Designation: B689 − 97 (Reapproved 2018)ε1

Standard Specification for Electroplated Engineering Nickel Coatings[1]

This standard is issued under the fixed designation B689; 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.

ε1 NOTE—Reference links in subsection 6.5 updated editorially in August 2018.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This specification covers the requirements for electroplated nickel coatings applied to metal products for engineering applications, for example, for use as a buildup for mismachined or worn parts, for electronic applications, including as underplates in contacts or interconnections, and in certain joining applications.

1.2 Electroplating of nickel for engineering applications (Note 1) requires technical considerations significantly different from decorative applications because the following functional properties are important:

1.2.1 Hardness, strength, and ductility,
1.2.2 Wear resistance,
1.2.3 Load bearing characteristics,
1.2.4 Corrosion resistance,
1.2.5 Heat scaling resistance,
1.2.6 Fretting resistance, and
1.2.7 Fatigue resistance.

NOTE 1—Functional electroplated nickel coatings usually contain about 99 % nickel, and are most frequently electrodeposited from a Watts nickel bath or a nickel sulfamate bath. Typical mechanical properties of nickel electroplated from these baths, and the combined effect of bath operation and solution composition variables on the mechanical properties of the electrodeposit are given in Guide B832. When electroplated nickel is required to have higher hardnesses, greater wear resistance, certain residual stress values and certain leveling characteristics, sulfur and other substances are incorporated in the nickel deposit through the use of certain addition agents in the electroplating solution. For the effect of such additives, see Section 4 and Annex A3. Cobalt salts are sometimes added to the plating solution to produce harder nickel alloy deposits.

1.3 *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.*

1.4 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B183 Practice for Preparation of Low-Carbon Steel for Electroplating
B242 Guide for Preparation of High-Carbon Steel for Electroplating
B252 Guide for Preparation of Zinc Alloy Die Castings for Electroplating and Conversion Coatings
B253 Guide for Preparation of Aluminum Alloys for Electroplating
B254 Practice for Preparation of and Electroplating on Stainless Steel
B281 Practice for Preparation of Copper and Copper-Base Alloys for Electroplating and Conversion Coatings
B320 Practice for Preparation of Iron Castings for Electroplating
B322 Guide for Cleaning Metals Prior to Electroplating
B343 Practice for Preparation of Nickel for Electroplating with Nickel
B374 Terminology Relating to Electroplating
B480 Guide for Preparation of Magnesium and Magnesium Alloys for Electroplating
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
B507 Practice for Design of Articles to Be Electroplated on Racks

[1] This specification is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.03 on Engineering Coatings.

Current edition approved June 1, 2018. Published June 2018. Originally approved in 1981. Last previous edition approved in 2013 as B689 – 97(2013). DOI: 10.1520/B0689-97R18.

[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.

B530 Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Electrodeposited Nickel Coatings on Magnetic and Nonmagnetic Substrates
B558 Practice for Preparation of Nickel Alloys for Electroplating
B568 Test Method for Measurement of Coating Thickness by X-Ray Spectrometry
B571 Practice for Qualitative Adhesion Testing of Metallic Coatings
B602 Test Method for Attribute Sampling of Metallic and Inorganic Coatings
B697 Guide for Selection of Sampling Plans for Inspection of Electrodeposited Metallic and Inorganic Coatings
B765 Guide for Selection of Porosity and Gross Defect Tests for Electrodeposits and Related Metallic Coatings
B809 Test Method for Porosity in Metallic Coatings by Humid Sulfur Vapor ("Flowers-of-Sulfur")
B832 Guide for Electroforming with Nickel and Copper
B849 Specification for Pre-Treatments of Iron or Steel for Reducing Risk of Hydrogen Embrittlement
B850 Guide for Post-Coating Treatments of Steel for Reducing the Risk of Hydrogen Embrittlement
B851 Specification for Automated Controlled Shot Peening of Metallic Articles Prior to Nickel, Autocatalytic Nickel, or Chromium Plating, or as Final Finish
D762 Method of Test for Hot Extraction of Asphaltic Materials and Recovery of Bitumen by the Modified Abson Procedure (Withdrawn 1965)[3]
D1193 Specification for Reagent Water
D3951 Practice for Commercial Packaging
F519 Test Method for Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments

2.2 *Military Standards:*
MIL-R-81841 Rotary Flap Peening of Metal Parts[4]
MIL-S-13165 Shot Peening of Metal Parts[4]
MIL-W-81840 Rotary Flap Peening Wheels[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *significant surfaces*—those surfaces normally visible (directly or by reflection) that are essential to the appearance or serviceability of the article when assembled in normal position; or that can be the source of corrosion products that deface visible surfaces on the assembled article. When necessary, the significant surfaces shall be indicated on the drawing for the article, or by the provision of suitably marked samples.

3.1.1.1 *Discussion*—The thickness of the electrodeposit in holes, corners, recesses, and other areas where thickness cannot be controlled under normal electroplating conditions shall be specified by the buyer (see Note 3).

3.1.1.2 *Discussion*—When a deposit of controlled thickness is required in holes, corners, recesses, and similar areas, special racking, auxiliary anodes or shielding will be necessary.

3.2 Terminology B374 contains most of the terms used in this specification.

4. Classification

4.1 Electroplated nickel shall be provided in any one of the following three types (Note 2):

4.1.1 *Type 1*—Nickel electroplated from solutions not containing hardeners, brighteners, or stress control additives.

4.1.2 *Type 2*—Nickel electrodeposits used at moderate temperatures and containing sulfur or other codeposited elements or compounds that are present to increase the hardness, to refine the grain structure, or to control the internal stress of the electrodeposited nickel.

4.1.3 *Type 3*—Electrodeposited nickel containing dispersed submicron particles, such as silicon carbide, tungsten carbide, and aluminum oxide that are present to increase hardness and wear resistance at temperatures above 325°C (618°F).

NOTE 2—Good adhesion of electroplated nickel to stainless steels and high alloy steels usually requires a preliminary strike of electrodeposited nickel. The recommended practices for the preparation of and electroplating on stainless steels and nickel alloys are given in Practices B254 and B558, respectively.

4.2 *Thickness Classification*—The electroplated nickel thickness, in view of the wide variety for industrial uses, shall be specified according to the following classes (Note 3):

Class	Minimum Nickel Thickness, µm
5	5
25	25
50	50
100	100
200	200
X	thickness as specified

NOTE 3—There is no technical limit to the nickel thickness that can be electroplated. There are practical limits to nickel thickness and uniformity of thickness distribution caused by the size and geometric configuration of the parts. (See 3.1.)

5. Ordering Information

5.1 The buyer shall supply the following information to the seller in either the purchase order or engineering drawings, marked samples, or other governing documents.

5.1.1 Title, ASTM designation number, and year of the standard.

5.1.2 Classification type and thickness classification of electroplated nickel to be applied (see 4.1 and 4.2).

5.1.3 Significant surfaces (see 3.1).

5.1.4 Sampling plan (see Section 8).

5.1.5 Number of test specimens for destructive testing (see 7.1). Identify the substrate material by alloy identification, such as by ASTM, AISI, or SAE numbers, or by equivalent composition information.

5.1.6 The thickness, adhesion, porosity, and hydrogen embrittlement tests required. See 6.3 – 6.7.

5.1.7 The required grinding or polishing operations of the basis metal as are necessary to yield deposit with the desired properties.

5.1.8 Where required, the basis metal finish shall be specified in terms of centerline average (CLA), or arithmetical average (AA).

[3] The last approved version of this historical standard is referenced on www.astm.org.
[4] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

5.1.9 Appearance: whether superficial staining from final rinsing or discoloration after baking is acceptable.

5.1.10 Where required, post-treatment grinding or machining shall be specified for parts which are to be electroplated and subsequently ground or machined to size.

5.1.11 Where required dimensional tolerances allowed for the specified electroplated nickel thickness or class shall be specified.

5.1.12 Where required, microhardness ranges shall be specified for the nickel deposit.

5.1.13 The buyer of the parts to be electroplated shall provide the electroplater with the following information as required:

5.1.13.1 Ultimate tensile strength of the parts.

5.1.13.2 Rockwell C hardness of the parts.

5.1.13.3 Heat treatment for stress relief, whether it has been performed or is required (see 6.2).

5.1.13.4 Heat treatment for hydrogen embrittlement relief (see 6.3 and Test Method F519).

5.1.13.5 Tensile loads required for the embrittlement relief test, if applicable.

5.1.13.6 Procedures and requirements for peening to induce residual compressive stress in specified surfaces (see Note 4 and 6.4).

NOTE 4—Electroplating on hardened (high alloy and high carbon) steels can reduce the fatigue strength of the metal parts. This must be considered if the parts will be subjected to repeated applications of complex load patterns in service. Shot peening of significant surfaces before electroplating can reduce the loss of fatigue strength.[5] Rotary flap peening, a manual method, can also be used in the repair of components in the field where conventional shot peening equipment is not available. If rotary flap peening is used, extreme care should be taken to ensure that the entire surface to be treated has been peened. Also, reduction in the fatigue life of nickel-electroplated steels can be reduced by considering the relations among the variables that influence fatigue life of nickel-electroplated, hardened steels.[6]

5.1.13.7 What, if any, mechanical treatment was applied by the manufacturer to the significant surface; that is, particulate blasting, grinding, polishing, or peening.

5.1.14 The manufacturer of the parts to be electroplated shall provide the electroplating facility with test specimens (see Section 7) to be electroplated for conformance tests as requested for preparation, control, inspection, and lot acceptance.

6. Coating Requirements

6.1 *Appearance:*

6.1.1 The coating on the significant surfaces of the product shall be smooth and free of visual defects such as blisters, pits, roughness, cracks, flaking, burned deposits, and uncoated areas. Visual defects are defined as those visible, unmagnified, to the unaided eye, 20/20 vision, or vision corrected to 20/20. The boundaries of electroplating that cover only a portion of the surface shall, after finishing as indicated in the drawing, be free of beads, nodules, jagged edges, and other detrimental irregularities. Imperfections and variations in appearance in the coating that arise from surface conditions of the basis metal (scratches, pores, roll marks, inclusions, etc.) and that persist in the finish despite the observance of good metal finishing practices shall not be cause for rejection (Note 5).

6.1.2 For parts that are electroplated and subsequently ground to size, the grinding shall be done with a sulfur-free liquid coolant, never dry, and with a sufficiently light cut to prevent cracking.

NOTE 5—Applied finishes generally perform better in service when the substrate over which they are applied is smooth and free of torn metal, inclusions, pores, and other defects. It is recommended that the specifications covering the unfinished product provide limits for these defects. A metal finisher can often remove defects through special treatments, such as grinding, polishing, abrasive blasting, chemical treatments, and electropolishing. However, these are not normal in the treatment steps preceding the application of the finish. When they are desired they must be stated in the purchase order (see 5.1.7).

6.2 *Pretreatment of Iron and Steel for Reducing the Risk of Hydrogen Embrittlement*—Parts for critical applications that are made of steels with ultimate tensile strengths of 1000 MPa, hardness of 31 HRC or greater, that have been machined, ground, cold formed, or cold straightened subsequent to heat treatment, shall require stress relief heat treatment when specified by the purchaser, the tensile strength to be supplied by the purchaser. Specification B849 may be consulted for a list of pretreatments that are used widely.

6.3 *Post-Coating Treatments of Iron and Steel for Reducing the Risk of Hydrogen Embrittlement*—Parts for critical applications that are made of steels with ultimate tensile strengths of 1000 MPa, hardness of 31 HRC or greater, as well as surface hardened parts, shall require post coating hydrogen embrittlement relief baking when specified by the purchaser, the tensile strength to be supplied by the purchaser. Specification B850 may be consulted for a list of post treatments that are used widely.

6.4 *Peening of Metal Parts*—If peening is required before electroplating to induce residual compressive stress to increase fatigue strength and resistance to stress corrosion cracking of the metal parts, refer to Specification B851 and to MIL-S-13165, MIL-R-81841, and MIL-W-81840.

6.5 *Thickness*—The thickness of the coating everywhere on the significant surface shall conform to the requirements of the specified class as defined in 4.2 (see Note 6 and 7.2).

NOTE 6—The coating thickness requirements of this specification are minimum requirements; that is, the coating thickness is required to equal or exceed the specified thickness everywhere on any significant surface (see 3.1.1). Variation in the coating thickness from point to point on a coated article is an inherent characteristic of the electroplating process. Therefore, the coating thickness will have to exceed the specified value at some points on the significant surfaces to ensure that the thickness equals or exceeds the minimum specified value at all points. Hence, in most cases, the average coating thickness on an article will be greater than the specified value; how much greater is largely determined by the shape of the article (see Practice B507) and the characteristics of the electroplating process. In addition, the average coating thickness on articles will vary from article to article within a production lot. Therefore, if all of the articles in a production lot are to meet the thickness requirement, the average coating thickness for the production lot as a whole will be greater that the average necessary to assure that a single article meets the requirement.

[5] Hammond, R. A. F., "Technical Proceedings," *TPAEA*, American Electroplaters' Society, 1964, pp. 9–20.

[6] Sanborn, C. B., and Carlin, F. S., "Influence of Nickel Plating on the Fatigue Life of Hardened Steel," Electrodeposited Metals for Selected Applications. Battelle Memorial Institute, Columbus, OH, November 1973.