



Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners [Metric]¹

This standard is issued under the fixed designation F 2674; 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 that are manufactured in SI units (metric). Nails and rivets are not included in this specification.

NOTE 1—This specification is the metric companion of Specification F 2329.

1.2 This specification 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 SI units are to be regarded as standard. No other units of measurement are included in this 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

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

A 563M Specification for Carbon and Alloy Steel Nuts [Metric]

B 487 Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of Cross Section

E 376 Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Examination Methods

F 606M Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets [Metric]

F 1470 Guide for Fastener Sampling for Specified Mechanical Properties and Performance Inspection

F 1789 Terminology for F16 Mechanical Fasteners

F 2329 Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

3. Terminology

3.1 Terms used in this specification are defined in Terminology F 1789 unless otherwise defined in this specification.

3.2 *Definitions of Terms Specific to This Standard:*

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

3.4 *galvanizing*—hot-dip zinc coating.

3.5 *high temperature galvanizing*—galvanizing process carried out in a ceramic vessel (kettle) at an approximate temperature ranging between 530 and 560 °C.

3.6 *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 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.

3.7 *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.

3.8 *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:

¹ This test method is under the jurisdiction of ASTM Committee F16 on Fasteners and is the direct responsibility of Subcommittee F16.03 on Coatings on Fasteners.

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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.

- 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, 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 A 153/A 153M.

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, 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 2—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 A 563M (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.

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 A 153/A 153M.

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 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 shall 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, then the purchaser shall make provision for mechanical testing.

7.2.1.3 Threaded fasteners made from carbon or alloy steel heat treated to the specified hardness of 40 HRC or above, or case hardened steel fasteners, or fasteners made to specifications which forbids zinc coatings 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 larger than M24 with a specified minimum

TABLE 1 Process Control of Batch Lot^A

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

^AThe acceptance criterion in all cases is zero defects.

^BThe sample size is the number of specimen(s) required to be tested/inspected.

^CCoating thickness frequency of measurements: one set of specimen(s) for every five batch lots. For test method see 1.1

^DVisual inspection for conformance.

hardness of HRC 33 and higher shall not be hot-dip zinc coated at high temperature 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 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 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:*

9.1.1 After hot-dip galvanizing, fasteners shall meet the requirements of the section on Workmanship, Finish, and Appearance of Specification **A 153/A 153M**. Galvanized washers shall not be bonded to each other (see **Note 3**). Parts may be dull due to the presence of silicon in the steel. The dull appearance shall not be cause for rejection.

NOTE 3—Hot-dip washers tend to bond to each other. Suitable acceptance criteria shall be agreed between the purchaser and the galvanizer before placing the order. Unless otherwise agreed to in the purchase order, delivered galvanized washers shall not be bonded to each other.

9.1.2 The test method shall be in accordance with **11.3**.

9.2 *Smoothness of Zinc Coating:*

9.2.1 The zinc coating shall be smooth and reasonably uniform in thickness, as defined in the section on Workmanship, Finish, and Appearance of Specification **A 153/A 153M**. Smoothness of a surface is a relative term. Minor roughness that does not impair the intended use of the part, or roughness

that is related to the uncoated surface condition of the part, shall not constitute grounds for rejection of the parts.

9.2.2 The test method shall be in accordance with **11.3**.

10. Sampling

10.1 Test specimens shall be selected at random from each production lot or batch lot, when applicable.

10.2 *Selection of the Sampling Plan—Production Lot*—Two sampling plans are proposed, one based on detection process and one based on prevention process as defined in Terminology **F 1789**. The selection of the sampling plan shall be in accordance with Guide **F 1470**.

10.2.1 *Production Lot—Detection Process*—Sampling for coating thickness and for visual appearance shall be conducted in accordance with Table 1, Sample Level A, and Table 3, Sample Size A, of Guide **F 1470**. Sampling for adhesion test shall be in accordance with Table 1, Sample Level C, and Table 3, Sample Size C, of Guide **F 1470**.

10.2.2 *Production Lot—Prevention Process*—Sampling for coating thickness and for visual appearance shall be conducted in accordance with Table 2, Sample Level B, and Table 3 Sample Size B, of Guide **F 1470**. Sampling for adhesion test shall be in accordance with Table 2, Sample Level D, and Table 3, Sample Size D, of Guide **F 1470**.

11. Test Methods

11.1 Tests shall be made to ensure that the zinc coating is being furnished in accordance with this specification and as specified for the following:

11.2 *Coating Thickness :*

11.2.1 *Average Coating Thickness on an Individual Specimen:*

11.2.1.1 To calculate the average coating thickness of one specimen, a minimum of five readings shall be taken. In case the geometry of the specimen does not permit five readings, five test specimens shall be used to establish the average reading.

11.2.1.2 The determination of the coating thickness shall be made on a portion of the fastener that does not include any threads in accordance with Practice **E 376**.

TABLE 2 Zinc Coating Thickness

Dimension ^A	Minimum Thickness on Surface		
	Average Thickness of All Specimens Tested (Production Lot) ^B	Average Thickness of All Specimens Tested (Batch Lot) ^C	Average Thickness of Individual Specimens
Fasteners with a diameter larger than M8 Washers 470 mm to 660 mm in thickness	50 µm	43 µm	43 µm
Fasteners with a diameter up to M8 Washers under 470 mm in thickness	43 µm	38 µm	38 µm

^A In the case of long pieces, such as anchor rods and similar articles over 1.5 m 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, 305 g/m² of zinc surface corresponds to an average coating thickness of 43 µm.

^B 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

^C 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.

11.2.1.3 In case of arbitration, the thickness of coating shall be determined by cross section and optical measurement, in accordance with Test Method **B 487**. Thus, the thickness determined is a point value. No less than five measurements shall be made at locations on the test specimen, which are as widely dispersed as practical, so as to be representative of the whole surface of the test specimen. The average of those selected measurements is the average coating thickness.

11.3 *Finish and Appearance*—Finish and appearance shall be visually inspected.

11.4 *Embrittlement Test*—If the product standard requires testing for hydrogen embrittlement of galvanized fasteners, testing shall be done in accordance with Test Methods **F 606M** or other test method(s), as required by the purchaser.

11.5 *Adhesion Test*—Testing for adherence shall be conducted as determined in the section on Adherence of Specification **A 153/A 153M**.

12. Inspection

12.1 When dimensional inspection of the fasteners by the galvanizer is required by the purchaser in the order, the purchaser shall provide the necessary inspection tools and gages to the galvanizer.

12.2 The representative of the purchaser shall have access at all times while work on the contract of the purchaser is being performed, to those areas of the galvanizer's work which concern the application of the zinc coating to the fastener ordered. The manufacturer shall afford the representative of the purchaser all reasonable facilities to satisfy him that the zinc coating is being furnished in accordance with this specification. All inspections and tests shall be made at the place of manufacture prior to shipments, unless otherwise specified, and shall be conducted so as not to unnecessarily interfere with the operation of the works.

13. Rejection and Rehearing

13.1 When partial inspection of fasteners to determine conformity with visual requirements of Section 9 warrants rejection of a lot, the galvanizer may sort the lot and submit it once again for inspection.

13.2 Disposition of nonconforming lots shall be in accordance with the section on Disposition of Nonconforming Lots of Guide **F 1470**.

13.3 Fasteners that have been rejected for reasons other than embrittlement may be stripped and re-galvanized and submitted for test and inspection. They shall then conform to the requirements of this specification.

14. Certification

14.1 When specified in the purchase order or contract, certification shall be furnished declaring that samples representing each lot have been either tested or inspected, as required by this specification, and that the requirements have been met. When specified in the purchase order or contract, the average galvanizing temperature shall be reported and the average thickness of the production lot shall be furnished.

15. Product Marking

15.1 When the galvanizer is required to pack hot-dip galvanized fasteners, they should not be packed in unventilated containers, if fabricated from unseasoned wood. The packaging shall comply with the purchaser requirements.

16. Keywords

16.1 coatings, zinc; galvanized coatings; steel fastener products, metallic coated; steel zinc coated; zinc coating fastener products

APPENDIXES

(Nonmandatory Information)

X1. GALVANIZING TEMPERATURE

X1.1 Normally galvanizing is carried out at a bath temperature of 435°C to 480°C. High temperature galvanizing is used to produce a smoother and thinner coating and is carried out at

a bath temperature of 530°C to 560°C. The finish obtained using the high temperature process is dull.

X2. VARIATION IN COATING

X2.1 During galvanizing of a production lot, variation can be experienced due to factors inherent to the galvanizing process, such as immersion time, zinc temperature, time span between

removal of fasteners from the zinc bath and the centrifuging, and the like.

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