1. Scope

1.1 This specification covers the requirements for a coating of zinc mechanically deposited on iron and steel basis metals. The coating is provided in several thicknesses up to and including 107 µm. The seven thickest classes are usually referred to as “mechanically galvanized.”

1.2 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.

NOTE 1—The performance of this coating complies with the requirements of Specification A153/A153M and MIL-C-81562.

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound equivalents of SI units are given for informational purposes.

2. Referenced Documents

2.1 ASTM Standards:
   A153/A153M Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   A194/A194M Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
   A325 Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
   A325 Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

2.2 MIL Standard

3. Classification

3.1 Classes—Zinc coatings are classified on the basis of thickness, as follows:

<table>
<thead>
<tr>
<th>Class</th>
<th>Minimum Thickness, µm</th>
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<tr>
<td>110</td>
<td>107</td>
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</table>

3.2 Types—Zinc coatings are identified by types on the basis of supplementary treatment required, as follows:

Type I—As coated, without supplementary treatment (Appendix X2.1).

Type II—With colored chromate conversion treatment (Appendix X2.2).

4. Ordering Information

4.1 Supplying the following information by the purchaser to the seller in the purchase order or other governing document will make the application of this specification complete:

4.1.1 Class, including a maximum thickness, if appropriate, type, and for Type II, color and need for supplemental lubricant (3.1, 3.2, and 6.2.5).

4.1.2 Nature of substrate (for example, high-strength steel), need for stress relief (6.2.1), and cleaning precautions to be followed (6.2.2 and 6.2.3).

4.1.3 Significant surfaces (6.3).

4.1.4 Requirements for and methods of testing for one or more of the following, if required: need for and type of test specimens (8.1), thickness (6.3 and 8.3), adhesion (6.4 and 11.4), corrosion resistance (8.4 and 11.4), physical properties (11.2), and other factors (11.3).

5. Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098
and including roots
bolts references the use of lubricants on nuts to be used with paragraph 4.8 of Specification .
A325
2H nuts when supplied for use with Specification
A194/A194M
in a container with the following:
A325
8.4), corrosion resistance (6.5 and 8.5), absence of hydrogen embrittlement, and the waiting period before testing and testing loads (6.6 and 8.6),
4.1.5 Inspection responsibility (Section 11) and sampling plan for each inspection criterion (Section 7), and
4.1.6 Requirements for certified report of test results (Section 10).

5. Workmanship
5.1 The coating shall be uniform in appearance and free of blisters, pits, nodules, flaking, and other defects that are capable of adversely affecting the function of the coating. The coating shall cover all surfaces as stated in 6.3 including roots of threads, thread peaks, corners, recesses, and edges. The coating shall not be stained or discolored throughout to an extent capable of adversely affecting appearance as a functional requirement. However, superficial staining, that results from rinsing or drying, and variations in color or luster shall not be cause for rejection.

Note 2—The nature of the mechanical plating process is such that coatings characteristically will not be as smooth or as bright as some electroplated coatings.

6. Requirements
6.1 Appearance—The coating as deposited shall have a uniform silvery appearance, and a matte to medium-bright luster.
6.2 Process:
6.2.1 Stress-Relief Treatment—All steel parts that have an ultimate tensile strength of 1000 MPa and above and that contain tensile stresses caused by machining, grinding, straightening, or cold-forming operation shall be given a stress-relief heat treatment prior to cleaning and metal deposition. The temperature and time at temperature shall be 190 ± 15°C for a minimum of 3 h so that maximum stress relief is obtained without reducing the hardness below the specified minimum.
6.2.2 High-strength steels (which become embrittled when charged with hydrogen) and that have heavy oxide or scale shall be cleaned before application of the coating in accordance with Practice . In general, nonelectrolytic alkaline, anodic-alkaline, and some inhibited acid cleaners are preferred to avoid the risk of producing hydrogen embrittlement from the cleaning procedure.
6.2.3 For low-carbon steels, see Practice . Useful guidelines are also given in Guide .
6.2.4 Mechanical deposition of zinc coatings shall consist, in general, of all of the steps listed below, and in the sequence as shown:
6.2.4.1 Preparation of the surface of the parts to be coated, by chemical (generally acidic) procedure to an extent that permits uniformly satisfactory results from subsequent steps.
6.2.4.2 Deposition of a thin metal coating, generally of copper, by immersion in appropriate chemical solutions, without the use of electric current. There are no thickness requirements for this coating.
6.2.4.3 Tumbling of the parts that have been treated according to 6.2.4.1 and 6.2.4.2 in a container with the following:
(1) The zinc metal to be deposited, in powder form;
(2) Impact media, which includes glass, for example, or other substances that are essentially inert to the chemicals of the deposition process. The function of this media is to aid in providing mechanical forces to drive the metal powder onto the substrate parts;
(3) A “promoter” or “accelerator” which aids in the uniform deposition of the metal powder; and
(4) A liquid medium, generally water.
6.2.4.4 Separation of the parts from the solid and liquid media.
6.2.4.5 Rinsing.
6.2.4.6 Drying.
6.2.5 Supplementary Treatments:
6.2.5.1 Colored Chromate Conversion Treatments (Type II)—Colored chromate conversion treatment for Type II shall be done in a solution containing hexavalent chromium ions. This solution shall produce a bright or semi-bright continuous, smooth, protective film with a uniform color that is capable of ranging from yellow through bronze and olive-drab to brown and black that are capable of being dyed to a desired color. Bright dips that do not contain salts that yield films containing hexavalent chromium ions are precluded as treatments for producing Type II coatings.
6.2.5.2 Waxes, lacquers, or other organic coatings are not prohibited from being used to improve lubricity, and the need for them shall be supplied in the purchase order or other governing document (see 4.1.1). Supplemental lubrication treatments shall not be used to ensure conformance to the salt spray corrosion resistance requirements (see 8.5.4).
6.2.5.3 Lubrication of grade DH nuts processed in accordance with this specification and used with Specification A325 high-strength bolts is a requirement of paragraph 6.5 of Specification A325 and paragraph 4.8 of Specification .

Note 3—Although not included in Specification A194/A194M, this provision should apply to mechanically galvanized Specification A194/ A194M 2H nuts when supplied for use with Specification A325 bolts.

Note 4—Specifications for structural joints using Specification A325 or A325 bolts reference the use of lubricants on nuts to be used with Specification A325 high-strength bolts and is found in the commentary on this RCSC (Research Council on Structural Connections of the Engineering Foundation) Specification, within the paragraphs entitled “Effect Of Galvanizing Upon Torque Involved In Tightening” and “Shipping Requirements For Galvanized Bolts and Nuts,” published November 1985, page 30.4

6.2.6 Surface Defects—Defects and variations in appearance in the coating that arise from surface conditions of the substrate (scratches, pores, roll marks, inclusions, etc.) and that persist in the finish despite the observance of good metal finishing practices shall not be cause for rejection.

Note 5—Applied finishes generally perform better in service when the substrate over which they are applied is smooth and free of torn metal, inclusions, pores, and other defects. It is recommended that the specifications covering the unfinished product provide limits for these defects. A metal finisher can often remove defects through special treatments, such as grinding, polishing, abrasive blasting, chemical treatments, and electropolishing. However, these are not normal in the treatment steps

preceding the application of the finish. When desired they must be specified on the purchase order (4.1.2).

6.3 Thickness:

6.3.1 The thickness of the coating everywhere on the significant surfaces shall be at least that of the specified class as defined in 3.1.

6.3.2 Significant surfaces are defined as those normally visible (directly or by reflection) that are essential to the appearance or serviceability of the article when assembled in normal position; or that are capable of providing the source of corrosion products that deface visible surfaces on the assembled article. When necessary, the significant surfaces shall be indicated on the drawing for the article, or by the provision of suitably marked samples.

Note 6—The thickness of mechanically-deposited coatings varies from point-to-point on the surface of a product, characteristically tending to be thicker on flat surfaces and thinner at exposed edges, sharp projections, shielded or recessed areas, interior corners and holes, with such thinner areas often being exempted from thickness requirements.

6.3.3 When significant surfaces are involved on which the specified thickness of deposit cannot readily be controlled, it is incumbent upon the purchaser and manufacturer to recognize the necessity for either thicker or thinner deposits. For example, to reduce buildup in thread roots, holes, deep recesses, bases of angles, and similar areas, the deposit thickness on the more accessible surfaces will have to be reduced proportionately.

Note 7—The coating thickness requirement of this specification is a minimum requirement; that is, the coating thickness is required to equal or exceed the specified thickness everywhere on the significant surfaces. Variation in the coating thickness from point to point on a coated article is an inherent characteristic of mechanical deposition processes. Therefore, the coating thickness will have to exceed the specified value at some points on the significant surfaces to ensure that the thickness equals or exceeds the specified value at all points. Hence, in most cases, the average coating thickness on an article will be greater than the specified value; how much greater is largely determined by the shape of the article and the characteristics of the deposition process.

In addition, the average coating thickness on articles will vary from article to article within a production lot. Therefore, if all of the articles in a production lot are to meet the thickness requirement, the average coating thickness for the production lot as a whole will be greater than the average necessary to ensure that a single article meets the requirement.

6.4 Adhesion—The zinc coating shall be sufficiently adhesive to the basis metal to pass the tests specified in 8.4.

6.5 Corrosion Resistance:

6.5.1 The presence of corrosion products visible to the unaided eye at normal reading distance at the end of the specified test periods stated in Table 1 shall constitute failure, except that corrosion products at edges of specimens shall not constitute failure. Slight “whisps” of white corrosion, as opposed to obvious accumulations, shall be acceptable.

Note 8—Mechanical deposition is exclusively a barrel-finishing process. It is recognized that mechanical deposition on parts may therefore produce surfaces that have a different characteristic from those on parts that are finished exclusively by racking. Similarly, corrosion testing of actual parts may produce different results from those on test panels. Salt spray requirements that are appropriate to indicate the technical quality with which a process is carried out may be impractical for acceptance of actual parts. In such cases the purchaser shall indicate his requirements on the purchase order (4.1.4).

Note 9—In many instances, there is no direct relation between the results of an accelerated corrosion test and the resistance to corrosion in other media, because several factors that influence the progress of corrosion, such as the formation of protective films, vary greatly with the conditions encountered. The results obtained in the test should not, therefore, be regarded as a direct guide to the corrosion resistance of the tested materials in all environments where these materials may be used. Also, performance of different materials in the test cannot always be taken as a direct guide to the relative corrosion resistance of these materials in service.

6.5.2 On parts with Type II coatings, the greater number of hours for either white corrosion products or rust shall apply. For example, for Type II, Class 8, the test shall be continued until the 72-h requirement is met for white corrosion products; similarly, for Type II, Class 25, if no white corrosion products appear before 72 h, test shall be continued until the 192-h requirement for basis metal corrosion is met (8.5.2).

6.6 Absence of Hydrogen Embrittlement—Springs and other high-strength parts subject to flexure shall be held for a minimum of 48 h at room temperature after coating before being loaded, flexed, or used. Such high-strength steel parts shall be free of hydrogen embrittlement. When specified in the purchase order, freedom from embrittlement shall be determined by the test specified herein (4.1.4 and 8.6).

7. Sampling

7.1 The purchaser and producer are urged to employ statistical process control in the coating process. Properly performed, statistical process control will assure coated products of satisfactory quality and will reduce the amount of acceptance inspection. The sampling plan used for the inspection of the quality coated article shall be agreed upon between the purchaser and producer.

7.1.1 When a collection of coated articles (inspection lot, see 7.2) is examined for compliance with the requirements placed on the articles, a relatively small number of the articles (sample) is selected at random and is inspected. The inspection lot is then classified as complying with the requirements based on the results of the inspection of the sample. The size of the sample and the criteria for compliance are determined by the application of statistics. The procedure is known as sampling inspection. Test Method, Guide, and Method contain sampling plans that are designed for sampling inspection of coatings.

7.1.2 Test Method contains four sampling plans, three for use with tests that are nondestructive and one when they are destructive. Test Method provides a default plan if one is not specified.