Designation: D 6386 – 99

AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428
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Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting[1]

This standard is issued under the fixed designation D 6386; 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 new and weathered hot-dip galvanized steel for painting. Hot-dip galvanized steel is produced by the immersion of fabricated or unfabricated products in a bath of molten zinc, as specified in Specifications A 123 or A 153/A 153M. This practice covers surface preparation on iron and steel products and hardware that have not been painted previously. Galvanized surfaces may have been treated with protective coatings to prevent the occurrence of wet storage stain. This practice does not apply 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 to determine the application of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

A 123 Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products[2]

A 153/A 153M Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware[2]

A 780 Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings[2]

B 201 Practice for Testing Chromate Coatings on Zinc and Cadmium Surfaces[3]

E 376 Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Test Methods[4]

2.2 *Society for Protective Coatings Specifications:*[5]

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. 7 Brush-Off Blast Cleaning

Paint Specification No. 27 Basic Zinc Chromate-Vinyl Butyral Wash Primer

3. Summary of Practice

3.1 This practice describes the preparation methods that provide clean and suitable galvanized surfaces for painting, specifically so that an applied coating system can develop the adhesion necessary for a satisfactory service life.

3.2 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, next zinc hydroxides, and then zinc carbonates.[6] 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 climatological conditions. During the first stage, known as newly galvanized steel, the exposed surface consists mainly of zinc metal with a small amount of zinc oxide. During the second stage, known as partially weathered galvanized steel, the exposed surface consists mainly of zinc oxides and zinc hydroxides with some zinc carbonates. At the final stage, known as weathered galvanized steel, the exposed surface consists mainly of water-insoluble zinc carbonates, some zinc oxides, and rarely, zinc hydroxides. The surface preparation for each of these stages must be treated separately.

3.3 Variations in surface preparation produce end conditions that differ, hence they do not necessarily yield identical results when paints are subsequently applied. Service conditions will dictate the type of surface preparation to be selected, although the quality produced by any individual process may vary with different compositions of the zinc surface.

4. Significance and Use

4.1 This practice describes the procedures that can be used

[1] This practice is under the jurisdiction of ASTM Committee D-01 on Paint and Related Coatings, Materials, and Applications, and is the direct responsibility of Subcommittee D01.46 on Industrial Protective Clothing.

Current edition approved Feb. 10, 1999. Published April 1999.

[2] *Annual Book of ASTM Standards*, Vol 01.06.

[3] *Annual Book of ASTM Standards*, Vol 02.05.

[4] *Annual Book of ASTM Standards*, Vol 03.03.

[5] Available from the Society for Protective Coatings, 40 24th St., 6th Floor, Pittsburgh, PA 15222–4623.

[6] 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.

to prepare new and weathered zinc-coated surfaces on after-fabrication steel products for painting, and that can improve the bond of paint to the zinc surface.

5. Processes for Newly Galvanized Steel

5.1 *Newly Galvanized Steel*—The category of newly galvanized steel refers to zinc-coated steel 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 should be no visible signs of zinc oxide or zinc hydroxide, which first appear as a fine white powder.

5.2 *Surface Smoothing*—Hot-dip galvanized surfaces generally are relatively smooth after galvanizing. There may be some thick edges due to excess liquid zinc run-off during the galvanizing, or high spots in the coating due to included iron-zinc intermetallics (dross) or zinc oxide particles. These high spots and rough edges, such as the metal drip line, must be smoothed to avoid paint film gaps in the areas of the high spots.

5.2.1 Zinc high spots, those that would cause paint film gaps such as the metal drip line, should be removed by cleaning with hand or power tools as described in SSPC Surface Preparation Specification 2 or 3. The zinc should be removed until it is level with the surrounding area, taking care that the base coating is not removed by the cleaning methods. After cleaning, the surface shall be inspected for conformance to the required zinc thickness in accordance with Specifications A 123 or A 153/A 153M utilizing a magnetic thickness instrument in accordance with Practice E 376. Any item falling below the required zinc thickness, before or after removal of any high spots, shall be repaired in accordance with Practice A 780.

5.3 *Surface Cleaning*—Hot-dip galvanized surfaces must be clean and free of oil and grease before they are painted. 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 painted.

5.3.1 *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. An alkaline cleaner is unsuitable for removal of heavy build-up of zinc oxide or wet storage stain (see American Galvanizers Publications, *Wet Storage Stain*[7], for description of these conditions). See 5.4 for removal of zinc oxide layer. The alkaline solution nominally is 2 to 5 % sodium compounds, with small 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. 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.

5.3.2 *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 Surface Preparation Specification 1. Proper rags or brushes should be used to wipe the galvanized parts.

NOTE 1—**Caution:** 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. After cleaning, rinse thoroughly in hot water or water under pressure. Allow to dry completely before proceeding.

5.3.3 *Hand or Power Tool Cleaning*—Hand or power tool cleaning may be used to clean light deposits of zinc reaction by products, such as wet-storage stain, as specified in SSPC Surface Preparation Specification 2 or 3.

5.4 *Surface Preparation*—Hot-dip galvanized surfaces have a layer of zinc oxide and zinc hydroxide that must be removed before paint will adhere to the zinc coating. Zinc coatings generally are relatively smooth and may be slightly roughened prior to painting. The following four methods may be used to prepare the galvanized surface for painting.

5.4.1 *Sweep Blasting*—Abrasive sweep or brush blasting, which uses a rapid nozzle movement will roughen the galvanized surface profile. The abrasive material must be chosen with care to provide a stripping action without removing excess zinc layers. One of the materials that has been used successfully is aluminum/magnesium silicate. Particle size should be in the range of 200 to 500 µm (8 to 20 mils). Other materials that can be used are soft mineral sands with a Mhos hardness of five or less, organic media, such as corn cobs or walnut shells, corundum, and limestone. Depending on the value of hardness for the abrasive medium, blasting pressure may need to be determined for the appropriate nozzle to work-piece distance, geometry of the component, and blasting medium. For some all-alloy coatings, even the relatively low-pressure blast of 0.15 to 0.25 MPa (20 to 40 psi) can be too great, causing cohesion problems. Oil contamination of the compressed air will degrade paint adhesion to sweep-blasted hot-dip galvanized surfaces. Care is needed in averting this type of contamination. Care must be taken to leave zinc layers intact. 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, should be repaired in accordance with Practice A 780. The procedure for this process can be found in SSPC Surface Preparation Specification 7. Sweep blasting of zinc should be not less than 110 m^2/h (1200 ft^2/h) using these abrasive materials. The substrate should be maintained at a temperature greater than 3°C (5°F) above the dew point temperature. Following abrasive blast cleaning, surfaces should be blown down with clean, compressed air. In some atmospheric conditions, such as high humidity, or high temperature, or both, the formation of zinc oxide on the blasted surface will begin very quickly, so the paint coating should be applied immediately, within 60 min, after sweep blasting. Zinc oxide formation is not visible to the naked eye; therefore, in any atmosphere, painting should be stated as soon as possible

[7] Available from American Galvanizers Association, 12200 E. Iliff Ave., No. 204, Aurora, CO 80014–5376.

after surface preparation.

5.4.2 *Zinc-Phosphate Treatment*—This conversion-coating process consists of reacting the newly galvanized zinc surface in an acidic zinc phosphate solution containing 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 paint film. This process may be applied by immersion, spray or soft bristle brush application. After a time period of 3 to 6 min, the surface should be washed with clean water and allowed to completely dry before application of the paint system. Painting should take place soon after treatment to avoid pick up of surface contaminants.

5.4.3 *Wash Primer Treatment*—This process involves the use of a metal conditioner to neutralize surface oxides and hydroxides along with etching the surface. One example of a wash primer is SSPC Paint Specification 27. The process is based on three primary components: a hydroxyl-containing resin: a pigment capable of reacting with resin and acid: and, an acid capable of making the resin insoluble by reacting with the resin, the pigment, and the zinc surface. The result is a film of approximately 8 to 13 µm (0.3 to 0.5 mils). Failures can occur if the film exceeds 13 µm (0.5 mils). The film usually is applied by spray but may be applied by soft bristle brush, dip, or roller coater. Using these latter coating methods, it may be difficult to control the film thickness. For drying time prior to topcoating, follow the manfacturer's instructions. This wash primer treatment may be better suited to certain types of paint systems. See SSPC Paint Specification 27 for the best match of this treatment to a paint system.

5.4.4 *Acrylic Passivation/Pretreatment*—The passivation/pretreatment process consists of applying an acidic acrylic solution to the newly galvanized surface and then allowing it to dry, forming a thin film coating. When applied, the solution first reacts with the zinc surface forming a passivating conversion coating while simultaneously forming an acrylic coating suitable for painting on top of the passivation layer. The underlying conversion coating provides strong adhesion to the galvanized surface while the thin film acrylic layer provides barrier protection, which inhibits corrosion and provides a highly compatible surface for the application of organic paint films. There are versions of these solutions that contain chrome and versions without chrome. The application methods for these water based treatments are dipping, flow coating, spraying, or other appropriate means. Following application the coating is dried in an oven or in air. In some instances, the coating is applied to hot-galvanized articles, in which case separate drying is not necessary. Rinsing is not required. The coating is approximately 1-µm (0.04-mils) thick. Painting is possible any time during a period of four months after application, as long as the surface is free of visible zinc oxides or zinc hydroxides; however, if harmful contaminants, such as dust, dirt, oils, grease or deposits are present, they must be removed with a mild alkaline degreasing solution (pH 11.5 max) followed by a thorough rinse with hot water (60°C maximum temperature) or a pressure wash, then thoroughly dried. This treatment is applied in the galvanizing plant or later in the paint shop. When applied in the paint shop, the surface must first be appropriately cleaned as just described to remove contaminants picked up after galvanizing.

5.4.5 *Notification of Surface Treatment*—The paint shop must be notified as to how the galvanized articles have been processed and which surface treatment method, if any, is used to prepare the surface.

6. Processes for Partially Weathered Galvanized Steel

6.1 Before preparing the surface of partially weathered galvanized steel, the surface must be checked for the presence of chromate conversion coating. The presence of a chromate conversion coating can severely impair the adhesion of some paint coating system. Chromate conversion coatings can be applied at the galvanizing facility to protect the newly galvanized surface from excessive growth of zinc oxide and zinc hydroxide, commonly called wet storage stain. The presence of chromate conversion coatings can be detected by the procedure outlined in Appendix X1. The removal of the chromate conversion coating also is outlines in Appendix X1. The surface preparation method described in 5.4.4 could test positive for the presence of chrome. The surface preparation technique described in 5.4.4 should not be removed if it tests positive for the presence of chrome. This process is not a chromate conversion coating. If the galvanized surface has thick edges or high spots, these should be removed, see 5.2.1. When the high spots have been treated and the chromate has been removed completely by sanding or sweep blasting in accordance with 5.4.1, surfaces should be blown down with clean, compressed air. In some atmospheric conditions, such as high humidity or high temperature, or both, the formation of zinc oxide on the blasted surface will begin very quickly so the paint coating should be applied within 30 min after sweep blasting. Zinc oxide formation is not visible to the naked eye; therefore, in any atmosphere, painting should be as soon as possible after surface preparation.

6.2 Before preparing the surface of partially weathered galvanized steel, 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 Association Publication, *Wet Storage Stain.* Wet storage stain consists primarily of beta zinc hydroxide and small percentages of zinc oxide and zinc carbonate. Since wet storage stain is hygroscopic and has a larger volume than zinc metal, paint adhesion can be affected seriously when painting 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. More severe cases of wet storage stain that 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. After the part has completely dried, the surface profile should be applied in accordance with 5.4, and, then the surfaces should be blown down with clean, compressed air. If no protective treatment, such as those described in 5.4.2-5.4.4

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 so the paint coating should be applied within 30 min. If a protective treatment is applied, it is not necessary to paint immediately. Zinc oxide formation is not visible to the naked eye; therefore, in any atmosphere, painting should be as soon as possible after surface preparation.

6.3 If there is no indication of either chromate conversion coating or wet storage stain, the surface can be prepared as detailed in Section 5.

7. Processes for Weathered Galvanized Steel

7.1 Fully weathered galvanized steel, as described in 3.2, has developed a stable and finely etched surface that is very suited for paint coating adhesion. If there are organic contaminants, such as oil, grease, or soot on the surface of the part, surface cleaning in accordance with 5.3 should be performed before any other cleaning is done.

7.2 The natural corrosion of the zinc metal produces a roughened surface film consisting primarily of basic zinc carbonate. The surface preparation that is needed is a power wash with warm water to remove loose particles from the surface. The power wash should 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 paint system.

7.3 Fully-weathered galvanized steel can be painted successfully with the application of appropriate paint systems including primers and top coat paints. The use of pretreatments, such as those described in 5.4, can enhance paint adhesion and extend long term performance.

8. Keywords

8.1 galvanized steel; galvanizing; hot-dipped galvanizing; painting; paint preparation; surfacing preparation; zinc coating

APPENDIX

(Nonmandatory Information)

X1. IDENTIFYING THE PRESENCE OF AND REMOVING CHROMATE TREATMENTS USED AS WET STORAGE (ALSO CALLED HUMID-STORAGE) STAIN INHIBITORS

X1.1 One of the inhibitors used by producers of zinc-coated steel is a hexavalent chromium solution. This treatment prevents adhesion of many paint coatings to zinc coated steel surfaces.

X1.2 If zinc-coated steel to be painted is galvanized to order, the order should prohibit the use of hexavalent chromium humid-storage strain treatments.

X1.3 Hexavalent chromium treatment can be removed from galvanized surfaces by one of the following three methods:

X1.3.1 Weathering the surfaces for six months, or

X1.3.2 Abrading the surfaces by sanding, or

X1.3.3 Sweep blast clean in accordance with 5.4.1.

X1.4 The presence of hexavalent chromium on galvanized surfaces can be determined by spot testing used Practice B 201.

X1.5 Conduct the spot test on several representative spots on each individual piece of galvanized steel.

X1.6 Test, in accordance with Practice B 201, every piece of galvanized steel that is to be treated for painting.