Designation: F 1941 – 00

Standard Specification for Electrodeposited Coatings on Threaded Fasteners (Unified Inch Screw Threads (UN/UNR))[1]

This standard is issued under the fixed designation F 1941; 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 screw threaded fasteners by electrodeposition. The properties of the coatings shall conform to the ASTM standards for the individual finishes listed.

Coating thickness values are based on the tolerances for 1A and 2A external Unified Inch Screw Threads. The coating must not cause the basic thread size to be transgressed by either the internal or external threads. The method of designating coated threads shall comply with ASME B1.1.

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 40 HRC or above. 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 screw threads. It specifies coating thickness, supplementary chromate finishes, 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 SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 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:*

B 117 Practice for Operating Salt Spray (Fog) Apparatus[2]

B 487 Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of a Cross Section[3]

B 499 Test Method for Measurement of Coating Thickness by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals[3]

B 504 Test Method for Measurement of Thickness of Metallic Coatings by the Coulometric Method[3]

B 567 Test Method for Measurement of Coating Thickness by the Beta Backscatter Method[3]

B 568 Test Method for Measurement of Coating Thickness by X-Ray Spectrometry[3]

B 633 Specification for Electrodeposited Coatings of Zinc on Iron and Steel[3]

B 659 Guide for Measuring Thickness of Metallic and Inorganic Coatings[3]

B 766 Specification for Electrodeposited Coatings of Cadmium[3]

B 840 Specification for Electrodeposited Coatings of Zinc

[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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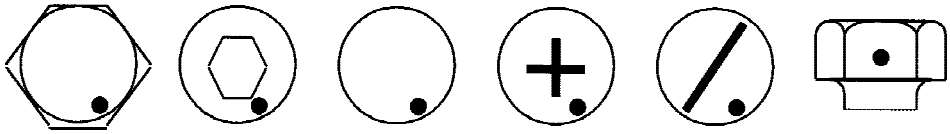
[2] *Annual Book of ASTM Standards*, Vol 03.02.

[3] *Annual Book of ASTM Standards*, Vol 02.05.



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

FIG. 1 Significant Surfaces on Externally Threaded Fasteners

Cobalt Alloy Deposits[3]

B 841 Specification for Electrodeposited Coatings of Zinc Nickel Alloy Deposits[3]

B 842 Specification for Electrodeposited Coatings of Zinc Iron Alloy Deposits[3]

E 376 Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Test Methods[4]

F 606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets[5]

F 1470 Guide for Fastener Sampling for Specified Mechanical Properties and Performance Inspection[5]

F 1624 Test Method for Measurement of Hydrogen Embrittlement in Steel by the Incremental Loading Technique[6]

F 1940 Test Method for Precess Control Verification to Prevent Hydrogen Embrittlement in Plated or Coated Fasteners[5]

2.2 *ASME Standard:*

B1.1 Unified Inch Screw Threads (UN and UNR Thread Form)[7]

2.3 *National Aerospace Standard (AIA):*

NASM-1312-5 Fast Test Method - Method 5: Stress Durability[8]

2.4 *IFI Standard:*

IFI-142 Hydrogen Embrittlement Risk Management[9]

3. Terminology

3.1 *Definitions:*

3.1.1 *local thickness*—the mean of the thickness measurements, of which a specified number is made within a reference area.

3.1.2 *minimum local thickness*—the lowest local thickness value on the significant surface of a single article.

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

3.1.4 *significant surface*—significant surfaces are areas where the minimum thickness to be met shall be designated on the applicable drawing or by the provision of a suitably marked sample. However, if not designated, significant surfaces shall be defined as those normally visible, directly or by reflection, which are essential to the appearance or serviceability of the fastener when assembled in normal position, or which can be the source of corrosion products that deface visible surfaces on the assembled fastener. Figs. 1 and 2 illustrate significant surfaces on standard externally threaded and internally threaded fasteners.

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 *Chromate Finish*— The chromate finish shall be selected and designated in accordance with Table 3.

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 and the chromate finish, or the classification codes as specified in Tables 1-3. (for example, Fe/Zn 5C denotes yellow zinc plated with a minimum thickness of 0.0002 in. on significant surfaces.)

5.1.2 The identification of significant surfaces (optional).

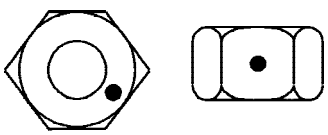
5.1.3 The requirement, if any, for stress relief before electroplating, in which case the stress-relief conditions must be specified.

5.1.4 The requirements, if any, for hydrogen embrittlement relief by heat treatment (baking) stating the tensile strength or surface hardness of the fasteners and/or baking time and temperature.

NOTE 1—Fasteners with a specified maximum hardness of 34 HRC and below have a very low susceptibility to hydrogen embrittlement and do not require baking.

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

5.1.6 The designation of coated thread class shall comply with ASME B1.1.



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

FIG. 2 Significant Surfaces on Internally Threaded Fasteners

[4] *Annual Book of ASTM Standards*, Vol 03.03.

[5] *Annual Book of ASTM Standards*, Vol 01.08.

[6] *Annual Book of ASTM Standards*, Vol 15.03.

[7] Available from American Society of Mechanical Engineers (ASME) 345 E. 47th Street, New York, NY 10017.

[8] Available from Standard Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111–5094, Attn: NPODS.

[9] Available from Industrial Fasteners Institute (IFI), 1717 East 9th Street, Suite 1105, Clevland, 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

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.
3	0.0001
5	0.0002
8	0.0003
12	0.0005

TABLE 3 Designation of Chromate Finish

Designation	Type	Typical Appearance
A	Clear	Transparent colorless with slight iridescence
B	Blue-bright	Transparent with a bluish tinge and slight iridescence
C	Yellow	Yellow iridescent
D	Opaque	Olive green, shading to brown or bronze
E	Black	Black with slight iridescence
F	Organic	Any of the above plus organic topcoat

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

6.1.3 The coating shall not be stained, discolored or exhibit any evidence of white or red corrosion products.

6.1.3.1 Slight discoloration that results from baking, drying, or electrode contact during rack-plating, or all of these, as well as slight staining that results from rinsing shall not be cause for rejection.

6.2 *Corrosion Resistance*—Coated fasteners, when tested by continuous exposure to neutral salt spray in accordance with 9.3, shall show neither corrosion products of coatings (white corrosion) nor basis metal corrosion products (red rust) at the end of the test period. The appearance of corrosion products visible to the unaided eye at normal reading distance shall be cause for rejection, except when present at the edges of the tested fasteners. Refer to Annex A1 for neutral salt spray performance requirements for zinc, zinc alloy and cadmium coatings.

6.3 *Thickness*—The coating thickness shall comply with requirements of Table 2 when measured in accordance with 9.1.

6.3.1 *Restrictions on Coating Thickness*—This specification imposes minimum local thickness requirements at significant surfaces in accordance with Table 2. Thick or thin local thickness in a location other than a significant surface shall not be a cause for rejection. However the following restrictions apply:

6.3.1.1 Minimum coating thickness at low current density areas, such as the center of a bolt or recesses, must be sufficient to provide for adequate chromate adhesion.

6.3.1.2 *External Threads*— Maximum coating thickness at high current density threaded tips must provide for class 3A GO thread gauge acceptance.

6.3.1.3 *Internal Threads*— Maximum coating thickness of internal threads must provide for class 1B, 2B, or 3B Go thread gage acceptance.

6.3.1.4 Surfaces such as threads, holes, deep recesses, bases of angles, and similar areas on which the specified thickness of deposit cannot readily be controlled, are exempted from minimum thickness requirements unless they are specially designated as not being exempted. When such areas are subject to minimum thickness requirements, the purchaser and the manufacturer shall recognize the necessity for either thicker deposits on other areas or special racking.

6.3.2 *Applicability to Unified Inch Screw Threads*:

6.3.2.1 The applicability of the required coating to unified inch screw threads is limited by the basic deviation of the threads, and hence limited by the pitch diameter, allowance and tolerance positions. Refer to Appendix X3 as a guideline for the tolerances of the various thread sizes and classes and the coating thickness they will accommodate.

6.3.2.2 Because of the inherent variability in coating thickness by the barrel-plating process, the application of a minimum coating thickness of 0.0005 in. is not recommended for a standard screw thread by this method due to the fact that dimensional allowance of most threaded fasteners normally does not permit it. If the size of the fastener is large enough to economically use the rack-plating process, then the latter shall be used to obtain this thickness requirement. If heavier coatings are required allowance for the deposit buildup must be made during the manufacture of fasteners.

6.3.3 *Applicability to Wood Screws and Thread Forming Screws*—Any classification code in Table 2 may be applied to screws that cut or form their own threads.

6.4 *Hydrogen Embrittlement Relief*:

6.4.1 *Requirement for Baking*—Coated fasteners made from steel heat treated to a specified hardness of 40 HRC or above, case-hardened steel fasteners, and fasteners with captive washers made from hardened steel shall be baked to minimize the risk of hydrogen embrittlement. Unless otherwise specified by the purchaser, baking is not mandatory for fasteners with specified maximum hardness below 40 HRC.

NOTE 2—With proper care many steel fasteners can be plated without baking by correlating process conditions to the susceptibility of the fastener material to hydrogen embrittlement, and by applying adequate process control procedures, such as those outlined in Appendix X4.2. Test Method F 1940 is a recognized verification method for process control to minimize the risk of hydrogen embrittlement. Upon agreement between the supplier and the purchaser, this test method can be used as a basis for

determining if baking should be mandated in a controlled process environment.

6.4.2 *Baking Conditions*—At the time of publication of this specification it was not considered possible to give an exact baking duration. Eight hours is considered a typical example of baking duration. However, upon agreement between the purchaser and the manufacturer, baking times between 2 and 24 h at temperatures of 350 to 450°F are suitable depending on the type and size of the fastener, geometry, mechanical properties, cleaning process and cathodic efficiency of the electroplating process used. The baking conditions shall be selected based on the results of recognized embrittlement test procedures such as Test Methods F 606, F 1624, F 1940, or NASM–1312–5.

6.4.2.1 Bake time and temperatures may require lowering to minimize the risk of solid or liquid metal embrittlement resulting from alloy compositions such as those containing lead or from the lower melting point of cadmium (610°F) in comparison to zinc (786°F).

6.4.2.2 Fasteners must be baked within 4 h, preferably 1 h after electroplating. Baking to relieve hydrogen embrittlement must be performed prior to the application of the chromate finish because temperatures above 150°F damage the chromate film thereby negating its performance.

6.4.3 *Hydrogen Embrittlement Testing*—Hydrogen embrittlement testing is mandatory for fasteners with a specified hardness of 40 HRC or above unless the electroplating process has been qualified in accordance with Test Method F 1940 (that is, the process has been shown not to cause embrittlement for a given product or class of product). This specification does not require mandatory testing of fasteners having a specified hardness below 40 HRC, unless otherwise specified by the purchaser.

7. Dimensional Requirements

7.1 Threaded components, except those with spaced and forming threads, supplied for electrodeposited coating shall comply with ASME B1.1. Screw threads that are specifically manufactured to allow the application of 0.0005 in. or greater coating thickness by the barrel-plating process, must adhere to a special allowance specified by the manufacturer or in ASME B1.1. The other dimensional characteristics shall be as specified in the applicable standard or drawing. It should be noted that modifications to the threads of a fastener could affect its properties or performance, or both. Refer to Appendix X3 for further information on effects of coating on pitch diameter, allowances and tolerances for external and internal threads.

8. Sampling

8.1 Sampling for coating thickness, salt spray and embrittlement testing shall be conducted based on lot size in accordance with Guide F 1470.

9. Test Methods

9.1 *Coating Thickness*—Unless otherwise specified, the requirement to measure coating thickness is applicable to significant surfaces only. The test methods for determining the coating thickness are defined in Test Methods B 487, B 499, B 504, B 567, B 568, Guide B 659, or Practice E 376 as applicable.

9.2 *Embrittlement Test Method*—The embrittlement test method shall conform to those specified in Test Methods F 1940 for process verification, or F 606, F 1624, or NASM-1312-5 for product testing.

9.3 *Corrosion Resistance*—The requirement to determine corrosion resistance is applicable to significant surfaces only. When specified in the contract or purchase order, a salt spray test shall be conducted in accordance with Practice B 117. To secure uniformity of results, samples shall be aged at room temperature for 24 h before being subjected to the salt spray test.

10. Electroplating Processes

10.1 Two electroplating processes are most commonly used to apply a metallic coating by electrodeposition on threaded fasteners: barrel-plating and rack-plating. When thread fit or thread integrity, or both, is a concern for externally threaded fasteners, rack-plating is preferable to barrel-plating. Refer to Appendix X1.

ANNEX

(Mandatory Information)

A1. NEUTRAL SALT SPRAY PERFORMANCE

TABLE A1.1 Classification Code and Neutral Salt Spray Corrosion Protection Performance of Zinc and Cadmium Coatings

Classification Code	Minimum Coating Thickness, in.	Chromate Finish Designation	First Appearance of White Corrosion Product, (hour)	First Appearance of Red Rust Cadmium, (hour)	First Appearance of Red Rust Zinc, (hour)
Fe/Zn or Fe/Cd 3A	0.0001[A]	A	3	24	12
Fe/Zn or Fe/Cd 3B	. . .	B	6	24	12
Fe/Zn or Fe/Cd 3C	. . .	C	24	36	24
Fe/Zn or Fe/Cd 3D	. . .	D	24	36	24
Fe/Zn or Fe/Cd 5A	0.0002	A	6	48	24
Fe/Zn or Fe/Cd 5B	. . .	B	12	72	36
Fe/Zn or Fe/Cd 5C	. . .	C	48	120	72
Fe/Zn or Fe/Cd 5D	. . .	D	72	168	96
Fe/Zn or Fe/Cd 5E	. . .	E	12	72	
Fe/Zn or Fe/Cd 8A	0.0003	A	6	96	48
Fe/Zn or Fe/Cd 8B	. . .	B	24	120	72
Fe/Zn or Fe/Cd 8C	. . .	C	72	168	120
Fe/Zn or Fe/Cd 8D	. . .	D	96	192	144
Fe/Zn or Fe/Cd 8E	. . .	E	24	120	72
Fe/Zn or Fe/Cd 12A	0.0005	A	6	144	72
Fe/Zn or Fe/Cd 12B	. . .	B	24	192	96
Fe/Zn or Fe/Cd 12C	. . .	C	72	240	144
Fe/Zn or Fe/Cd 12D	. . .	D	96	264	168
Fe/Zn or Fe/Cd 12Bk	. . .	E	24	192	96

[A] Low coating thickness impairs chromate adhesion and performance.

TABLE A1.2 Classification Code and Neutral Salt Spray Corrosion Protection Performance of Zinc-Cobalt Coatings

Classification Code	Minimum Coating Thickness, in.	Chromate Finish Designation	First Appearance of Zinc Alloy Corrosion Product (hour)	First Appearance of Red Rust (hour)
Fe/Zn-Co 5C	0.0002	C	96	240
Fe/Zn-Co 5D	. . .	D	96	240
Fe/Zn-Co 5E	. . .	E	100	240
Fe/Zn-Co 5F	. . .	F	196	340
Fe/Zn-Co 8C	0.0003	C	96	240
Fe/Zn-Co 8D	. . .	D	96	240
Fe/Zn-Co 8E	. . .	E	100	240
Fe/Zn-Co 8F	. . .	F	200	340
Fe/Zn-Co 12B	0.0005	B	12	240
Fe/Zn-Co 12C	. . .	C	96	400
Fe/Zn-Co 12D	. . .	D	96	400
Fe/Zn-Co 12E	. . .	E	100	400
Fe/Zn-Co 12F	. . .	F	196	500

TABLE A1.3 Classification Code and Neutral Salt Spray Corrosion Protection Performance of Zinc-Nickel Coatings

Classification Code	Minimum Coating Thickness, in.	Chromate Finish Designation	First Appearance of Zinc Alloy Corrosion Product (hour)	First Appearance of Red Rust (hour)
Fe/Zn-Ni 5B	0.0002	B	20	150
Fe/Zn-Ni 5C	. . .	C	120	500
Fe/Zn-Ni 5D	. . .	D	180	750
Fe/Zn-Ni 5E	. . .	E	100	500
Fe/Zn-Ni 5B/F	. . .	B/F	150	300
Fe/Zn-Ni 5C/F	. . .	C/F	240	620
Fe/Zn-Ni 5D/F	. . .	D/F	300	1000
Fe/Zn-Ni 5E/F	. . .	E/F	220	620
Fe/Zn-Ni 8B	0.0003	B	20	240
Fe/Zn-Ni 8C	. . .	C	120	720
Fe/Zn-Ni 8D	. . .	D	180	960
Fe/Zn-Ni 8E	. . .	E	100	720
Fe/Zn-Ni 8B/F	. . .	B/F	150	400
Fe/Zn-Ni 8C/F	. . .	C/F	240	840
Fe/Zn-Ni 8D/F	. . .	D/F	300	1200
Fe/Zn-Ni 8E/F	. . .	E/F	220	840
Fe/Zn-Ni 12B	0.0005	B	20	500
Fe/Zn-Ni 12C	. . .	C	120	960
Fe/Zn-Ni 12D	. . .	D	180	1000
Fe/Zn-Ni 12E	. . .	E	100	960
Fe/Zn-Ni 12B/F	. . .	B/F	150	620
Fe/Zn-Ni 12C/F	. . .	C/F	240	1080
Fe/Zn-Ni 12D/F	. . .	D/F	300	1500
Fe/Zn-Ni 12E/F	. . .	E/F	220	1080

TABLE A1.4 Classification Code and Neutral Salt Spray Corrosion Protection Performance of Zinc-Iron Coatings

Classification Code	Minimum Coating Thickness, in.	Chromate Finish Designation	First Appearance of Zinc Alloy Corrosion Product (hour)	First Appearance of Red Rust (hour)
Fe/Zn-Co 5E	0.0002	E	144	312
Fe/Zn-Co 8E	0.0003	E	144	312
Fe/Zn-Co 12E	0.0005	E	144	480

APPENDIXES

(Nonmandatory Information)

X1. STANDARD ELECTRODEPOSITION PROCESSES

X1.1 *Barrel-Plating Process*—The preparation and metallic coating of threaded fasteners is usually accomplished by the barrel-plating process. In this process, quantities of an item are placed within a containment vessel, called a barrel. The barrel is designed to move the group of items, together, through each of the process steps, allowing ready ingress and egress of processing solutions and rinses. As the barrel is moved through the process steps, it is also rotated such that the individual items are constantly cascading over one another. This can damage the external threads of fasteners. The effect of thread damage is worse on heavy fine threaded fasteners than on light course threaded fasteners. In some of the process steps, notably the electrocleaning and electroplating steps, an electric current is applied to the group of items. The cascading action randomly exposes the surface of each individual piece to the process electrodes while also maintaining electrical continuity between all of the parts. The local coating thickness on a part is a result of the electrical current density at that location. Therefore, the

coating thickness on an individual screw or bolt tends to be greatest at the extremities (head and threaded tip). The extremities being the high current density areas receive the greatest coating thickness. In contrast, the center or recesses such as the bottom of the threads, which are the low current density areas, receive the lowest coating thickness. This phenomenon is accentuated with increasing length and decreasing diameter of the screw or bolt. The extremity-to-center coating thickness ratio increases with increasing length and decreasing diameter, but is also a function of process parameters such as plating solution chemistry and efficiency, anodic/cathodic efficiency, average current density and plating time.

X1.2 *Rack-Plating Process*—The preparation and metallic coating of threaded fasteners can be accomplished by the rack-plating process, particularly on large size fasteners where thread fit and/or damage is a concern, or for smaller size fasteners, when it is economically feasible. In this process, quantities of an item are placed on a support, called a rack. The rack is designed to move the group of items, together, through each of the process steps, allowing ready ingress and egress of processing solutions and rinses. In some of the process steps, notably the electrocleaning and electroplating steps, an electric current is applied to the group of items. The electrical continuity is maintained between the parts by the rack itself. The average current density is usually low enough such that the extremity-to-center coating thickness ratio is much lower than with barrel-plating. The external thread damage is also minimized in comparison to barrel-plating due to the absence of tumbling.

X2. GUIDELINES FOR CHOOSING BETWEEN BARREL-PLATING AND RACK-PLATING

X2.1 Short screws and bolts are those with a length-to-diameter ratio equal to or less than 5. Long screws and bolts have a length-to-diameter ratio greater than 5 but less than 10. Special processing is normally required for bolts with a ratio greater than 10 in order to minimize the extremity-to-center thickness ratio.

X2.2 Tables X2.1 and X2.2 indicate the recommended electroplating process for each size of externally coarse (UNC) and fine (UNF) threaded fasteners for all thickness classes in Table 2. For externally threaded fasteners with UNS and UN thread series, rack-plating is recommended. For internally threaded fasteners barrel-plating is generally suitable.

TABLE X2.1 Recommended Electroplating Process for Each Size of Externally Coarse Threaded Fasteners (UNC)

NOTE 1—Barrel-plating process (B) and rack-plating process (R).

Diameter (D), (in.)	Length (L)				
	L ≤ 5D	5D < L ≤ 10D	10D < L ≤ 20D	20D < L ≤ 30D	L > 30D
¼	B	B	B	B	R
5⁄16	B	B	B	B	R
3⁄8	B	B	B	R	R
7⁄16	B	B	B	R	R
½	B	B	R	R	R
9⁄16	B	B	R	R	R
5⁄8	B	B	R	R	R
¾	B	R	R	R	R
7⁄8	R	R	R	R	R
1 – 4	R	R	R	R	R

TABLE X2.2 Recommended Electroplating Process for Each Size of Externally Fine Threaded Fasteners (UNF)

NOTE 1—Barrel-plating process (B) and rack-plating process (R).

Diameter (D), (in.)	Length (L)				
	L ≤ 5D	5D < L ≤ 10D	10D < L ≤ 20D	20D < L ≤ 30D	L > 30D
¼	B	B	B	B	R
5/16	B	B	B	R	R
⅜	B	B	B	R	R
7/16	B	B	R	R	R
½	B	B	R	R	R
9/16	B	B	R	R	R
⅝	B	R	R	R	R
¾	R	R	R	R	R
⅞	R	R	R	R	R
1 – 4	R	R	R	R	R

X3. COATING ACCOMMODATION TOLERANCES FOR EXTERNALLY AND INTERNALLY THREADED FASTENERS

X3.1 This specification does not impose maximum thickness values on high current density areas, where the coating thickness tends to be the greatest. On an externally threaded fastener this occurs at the threaded tip. Measuring coating thickness on the threaded portion of a fastener is possible but impractical for in-process quality control verification. For this reason the control mechanism specified in this document is by means of GO thread gauges. Nevertheless Tables X3.1-X3.4 illustrate maximum coating thickness permitted by Class 1A and 2A allowance, and are supplied as an informative guideline.

NOTE X3.1—The following information is based on ASME B1.1 Section 7. That standard should be consulted for more detailed information.

X3.2 Size limits for standard external 1A and 2A thread classes apply prior to coating. The external thread allowance may thus be used to accommodate the coating thickness on threaded fasteners, provided the maximum coating thickness is no more than ¼ of the allowance. Thus, threads after coating are subject to acceptance using a basic Class 3A GO gage and a class 2A gage as a NOT-GO gage.

X3.3 In certain cases size limits must be adjusted, within the tolerances, prior to coating, in order to insure proper thread fit. This applies to the following cases:

X3.3.1 Standard internal threads, because they provide no allowance for coating thickness.

X3.3.2 Where the external thread has no allowance, such as Class 3A threads.

TABLE X3.1 Coating Accommodation Tolerances for Externally Coarse Threaded (UNC) Fasteners

Thread Pitch, TPI	Diameter, in.	Pitch Diameter Allowance for 1A and 2A Thread Classes, in.	Maximum Allowable Coating Thickness on Threaded Tip, × 0.0001 in.
20	¼	0.0011	2.75
18	5/16	0.0012	3.00
16	⅜	0.0013	3.25
14	7/16	0.0014	3.50
13	½	0.0015	3.75
12	9/16	0.0016	4.00
11	⅝	0.0016	4.00
10	¾	0.0018	4.50
9	⅞	0.0019	4.75
8	1	0.0020	5.00
7	1 ⅛ and 1 ¼	0.0022	5.50
6	1 ⅜ and 1 ½	0.0024	6.00
5	1 ¼	0.0027	6.75
4 ½	2 and 2 ¼	0.0029	7.25
4	2 ½	0.0031	7.75
4	2 ¾ and 3	0.0032	8.00
4	3 ¼ and 3 ½	0.0033	8.25
4	3 ¾ and 4	0.0034	8.50

X3.3.3 Where allowance must be maintained after coating for trouble free thread fit.

X3.4 Tables X3.1-X3.4 provide maximum thickness values based only on the allowance for the 1A and 2A thread classes. It assumes that the external thread pitch diameter is at the maximum and that the internal thread pitch diameter is at the minimum of the tolerance (see Fig. X3.1).

TABLE X3.2 Coating Accommodation Tolerances for Externally Fine Threaded (UNF) Fasteners

Thread Pitch, TPI	Diameter, in.	Pitch Diameter Allowance for 1A and 2A Thread Classes, in.	Maximum Allowable Coating Thickness on Threaded Tip, × 0.0001 in.
28	¼	0.0010	2.50
24	5⁄16 and ⅜	0.0011	2.75
20	7⁄16 and ½	0.0013	3.25
18	9⁄16 and ⅝	0.0014	3.50
16	¾	0.0015	3.75
14	⅞	0.0016	4.00
12	1, 1 ⅛ and 1 ¼	0.0018	4.50
12	1 ⅜ and 1 ½	0.0019	4.75

TABLE X3.3 Coating Accommodation Tolerances for Externally Threaded (UNS) Fasteners

Thread Pitch, TPI	Diameter, in.	Pitch Diameter Allowance for 1A and 2A Thread Classes, in.	Maximum Allowable Coating Thickness on Threaded Tip, × 0.0001 in.
14	1	0.0017	4.25

TABLE X3.4 Coating Accommodation Tolerances for Externally Threaded (UN) Fasteners

Thread Pitch, TPI	Diameter, in.	Pitch Diameter Allowance for 1A and 2A Thread Classes, in.	Maximum Allowable Coating Thickness on Threaded Tip, × 0.0001 in.
8	1 ⅛ and 1 ¼	0.0021	5.25
8	1 ⅜ , 1 ½ and 1 ⅝	0.0022	5.50
8	1 ¾ , 1 ⅞ and 2	0.0023	5.75
8	2 ¼ and 2 ½	0.0024	6.00
8	2 ¾	0.0025	6.25
8	3, 3 ¼ and 3 ½	0.0026	6.50
8	3 ¾ and 4	0.0027	6.75

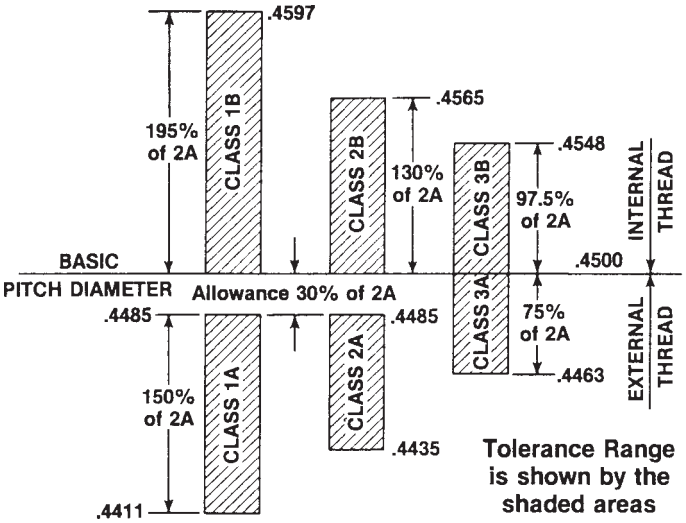


FIG. X3.1 Relationship of Pitch Diameter Allowance for Classes of Fit on ½-13 UNC Thread

X4. APPLICATION REQUIREMENTS

X4.1 *Cleaning of Basis Metal*—Thorough cleaning of the basis metal is essential in order to ensure satisfactory adhesion, appearance and corrosion resistance of the coating.

X4.2 *Hydrogen Embrittlement Risk Management*:

X4.2.1 *Process Considerations*—The following are some general recommendations for managing the risk of hydrogen embrittlement. For more detailed information refer to IFI-142 "Hydrogen Embrittlement Risk Management".

X4.2.1.1 Clean the fasteners in non-cathodic alkaline solutions and in inhibited acid solutions.

X4.2.1.2 Use abrasive cleaners for fasteners having a hardness of 40 HRC or above and case hardened fasteners.

X4.2.1.3 Manage anode/cathode surface area and efficiency, resulting in proper control of applied current densities. High current densities increase hydrogen charging.

X4.2.1.4 Use high efficiency plating processes such as zinc chloride or acid cadmium.

X4.2.1.5 Control the plating bath temperature to minimize the use of brighteners.

X4.2.1.6 Select raw materials with a low susceptibility to hydrogen embrittlement by controlling steel chemistry, microstructure, and mechanical properties.

X4.2.2 *Process Control Verification*—Test Method F 1940 should be used as a test method for process control to minimize the risk of hydrogen embrittlement. Periodic inspections should be conducted according to a specified test plan. The test plan should be designed based upon the specific characteristics of a process, and upon agreement between the purchaser and the manufacturer. The testing frequency should initially establish and subsequently verify over time, the ability of a process to produce parts that do not have the potential for hydrogen embrittlement.