



Designation: F3393 – 24

Standard Specification for Zinc-Flake Coating Systems for Fasteners¹

This standard is issued under the fixed designation F3393; 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 Zinc-flake coating systems are fluid dispersions of zinc-flakes, sometimes with the addition of aluminum flakes, which are non-electrolytically applied to steel substrates. The zinc-flake coating system shall be supplied without hexavalent chromium and can be water based or solvent based systems. Cohesion among the zinc-flakes and adhesion to the steel substrate is achieved through a matrix that is formed during the curing process.

1.2 This specification covers the classification, performance, and basic requirements for non-electrolytically applied zinc-flake coatings on unified inch and metric series threaded fasteners with minimum nominal diameters of 0.250 in. for inch series and 6 mm for metric.

1.3 This standard is a consolidation and replacement of three ASTM standards: Specifications [F1136/F1136M](#), [F2833](#), and [F3019/F3019M](#).

1.4 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

¹ This specification 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. Referenced Documents

2.1 *ASTM Standards*:²

- [B117](#) Practice for Operating Salt Spray (Fog) Apparatus
- [B487](#) Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of Cross Section
- [B499](#) Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals
- [B568](#) Test Method for Measurement of Coating Thickness by X-Ray Spectrometry
- [D610](#) Practice for Evaluating Degree of Rusting on Painted Steel Surfaces
- [D3359](#) Test Methods for Rating Adhesion by Tape Test
- [E376](#) Practice for Measuring Coating Thickness by Magnetic-Field or Eddy Current (Electromagnetic) Testing Methods
- [F606/F606M](#) Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets
- [F788](#) Specification for Surface Discontinuities of Bolts, Screws, Studs, and Rivets, Inch and Metric Series
- [F1136/F1136M](#) Specification for Zinc/Aluminum Corrosion Protective Coatings for Fasteners
- [F1470](#) Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection
- [F1624](#) Test Method for Measurement of Hydrogen Embrittlement Threshold in Steel by the Incremental Step Loading Technique
- [F1789](#) Terminology for F16 Mechanical Fasteners
- [F1940](#) Test Method for Process Control Verification to Prevent Hydrogen Embrittlement in Plated or Coated Fasteners
- [F2660](#) Test Method for Qualifying Coatings for Use on F3125 Grade A490 Structural Bolts Relative to Environmental Hydrogen Embrittlement
- [F2833](#) Specification for Corrosion Protective Fastener Coatings with Zinc Rich Base Coat and Aluminum Organic/Inorganic Type

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.

F3019/F3019M Specification for Chromium Free Zinc-Flake Composite, with or without Integral Lubricant, Corrosion Protective Coatings for Fasteners

F3125/F3125M Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

2.2 *ASME Standards*:³

B1.1 Unified Inch Screw Threads (UN, UNR, and UNJ Thread Forms)

B1.2 Gages and Gaging for Unified Inch Screw Threads

B18.18 Quality Assurance for Fasteners

2.3 *ISO Standards*:⁴

ISO 965-1 ISO General Purpose Metric Screw Threads – Tolerances – Part 1: Principles and Basic Data

ISO 965-2 ISO General Purpose Metric Screw Threads – Tolerances – Part 2: Limits of Sizes for General Purpose External and Internal Screw Threads – Medium Quality

ISO 965-3 ISO General Purpose Metric Screw Threads – Tolerances – Part 3: Limit Deviations for Screw Threads

ISO 1502 ISO General Purpose Metric Screw Threads – Gauges and gauging

ISO 9227 Corrosion Tests in Artificial Atmospheres – Salt Spray Tests

ISO 10683 Fasteners – Non-Electrolytically Applied Zinc Flake Coating Systems

ISO 16047 Fasteners – Torque/clamp force testing

2.4 *Industrial Fasteners Institute*:⁵

IFI-144 Test Evaluation Procedures for Coating Qualification Intended for use on High Strength Structural Bolts

reductions in corrosion protection depending upon the coating system and geometry of the coated part. This reduction in corrosion protection can also occur when topcoats that are sensitive to impact damage or abrasion are utilized. An agreement to reduce the minimum corrosion resistance requirement or increase the minimum coating thickness or minimum coating weight described in **Table 1** may be made between the purchaser and the coating applicator.

3.2 *Appearance*—Zinc-flake coating systems shall be applied to the articles to be coated and have an appearance as specified in **Table 2**.

3.3 *Average Total Coefficient of Friction*—Zinc-flake coating systems shall have an average total coefficient of friction as specified in **Table 3**.

3.4 *Zinc-Flake Coating Systems*—Zinc-flake coating systems (base coat only, base coat(s) plus topcoat(s)), including coating thickness or coating weight shall be specified and agreed upon at the time of the order.

3.4.1 Zinc-flake coating systems can be supplied with or without a topcoat.

NOTE 2—Topcoats, either organic or inorganic, provide additional performance enhancing characteristics such as corrosion resistance, colored appearance, integral lubricant for friction control, chemical resistance, abrasion resistance, and UV resistance. A topcoat may not be required to fulfill a specified average total coefficient of friction requirement if the zinc-flake coating contains integral lubricant.

3.4.2 Zinc-flake coating systems shall be applied via the dip-spin, dip-drain, rack dip-spin, or spray methods. Special application techniques may be necessary to avoid excessive or insufficient coating thickness and part sticking. For guidance in determining the dimensional accommodations of zinc-flake coating systems in the pitch, major, and/or minor diameter refer to ASME B1.1 Section 7 and ISO 965.

NOTE 3—The dip-spin, dip-drain, rack dip-spin, or spray application of zinc-flake coating systems may lead to non-uniform local coating thickness that typically does not impair thread fit.

3.4.3 Zinc-flake coating systems may require a peak metal temperature up to 671 °F (355 °C) for proper curing conditions of the coating; however, the curing temperature shall not exceed the tempering temperature of quenched and tempered fasteners. The curing temperature shall not alter the mechanical or physical properties of the coated articles.

NOTE 4—Prior to installation, contact with liquids, condensation, dust, or any other conditions that are detrimental to the coating system should be avoided.

4. Surface Preparation

4.1 Surface cleaning may consist of vapor, thermal, alkaline, or other degreasing methods intended to remove

3. Classification

3.1 *Corrosion Resistance, Minimum Coating Thickness, or Minimum Coating Weight*—Unless otherwise agreed between the purchaser and the coating applicator, zinc-flake coating systems shall meet the minimum corrosion resistance and coating thickness or coating weight specified in **Table 1**.

NOTE 1—Bulk handling processes, including secondary operations such as automatic feeding, sorting, transportation, and storage can lead to

³ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

⁴ Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <http://www.iso.org>.

⁵ Available from Industrial Fasteners Institute, 6363 Oak Tree Boulevard, Independence, OH 44131, <https://www.indfast.org>.

TABLE 1 Minimum Corrosion Resistance, Minimum Coating Thickness, or Minimum Coating Weight

Classification Code	Minimum Corrosion Resistance	Minimum Coating Thickness	Minimum Coating Weight
A	240h	0.00016 in. - 4µm	0.0430oz/ft ² – 13g/m ²
B	480h	0.00020 in. - 5µm	0.0524oz/ft ² – 16g/m ²
C	600h	0.00025 in. - 6µm	0.0688oz/ft ² – 21g/m ²
D	720h	0.00030 in. - 8µm	0.0754oz/ft ² – 23g/m ²
E	1000h ^A	0.00050 in. - 12µm	0.0800oz/ft ² – 24g/m ²
F	1200h	0.00060 in. - 15µm	0.1180oz/ft ² – 36g/m ²
G	As Agreed Upon	As Agreed Upon	As Agreed Upon

^A A minimum corrosion resistance of 1000 h may require up to 1008 h of testing as the assessment of corrosion is typically performed in 24 hour intervals.

TABLE 2 Appearance

Classification Code	Appearance
1	Silver / Gray
2	Black
3	Other Colors (As Agreed Upon)

TABLE 3 Average Coefficient of Total Friction Range and Test Program

Classification Code	Average Coefficient of Total Friction (μ_{tot}) ^A
M	0.09 (±) 0.03
N	0.12 (±) 0.03
R	0.15 (±) 0.04
S	0.19 (±) 0.05
T	0.26 (±) 0.06
W	As Agreed Upon

^A The results for all tested samples must lie within the permissible range

organic soils. Thermal degreasing shall be performed at temperatures that do not negatively alter the mechanical or physical properties of the articles to be coated. Electrochemical cleaning shall not be performed.

4.2 Surface preparation methods intended to remove inorganic soils may include mechanical descaling (for example, shot blasting) or chemical descaling (for example, acidic cleaning, see 4.3) that is then followed by pretreatment with a chemical conversion coating (for example, zinc-phosphate). Prior to mechanical or chemical descaling, surface preparation in accordance with 4.1 shall be performed for articles that require removal of organic soils.

4.3 Acidic cleaning processes (for example, acid pickling) increase the risk of Internal Hydrogen Embrittlement (IHE) for high strength fasteners. To reduce the risk of Internal Hydrogen Embrittlement (IHE), the acidic cleaning process shall contain suitable inhibitor(s) and be performed utilizing minimum cleaning cycle times.

NOTE 5—While non-electrolytically applied zinc-flake coating systems do not generate hydrogen during the coating application process, surface preparation processes which incorporate the use of acid cleaners (for example, acid pickling) may lead to hydrogen adsorption.

4.3.1 Acidic cleaning processes shall not be utilized for steel fasteners having an ultimate tensile strength greater than 173 ksi / 1193 MPa or products with a specified core hardness greater than 39 HRC (385 HV), unless specified by the purchase order.

5. Ordering Information

5.1 Orders for materials in accordance with this specification shall include the following information (where applicable):

5.1.1 Quantity and description of parts, according to a standard or a drawing.

5.1.2 Minimum Corrosion Resistance, Minimum Coating Thickness, or Minimum Coating Weight (see Table 1).

5.1.3 Appearance (see Table 2).

5.1.4 Average Coefficient of Total Friction Range and Test Program (see Table 3 and 7.7).

5.1.5 Preferred surface preparation method (see Section 4).

5.1.6 Any applicable processing restrictions (for example, no acidic cleaning).

5.1.7 Part Sampling Plans, Inspection Plans, Testing (including any special testing), and Test Reports shall be as agreed upon between the purchaser and the coating applicator prior to processing.

5.1.8 When the parts to be coated are Specification F3125/F3125M structural fasteners with minimum tensile strength 150 ksi / 1040 MPa, this shall be declared in the inquiry and order (see A1.5).

5.1.9 Any additions or modifications to this specification shall be agreed upon between the purchaser and the coating applicator.

6. Coating System Requirements

6.1 *Corrosion Resistance*—The coating system shall be capable of withstanding exposure to salt spray for the minimum hours specified in Table 1.

6.2 *Cathodic Protection*—The coating shall not exhibit red corrosion after exposure to neutral salt spray testing for a minimum of 72 h when scratched to the base metal with a sharp cutting tool having a nominal width of 0.02 ± 0.005 in. (0.5 ± 0.13 mm).

6.3 *Coating Appearance*—When viewed without magnification, the coating shall have a uniform appearance and be free from uncoated areas, discontinuities, and excess coating which affects fit, form, or part function.

6.4 *Adhesion*—When an adhesive tape with 25 mm width and minimum adhesive strength of 6 N is firmly pressed by hand on to the surface and is subsequently pulled off rapidly and perpendicularly to the surface, the coating shall not be peeled off the base metal. Small amounts of the coating left sticking to the tape are acceptable.

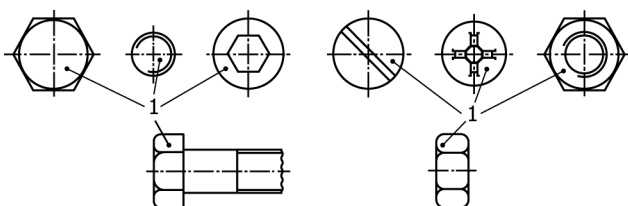


FIG. 1 Reference Areas for Coating Thickness Measurement

