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Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners¹

This standard is issued under the fixed designation F2329; 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 specification covers the requirements for hot-dip zinc coating applied to carbon steel and alloy steel bolts, screws, washers, nuts, and special threaded fasteners applied by the hot-dip coating process. Nails and rivets are not included in this specification.

1.2 It is intended to be applicable to fasteners that are centrifuged or otherwise handled to remove excess galvanizing bath metal (free zinc).

~~1.3 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.~~

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.4 *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

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

A563 [Specification for Carbon and Alloy Steel Nuts](#)

A563M [Specification for Carbon and Alloy Steel Nuts \(Metric\)](#)

B487 [Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of Cross Section](#)

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

F606 [Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets](#)

F606M [Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets \(Metric\)](#)

F1470 [Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection](#)

F1789 [Terminology for F16 Mechanical Fasteners](#)

3. Terminology

3.1 Terms used in this specification are defined in Terminology F1789 unless otherwise defined in this specification.

3.1.1 *batch lot*—quantity of identical parts cleaned, pickled, fluxed, and galvanized together at one time in a galvanizing basket.

3.1.2 *galvanizing*—hot-dip zinc coating.

3.1.3 *high temperature galvanizing*—galvanizing process carried out in a ceramic vessel (kettle) at an approximate temperature ranging between 990°F and 1040°F [530°C and 560°C].

3.1.4 *hot-dip zinc coating of mechanical fasteners*—process whereby fasteners are zinc coated by immersion in a bath of molten zinc, resulting in the formation of the iron/zinc alloy coating and a zinc coating at the surface of the fastener. This process involves

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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.

the removal of excess zinc by spinning the parts in a centrifuge, or brushing the threaded portion, or handling otherwise to remove the excess zinc.

3.1.5 *production lot*—batches of parts originating from the same manufacturing lot, processed continuously through cleaning, pickling, fluxing, dipping in molten zinc and spun in a centrifuge, or other means, without any significant change in time, temperature, and concentration of the constituents of the process.

3.1.6 *stress relief*—process of heating parts for a definite time at a given temperature in order to relieve stress induced by work hardening.

4. Ordering Information

4.1 Orders for zinc coating of fasteners to this specification shall include the following:

4.1.1 Name of product (that is bolt, stud, nut, washers, or other);

4.1.2 ASTM designation and year of issue, including fastener specification number;

4.1.3 Hydrogen embrittlement relief treatment, as required by the purchaser (see, 7.2.3+);

4.1.4 Quantity of fasteners to be hot-dip zinc coated;

4.1.5 Stress relief or tempering temperature to which the fasteners were subjected, if applicable;

4.1.6 Secondary processing such as chromating, phosphating, or lubrication, if applicable;

4.1.7 Average galvanizing temperature to which fasteners will be subjected, if required by the purchaser (see 7.2.2);

4.1.8 Specify baking if required (see 7.2.3); and

4.1.9 Certification, if required (see 14.1).

5. Materials and Manufacture

5.1 *Condition of the As-Received Fasteners*—The fasteners as received by the galvanizer shall be free from contaminants that are not readily removed in the cleaning process and would adversely affect the galvanizing.

5.2 *Process*—Unless otherwise covered in this specification, all processing parameters shall be in accordance with the requirements of Specification A153/A153M.

5.2.1 *Process Control*—Galvanized fasteners subjected to a process control plan based upon batch lot level shall comply with the batch lot sampling plan in Table 1, and the sampling plan for production lot (prevention process) as determined in 10.2.2 shall be applied.

5.3 *Spinning and Quenching*:

5.3.1 Parts shall be spun immediately following removal from the galvanizing bath and quenched in water. In addition, small parts shall be air cooled, as needed, in order to prevent the formation of zinc oxide.

5.3.2 Parts, which cannot be spun shall be brushed or handled otherwise to remove the excess zinc.

5.4 *Alteration of Threaded Fasteners*:

5.4.1 Fasteners that have been hot-dip galvanized shall not be further altered (such as subjected to a cutting, rolling, or finishing-tool operation) by the galvanizer unless specifically authorized in writing by the purchaser.

5.4.2 Hot-dip galvanizing of externally threaded fasteners shall meet the thread fitting requirements of the specified product standard or specific allowance as determined by the customer.

NOTE 1—The scope of this specification does not cover the requirements regarding the overtapping of galvanized nuts. These requirements are established by the applicable product standard, such as Specification A563, Specification A563M (or others), or in writing by the purchaser, if needed.

5.5 *Secondary Processing*:

5.5.1 When requested by the purchaser, treatments such as chromating or phosphating shall be applied to reduce the possibility of wet storage staining (white corrosion) or to assist subsequent painting.

5.5.2 When specified on the purchase order, the nuts, bolts, or screws shall be lubricated to enhance assembly.

**TABLE 1 Process Control of Batch Lot^A
Sampling Plan**

| Batch Lot Size | Sample Size ^B | | |
|----------------|--|----------|-------------------------|
| | Average Coating Thickness ^C | Adhesion | Appearance ^D |
| 5 to 25 | 1 | 1 | 1 |
| 26 to 50 | 1 | 1 | 2 |
| 51 to 150 | 2 | 1 | 2 |
| 151 and over | 2 | 2 | 2 |

^A The acceptance criterion in all cases is zero defects.

^B The sample size is the number of specimen(s) required to be tested/inspected to the applicable criteria.

^C Frequency of coating thickness frequency of measurements: one set of specimen(s) for every five batch lots. For test method, see 11.1.

^D Visual inspection for conformance.

6. Chemical Composition of Zinc

6.1 Unless otherwise specified in the product standard, the zinc used for the coating shall conform to the requirements of the section on Zinc of Specification A153/A153M.

7. Safeguards Against Alteration of Fasteners Mechanical Properties

7.1 *Stress Relief*—Fasteners subjected to severe work hardening shall be stress-relieved by the fastener manufacturer prior to hot-dip zinc coating (galvanizing).

7.2 Hot-Dip Zinc Coating:

7.2.1 Effect of Temperature on Mechanical Properties:

7.2.1.1 Galvanizing carried out at a temperature above 800°F [425°C] can adversely affect the final mechanical properties of the fasteners. Therefore, the supplier of the fasteners submitting the product to the galvanizer shall be aware of the tempering temperature of the fasteners relative to the temperature of the galvanizing bath and the potential effect it may have on the product. When requested by the purchaser, the average galvanizing temperature that the fasteners will be subjected to shall be furnished.

7.2.1.2 Unless otherwise required by the product standard or by the purchaser, testing for mechanical properties is not necessary if the galvanizing process is carried out at a lower temperature than the stress relief or tempering temperature of the fasteners. If the galvanizing process is carried out at a higher temperature than the stress relief or the tempering temperature of the fasteners, than the purchaser shall make provision for mechanical testing.

7.2.1.3 Threaded fasteners made from carbon or alloy steel heat treated to a minimum specified hardness of 40 HRC, or case hardened steel fasteners shall not be hot-dip zinc coated.

7.2.2 *Effect of Hydrogen on the Mechanical Properties after Galvanizing*—Hydrogen has the potential of being introduced into the steel during acid pickling, prior to hot-dip galvanizing. For high strength fasteners (having a specified minimum product hardness of 33 HRC), there is a risk of internal hydrogen embrittlement. If required by the product standard or by the purchaser, mechanical descaling (with or without flash pickling) or baking shall be conducted to reduce the risk of internal hydrogen embrittlement. Baking shall be conducted after pickling and prior to hot-dip galvanizing.

7.2.3 *Effect of the Galvanizing Temperature*—Externally threaded ferrous fasteners over 1.00 in. [M24] diameter with a specified minimum hardness of HRC 33 and higher shall not be hot-dip zinc coated at high temperature (see definition in 3.1.3) in order to avoid microcracks.

8. Coating and Dimensional Requirements

8.1 *Coating Thickness*—The zinc coating thickness shall meet the requirements of Table 2.

8.2 *Dimension*—The dimensional characteristics of the fasteners shall be in accordance with the requirements of the purchaser, when specified in the order. The purchaser shall ensure that the effect of the heat generated by the galvanizing process is compatible with the fastener regarding the final dimensional characteristics of the parts. Furthermore, the galvanizer shall not be held responsible for any unanticipated distortion of parts. In addition, the purchaser shall provide fasteners having sufficient dimensional allowance to accommodate the zinc thickness deposition, as required in 8.1.

8.3 *Adhesion of Zinc Coating*—The zinc coating shall adhere tenaciously to the surface of the base metal. The method for testing the condition of adherence is specified in 11.5.

9. Workmanship, Finish, and Appearance

9.1 Appearance of Zinc Coating:

TABLE 2 Zinc Coating Thickness

| Dimension ^{A,B} | Minimum Thickness on Surface | | |
|--|---|--|---|
| | Average Thickness of All Specimens Tested (Production Lot) ^{C,B} | Average Thickness of All Specimens Tested (Batch Lot) ^{C,D,B} | Average Thickness of Individual Specimen ^B |
| Fasteners and nuts over 3/8 in. in diameter Washers 3/16 in. and in. in thickness | 0.0020 in. | 0.0017 in. | 0.0017 in. |
| Fasteners and nuts over 3/8 in. [M10] in diameter Washers 3/16 in. [4.7 mm] and over in thickness | 0.0020 in. [50 μm] | 0.0017 in. [43 μm] | 0.0017 in. [43 μm] |
| Fasteners and nuts 3/8 in. and under in diameter Washers under 3/16 in. in thickness | 0.0017 in. | 0.0015 in. | 0.0015 in. |
| Fasteners and nuts 3/8 in. [M10] and under in diameter Washers under 3/16 in. [4.7 mm] in thickness | 0.0017 in. [43 μm] | 0.0015 in. [38 μm] | 0.0015 in. [38 μm] |

^A In the case of long pieces, such as anchor rods and similar articles over 5 ft [1.5 m] in length, the thickness measurement shall be determined at each end and the middle of the article. In the case of a fully threaded rod, the thickness measurements shall be determined at each end of the article. In no case shall the average of the measurements be below the average thickness shown in the Average Thickness on Individual Specimen column (see 11.2). The number of specimens to be tested per order shall be as specified in Section 10. Note—Based upon mathematical calculations, 1.0 oz /ft² [305 g/m²] of zinc surface corresponds to an average coating thickness of 0.0017 in. [43 μm].

^B Inch-pound and SI units may not be exact equivalents. See 1.3.

^C For test method, see 11.2. In no case shall the average reading of a single specimen be below the average thickness shown in the Average Thickness on Individual Specimen column.

^D See 5.2.1 and Table 1. For test method, see 11.2. In no case shall the average reading of a single specimen be below the average thickness shown in the Average Thickness on Individual Specimen column.