Designation: D7803 – 12

Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Powder Coating[1]

This standard is issued under the fixed designation D7803; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes methods of preparing surfaces of hot-dip galvanized iron and steel for powder coating and the application of powder coating materials.

1.1.1 Powder coating is a dry finishing process which uses finely ground particles of pigment and resin, electrostatically charged, and sprayed onto a part to be coated. The parts are electrically grounded so that the charged particles projected at them adhere to the surface and are held there until melted and fused into a smooth coating in the curing oven.

1.1.2 Hot-dip galvanized iron or steel is produced by the immersion of fabricated or un-fabricated products in a bath of molten zinc, as specified in Specification A123/A123M or A153/A153M. This practice covers surface preparation and thermal pretreatment of iron and steel products and hardware which have not been painted or powder coated previously (Practice D6386). Galvanized surfaces may have been treated with protective coatings to prevent the occurrence of wet storage stain. This practice neither applies to sheet galvanized steel products nor to the coil coating or continuous roller coating processes.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A123/A123M Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

A153/A153M Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

A780 Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

B201 Practice for Testing Chromate Coatings on Zinc and Cadmium Surfaces

D4285 Test Method for Indicating Oil or Water in Compressed Air

D6386 Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting

D7091 Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals

E376 Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Testing Methods

F21 Test Method for Hydrophobic Surface Films by the Atomizer Test

2.2 *Society for Protective Coatings Specifications:*[3]

Surface Preparation Specification No. 1 Solvent Cleaning

Surface Preparation Specification No. 2 Hand Tool Cleaning

Surface Preparation Specification No. 3 Power Tool Cleaning

Surface Preparation Specification No. 12 Surface Preparation and Cleaning of Metals by Water-Jetting Prior to Recoating

Surface Preparation Specification No. 16 Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals

3. Summary of Practice

3.1 This practice describes the procedures that can be used to prepare surfaces for powder coating application on new, partially weathered, and fully weathered zinc-coated surfaces on after-fabrication iron and steel products. These procedures

[1] This practice is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.46 on Industrial Protective Coatings.

Current edition approved June 1, 2012. Published June 2012. DOI: 10.1520/D7803-12.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Society for Protective Coatings (SSPC), 40 24th St., 6th Floor, Pittsburgh, PA 15222-4656, http://www.sspc.org.

improve the bond of the powder coating to the zinc surface providing for long life.

3.2 The proper preparation of galvanized surfaces prior to application of powder coating is dependent on cleaning, profiling, and thermal pretreatment.

4. Significance and Use

4.1 This practice describes the methods of preparation of hot-dip galvanized surfaces prior to the application of powder coating. The key to achieving proper adhesion between powder coatings and galvanized steel is surface preparation. The surface must be entirely free from metal oxides prior to powder coating. Any metal oxides that remain on the surface of the galvanized steel can potentially retain air or moisture. Upon heating during the curing stages of the powder application, the oxides may release water vapor or air, which can expand and penetrate the powder coating, causing blisters or voids.

4.2 The zinc coating is constantly in a state of change. From the time the steel part is removed from the galvanizing kettle, the exposed zinc coating interacts with the environment to form, first zinc oxides and zinc hydroxides, and then zinc carbonates.[4] The process of complete conversion of the outer layer of zinc carbonates can take up to two years of exposure to the environment, depending on the local weather and moisture conditions.

4.3 The zinc surface after full weathering is very resistant to atmospheric corrosion because the tight patina that is formed (zinc oxide, zinc hydroxide and zinc carbonate) is dense and tenacious. However, during the formative stages of patina development, the oxide/hydroxide layer is poorly adhered and must be removed in order for the powder coating to adhere properly to the galvanized coating. The second is pinholing/blistering of the coating which can severely limit its potential performance, especially in aggressive chloride environments. Entrapped gasses developed during the galvanizing process escape the surface through the coating as it cures at high temperatures. If these volatile materials are not removed through an outgassing process prior to the baking of the powder, then pinholing or blistering can occur. The presence of pinholes gives chlorides and other corrosive agents access to the zinc substrate consequently producing zinc corrosion products which may leach out through the coatings. While the presence of these corrosion products may not result in associated delamination of the coating, unsightly white staining of the coating can occur. Blisters are defects that are not adhered to the surface and may easily be broken into or off during handling, which creates performance and aesthetic issues. The proper preparation of the galvanized coating surface can increase the adhesion and coverage necessary to overcome these problems and results in a satisfactory service life of the powder coating and the galvanized coating together.

4.4 Variations in surface preparation produce end conditions that differ as far as surface roughness and zinc composition, hence they do not necessarily yield identical results when powder coatings are subsequently applied. The age of the zinc corrosion products on the galvanized coating will dictate the type of surface preparation to be selected.

5. Processes for Cleaning and Preparing Hot Dipped Galvanized Iron and Steel Surfaces for Powder Coating

5.1 *Newly Galvanized Metal*—The category of newly galvanized metal refers to zinc-coated metal that has no surface treatment after galvanizing, such as water quenching or chromate conversion coating, and has been galvanized within the previous 48 h. There also shall be no visible signs of zinc oxide or zinc hydroxide, which first appear as a fine white powder.

5.1.1 *Surface Smoothing*—Hot-dip galvanized surfaces, in general, are relatively smooth after galvanizing. There may be some thick/rough edges at the drip line due to excess liquid zinc run-off during the galvanization process, or high spots in the coating from included iron-zinc intermetallics (dross) or zinc oxide particles. These high spots and rough edges must be smoothed to avoid powder coat film gaps in the areas of the high spots. Zinc high spots shall be removed by cleaning with hand or power tools as described in SSPC Surface Preparation Specification 2 or 3 until they are level with the surrounding zinc area, taking care that the base coating is not removed by the cleaning methods. After smoothing, the surface shall be inspected for conformance to the required zinc thickness in accordance with Specification A123/A123M or A153/A153M utilizing a magnetic thickness instrument in accordance with Practice E376 and/or D7091. Any area falling below the required zinc thickness, before or after removal of any high spots, shall be repaired in accordance with Practice A780 using an appropriate method that is compatible with the curing temperature and time of the powder coating.

5.1.2 *Surface Cleaning*—Hot-dip galvanized surfaces must be clean and free of oil and grease before they are powder coated. Adhesion problems have been experienced with newly galvanized articles that have been water quenched or treated with chromate conversion coatings. These two post-galvanizing treatments are not recommended for galvanized articles that are to be coated. Test Method F21 can determine if contamination is on the galvanized surface prior to powder coating.

5.1.2.1 *Checking for Chromate Conversion Coating*—Before preparing the surface of any state of the galvanized steel for powder coating, if the galvanizer has not indicated if he avoided the chromate bath, the surface of a sample group from each shipment must be checked for the presence of a chromate conversion coating. The presence of a chromate conversion coating can severely impair the adhesion of powder coating. The presence of chromate conversion coatings can be detected by the procedure outlined in Practice B201. Chromate conversion coating can be removed completely by weathering galvanized metal for six months outdoors, sanding in accordance with 5.1.3.3, or sweep blasting in accordance with 5.1.3.1.

5.1.2.2 *Aqueous Alkaline Cleaning*—An alkaline solution, pH in the range of 11 to 12, definitely not greater than 13, can be used to remove traces of oil, grease, or dirt. The alkaline solution nominally is 2 to 5 % sodium compounds, with small

[4] This interaction is described in "Duplex Systems," van Eijnsbergen, J. F. H., *Elsevier Science*, New York, NY 1994, and in *Zinc Handbook*, Porter, F., Marcel Dekker, Inc., New York, NY 1991.

additions of emulsifying, chelating, or sequestering agents, or a combination thereof. This solution can be applied through immersion in a tank filled with the solution, sprayed, or brushed with a soft bristle brush, usually nylon and not steel or copper. When dipping or spraying, the solution works best in the temperature range from 60 to 85°C (140 to 185°F). After cleaning, rinse thoroughly in hot water or water under pressure. Allow to dry completely before proceeding. Whenever galvanized steel is rinsed, it is desirable to use heated drying to accelerate the complete removal of water from the surface.

NOTE 1—An alkaline cleaner is unsuitable for removal of heavy build-up of zinc oxide or wet storage stain (see American Galvanizers Publication, *Wet Storage Stain*,[5] for description of these conditions). See 5.1.3 for removal of zinc oxide layer.

5.1.2.3 *Solvent Cleaning*—Typical cleaning solvents, such as mineral spirits or high-flash naphtha, can be used to remove oil and grease. The procedure to be used is as specified in SSPC SP 1. Proper rags or brushes shall be used to wipe the galvanized parts. After cleaning, rinse thoroughly in hot water or water under pressure. Allow to dry completely before proceeding. Whenever galvanized steel is rinsed, it is desirable to use heated drying to accelerate the complete removal of water from the surface. (**Warning**—These rags or brushes should be cleaned or recycled often since oil can accumulate on their surfaces and be transferred back to the galvanized part. Small parts may be dipped or cleaned in ultrasonic baths of solvents.)

5.1.3 *Surface Preparation*—Hot-dip galvanized surfaces have a layer of zinc oxide and zinc hydroxide that must be removed before powder coating will adhere to the zinc coating. Zinc coatings are generally smooth and must be slightly roughened prior to powder coating. One of the following three methods shall be used to prepare the galvanized surface for powder coating.

5.1.3.1 *Sweep Blasting*—Abrasive sweep or brush blasting in accordance with SSPC SP 16, which uses a rapid nozzle movement, will roughen the galvanized surface profile. The abrasive material must be chosen carefully to provide a stripping action that removes the oxide reaction products without excessive removal of the zinc. One of the materials that has been used successfully is aluminum/magnesium silicate with a particle size in the range of 200 to 500 µm (8 to 20 mils.). Other materials that can be used are soft mineral sands with a Mohs hardness of five or less, organic media, such as corn cobs or walnut shells, corundum, or limestone. Depending on the value of hardness for the abrasive medium, blasting pressure may need to be adjusted for the appropriate nozzle to work-piece distance, geometry of the component, and blasting medium. For reactive steel with all-alloy coatings which may have compromised adhesion, even the relatively low-pressure blast of 0.15 to 0.25 MPa (20 to 40 psi) can be too great, causing adhesion problems. Care must be taken to leave zinc layers intact. Oil contamination of the compressed air will degrade adhesion to sweep-blasted hot-dip galvanized surfaces (Test Method D4285). Care is needed in averting this type of contamination. The purpose of sweep blasting is to deform, not remove the galvanized metal. Any area falling below the required zinc thickness, before or after sweep blasting, shall be repaired in accordance with Practice A780. Sweep blasting of zinc shall be not less than 110 m^2/h (1200 ft^2/h) using these abrasive materials. The substrate shall be maintained at a temperature of at least 3°C (5°F) above the dew point temperature. Following abrasive blast cleaning, surfaces shall be blown down with clean, compressed air. In some atmospheric conditions, such as high humidity, high temperature, or both, the formation of zinc oxide on the blasted surface will begin very quickly. Because newly formed zinc oxide is not visible to the naked eye, powder coating shall be applied as soon as possible after surface preparation.

5.1.3.2 *Phosphate Treatment*—This conversion-coating process consists of reacting the newly galvanized zinc surface in phosphate solution which contains oxidizing agents and other salts for accelerating the coating action. The zinc surface is converted to a crystalline phosphate coating of the proper texture to inhibit corrosion and increase the adherence and durability of the powder coating. This process can be applied by immersion, spray or soft bristle brush application. After a time period of 3 to 6 min, the surface shall be washed with clean water and allowed to completely dry before application of the powder coating system. Whenever galvanized steel is rinsed, it is desirable to use heated drying to accelerate the complete removal of water from the surface. Powder coating shall take place soon after treatment to avoid pick up of surface contaminants.

5.1.3.3 *Surface Grinding*—Power tools such as grinders or sanders will roughen the surface of galvanized metal and produce a surface profile suitable for powder coating adhesion. The grinder or sander shall not be applied with sufficient force to remove all of the zinc coating rather a removal of up to 25 microns (1.0 mil) is acceptable. This grinding or sanding process produces a sharper surface profile if the galvanized metal is over 50°C (122°F) as the zinc metal is softer at elevated temperatures. Following grinding or sanding, surfaces shall be blown down with clean, compressed air. In some atmospheric conditions, such as high humidity, high temperature, or both, the formation of zinc oxide on the ground surface will begin very quickly. Because newly formed zinc oxide is not visible to the naked eye, powder coating shall be applied as soon as possible after surface preparation.

5.1.3.4 *Notification of Surface Treatment*—The powder coating shop must be notified as to how the galvanized articles have been processed and which surface preparation method, if any, was used to prepare the surface.

5.2 *Partially Weathered Galvanized Metal*—The category of partially weathered galvanized metal refers to zinc-coated iron or steel that has been galvanized for over 48 h and may have had surface treatment after galvanizing, such as water quenching or chromate conversion coating. There also may be visible signs of zinc oxide or zinc hydroxide, which appears as a fine white powder.

[5] Available from American Galvanizers Association, 6881 South Holly Circle, Suite 108, Centennial, CO, 80112, www.galvanizeit.org.

5.2.1 *Checking for Chromate Conversion Coating*—Perform check and removal as described in 5.1.2.1. After the chromate conversion coating is removed proceed with surface preparation in accordance with 5.1.3.

5.2.2 *Checking for Wet Storage Stain*—Before preparing the surface of partially weathered galvanized metal for powder coating, the surface must be checked for the presence of wet storage stain. Wet storage stain is the whitish zinc corrosion product formed when galvanized parts are exposed to moist air without sufficient air circulation between the parts and is described in the American Galvanizers Publication, *Wet Storage Stain*.[5] Wet storage stain consists primarily of zinc hydroxide and small percentages of zinc oxide and zinc carbonate. Because wet storage stain is hygroscopic and has a larger volume than zinc metal, powder coating adhesion can be affected seriously when coating over wet storage stain. Careful brushing with a mild ammonia solution using a soft bristle brush will remove mild cases of wet storage stain. Thorough water rinsing must immediately follow the brushing. Whenever galvanized steel is rinsed, it is desirable to use heated drying to accelerate the complete removal of water from the surface. More severe cases of wet storage stain have thick white corrosion products on the zinc surface, or even black corrosion products, can be cleaned using vigorous soft bristle brushing with a mild acidic solution with a pH of 3.5 to 4.5, such as acetic acid or citric acid, but not hydrochloric or sulfuric acid solutions. Thorough water rinsing must immediately follow the brushing. Whenever galvanized steel is rinsed, it is desirable to use heated drying to accelerate the complete removal of water from the surface. After the part has completely dried, the surface profile shall be applied in accordance with 5.1.3. If no protective treatment, such as those described in 5.1.3.2 is applied, in some atmospheric conditions, such as high humidity, or high temperature, or both, the formation of zinc oxide on the surface will begin very quickly. Because newly formed zinc oxide is not visible to the naked eye, powder coating shall be applied as soon as possible after surface preparation.

5.2.3 *Surface Preparation*—If there is no indication of either chromate conversion coating or wet storage stain, the surface can be prepared for powder coating by performing the steps in 5.1.

5.3 *Fully Weathered Galvanized Metal*—Fully weathered galvanized metal has been galvanized for six months or longer with the exposed surface consisting mainly of water-insoluble zinc carbonates. Zinc carbonate forms a rough surface layer that does not need further roughening to be ready to accept a powder coating.

5.3.1 *Surface Cleaning*—Fully weathered galvanized metal has developed a stable and finely etched surface that is very suited for powder coating adhesion. If there are organic contaminants, such as oil, grease, or soot on the surface of the part, surface cleaning in accordance with 5.1.2 shall be performed before any other processing is done.

5.3.2 *Power Washing*—The natural corrosion of the zinc metal produces a roughened surface film consisting primarily of basic zinc carbonate. The surface preparation that can be used is a power wash with warm water to remove loose particles from the surface as described in SSPC SP 12. The power wash shall use water jets with a pressure of less than 10 MPa (1450 psi) so as not to damage the protective film. This film is naturally roughened in its growth process, so no extra surface profiling is needed. Allow the surface to completely dry before application of the powder coating system. Whenever galvanized steel is rinsed, it is desirable to use heated drying to accelerate the complete removal of water from the surface.

6. Process for Thermal Pretreatment of Hot Dipped Galvanized Iron and Steel Prior to Powder Coating

6.1 *Newly Galvanized, Partially Weathered and Fully Weathered Galvanized Metal Outgassing*—Following cleaning and surface preparation, the work shall be thermally treated through a dry-off/oven facility to remove residual moisture from the work prior to powder application to reduce pinholing and blistering.

6.1.1 *Thermal Treatment*—Pre-baking in a drying oven can reduce the potential for the galvanized coating to outgas. This process will aid in the expulsion of any trapped air or water in the coating as well as ensure that the surface of the metal is free from any moisture. The pre-baking oven shall be operated at a higher temperature than the powder coating curing oven.

6.1.2 *Baking Requirements*—The temperature of the pre-bake oven shall be capable of heating the work to 30°C (65°F) higher than the curing oven. If the galvanized metal is run through a phosphate wash prior to powder coating, it is recommended that the pre-bake temperature of the work not exceed 280°C (535°F). Higher temperatures will deteriorate the thin phosphate coating, converting it into a powdery substance that could affect adhesion.

6.1.3 *Baking Procedure*—The galvanized work piece shall be kept in the prebake oven for a sufficient time for the galvanized surface to reach the temperature of the prebake oven. Typically, this is one hour to assure all moisture and entrapped gasses are expelled. After the prebaking cycle is complete, the part shall be cooled to a temperature sufficiently below the curing temperature of the powder coating before the application of the powder coating.

7. Inspection

7.1 Testing, including sampling, lot size, etc., shall be according to the regime specified in Specification A123/A123M or A153/A153M. The galvanized component of the duplex coating shall meet all requirements of Specification A123/A123M or A153/A153M. Coating thickness values for either the galvanized coating or the powder coated component shall be measured independently.

8. Keywords

8.1 galvanized steel; galvanizing; hot-dipped galvanizing; phosphating; powder coating; surface preparation; zinc coating