Surface Preparation: Practices, Equipment, and Standards through 25 Years

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As surface preparation practices, regulations, and equipment changed, so did SSPC’s standards. This article looks at the changing world of surface preparation through the lens of SSPC’s ever-evolving standards. The article is not intended to be comprehensive.

**Abrasive Blasting and Its Continuing Impact**

In the premiere issue of *JPCL* (June 1984, p. 31), John D. Keane wrote a feature on the process of developing surface preparation specifications. In the article, he wrote, “Surface preparation is the first component in the painting system concept, which has come to mean a union of the principal elements in a protective coating scheme.” At the time of the article, four abrasive blasting standards were available, and by 2009, not only had these standards been updated and reconciled with their counterpart documents from NACE International, but a fifth was added to the list.

In 1985, SSPC-SP 5, White Metal Blast Cleaning, was used when the highest degree of blast cleaning was required. This degree of cleaning left no visible matter on the surface. In 2009, the standard has the same expectations, but became a joint standard with NACE in 1994, making its full title SSPC-SP 5/NACE No. 1, White Metal Blast Cleaning.

Commercial Blast Cleaning, known as SSPC-SP 6 in 1985, produced a surface with no visible foreign matter except for staining, which was limited to 33% of each square inch of surface. It was also permissible for slight residues of rust and paint to be left on the bottoms of pits if the original surface was pitted. Since 1994, the standard has become a joint effort, titled SSPC-SP 6/NACE No. 3. As of 2009, the staining is still acceptable at 33%, but the area covered is now 9 square inches. In addition, residues of rust or paint are no longer permitted in the bottoms of pits. Added to the specification is, “The presence of toxic metals in abrasives or coating being removed may place restriction on the methods of cleaning permitted. The chosen method shall comply with all applicable regulations.”

SSPC-SP 7 (called SSPC-SP 7/NACE No. 4 since 1994), Brush-Off Blast Cleaning, allows tightly adherent mill scale, rust, and paint to remain on the surface if they cannot be removed with a dull putty knife. The recent online version adds that surface imperfections must be removed before and after cleaning based on the requirements in procurement documents. Also, toxic materials in the abrasives or coatings removed may place restrictions on the methods of cleaning permitted.

Near-White Blast Cleaning, SSPC-SP 10 in 1985 and SSPC-SP 10/NACE No. 2 after 1994, allows no visible foreign matter, with the exception of some staining. In 1985, the staining was limit-
ed to 5% of each square inch. In 2009, the standard limits staining to 5% of each unit area, which is defined as 9 square inches. This standard also added that toxic materials might restrict the cleaning methods permitted.

In 1998, SSPC and NACE formed a new joint standard—SSPC-SP 14/NACE No. 8, Industrial Blast Cleaning. There was a need for a degree of cleaning between commercial and brush off that would remove most, but not all, of the paint and mill scale. An industrial blast cleaned surface allows tightly adherent mill scale, coating, and rust to remain on less than 10% of each unit area. The presence of some discoloration from previously applied coatings or stains is acceptable.

A new standard nearing completion addresses brush-off blast cleaning of non-ferrous metal surfaces. The standard is needed for the cleaning and roughening before painting of metals such as stainless steel, aluminum, and galvanizing.

In the 1980s, many concerns about surface preparation centered on fine-tuning the available standards, but as the industry became increasingly aware of the risks of abrasive blasting, protection of workers and the environment drove much of the product development in the early 90s. An article in the June 1992 JPCL (p. 5) stated that 80 out of the 140 products included in the Buyer’s Guide Review were for surface preparation. Again in June 1993, a JPCL article noted that 86 out of the 134 products introduced in the New Product Review were for surface preparation (p. 6). Plastic media blasting machines were offered, touting soft particles that could be recycled. Machines for abrasive blasting now offered a vacuum system as well to remove and collect dust and loose abrasive to protect the environment and the workers’ breathing zone. Companies pushed to develop the machine that could clean the largest amount of surface area in the least amount of time with reduced risks to workers. In 1996, there were blasting machines that could hold 27 tons of steel abrasive and others that could operate three nozzles simultaneously. In 1998, robotic blasting equipment operated by remote controls was introduced (JPCL, June 1996, p. 32; Jan. 1998, p. 102; Sept. 1998, p. 96). Efforts continue in the 21st century to improve abrasive blasting equipment (see, for example, JPCL, May 2005, p. 22).

A Profile of Standards for Abrasives
When JPCL launched in 1984, SSPC did not have standards for abrasives. Now the industry has three guides with a fourth on the way. The standards were necessary because the industry needed a way to control the quality of abrasives being provided, the cleanliness of recycled abrasives, and the use of recycled ferrous abrasives when removing lead paint.

SSPC-AB 1, Mineral and Slag Abrasives, defines the requirements for selecting and evaluating mineral and slag abrasives intended for one-time use without recycling. The guide categorizes the abrasives into two types, three classes, and five grades, specifying physical and safety requirements.

Cleanliness of Recycled Ferrous Metallic Abrasives is covered in SSPC-AB 2. Recycled ferrous metallic abrasives are valued for their ability to be reused, but debris needs to be removed prior to each reuse, and precautions need to be taken when working with lead and other hazardous materials. The SSPC standard defines the necessary testing procedures.

The third standard for abrasives, SSPC-AB 3, Ferrous Metallic Abrasive, defines previously unused ferrous metallic abrasives. It divides the materials into two shapes (round or angular) and two classes (steel or iron). Physical and chemical properties, test methods, and acceptance criteria are defined.

A fourth abrasive standard currently in its final stages of development will cover abrasives encapsulated in a compressible open-cell (sponge-like) material—a novel abrasive material that did not exist in 1985.

Sand continued to be used for blast cleaning in the U.S., with protection added for workers and the environment, but mineral abrasives, mainly from naturally occurring sources, or slags produced as by-products of refining or smelting operations, gained market share (JPCL, Nov. 1984, p. 34), as did recyclable steel abrasives, as evidenced by SSPC-AB 2 and AB 3. (Editor’s Note: On the need for protection from any abrasive, sand or other, containing free silica, see “Regulations and Coatings Work: Developments over 25 Years,” pp. 72-77.) In 1985, the Navy used walnut shells as an abrasive to remove layers of spent antifouling paint while leaving the underlying sound anticorrosion system intact (JPCL, March 1985, p. 6). Plastic abrasives were promoted in the late 80s, with claims of little dust and the ability to be recycled at least ten times. During the 90s, dry ice and sponge media garnered attention in the industry, as these methods offered innovative ways to increase portability and perform a “softer” cleaning.
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The Expanding Standards for Power Tool Cleaning

Two and a half decades ago, only one standard for power tool cleaning existed. SSPC-SP 3, simply titled “Power Tool Cleaning,” defined the practice as a method of preparing steel surfaces by the use of power-assisted hand tools to remove loose mill scale, loose rust, loose paint, and other detrimental foreign matter, but not adherent matter. The methods listed in the standard were rotary or impact power tools for the removal of rust scale, and power wire brushing, power abrading, and other power rotary tools for the removal of mill scale, rust, and paint.

Since the 80s, SP 3 has not changed much, but it has been revised to require nonvisible surface contaminants to be treated as agreed upon in procurement documents and to add points of reference from new SSPC Visual Standards, as well as others. Power Tool Cleaning to Bare Metal, SSPC-SP 11, was added in 1987, prompted by a request from the nuclear industry to provide a degree of cleaning and roughening similar to abrasive blast, but with power tools. Power tools were preferred because the dust generated by blast cleaning could not be tolerated within the primary containment of a nuclear power plant.

SP 11 requires the removal of all rust, mill scale, and paint, and producing or retaining a surface profile of a minimum of one mil. Tools that can be used under this standard are identified as surface cleaning or profile producing. Surface cleaning media include a non-woven synthetic fiber web material impregnated with an abrasive grit, and coated abrasive discs, coated abrasive flap wheels, and coated abrasive bands. Profile-producing media include rotary impact flap assemblies, needle guns, cutter bundles, and hammer assemblies.

Differing slightly from SP 11 is SSPC-SP 15, Commercial Grade Power Tool Cleaning. It still requires a surface profile of at least one mil, but allows stains of rust, paint, or mill scale to remain on the surface. It provides a much higher degree of surface cleanliness than is required by SP 3, but not the extreme cleaning mandated by SP 11. The acceptable tools and media are the same as allowed in SP 11.

SP 15 was developed when the industry started dealing with lead, and the use of vacuum shrouded tools became more commonplace for localized paint removal. SP 11 was extremely costly to achieve on large surfaces such as top flanges of bridge beams when a deck was replaced, so a degree of cleaning with power tools that approached SP 11 but was more practical to achieve in the field was needed.

As the desire for alternatives to abrasive blast cleaning grew, so did the product line for power tools. New orbital sander disc pads became available with different diameters and constructed out of materials like uniform action urethane foam with a fiberglass/epoxy backing (JPCL, Nov. 1990, p. 149). The Sept. 1992
JPCL described a project that specified a dustless power tool system with three shrouded needle guns attached to a vacuum to remove lead-based paint from portions of several bridges (p. 83). In this decade, new, smaller tools have been developed such as a power tool, or suction blast tool, that uses compressed air, hoses, and conventional abrasive media to clean small surfaces where standard (large) abrasive blasting equipment is not practical (JPCL, July 2006, p. 17). Another new product is a rotary bristle tool with heat-treated steel wires operating at around 2,500 rpm (JPCL, Jan. 2009, p. 67).

**Water Jetting: The Pressures Mount**

Although dry abrasive blasting of carbon steel substrates dominated the surface preparation industry for decades, environmental and worker health regulations related to the hazardous waste generated by blasting prompted the pursuit of alternatives. Water jetting, one such alternative, reduced worker and environmental exposure to lead dust and particulate emissions, and initially gained a foothold in the marine industry.

Water jetting does not produce an anchor pattern/profile—it is primarily used for surfaces where a profile already exists, particularly those surfaces on which abrasive blasting will not remove all contaminants, such as those found at the bottom of pits of corroded metal. Respiratory exposure and work area air quality requirements for water jetting can be less stringent than those for abrasive blasting because water jetting creates less dust, although exposures still exist.

In 1985, no standard for the use of water jetting had been published. In the first issue of JPCL, June 1984 (p. 53), there is a brief product announcement for a “water blaster” that operated at 20,000 psi and could achieve an SSPC-SP 5 White Metal finish. To see how much water jetting technology advanced since 1984, jump ahead 17 years, to the May 2001 issue (p. 22), where an ultra-high-pressure (UHP) water jet product is described that operates at 55,000 psi, developed “for the removal of tenacious coatings such as anti-skid coatings on aircraft carriers.”

To help make water jetting practices uniform, and because water jetted surfaces exhibit flash rust, leaving a surface with an appearance different than that created by abrasive blasting, a joint standard was approved in 1995: SSPC-SP 12/NACE No. 5, “Surface Preparation and Cleaning of Metals by Water-jetting Prior to Recoating.” The standard was revised July 2002.

In 1884 the A.W. Chesterton Company started business as a purveyor of steamboat and engineers supplies. The company’s focus was on providing a broad range of high value products to the shipping industry specifically designed to minimize the time a ship spent in port. This was very important to a shipping industry busy transporting products that were driving the industrial revolution around the world.

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Requirements of the standard include the end condition of substrate and the materials and procedures necessary to verify the end condition. Table 1 of SP 12 shows a unique characteristic of this standard. Rather than SP 12 defining a single grade of cleaning, it encompasses four different definitions of surface cleanliness in terms of visible appearance: WJ-1, Clean to Bare Substrate; WJ-2, Very Thorough or Substantial Cleaning; WJ-3, Thorough Cleaning; WJ-4, Light Cleaning. To properly utilize SP 12, the specifier must invoke both SP 12 and WJ-1, 2, 3, or 4. To make the water jetting standard consistent with the other surface preparation specifications, SP 12 is currently being split into four new separate standards, based on these four grades of cleanliness; these new standards are near completion. Each grade of cleaning will then be assigned its own SP number.

Other advances include hand-held and robotic UHP units; developments in UHP pumps, nozzles, and lances that increase productivity; and, as described in the Aug. 2005 JPCL (p. 14), reverse osmosis circuits that desalinate water used in UHP operations, thus improving water quality, which helps maintain the performance of the plunger pumps used in UHP equipment.

Wet Abrasive Blasting: The Blast of Both Worlds?
Wet abrasive blasting equipment, methods, and standards have advanced in a parallel fashion to those aspects of water jetting. An SSPC technical report (TR) was published in May 1998, revised in November 2004, and is currently undergoing another revision. At the time of JPCL's debut, however, no standard existed for the use of wet abrasive blasting; as of 2009, SSPC reports that one is nearing completion.

SSPC-TR 2/NACE 6G198, "Wet Abrasive Blast Cleaning," is a joint technical report that covers procedures, equipment, and materials used in a variety of air/water/abrasive, water/abrasive, and water-pressurized abrasive blast cleaning systems.

Revisions to the technical report and forthcoming standard are in response to the increased use of this technique, which provides degrees of surface cleanliness comparable to dry abrasive blasting while controlling the associated dust. As with water jetting, wet abrasive blasting creates flash rust, which entails a surface appearance different than that of dry abrasive blasting, and therefore a different standard for evaluation.

Generally, wet abrasive blasting can be used on any substrate for which the use of abrasive is appropriate. The water and abrasive function remove contaminants, while the abrasive creates the profile. The technical report discusses wet abrasive blasting equipment; the selection of abrasives; the use of rust inhibitors; equipment operation; and safety guidelines. The draft standard defines surface cleanliness according to the five grades of dry abrasive blast cleaning, three levels of flash rusting, and requirements before and after cleaning.
Visual Standards Help Users See Eye to Eye

As JPCL’s Harold Hower noted in the March 1994 JPCL (p. 70), there is “sufficient ambiguity in the end condition definitions” contained in specifications for the many forms of surface preparation—and visual standards are therefore useful. In the 25 years since the first issue of JPCL, SSPC has developed the following four visual standards for surface preparation. These standards, consisting of photos and directions laminated on heavy stock paper, are products available from SSPC.

- SSPC-VIS 1, Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning
- SSPC-VIS 3, Guide and Reference Photographs for Steel Surfaces Prepared by Power- and Hand-Tool Cleaning
- SSPC-VIS 4/NACE VIS 7, Guide and Reference Photographs for Steel Surfaces Prepared by Waterjetting
- SSPC-VIS 5/NACE VIS 9, Guide and Reference Photographs for Steel Surfaces Prepared by Wet Abrasive Blast Cleaning

The history of the development of VIS 1 reaches even further back in time. The original SSPC definitions of blast cleaning, dated 1952, were written, and the emphasis was on the rate of cleaning; in 1963, the definitions were revised to focus on the thoroughness of the cleaning. Also in 1963, Swedish Standards (SIS 05 59 00-1962) were published for use as a pictorial reference for the appearance of blast-cleaned steel.

The Swedish Standards were in use internationally for the next 20 years, but in the early 1980s, concerns mounted that the Swedish photographs, particularly BSa2, contradicted the SSPC written definitions of the same purported conditions. Meanwhile, the Swedish Standards were in the process of being approved by the ISO as international standards, and the disparity was not being addressed. SSPC therefore set out to develop its own visual standards, the first of which, VIS 1, was published in Sept. 1989.
For VIS 1, in fact for all SSPC visual standards, the photographs are supplemental, used as a visual aid in making judgments, and the written specification takes precedence.

VIS 3 was issued in 1993 and revised in 2003; its development can be credited to several factors, including the increased use of power tool cleaning and new environmental regulations.

SSPC and NACE jointly introduced SSPC-SP 12/NACE No. 5, the water jetting standard, in 2002. Visual standard SSPC-VIS 4/NACE VIS 7 shortly followed to depict the four cleanliness conditions described in SP 12. The three levels of flash rusting defined in SP 12 are also depicted in VIS 4.

The year 2002 also saw the publication of VIS 5, which was developed to visually correspond to the written standards SSPC-SP 6/NACE No. 3, Commercial Blast Cleaning, and SSPC-SP 10/NACE No. 2, Near-White Blast Cleaning, when created by wet abrasive blast cleaning. The three levels of flash rusting are also shown over each cleanliness level.

**Coating Concrete? Be Prepared**

Structural steel is not the only substrate in industrial facilities that benefits from the use of protective coatings. Concrete, the most common material of construction in the world and one that is widely used in industrial settings, also benefits from the use of coatings. Consensus standards for preparing and coating concrete have trailed those for structural steel, however, with one of the major issues being the very definition of concrete. Unlike steel, what comprises concrete is so variable that its appearance cannot be defined.

No standard for preparing concrete existed in 1985. SSPC-SP 13/NACE No. 6, “Surface Preparation of Concrete” was approved in 1997 and reaffirmed in March 2003. The standard states, “This standard gives requirements for surface preparation of concrete by mechanical, chemical, or thermal methods prior to the application of bonded protective coating or lining systems. The requirements of this standard are applicable to all types of cementitious surfaces including cast-in-place concrete floors and walls, precast slabs, masonry walls, and shotcrete surfaces. An acceptable prepared concrete surface should be free of contaminants, laitance, loosely adhering concrete, and dust…” Table 1 in the standard provides “Suggested Acceptance Criteria for Concrete Surfaces After Surface Preparation.” These criteria include surface tensile strength,
profile, cleanliness, residual contaminants, pH, and moisture content.

In an Aug. 1997 JPCL article (p. 48), Fred Geliff, then the chair of SSPC/NACE Joint Task Groups on concrete, says that increasing federal and state regulations on secondary containment were responsible for growing interest in and, thus, development of consensus documents on the protection of concrete.

There have been countless developments in the equipment and methods used to prepare concrete for coating. A May 1989 JPCL Maintenance Tip article (p. 25) breaks down concrete preparation into six basic methods: cleaning and etching, abrasive blasting, scabbling, scarifying, shot blasting, and UHP water jetting. Many of the developments in the gear used to perform these tasks involve capturing or containing the dust generated, and making the equipment more ergonomically designed. For example, the June 2008 JPCL (p. 64) describes an edge grinder that allows the user to grind in an upright position, helping to reduce fatigue, backaches, and jobsite injuries. Another example of advances in the preparation of concrete is described in the Dec. 2002 JPCL (p. 71): controlled permeability formwork (CPF), which consists of liners applied to conventional formwork. The CPF liner reportedly retains cement fines during compaction, while allowing water and air to escape from the interface of the concrete and the formwork, thus eliminating most common surface blemishes. This creates a surface that is said to only require cleaning, thus bypassing the need for mechanical or other preparation techniques.

Conclusion
All SSPC standards are available through sspc.org. SSPC members can download standards at no cost.

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