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StandardSpecification for Electrodeposited Coatings of Silver for Engineering Use[1]

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1. Scope

1.1 This specification covers requirements for electrodeposited coatings of silver used for engineering purposes that may be mat, bright, or semibright and are not less than 98 % silver purity.

1.2 Coatings of silver covered by this specification are usually employed for solderable surfaces, electrical contact characteristics, high electrical and thermal conductivity, thermocompression bonding, wear resistance of load-bearing surfaces, and spectral reflectivity.

1.3 In the Appendixes important characteristics of electrodeposited silver coatings are briefly described which must be considered when used in engineering applications, namely electrical conductivity (see Appendix X1), silver migration (see Appendix X2), thickness (see Appendix X3), hardness (see Appendix X4), and atmospheric tarnish (see Appendix X5).

1.4 The following hazards caveat pertains only to the test methods section of this specification: *This standard does not purport to address 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]

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

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

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

B507 Practice for Design of Articles to Be Electroplated on Racks

B542 Terminology Relating to Electrical Contacts and Their Use

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

B571 Practice for Qualitative Adhesion Testing of Metallic Coatings

B578 Test Method for Microhardness of Electroplated Coatings

B579 Specification for Electrodeposited Coatings of Tin-Lead Alloy (Solder Plate)

B602 Test Method for Attribute Sampling of Metallic and Inorganic Coatings

B678 Test Method for Solderability of Metallic-Coated Products

B697 Guide for Selection of Sampling Plans for Inspection of Electrodeposited Metallic and Inorganic Coatings

B762 Test Method of Variables Sampling of Metallic and Inorganic Coatings

B849 Specification for Pre-Treatments of Iron or Steel for Reducing Risk of Hydrogen Embrittlement

[1] This specification is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.04 on Precious Metal Coatings.

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[2] B08 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.

B850 Guide for Post-Coating Treatments of Steel for Reducing the Risk of Hydrogen Embrittlement
D3951 Practice for Commercial Packaging
E1004 Test Method for Determining Electrical Conductivity Using the Electromagnetic (Eddy-Current) Method
F519 Test Method for Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments

3. Terminology

3.1 *Definitions*—Many of the terms used in this specification are defined in Terminologies B374 or B542.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *rack-plating*—an electrodeposition process in which articles to be coated are mounted on racks or other fixtures during the process.

3.2.2 *significant surfaces*—surfaces that are normally visible, directly or by reflection, or that 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 appearances of the article. When necessary, the significant surfaces shall be indicated on the drawings of the parts, or by the provisions of suitably marked samples.

3.2.2.1 *Discussion*—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. The average coating thickness on the article usually will be greater than that specified; how much greater is largely determined by the shape of the article (see Practice B507) and the characteristics of the electroplating process. Additionally, the average coating thickness on an article will vary from article to article within a production lot. If all the articles in a production lot are to meet the thickness requirement, the average coating thickness of a production lot as a whole will be greater than the average necessary to ensure that a single article meets requirements.

3.2.3 *strike or flash*—a thin, typically less than 0.25-µm (10 µ-in.) metallic coating layer between metallic coatings to improve adhesion.

3.2.4 *underplating*—an application of a metallic coating layer between the basis metal or substrate and the topmost metallic coating or coatings (see 6.3.4).

4. Classification

4.1 Electrodeposited coatings of silver shall be classified for *Type* based on minimum purity, *Grade* whether bright, semibright, or mat, *Class* if supplementary surface treatment is applied, and thickness in micrometers.

4.2 *Purity*—Specify by *Type* as follows:

Type 1—99.9 % min

Type 2—99.0 % min

Type 3—98.0 % min

NOTE 1—Metallic or organic brighteners used for grain refinement may be present in the electrodeposit so long as they do not interfere with the stated function of the coating and are acceptable to the purchaser (see Appendix X1).

4.3 *Surface Appearance*—Specify by *Grade* in letter code as follows:

Grade A, Mat—Electrodeposits without luster, obtained from electroplating solutions operated without the use of brighteners.

Grade B, Bright—Electrodeposits obtained by the use of brighteners in the electroplating bath.

Grade C, Bright—Electrodeposits obtained by mechanical or chemical polishing of *Grade A* silver coatings.

Grade D, Semibright— Semi-lustrous electrodeposits obtained by the use of addition agents in the electroplating bath.

4.4 *Supplementary Surface Treatment*— Specify by *Class* in letter code as follows:

Class N—A finish that has had no supplementary tarnish resistant (that is, chromate) treatment (see Appendix X5).

Class S—A finish that has had a supplementary tarnish resistant (that is, chromate) treatment.

NOTE 2—*Class S* is not suitable for food service applications.

5. Ordering Information

5.1 To make 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 Name, designation, and year of issue of this standard.

5.1.2 Type (see 4.2), Grade (see 4.3), Class (see 4.4) and Thickness (see 6.6 and Appendix X3).

5.1.3 *Nature of Substrate*—If, for example, it is high strength steel, the need for stress relief (see 6.3.2.1) and embrittlement relief (see 6.3.5.1). If it is copper, an undercoat is needed (see S1.3) for some applications.

5.1.4 *Significant Surfaces* (see section 3.2.2).

5.1.5 *Appearance* (see 6.7).

5.1.6 *Underplates* (see 6.3.4 and S1.3).

5.1.7 Requirements and methods of testing for one or more of the following: need for and type of test specimens (see 8.1), thickness (see 6.6, 8.2, and Appendix X3), adhesion (see 6.8 and 8.3), hardness (see 6.10.1 and 8.7), absence of embrittlement (see 8.4), solderability (see 6.9 and 8.5), spectral reflectance (see 6.10.2 and 8.8), or electrical conductivity (see 6.10.3 and 8.9).

5.1.8 *Sampling Plans and Quality Assurance* (see Section 7 and S1.2).

6. Coating Requirements

6.1 *Nature of Coating*—The coating essentially shall be silver, considering the type specified, produced by electrodeposition from aqueous electrolytes.

6.2 *Purity of Coating*—The coating shall meet the chemical composition requirements of the specified type as defined in 4.2 and measured as described in 8.6.

6.3 *Process:*

6.3.1 The basis metal shall be subjected to such cleaning procedures as are necessary to ensure a surface satisfactory for subsequent electroplating. Materials used for cleaning shall

have no damaging effects on the basis metal resulting in pits, intergranular attack, stress corrosion cracking, or hydrogen embrittlement.

NOTE 3—For basis metal preparations, the following appropriate ASTM standards are recommended: Practices B183, B254, B281, B343, B481, and B482, and Guides B242, B252, B253, and B322.

6.3.2 *Preplating Operations*—Electroplating shall be applied after all basis metal heat treatments and mechanical operations such as forming, machining, and joining of the article have been completed.

NOTE 4—Silver deposits may be used to facilitate mechanical operations such as forming and drawing. In these applications, silver is applied before such process steps.

6.3.2.1 *Stress Relief Treatment*—Parts that are made of steels with ultimate tensile strength of 1000 MPa or over (hardness of 31 HRC or greater) that have been machined, ground, cold-formed or cold-straightened subsequent to heat treatment, may 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.

6.3.3 *Strike*—The final silver coating shall be preceded by a silver or gold strike for optimum adhesion.

6.3.4 *Underplating*—A nickel or nickel-alloy intermediate layer, at least 1 µm (39 µ-in.) thick, shall be applied before the silver electroplate when the product being plated is made from copper or copper alloy. Nickel underplatings are also applied for other reasons.

6.3.5 *Post-Plating Procedures:*

6.3.5.1 *Embrittlement Relief*—Parts that are made of steels with ultimate tensile strength of 100 MPa or over (hardness of 31 HRC or greater), as well as surface-hardened parts, may 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 *Surface Appearance*—The coating's surface finish shall meet the requirements of the specified grade defined in 4.3.

6.5 *Supplementary Post Treatment*—The coating shall meet the requirements of the specified class defined in 4.4.

6.6 *Thickness*—The silver coating thickness on significant surfaces shall be at least that specified (see Appendix X3) when measured as described in 8.2.

6.7 *Appearance*—Silver electroplated coated articles shall be covered completely on all surfaces as specified in the manufacturing document and shall have a uniform appearance with no visible defects to the extent that the nature of the basis metal and good commercial practice permit. The requirement for uniform color or appearance need not apply for subsequent passivation or other treatments of the silver.

6.7.1 *Defects*—Defects in the surface of the basis metal such as scratches, pits, non-conducting inclusions, and roll and die marks may adversely affect the appearance and performance of applied coatings. Such defects that persists in the finish despite the observance of good metal finishing practices shall not be cause for rejection.

NOTE 5—Coated finishes generally perform better in service when the substrate over which they are applied is smooth and free from torn metal, inclusions, pores, and other defects. It is recommended that the specifications covering the unfinished product provides limits for those defects. A metal finisher often can remove defects by means of special treatments such as grinding, polishing, abrasive blasting, chemical treatments, and electropolishing. However, these are not normal for the treatment steps preceding application of the finish. When they are desired, they are the subject of special agreement between the purchaser and the supplier.

6.8 *Adhesion*—The silver coatings shall be free of blisters and peeled areas indicating poor adhesion when tested in accordance with 8.3.

NOTE 6—Some applications may require no separation by any mechanical means such as machining or milling through the interface.

6.9 *Solderability*—The silver plated surfaces shall produce solder coatings which shall be bright, smooth, and uniform. At least 95 % of the sample surface shall show good wetting when tested as described in 8.5.

6.10 *Supplementary Requirements :*

6.10.1 *Hardness*—If a hardness requirement is specified, the hardness of the silver coatings shall conform to that specified as measured as described in 8.7.

6.10.2 *Spectral Reflectance*—The spectral reflectance of the silver coatings, if required, shall conform to that specified when measured as described in 8.8.

6.10.3 *Electrical Conductivity*—The electrical conductivity of the silver coatings, if required, shall conform to that specified when measured as described in 8.9.

7. Sampling

7.1 A random sample of the size required by Test Method B602 or Method B762 shall be selected from the inspection lot (see 7.2). The articles in the lot shall be classified as conforming or nonconforming to each requirement according to the criteria of the sampling plans in the chosen method.

NOTE 7—Test Method B602 contains four sampling plans, three for use with nondestructive test methods; the fourth is for use with destructive test methods. The three methods for nondestructive tests differ in the quality level they require of the product. Test Method B602 requires use of the plan with the intermediate quality level unless the purchaser specifies otherwise. It is recommended that the purchaser compare the plans with his needs and state which plan is to be used. If the plans in Test Method B602 do not serve the needs, additional ones are given in Guide B697 which provides a large number of plans and also gives guidance in the choice of a plan. When Guide B697 is specified, the buyer and seller need to agree on the plan to be used.

NOTE 8—Method B762 is a variables sampling plan. Such plans can only be used when a test yields a measured quantity, such as thickness, and when the requirements are stated as a numerical unit also such as thickness. Method B762 contains several plans for special needs. Buyer and seller may agree on the plan or plans to be used; if not, Method B762 identifies the plan to be used.

NOTE 9—When both destructive and nondestructive tests exist for the measurement of a characteristic, the purchaser needs to state which is to be used so the proper sampling plan is selected. Whether or not a test is destructive may not always be clear. A test may destroy the coating but in a noncritical area. The purchaser needs to state whether the test is to be considered destructive or nondestructive. The decision is important because the plans for destructive tests are significantly less able to discriminate between acceptable and unacceptable lots. This is because fewer parts are tested.