the surface and visually observing the surface for "swipe marks." When swipe marks are no longer discernible, the surface is considered ready for primer application. Alternatively, a specifier may elect to invoke ISO 8502, Part 3 – "Assessment of Dust on Steel Surfaces Prepared for Painting," which incorporates the use of a clear adhesive tape that is pressed onto the surface and removed. The tape is compared to a rating chart that illustrates five levels of surface dust. Dust size can also be comparatively rated by this method, although arguably less important. Naturally if this method is invoked, the acceptable level of dust must also be specified.

Coating mixing, thinning and application inspection. In this case, a review of the manufacturer's product data sheets, combined with observation, is the best "tool" available to verify that the coating materials are being mixed, thinned and applied properly

Courtesy of KTA-Tator, Inc.

Fig. 6



Courtesy of KTA-Tator, Inc.

Fig. 7

Courtesy of KTA-Tator, Inc.

Fig. 8

Courtesy of KTA-Tator, Inc.

Fig. 9

Courtesy of KTA-Tator, Inc.

Fig. 10

Fig. 11

(Figure 10). In fact, coating specifications often invoke the PDS for mixing and thinning instructions. PDS' also contain recommendations for compatible application equipment, spray pressures, tip sizes, etc. Note that the thinner type and amount is considered an essential variable by the *Specification for Structural Joints using High Strength Bolts*, Appendix A—"Testing Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints," published by AISC and the Research Council on Structural Connections (RCSC). Consideration should be given to this when connections are slip-critical. The minimum cure time, coating thickness and thinner type/amount are all listed on the test certificate prepared by the testing laboratory. The certificate can typically be provided to the shop by the coating manufacturer.

Dry film thickness. Achieving the specified thickness of each coating layer is perhaps one of the more challenging tasks for an applicator, particularly when complex elements are being coated. Measurement of coating thickness is governed by two standards: ASTM D7091, *Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals* and SSPC-PA 2, *Procedure for Determining Conformance to Dry Coating Thickness Requirements*. Like surface profile measurement, the two standards are designed to be used in conjunction with one another. The ASTM standard focuses on gage use (Figure 11), while the SSPC standard focuses on the frequency of coating thickness measurement, the acceptability of the measurements and how to handle nonconforming areas of thickness. Appendices 2 and 3, while not mandatory, provide methods for measurement of coating thickness on steel beams (girders) and for a laydown of beams, structural steel and miscellaneous parts after shop coating. The appendices can be invoked by the specifier if desired; otherwise the frequency of measurement is based on 100-sq.-ft areas. Note that the current (2012) version of SSPC-PA 2 contains a chart listing five "Coating Thickness Restriction Levels." Each level provides a tolerance for gauge readings (each individual gauge measurement), spot measurements (the average of five gauge readings within a 1.5-in. circle) and area measurements (the average of five spot measurements over 100-sq.-ft areas). If the level is unspecified, then Level 3 becomes the default (gauge readings unrestricted; spot measurements +/-20% of the specified thickness range; area measurements within the specified range). The tolerance of the spot measurements for Levels 1 and 2 are more restrictive, while levels 4 and 5 are less restrictive. Also, if the specifier does not establish an acceptable range of thickness for each coating layer (and the manufacturer does not indicate a range on the PDS), the range (minimum and maximum thickness) is established at 20% of the target thickness.

Curing. Drying, dry-to-recoat and curing are not the same, especially when it comes to industrial protective coatings. For example, inorganic zinc-rich primers (commonly used in the shop) dry very quickly, especially in a heated shop. However these primers need moisture to cure, so topcoating them when they appear to be dry but before adequate dry-to-recoat times are achieved can result in catastrophic delamination failure. Depending on the conditions in the shop and the coating type, it may take 18 to 24 hours or more (even a few days) before an applied coating has achieved an adequate dry-to-recoat condition. (For ethyl silicate inorganic zinc-rich primers, the coating manufacturer may permit misting with water or steam—after an initial cure for a few hours—to keep the coated surface wet for a minimum amount of time, in order to accelerate curing or to promote curing when the relative humidity is too low.) Solvent rub tests and hardness tests can be used to verify that coatings are dry-to-recoat and can withstand the solvents and contractive curing stresses of subsequent coating layers. ASTM D5402, *Standard Practice for Assessing the Solvent Resistance of Organic Coatings Using Solvent Rubs* can be used on convertible coatings like epoxy and urethane, while ASTM D4752, *Standard Practice for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub* was written specifically for assessing the cure of inorganic zinc-rich primers. Pencil hardness (ASTM D3363) is referenced by some coating manufacturers to assess the hardness of the applied coating. In this case, a minimum hardness value is used as an indication of adequate dry-to-recoat condition or cure. (Note that full curing of some coatings can take weeks or months to achieve, but the coating is serviceable during this time.)

Specifying quality and verifying quality workmanship (i.e., specification compliance) helps reduce the opportunity for premature coating breakdown and/or failure of the corrosion prevention system. Despite what can seem to be a higher up-front cost, facility owners should recognize the value and long-term benefits that come with preparing a well-written specification and contracting with a fabrication shop that embraces quality. Specifying an AISC-420-10/SSPC-QP 3 certified shop is a step in the right direction.