PPG Surface Preparation

Guide by substrate

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General surface preparation requirements

Governing industry standards for surface preparation are set forth by organizations such as the Society for Protective Coatings (SSPC), NACE International, the International Standards Organization (ISO), and the International Concrete Repair Institute (ICRI). Many of the published standards can be cited interchangeably.

Regardless of the substrate, the degree of adhesion and level of performance of protective coatings is dependent on the degree of surface preparation obtained. A properly prepared surface has the following characteristics:

- Sound and cohesively strong
- Clean and free of loose particles and contaminants
- Dry
- Exhibits a surface (anchor) profile for maximum adhesion of protective coatings

It is self-evident that surfaces must be clean for good coating adhesion. This means any oil, grease, chemicals, and particulate residues should be removed from the surface. The governing standard for removing visible contaminants from steel surfaces is SSPC SP-1. This can be accomplished by several methods, including wiping the surface with volatile solvents or power washing with or without emulsifying cleaners. Achieving an SSPC SP-1 criteria is a prerequisite to any of the other SSPC surface preparation requirements.

In many cases, such as coastal environments, mining, or some industrial processes, the surface has been exposed to soluble salts. Relatively low levels of soluble salts on the surface can cause premature coating failures. The soluble salts form an electrolytic solution which accelerates the rate of corrosion. Further, the soluble salts "pull" water through the coating film through osmotic pressure. This results in blistering of the coating. Depending on the service, there are varying levels of soluble salt levels recommended by PPG as detailed in the appendix.

Prior to abrasive blasting and subsequent coating application, it is important to address surface defects in structural steel and other metallic substrates such as rough welds, weld spatter, flame cut edges, laminations, protrusions, and sharp edges. NACE SP-0178 may be used as a guideline for specifying the degree of mechanical surface preparation required.

In general, it is recommended to remove any embedded weld spatter, laminations, or other protrusions which may not be covered by the protective coatings. For immersion service, rough or sharp edges should be ground to produce a smooth, rounded surface. Welds in immersion service should be ground to a condition "D" or smoother as per NACE SP-0178. For immersion or high temperature service, a higher level of weld preparation should be specified.

Preparation of mild (carbon) steel

Carbon steel is processed from a very stable raw material, iron ore. For the remainder of its service life, steel has the tendency to transform back into oxide or "rust." Protective coatings are the primary method for preserving steel structures. New hot-rolled steel develops a hard oxide layer called mill scale. It has a bluish-black appearance. The mill scale is electro-chemically cathodic to the underlying steel layers and as such will promote corrosion at varying rates depending on the prevailing environmental conditions. This being the case, mill scale should be removed prior to application of coating systems where long service lives are expected.

There are several processes available to prepare steel for coating application. Following are some common methods.

Dry abrasive blasting

Thorough blast cleaning with the proper abrasive is generally considered to be the best method for preparing steel. The applicable standards for blasting are as follows:

SSPC SP-5 / ISO 8501-1 Sa 3 / NACE 1

White metal blast cleaning requires the surface to be free of oil, grease, dirt, mill scale, rust, corrosion products, oxides, coatings, or foreign matter. Each square inch of surface area shall be completely free of all visible residues.

Since SSPC SP-5 does not allow for any level of rust staining in the substrate, it is often considered to be too stringent for practical specification.

SSPC SP-6 / ISO 8501-1 Sa 2 / NACE 3

Commercial blast cleaning requires removal of mill scale, rust scale, coatings, oil, grease, dust, dirt, oxides, corrosion products, and other foreign matter. Random staining must be limited to no more than 33% of each unit area of surface (3-inch x 3-inch area) and may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coating. An SSPC SP-6 standard is commonly specified for fabricated structural steel projects for atmospheric service environments.

SSPC SP-10 / ISO 8501-1 Sa 2.5 / NACE 2

Near white metal blast cleaning requires the surface to be free of all visible oil, grease, dust, dirt, mill scale, rust, coating, oxides, corrosion products, and other foreign matter. Random staining must be limited to no more than 5% of each unit area of surface (3-inch x 3-inch), and may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coating.

An SSPC SP-10 is the typical standard for preparation of steel for immersion, high temperature or other aggressive environments.

Abrasive selection

There are many abrasives available for blasting. Common blasting abrasives include:

- Steel grit
- Staurolite
- Garnet
- Glass beads
- Silica sand
- Coal slag
- Copper slag
- Aluminum oxide
- Steel shot
- Steel shot/grit mixtures

Abrasives are generally selected on the following attributes:

Size

Large particle sizes and heavier abrasives contain more impact energy and produce deeper profiles. Smaller abrasives are beneficial for scouring and light cleaning. Smaller abrasives also increase the number of impacts per area, effecting a more dense profile.

Shape

Shot spheres have an efficient geometry which maximizes the amount of weight per volume, thereby maximizing impact energy. However, angular abrasives (grit, amorphous shapes, etc.) are often specified to produce an angular profile which enhances adhesion of coatings.

Material

Ferrous abrasives are effective and widely used, but they are prone to corrosion if left embedded in the surface. They also have the benefit of being recycled and separated from other residue using magnetic attraction. Other abrasives are selected due to their level of cleanliness (such as the degree of salt contamination) or due to toxicity concerns.

Hardness

Harder abrasives are more resistant to wear and degradation. This maximizes the service life. Sufficient hardness is also needed to properly profile substrates that are very hard (or very soft).

Power tool cleaning

Power tool cleaning employs the use of angle grinders fitted with abrasive discs, wire wheels or cup brushes; needle guns; and power sanders, to remove loose rust and paint from the surface and in some cases to produce a profile.

SSPC SP-3 requires the removal of all rust scale, mill scale, loose paint, and loose rust to the degree specified by the use of various power tools. The substrate should have a pronounced metallic sheen and also be free of oil, grease, dirt, soil, salts, and other contaminants. The surface should not be buffed or polished smooth. SSPC SP-3 is suitable for maintenance operations and spot repairs in atmospheric exposures.

SSPC SP-11 requires the surface to be free of all rust scale, mill scale, rust, paint, oxides, corrosion products, and other foreign matter by the use of various power tools. Slight residues of rust and paint may be left in the lower portions of pits if the surface is pitted. The surface must be roughened to a degree suitable for the specified paint system and must have a surface profile of not less than 1 mil (25 microns). SSPC SP-11 is often specified in lieu of SSPC SP-3 in applications where spot repairs are made for coating systems in immersion service or other severe service environments.

SSPC SP-15 is commercial power tool cleaning. It is a modification of SSPC SP-11 which allows for up to 33% rust staining over the surface.

Hand tool cleaning

Hand tool cleaning employs scrapers, wire brushes and chipping hammers, and manual sanding. Hand tool cleaning is chosen when other methods are not practical such as remote or inaccessible areas. The quality of surface preparation is not optimum and the service life of coatings will be limited as compared to other surface preparation methods. However, it is often sufficient for maintenance painting to clean all loose corrosion products, mill scale, and coatings in order to achieve sufficient adhesion for the purposes.

SSPC SP-2 is a common standard for the use of hand tools to prepare steel for painting. This standard requires the removal of all rust scale, mill scale, loose paint, and loose rust to the degree specified by the use of various power tools. The substrate should have a pronounced metallic sheen and also be free of oil, grease, dirt, soil, salts, and other contaminants. The surface should not be buffed or polished smooth. SSPC SP-2 is suitable for maintenance operations and spot repairs in mild-to-moderate atmospheric exposures where abrasive blasting is not possible or practical.

Chemical treatments

Chemical conversion coatings usually involve phosphoric acid solutions applied via a dip or spray process to produce a surface rich in iron phosphate, zinc phosphate, or manganese phosphate. The crystalline phosphatized surface is porous and allows protective coatings to form a mechanical bond. Further, the phosphatized surface is less corrosive than the underlying steel.

Water jetting

Water jetting employs the use of water pumped to pressures greater than 10,000 psi and sprayed via a lance on the substrate. Water jetting is typically used for maintenance and repair operations. It has found wide acceptance in shipyards and in other industries where large, continuous, flat surfaces are to be prepared. Water jetting can be a cleaner alternative to abrasive blasting where the contamination, dust/particulate generation, and clean-up of spent abrasive is undesirable. Further, the water from water jetting has the added benefit of reducing the level of soluble (salt, et al.) contaminants. Though water jetting cannot produce a surface profile on metal substrates, it can remove tightly adherent coatings and corrosion products.

Use of pressures in excess of 30,000 psi is categorized as ultra-high-pressure water jetting. Pressures in this range are capable of removing all coatings and tightly adherent mill scale.

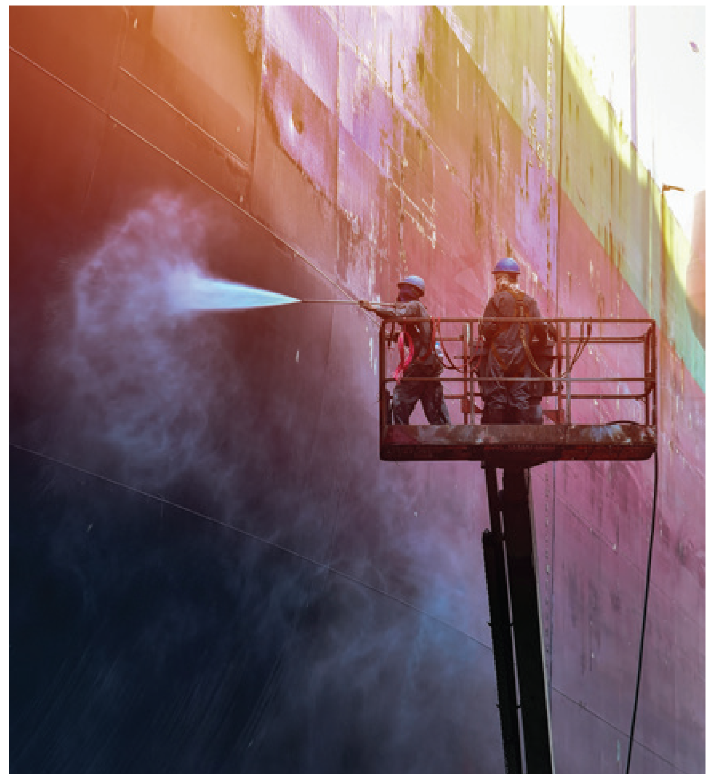
The SSPC water jetting standards are closely aligned with the abrasive blasting standards with graduated degrees of surface cleanliness as follows:

- SSPC WJ-1 (Clean to bare substrate)
- SSPC WJ-2 (Very thorough cleaning)
- SSPC WJ-3 (Thorough cleaning)
- SSPC WJ-4 (Light cleaning)

With wet cleaning methods, flash rusting is almost unavoidable. The rate of flash rusting is dependent on surface cleanliness, water quality and chemistry, surface temperatures, and environmental conditions. Per the SSPC standards, flash rusting is classified into Light, Medium and Heavy. Heavy flash rusting is generally considered to be deleterious to coating adhesion and performance. Light and Medium flash rust levels may be acceptable for coating application.

Wet abrasive blasting

Wet abrasive blasting is a surface cleaning technique which utilizes various configurations for injection of blasting abrasives into a high-pressure water stream or shrouding a blast nozzle with a water ring to mitigate dust generation. Wet abrasive blasting utilizes attributes of both water jetting and dry abrasive blasting to produce a clean surface using a dust-free method along with a surface profile.



Preparation of non-ferrous metal and stainless steel

Common non-ferrous metal substrates include aluminum, copper, brass and tin. For optimum performance and for coatings specified in aggressive service conditions, PPG recommends brush blasting the substrate using an angular non-metallic abrasive to produce a uniform and dense anchor profile in accordance with the specified product requirements. The applicable specification for this is SSPC SP-16.

For thin film coating systems (< 15 mils) specified for mild-to-moderate service conditions (ISO 12944 C1-C3), alternative methods of surface preparation can include chemical treatment via a chromating conversion coating product in accordance with Mil-DTL-5541 or sanding to produce a profile using medium-coarse, hard abrasive sandpaper.

Aluminum alloys can also be anodized to form a heavy oxide layer. Anodized aluminum lends itself well to coating adhesion. For more aggressive service conditions or for high build coating systems, additional abrasion of the surface may be recommended.

Stainless steel substrates in aggressive service conditions should be abrasive blasted using a non-ferrous, hard, angular abrasive in accordance with SSPC SP-16. In some cases with limited surface area, the surface can be abraded using power tools appropriate for SSPC SP-11 standards.

These substrates may also be considered for the use of polyvinyl butyral etch primers. These should be selected after confirming the compatibility with the proposed coating system and should not be specified in aggressive service environments.

Preparation of hot dipped galvanized steel

New galvanizing is typically very smooth. This smooth surface will typically limit the adhesion of coatings to an unacceptable level and further preparation is required. Some galvanizing is post-treated with chromate solutions to further passivate the surface. On some occasions oils are used to prevent wet storage stain. Either of these treatments will result in poor adhesion of protective coatings. Galvanized surfaces should always be cleaned by solvent wiping or detergent cleaning to remove oils. Also, coatings are not recommended over chromate-sealed galvanizing. Chromates can be detected by applying lead acetate solution to the surface. This is a colorimetric test described by ASTM B 201 where the solution turns black if the surface does not contain chromates. Chromated galvanizing must be brush blasted in accordance with SSPC SP-16 and re-tested to ensure the zinc chromate surface is removed.

The two primary approaches to preparation of new galvanized steel are:

1. Abrading
2. Chemical conversion

The primary surface preparation recommendation for optimum performance is to brush blast the galvanized surface in accordance with SSPC SP-16 guidelines. Smaller areas may be sanded using a hard abrasive to roughen the galvanizing.

New galvanizing can also be phosphatized with various conversion coatings to produce a zinc phosphate surface which promotes coating adhesion. Weathered galvanizing (with typically 12 months or greater of unprotected exterior exposure) will have a surface layer of the zinc corrosion product – commonly called “white rust.” Weathered galvanizing is dull and the surface has more porosity which promotes good adhesion with suitable primers. After white rust is removed by mechanical cleaning or pressure washing, the surface is recoatable with epoxy primers. Do not prime galvanizing with alkyd primer which may saponify and peel.

Preparation of Galvanneal and Galvalume®

These materials are generally used for metal building panels. They are prepared by modification of the hot-dipped galvanizing process which leaves a dull surface which provides for good coating adhesion for relatively thin film systems. Surfaces should be clean. When Galvanneal and *Galvalume* are specified in very aggressive service conditions, additional surface preparation recommendations may be necessary.

Preparation of ductile iron and cast iron

The exterior of ductile iron pipe and fittings typically contains a layer of annealing oxide that is very passive and well adhered. It also provides somewhat of a “macro” pattern for a surface profile. This can be enhanced with a “micro” profile with abrasive blasting, but over-blasting of this annealing layer can cause laminations and “blistering” of the outer annealing layer. This compromises the corrosion protection and can cause subsequent bubbling of coatings when applied.

In general, the steel abrasive blast standards do not apply well to ductile iron substrates. Blasting is typically a controlled and thorough brush blast which is monitored by the pipe / fitting fabricator to ensure the proper degree of blasting is obtained. The internals of ductile iron pipes and fittings do not have the same type of annealing layer and can be blasted more aggressively depending on the requirements of the lining being applied. Please refer to NAFP Standard 500-03 for further information on surface preparation of ductile iron pipe and fittings.

Cast iron also has varying degrees of natural surface porosity and often does not require further abrading for sufficient coating adhesion. However, abrasive blasting can and should be performed to enhance the anchor profile when needed for aggressive service conditions.

Preparation of Concrete and CMU

General

The composition, quality, and condition of concrete is more variable than possibly any other substrate. Surface preparation is often complicated and extensive due to the variable properties of concrete. The overall goals for concrete surface preparation are as follows:

- Removal of weak surface layers
- Removal of efflorescence and other surface contaminants
- Abrading to effect a suitably roughened surface for mechanical adhesion
- Testing the surface to ensure there are no hydrophobic compounds such as waterproofing sealers
- Testing for moisture content of the concrete and moisture transmission rates through concrete slabs-on-grade.
- Filling bug holes, cracks, and other surface discontinuities for proper sealing

Two of the more common comprehensive guidelines for surface preparation of concrete are SSPC SP-13 and ICRI Technical Guideline No. 03732.

Placement and curing of concrete and masonry

Concrete placement, curing, and finishing can have significant effects on subsequent surface preparation and coating performance. For slabs-on-grade, it is important that a sound vapor barrier be installed in accordance with ACI Standard 504 to mitigate moisture migration from the soils through the slab.

Sub-surface voids and weak surface layers can be avoided by the use of aggressive (trowel) finishing and vibrating during placement. Some admixtures, form release compounds, waterproofing sealers, and other "hydrophobic" compounds can also cause inter-coat adhesion problems with protective coatings. Their use should be scrutinized in applications where concrete and masonry is specified with protective coatings. A water break test is advisable to detect the presence of such compounds.

Cast-in-place concrete must also have a sufficient degree of curing to achieve full mechanical properties prior to coating application. The standard cure time for most concrete applications is generally considered to be 28 days.

Cleaning of concrete and masonry

Prior to mechanical surface preparation, it is important that concrete and masonry are free of contaminants. Due to the natural porosity of cementitious substrates, it is possible that oils, greases, salts, etc. penetrate the structure. Further, some form release compounds and waterproofing treatments prevent adhesion of coatings. Such contaminants must be cleaned prior to the application of protective coatings. Some methods include:

- Steam cleaning
- Use of detergents
- Vacuum cleaning
- Power washing
- Solvent cleaning

ASTM D4258 outlines methods and standards for cleaning concrete and masonry.

Abrading of concrete

ASTM D4259 provides generalized procedures and standards for abrading concrete. Concrete should be abraded to the degree specified for each particular coating. In general, thicker coating films require more aggressive abrasion. The minimum surface texture for most thin film coatings should be an equivalent to 60-grit sandpaper. Further, it is critical that concrete structures should be mechanically prepared not only to roughen the surface, but to remove unsound surface layers (laitance) and to expose sub-surface voids which should not be overcoated.

Surface roughness standards are available from ICRI to aid in the specification of concrete based on the specified coating type and degree of roughness desired or available.

CSP 1 – CSP 2	Sealers (0-3 mils)
CSP 1 – CSP 3	Thin film coatings (4-10 mils)
CSP 3 – CSP 5	High build coatings (10-40 mils)
CSP 4 – CSP 6	Self leveling coatings (40 mils-1/8")
CSP 5 – CSP 9	Surfacers/polymer overlays (1/8"-1/4")

Several methods for abrading are as follows:

Dry abrasive blasting

Dry abrasive blasting uses high-velocity abrasives which impact and abrade the surface of the concrete. Manual abrasive blasting can be used on vertical and horizontal concrete. It is an effective means of roughening the surface, removing weak layers, and exposing sub-surface voids. The aggressiveness of abrasive blasting can be controlled by the operator through adjustments in pressure, nozzle distance, dwell time, number of passes, and abrasive selection. Typical surface profiles induced are in the CSP 2 to CSP 4 range.

Steel shot blasting

Steel shot blasting is a self-contained centrifugal blast method utilizing steel shot to pulverize the surface of the concrete. Shot blast units can be adjusted to achieve varying profiles in the CSP 3 to CSP 8 range. Shot blasting generally produces a very uniform surface.

Grinding

Grinding is a technique which employs rotary equipment with abrasive discs or stones traveling across the surface of the concrete. Grinding is effective in removing existing thin film coatings and for removing surface imperfections. The typical amount of profile generated is slight (CSP 1 - CSP 3), thus limiting the usefulness to thin film coating systems.

Scarifying

Scarifying is a method which relies on a vertically rotating drum which impacts the concrete at a tangent. Scarifying is typically used on horizontal concrete structures (slabs). Blunt steel rods on the rotating drum pulverize the underlying substrate. The technique is capable of removing high build coating systems and producing a heavy profile in the range of CSP 4 to CSP 9. Scarifying is useful when heavy removal of contaminated or weak concrete is necessary. High build (trowel-down) resurfacing coating systems are often specified over surfaces which are prepared by scarification.

Power tool cleaning/needle scaling

Power tool cleaning/needle scaling can be used to address small areas, verical areas, and other areas not accessible with larger equipment. Hand grinders and needle guns are capable of removing thick film coatings and effecting profiles in the CSP 3 – CSP 8 range.

Scabbling

Scabbling is another method for preparing concrete floors which require heavy removal of the surface layers. As with scarification, the method relies on pulverizing the concrete. Scabbling equipment impacts the substrate at a right angle with cutters. This method can be very destructive to the surface and typically removes 1/8" – 3/4" of the surface layers. It tends to fracture brittle coatings and concrete, but is less effective on elastomeric coatings.

Acid etching

Acid etching can be used in some cases to profile floors in preparation for thin film coating systems. Typically, a mineral acid such as muriatic acid is used to chemically attack the cement on the surface of the concrete to induce a profile. The common governing standard for acid etching of concrete is ASTM D4260. Acid etching produces a surface profile in the range of CSP 1 – CSP 3 with removal of approxiately 4-10 mils of the surface. Residues from acid etching should be removed using copious amounts of rinse water in conjunction with scrubbing or pressurized spray to neutralize the surface and remove loose debris. Use of strong acids should be reviewed from safety, health, and environmental perspectives as well.

Water jetting

Use of water jetting at pressures of 5,000 psi to 40,000 psi can be employed for cleaning heavy residues, removing laitance and efflorescence, and removing weak layers of concrete. Water jetting also helps penetrate the porosity of the concrete to produce a clean surface. Pressures of approximately 10,000 psi are recommended for profiling the surface and removing weak layers. Higher pressures are utilized for heavy removal and resurfacing. The degree of uniformity can vary based on the control of the operator. Also, as with any wet method, the surface must be allowed to dry thoroughly prior to application of most coating systems.

Testing for moisture

A common failure mode for coatings applied to concrete is due to problems with moisture migration from the concrete structure through the coating and into the atmosphere. The hydrostatic pressure caused by this migration can result in the blistering of protective coatings. Moisture can come from three general sources:

- Environmental moisture from local sources
- Moisture from initial wet concrete mix
- Ground moisture transmission through the slab

Several methods existing for evaluating the moisture content of/transmission rate through concrete structure. One simple qualitative test is the plastic sheet test per ASTM D4263. This test relies on condensation of moisture on an 18” x 18” section of clear plastic sheeting which is sealed to the surface.

Quantitative tests include a 72-hour calcium chloride test per ASTM F1869. This test is often cited by coating manufacturers to provide a numerical result. The most widely accepted standard for moisture accumulation in this test is 3 lbs/1,000 ft /24 hrs. Higher results can be considered depending on the coating system involved. It is important that moisture testing be conducted after the surface has been properly abraded. Further, moisture testing should be done (if possible) in the same general environmental conditions the building will operate in. Often, a falsely low result can be achieved when the testing is done in cold, high humidity conditions. When the floor is exposed to climate-controlled conditions, the latent moisture problem is then discovered as moisture blisters develop in service.

It should be noted that any moisture test is a snap-shot of the equilibrium conditions at a given time. Sub-soil moisture levels, seasonal water tables, leaks, and environmental conditions can change the moisture emissions of slabs-on-grade.

Preparation of fiberglass (GRP), PVC and other plastics

Plastic substrates should first be wiped with a strong solvent to remove potential mold release compounds. The surface should then be thoroughly abraded with coarse grit sandpaper and wiped a second time prior to coating. These surfaces are typically primed with an epoxy or acrylic primer.

Preparation of drywall

Tape and fill joints and divots with a recommended joint compound and sand flush with a fine abrasive. Do not disturb the paper facing and remove any frayed (fibrous) areas. Wipe the surface clean of any dust.

Preparation of wood

Allow wood to dry as much as possible and within the recommended moisture levels for the specified product. Lightly sand with the grain of the wood to increase surface roughness and remove any loose fibers. Wipe to remove all dust, dirt, grime, natural resins, and any other form of contamination. Fill any holes or crevices with a suitable wood filler and sand flush with the surface. Specify a coating system recommended for wood substrates as coatings applied over large expanses of wood can crack as wood absorbs moisture and subsequently dries.

Preparation of previously coated surfaces

Previously coated surfaces should be inspected for the following parameters prior to recommending subsequent coating application:

- The coating should have sufficient adhesion to support subsequent coating applications. Adhesion tests by ASTM D3359 or ASTM D4541 is valuable for inspection of the existing coatings. A typical minimum coating adhesion should be in the 200-500 psi range depending on the proposed maintenance system.
- The dry film thickness of the coating system should be checked to ensure the coating thickness is not excessive for the generic type and the conditions. Excessive film thickness can cause cracking of the coatings. Often, application of additional coatings, introduction of solvents, and subsequent drying can cause sufficient stress to lift and/or crack the coatings.
- The existing coating should have sufficient solvent resistance to accept the proposed topcoat. A solvent rub test in accordance with ASTM D5402 is recommended for application of solvent-based systems.

Preparation of aged coating systems should include abrading the surface, feathering terminal edges, and removing any loosely adhered coatings in accordance with one of the following standards:

- SSPC SP-7 (Brush off blast cleaning)
- SSPC SP-3 (Power tool cleaning)
- SSPC SP-2 (Hand tool cleaning)

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