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

This standard is issued under the fixed designation B679; 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.

ε[1] NOTE—Warning note updated and keywords added editorially in April 2004.

1. Scope

1.1 This specification covers requirements for electrodeposited palladium coatings containing at least 99.7 mass % of palladium metal. Composite coatings consisting of palladium with 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. It has a specific gravity of 12.0, which is substantially less than gold (19.3) and platinum (21.5). This yields a greater volume or thickness of coating and, consequently, some saving of metal weight accompanied by a small sacrifice in corrosion resistance and reflectivity. The following table compares the hardness range of electrodeposited palladium with other electrodeposited noble metals and alloys (**1**,**2**).[2]

	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 the preferred values. Values provided 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 The following standards form a part of this specification to the extent referenced herein:

2.2 *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

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

B542 Terminology Relating to Electrical Contacts and Their Use

B558 Practice for Preparation of Nickel Alloys for Electroplating

B567 Test Method for Measurement of Coating Thickness

[1] This specification is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.08.02 on Precious Metal Coatings.

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[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.

by the Beta Backscatter Method
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
B689 Specification for Electroplated Engineering Nickel 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[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
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")
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 B542B374B542.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *underplating*—a metallic coating layer between the basis metal or substrate and the topmost metallic coating. The thickness of an underplating is usually greater than 1 µm (40 µin.), in contrast to a strike or flash.

4. Classification

4.1 Orders for articles to be plated in accordance with this specification shall specify the plating system, indicating the basis metal, the thickness of the underplatings, the thickness of the palladium coating, and the grade of the gold overplating according to Tables 1 and 2.

5. Ordering Information

5.1 In order to make the application of this standard complete, the purchaser needs to 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 standard.

5.1.2 The coating system including basis metal, thickness class and gold overplate grade (see 4.1 and Tables 1 and 2).

5.1.3 Presence, type, and thickness of underplating (see 3.2.3).

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

TABLE 1 Thickness Class[A]

Thickness Class	Minimum Thickness of Pd (µm)
0.08	0.08
0.15	0.15
0.25	0.25
0.50	0.50
0.75	0.75
1.00	1.00
1.25	1.25
1.5	1.5
2.5	2.5
3.0	3.0
5.0	5.0

[A] See Appendix X4 for specific applications of the various thickness classes.

TABLE 2 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.

5.1.4 Significant surfaces shall be defined (see 3.2.2).

5.1.5 Requirements, if any, for porosity testing (see 9.5):

5.1.6 Requirement, if any, for bend ductility testing (see 9.6):

5.1.7 Sampling plan employed (see Section 8), and

5.1.8 Requirement, if any, for surface coating cleanliness (absence of residual salts). See Appendix X3.

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, B254, B281, B322, B343, B481, B482, and B558, and Guide B242.

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 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 1—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 Apply the coating after all basis metal preparatory 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 when the product is made from copper or copper alloy. Nickel underplatings are also applied for other reasons. See Appendix X2.

NOTE 2—In certain instances where high frequency analog signals are employed, such as wave guides, the magnetic properties of nickel may attenuate the signal. Palladium itself is non-ferromagnetic.

6.5.2 *Strikes*—Standard practice calls for a gold or palladium strike to follow any underplate or substrate (other than silver or platinum) immediately prior to applying the palladium.

6.5.3 *Plating*—Good practice calls for the work to be electrically connected when entering the bath. A minimum of 0.5 V is suggested. During electroplating it is extremely important to maintain the voltage, current density, or both beneath the value for hydrogen evolution. (See 7.2)

6.5.4 *Stress Cracking*—Problems associated with the incorporation of hydrogen in the palladium, which can lead to stress cracking of the coating, shall be controlled by choosing plating baths and plating conditions that minimize the H/Pd deposition ratio (**3**). The presence of stress-induced microcracks that penetrate to the underlying substrate or underplating can be detected with one of the porosity tests specified in 9.5.

6.5.5 *Gold Overplating*—Apply a thin gold overplating after the palladium in any application in which palladium 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 3—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.

6.5.6 *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 X3.

7. Coating Requirements

7.1 *Nature of Coating*—The palladium deposit shall have minimum purity of 99.7 mass %.

7.2 *Appearance*—Palladium 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.

7.3 *Thickness*—Everywhere on the significant surface (see 5.1.4), the thickness of the palladium coating shall be equal to or exceed the specified thickness. The maximum thickness, however, shall not exceed the drawing tolerance.

NOTE 4—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. 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 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 plating 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 than the average necessary to assure that a single article meets the requirement.

7.4 *Adhesion*—The palladium coatings shall be adherent to the substrate, when tested by one of the procedures summarized in 9.4.

7.5 *Integrity of the Coating*:

7.5.1 *Gross Defects/Mechanical Damage*—The coatings shall be free of visible mechanical damage and similar gross defects when viewed at magnifications up to 10×. For some applications this requirement may be relaxed to allow for a small number of such defects (per unit area), especially if they are outside of or on the periphery of the significant surfaces. See 7.5.2 and 6.5.4.

7.5.2 *Porosity*—Almost all as-plated electrodeposits contain some porosity, and the amount of porosity to be expected for any one type of coating will increase with decreasing the thickness of that particular coating type. The amount of porosity in the coating that may be tolerable depends on the severity of the environment that the article is likely to encounter during service or storage. If the pores are few in number, or away from the significant surfaces, their presence can often be tolerated. Acceptance or pass-fail criteria, if required, shall be part of the product specification for the particular article or coating requiring the porosity test. See 9.5.

NOTE 5—Extensive reviews of porosity and porosity testing can be found in the literature (**4, 5**).

8. Sampling

8.1 The sampling plan used for the inspection of a quality of the coated articles shall be as agreed upon between the purchaser and the supplier.

NOTE 6—Usually, when a collection of coated articles, the inspection lot (see 8.2), is examined for compliance with the requirements placed on the articles, a relatively small number of the articles—the sample—is selected at random and is inspected. The inspection lot is then classified as complying or not complying with the requirements based on the results of the inspection of the sample. The size of the sample and the criteria of compliance are determined by the application of statistics. The procedure is known as sampling inspection. Test Method B602, Guide B697, and Test Method B762 contain sampling plans that are designed for the sampling inspection of coatings.

Test Method B602 contains four sampling plans, three for use with tests