Designation: B867 – 95 (Reapproved 2018)

Standard Specification for Electrodeposited Coatings of Palladium-Nickel for Engineering Use[1]

This standard is issued under the fixed designation B867; 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 *Composition*—This specification covers requirements for electrodeposited palladium-nickel coatings containing between 70 and 95 mass % of palladium metal. Composite coatings consisting of palladium-nickel and a thin gold overplate for applications involving electrical contacts are also covered.

1.2 *Properties*—Palladium is the lightest and least noble of the platinum group metals. Palladium-nickel is a solid solution alloy of palladium and nickel. Electroplated palladium-nickel alloys have a density between 10 and 11.5, which is substantially less than electroplated gold (17.0 to 19.3) and comparable to electroplated pure palladium (10.5 to 11.8). This yields a greater volume or thickness of coating per unit mass and, consequently, some saving of metal weight. The hardness range of electrodeposited palladium-nickel compares favorably with electroplated noble metals and their alloys (**1**, **2**).[2]

NOTE 1—Electroplated deposits generally have a lower density than their wrought metal counterparts.

	Approximate Hardness (HK_{25})
Gold	50–250
Palladium	75–600
Platinum	150–550
Palladium-Nickel	300–650
Rhodium	750–1100
Ruthenium	600–1300

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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

1.5 *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:*[3]

B183 Practice for Preparation of Low-Carbon Steel for Electroplating

B242 Guide for Preparation of High-Carbon Steel 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

B322 Guide for Cleaning Metals Prior to Electroplating

B343 Practice for Preparation of Nickel for Electroplating with Nickel

B374 Terminology Relating to Electroplating

B481 Practice for Preparation of Titanium and Titanium Alloys for Electroplating

B482 Practice for Preparation of Tungsten and Tungsten Alloys for Electroplating

B487 Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of Cross Section

B488 Specification for Electrodeposited Coatings of Gold for Engineering Uses

B489 Practice for Bend Test for Ductility of Electrodeposited and Autocatalytically Deposited Metal Coatings on Metals

B507 Practice for Design of Articles to Be Electroplated on Racks

B542 Terminology Relating to Electrical Contacts and Their Use

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

Current edition approved June 1, 2018. Published June 2018. Originally approved in 1995. Last previous edition approved in 2013 as B867 – 95 (2013). DOI: 10.1520/B0867-95R18.

[2] The boldface numbers in parentheses refer to the list of references at the end of this specification.

[3] 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.

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
B741 Test Method for Porosity In Gold Coatings On Metal Substrates By Paper Electrography (Withdrawn 2005)[4]
B748 Test Method for Measurement of Thickness of Metallic Coatings by Measurement of Cross Section with a Scanning Electron Microscope
B762 Test Method of Variables Sampling of Metallic and Inorganic Coatings
B765 Guide for Selection of Porosity and Gross Defect Tests for Electrodeposits and Related Metallic Coatings
B798 Test Method for Porosity in Gold or Palladium Coatings on Metal Substrates by Gel-Bulk Electrography
B799 Test Method for Porosity in Gold and Palladium Coatings by Sulfurous Acid/Sulfur-Dioxide Vapor
B809 Test Method for Porosity in Metallic Coatings by Humid Sulfur Vapor ("Flowers-of-Sulfur")
B827 Practice for Conducting Mixed Flowing Gas (MFG) Environmental Tests
B845 Guide for Mixed Flowing Gas (MFG) Tests for Electrical Contacts
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
D1125 Test Methods for Electrical Conductivity and Resistivity of Water
D3951 Practice for Commercial Packaging

3. Terminology

3.1 *Definitions:* Many terms used in this specification are defined in Terminology B374 or B542.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *overplating, n*—a coating applied onto the topmost palladium-nickel coating. The thickness of an overplating or "flash" is usually less than 0.25 µm.

3.2.2 *significant surfaces, n*—those surfaces normally visible (directly or by reflection) or which are essential to the serviceability or function of the article; or which can be the source of corrosion products or tarnish films that interfere with the function or desirable appearance of the article. The significant surfaces shall be indicated on the drawings of the parts, or by the provision of suitably marked samples.

3.2.3 *underplating, n*—a metallic coating layer or layers between the basis metal or substrate and the palladium-nickel coating. The thickness of an underplating is usually greater than 1 µm, in contrast to a strike which is thinner.

[4] The last approved version of this historical standard is referenced on www.astm.org.

4. Classification

4.1 Orders for articles to be plated in accordance with this specification shall specify the coating system, indicating the basis metal, the thicknesses of the underplatings, the type and thickness class of the palladium-nickel coating, and the grade of the gold overplating according to Table 1, Table 2, and Table 3. See Section 7.

5. Ordering Information

5.1 In order to make the application of this specification complete, the purchaser shall supply the following information to the seller in the purchase order or other governing document:

5.1.1 The name, designation, and date of issue of this specification;

5.1.2 The coating system including basis metal, composition type, thickness class and gold overplate grade (see 4.1 and Table 1, Table 2, and Table 3);

5.1.3 Presence, composition, and thickness of underplating (see 3.2.1). For nickel underplating see 6.5.1;

5.1.4 Significant surfaces shall be defined (see 3.2.3);

5.1.5 Requirements, if any, for porosity testing (see 9.6);

5.1.6 (Steel parts only) Stress relief if required (see Specification B849);

5.1.7 (Steel parts only) Hydrogen embrittlement relief (see B850);

5.1.8 Sampling plan employed (see Section 8); and,

5.1.9 Requirement, if any, for surface coating cleanliness (absence of residual salts). See Appendix X6.

6. Manufacture

6.1 Any process that provides an electrodeposit capable of meeting the specified requirements will be acceptable.

6.2 *Substrate:*

6.2.1 The surface condition of the basis metal should be specified and should meet this specification prior to the plating of the parts.

6.2.2 Defects in the surface of the basis metal, such as scratches, porosity, pits, inclusions, roll and die marks, laps, cracks, burrs, cold shuts, and roughness may adversely affect the appearance and performance of the deposit, despite the observance of the best plating practice. Any such defects on significant surfaces should be brought to the attention of the supplier and the purchaser.

6.2.3 Clean the basis metal as necessary to ensure a satisfactory surface for subsequent electroplating in accordance with Practices B183, B242, B254, B281, B322, B343, B481, B482, and B558.

6.2.4 Proper preparatory procedures and thorough cleaning of the basis metal are essential for satisfactory adhesion and performance of these coatings. The surface must be chemically

TABLE 1 Composition Type

Type	Nominal Composition (Mass %)	Range (Mass% Pd)
I	75 % Pd/25 % Ni	70–80 % Pd
II	80 % Pd/20 % Ni	75–85 % Pd
III	85 % Pd/15 % Ni	80–90 % Pd
IV	90 % Pd/10 % Ni	85–95 % Pd

TABLE 2 Thickness Class[A]

Thickness Class	Minimum Thickness of Pd-Ni (µm)
0.4	0.4
0.5	0.5
0.7	0.7
1.0	1.0
1.3	1.3
1.5	1.5
2.0	2.0
2.5	2.5
3.0	3.0

[A] See Appendix X3 on Electrical Contact Performance Versus Thickness Class.

TABLE 3 Gold Overplate[A]

Grade	Type	MIL-G-45204	Hardness (Code)	Thickness Range
0	No Overplate	...	...	...
1	1 (99.9 % Au min)	III	90 HK_{25} max (A)	0.05–0.12 µm
2	2 (99.7 % Au min)	I	130–200 HK_{25} (C)	0.05–0.25 µm

[A] See Specification B488 and Appendix X1 and Appendix X2.

clean and continuously conductive, that is, without inclusions or other contaminants. The coatings must be smooth and as free of scratches, gouges, nicks, and similar imperfections as possible.

NOTE 2—A metal finisher can often remove defects through special treatments such as grinding, polishing, abrasive blasting, chemical treatments, and electropolishing. However, these may not be normal in the treatment steps preceding the plating, and a special agreement is indicated.

6.3 If required (see 5.1.6), steel parts with a hardness greater than 1000 MPa (31 HRC) shall be given a suitable stress relief heat treatment prior to plating in accordance with Specification B849. Such stress relief shall not reduce the hardness to a value below the specified minimum. Avoid acid pickling of high strength steels.

6.3.1 Apply the coating after all basis metal preparatory heat treatments and mechanical operations on significant surfaces have been completed.

6.4 *Racking:*

6.4.1 Position parts to allow free circulation of solution over all surfaces. The location of rack or wire marks in the coating should be agreed upon between the producer and supplier.

6.5 *Plating Process:*

6.5.1 *Nickel Underplating*—Apply a nickel underplating before the palladium-nickel when the product is made from copper or copper alloy. Nickel underplatings are also applied for other reasons. See Appendix X5.

NOTE 3—In certain instances where high frequency analog signals are employed, such as wave guides, the magnetic properties of nickel may attenuate the signal. Palladium-nickel itself is non-ferromagnetic when the nickel content is less than 14 mass %.

NOTE 4—In applications where forming or flaring operations are to be applied to the plated component, a ductile nickel electrodeposit should be specified.

6.5.2 *Strikes*—Good practice suggests the use of a palladium strike to follow any underplate or substrate (other than silver or platinum) immediately prior to applying the palladium-nickel.

6.5.3 *Plating*—Good practice calls for the work to be electrically connected when entering the palladium-nickel solution.

NOTE 5—Some palladium-nickel electroplating solutions attack copper. This can result in codeposition of copper impurity. The situation is further aggravated when low current densities are utilized. Copper can be removed from solutions by low current density electrolysis (0.1 to 0.3 mA/cm^2).

6.5.4 *Gold Overplating*—Apply a thin gold overplating after the palladium-nickel in any application in which palladium-nickel plated electrical connectors are mated together in a contact pair. This process is necessary to preserve the performance of the contact surface. See Appendix X1 for other reasons for using a gold overplate.

NOTE 6—When using Type 1 gold, the thickness of the gold overplate shall not exceed 0.12 µm (5 µin.) due to increased risk of degrading durability and increasing the coefficient of friction.

6.5.5 *Residual Salts*—For rack and barrel plating applications, residual plating salts can be removed from the articles by a clean, hot (50 to 100°C) water rinse. A minimum rinse time of 2.5 min (racks) or 5 min (barrel) is suggested. Best practice calls for a minimum of three dragout rinses and one running rinse with dwell times of 40 s in each station when rack plating and 80 s when barrel plating. Modern high-velocity impingement type rinses can reduce this time to a few seconds. This is particularly useful in automatic reel-to-reel applications where dwell times are significantly reduced. See Appendix X6.

7. Coating Requirements

7.1 *Nature of Coating*—The palladium-nickel deposit shall have a minimum purity of 70 mass % palladium.

7.2 *Composition*—The composition of the palladium-nickel electrodeposit shall be within ±5 mass % of the specified type.

7.3 *Appearance*—Palladium-nickel coatings shall be coherent, continuous, and have a uniform appearance to the extent that the nature of the basis metal and good commercial practices permit.

7.4 *Thickness*—Everywhere on the significant surface (see 5.1), the thickness of the palladium-nickel coating shall be equal to or exceed the specified thickness. The maximum thickness, however, shall not exceed the drawing tolerance.

NOTE 7—The coating thickness requirement of this specification is a minimum requirement, that is, the coating thickness is required to equal or exceed the specified thickness everywhere on the significant surfaces while conforming to all maximum thickness tolerances given in the engineering drawing. Variation in the coating thickness from point to point on a coated article is an inherent characteristic of electroplating processes. The coating thickness at any single point on the significant surface, therefore, will sometimes have to exceed the specified value in order to ensure that the thickness equals or exceeds the specified value at all points. Hence, most average coating thicknesses 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 plating process. In addition, the average coating thickness on products will vary from article to article within a production lot. 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 than the average necessary to assure that a single article meets the requirement. See 8.1.