



Designation: F1941/F1941M – 16

Standard Specification for Electrodeposited Coatings on Mechanical Fasteners, Inch and Metric¹

This standard is issued under the fixed designation F1941/F1941M; 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.

INTRODUCTION

This specification covers the coating of steel unified inch and metric mechanical fasteners by electrodeposition. The properties of the coatings shall conform to the ASTM standards for the individual finishes. This standard shall be used in place of ASTM B633 for mechanical fasteners.

Coating thickness values are based on standard tolerances for inch and metric external threads. The coating must not cause the basic thread size to be transgressed by either the internal or external threads. The method of designating inch coated threads shall comply with ASME B1.1 and ISO 965-1, ISO 965-2, and ISO 965-3 for ISO metric coated threads.

With normal methods for depositing metallic coatings from aqueous solutions, there is a risk of delayed failure due to hydrogen embrittlement for case hardened fasteners and fasteners having a hardness above 39 HRC. Although this risk can be managed by selecting raw materials suitable for the application of electrodeposited coatings and by using modern methods of surface treatment and post heat-treatment (baking), the risk of hydrogen embrittlement cannot be completely eliminated. Therefore, the application of a metallic coating by electrodeposition is not recommended for such fasteners.

1. Scope*

1.1 This specification covers application, performance and dimensional requirements for electrodeposited coatings on threaded fasteners with unified inch and metric screw threads, but it may also be applied to other threaded parts and non-threaded parts such as washers and pins. It specifies coating thickness, supplementary hexavalent chromate or non-hexavalent conversion coatings, corrosion resistance, precautions for managing the risk of hydrogen embrittlement and hydrogen embrittlement relief for high-strength and surface-hardened fasteners. It also highlights the differences between barrel and rack plating and makes recommendations as to the applicability of each process.

1.2 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 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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1.3 Terms used in this specification are defined in Terminology F1789.

1.4 The following precautionary statement pertains to the test method portion only, Section 9, of this specification: *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.*

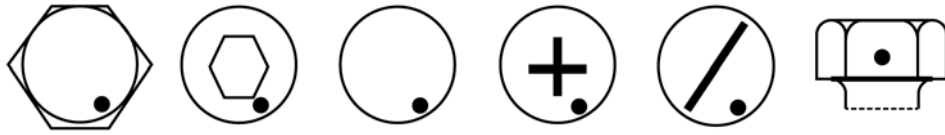
2. Referenced Documents

2.1 ASTM Standards:²

- 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
- B504 Test Method for Measurement of Thickness of Metallic Coatings by the Coulometric Method

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.

*A Summary of Changes section appears at the end of this standard



NOTE 1—Black dot (•) indicates test surface.

FIG. 1 Significant Surfaces on Externally Threaded Fasteners

- B567 Test Method for Measurement of Coating Thickness by the Beta Backscatter Method
- B568 Test Method for Measurement of Coating Thickness by X-Ray Spectrometry
- B633 Specification for Electrodeposited Coatings of Zinc on Iron and Steel
- B659 Guide for Measuring Thickness of Metallic and Inorganic Coatings
- D6492 Practice for Detection of Hexavalent Chromium On Zinc and Zinc/Aluminum Alloy Coated Steel
- E376 Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Testing Methods
- F519 Test Method for Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments
- 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, and Studs, Inch and Metric Series
- 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
- F2078 Terminology Relating to Hydrogen Embrittlement Testing
- 2.2 ASME Standards:³
 - B1.1 Unified Inch Screw Threads (UN and UNR Thread Form)
 - B1.2 Gages and Gaging for Unified Inch Screw Threads
 - B1.16M Gages and Gaging for Metric M Screw Threads
 - B18.6.3 Machine Screws, Tapping Screws, and Metallic Drive Screws (Inch Series)
- 2.3 National Aerospace Standard (AIA):⁴
 - NASM-1312-5 Fast Test Method – Method 5: Stress Durability
- 2.4 IFI Standard:⁵
 - IFI-142 Hydrogen Embrittlement Risk Management

2.5 ISO Standards:⁶

- 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
- ISO 965-3 ISO General Purpose Metric Screw Threads – Tolerances – Part 3: Deviations for Construction Screw Threads
- ISO 4042 Electroplated Coatings

3. Terminology

3.1 Definitions:

3.1.1 *reference area*—the area within which a specified number of single measurements are required to be made.

3.1.2 *sealant*—chemical with or without integral lubricant applied on the substrate which forms a composite layer with a conversion coating in order to improve chemical resistance, corrosion protection, UV resistance, etc.

3.1.3 *significant surface*—Figs. 1 and 2 illustrate significant surfaces on standard externally and internally threaded fasteners and washers.

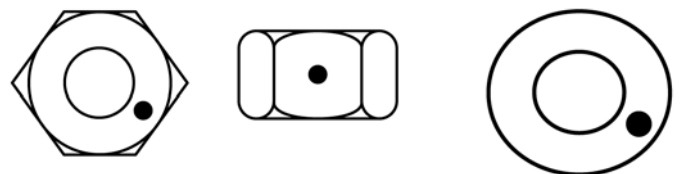
3.1.4 *top coat*—additional layer with or without integral lubricant applied on a substrate in order to achieve functional properties such as torque-tension control, color, chemical resistance, etc.

4. Classification

4.1 *Coating Material*—The coating material shall be selected and designated in accordance with Table 1.

4.2 *Coating Thickness*—The coating thickness shall be selected and designated in accordance with Table 2.

4.3 *Conversion Coating*—The conversion coating shall be selected and designated in accordance with Table 3. When not specified, hexavalent chromium, or hexavalent chromium free passivation such as trivalent chromium passivation or other



NOTE 1—Black dot (•) indicates test surface.

FIG. 2 Significant Surfaces on Internally Threaded Fasteners and Washers

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

⁴ Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, <http://quicksearch.dla.mil>.

⁵ Available from Industrial Fasteners Institute (IFI), 1717 East 9th Street, Suite 1105, Cleveland, OH 44114-2879.

TABLE 1 Designation of Common Coating Materials

Coating Designation	Coating Type
Fe/Zn	Zinc
Fe/Cd	Cadmium
Fe/Zn-Co	Zinc Cobalt Alloy
Fe/Zn-Ni	Zinc Nickel Alloy
Fe/Zn-Fe	Zinc Iron Alloy

TABLE 2 Designation of Coating Thickness – Inch and Metric

NOTE 1—The conversion factor from inch to microns is 2.54×10^4 (for example, 0.0001 in. = 2.54 μm).

Thickness Designation	Minimum Thickness	
	in.	μm
3	0.0001	3
5	0.0002	5
8	0.0003	8
12	0.0005	12

TABLE 3 Designation of Conversion Coating

Type	Typical Appearance	Conversion Designation	
		Hexavalent Chromium	Hexavalent Chromium Free
Clear	Transparent colorless with slight iridescence	A	AN
Blue-bright	Transparent with a bluish tinge and slight iridescence	B	BN
Yellow	Yellow iridescent	C	CN
Opaque	Olive green, shading to brown or bronze	D	DN
Black	Black with slight iridescence	E	EN

non-chromium passivation finish shall be used at the option of the manufacturer and its appearance shall be selected in accordance with the designation selected in [Table 3](#).

4.4 *Supplemental Lubricant, Sealants or Top Coats*—Additional sealants or top coats (with or without integral lubricant) may be chosen to increase corrosion resistance and to achieve other specific properties such as torque-tension, UV resistance, etc. The selection of the nature of a sealant or top coat should be based on desired additional properties. When sealants or top coats are specified, the classification code in [Table 3](#) shall be appended by adding the letter “S” (for example Fe/Zn 5ANS). When specifying a lubricant, the classification code in [Table 3](#) shall be appended with the letter “L” (for example Fe/Zn 5ANSL).

NOTE 1—When using a sealant or top coat, a separate conversion coating layer and/or lubricant layer may not be required to achieve the corrosion performance or provide lubricity.

4.5 [Fig. 3](#) illustrates the basic electroplating coating systems.

4.5.1 Only coating material layer(s).

4.5.2 Coating material layer(s) plus conversion coating (for example Fe/Zn 5A).

4.5.3 Coating material layer(s) plus conversion coating plus additional lubricant (example Fe/Zn 5ANL).

4.5.4 Coating material layer(s) plus conversion coating plus sealant top coat (example Fe/Zn 5ANS).

4.5.5 Coating material layer(s) plus conversion coating plus sealant top coat plus additional lubricant (example Fe/Zn 5ANSL).

5. Ordering Information for Electroplating

5.1 When ordering threaded fasteners to be coated by electrodeposition in accordance with this specification, the following information shall be supplied to the electroplater:

5.1.1 The desired coating, coating thickness, the conversion coating, the color and appearance (if applicable), or the classification codes as specified in [Tables 1-3](#) and additional sealants or top coats (for example, Fe/Zn 5C denotes yellow zinc plated with a minimum thickness of 0.0002 in. or 5 μm for metric on significant surfaces).

5.1.2 The identification of significant surfaces (optional).

5.1.3 The requirement, if any, for stress relief before electroplating, in which case the stress-relief conditions must be specified.

5.1.4 The requirements, if any, for hydrogen embrittlement relief by heat treatment (baking), other than as required by [6.4.1](#) must be specified. Requirements shall include baking time and temperature.

5.1.5 The requirements, if any, for embrittlement testing other than as required by [6.4.3](#) must be specified.

NOTE 2—Through hardened fasteners with a specified maximum hardness of 39 HRC and below have a low susceptibility to hydrogen embrittlement and do not require baking.

5.1.6 The requirements, if any, for the type of electroplating process (barrel-plating or rack-plating). See [Section 10](#) and [Appendix X1](#).

5.1.7 The designation of inch coated thread class shall comply with ASME B1.1 and metric threads shall comply with ISO 965-1, ISO 965-2 and ISO 965-3.

6. Requirements

6.1 *Coating Requirements*—The electrodeposited coating as ordered shall cover all surfaces and shall meet the following requirements:

6.1.1 The coating metal deposit shall be bright or semi-bright unless otherwise specified by the purchaser, smooth, fine grained, adherent and uniform in appearance.

6.1.2 The coated fastener shall be free of blisters, pits, nodules, roughness, unplated areas, and other defects that will affect the function of the coating.

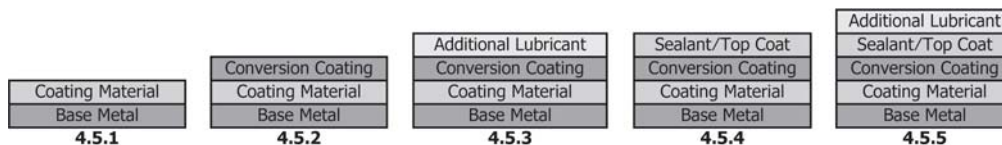


FIG. 3 Basic Electroplating Coating Systems