



Standard Specification for Electrodeposited Coatings of Silver for Engineering Use¹

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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:

- B 183 Practice for Preparation of Low-Carbon Steel for Electroplating²
- B 242 Practice for Preparation of High-Carbon Steel for Electroplating²
- B 252 Guide for Preparation of Zinc Alloy Die Castings for Electroplating Conversion Coatings²
- B 253 Guide for Preparation of Aluminum Alloys for Electroplating²
- B 254 Practice for Preparation of and Electroplating on Stainless Steel²
- B 281 Practice for Preparation of Copper and Copper-Base Alloys for Electroplating and Conversion Coatings²
- B 322 Practice for Cleaning Metals Prior to Electroplating²

- B 343 Practice for Preparation of Nickel for Electroplating with Nickel²
- B 374 Terminology Relating to Electroplating²
- B 481 Practice for Preparation of Titanium and Titanium Alloys for Electroplating²
- B 482 Practice for Preparation of Tungsten and Tungsten Alloys for Electroplating²
- B 487 Test Method for Measurement of Metal and Oxide Coating Thicknesses by Microscopical Examination of a Cross Section²
- B 499 Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals²
- B 504 Test Method for Measurement of Thickness of Metallic Coatings by the Coulometric Method²
- B 507 Practice for Design of Articles to be Electroplated on Racks²
- B 542 Terminology Relating to Electrical Contacts and Their Use³
- B 567 Test Method for Measurement of Coating Thickness by the Beta Backscatter Method²
- B 568 Test Method for Measurement of Coating Thickness by X-Ray Spectrometry²
- B 571 Test Methods for Adhesion of Metallic Coatings²
- B 578 Test Method for Microhardness of Electroplated Coatings²
- B 579 Specification for Electrodeposited Coatings of Tin-Lead Alloy (Solder Plate)²
- B 602 Test Method for Attribute Sampling of Metallic and Inorganic Coatings²
- B 678 Test Method for Solderability of Metallic-Coated Products²
- B 697 Guide for Selection of Sampling Plans for Inspection of Electrodeposited Metallic and Inorganic Coatings²
- B 762 Method of Variables Sampling of Metallic and Inorganic Coatings²
- B 849 Specification for Pre-treatments of Iron or Steel for Reducing the Risk of Hydrogen Embrittlement²
- B 850 Specification for Post-Coating Treatments of Iron or Steel for Reducing the Risk of Hydrogen Embrittlement²
- D 3951 Practice for Commercial Packaging⁴
- E 1004 Test Method for Electromagnetic (Eddy-Current)

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² *Annual Book of ASTM Standards*, Vol 02.05.

³ *Annual Book of ASTM Standards*, Vol 03.04.

⁴ *Annual Book of ASTM Standards*, Vol 15.09.

Measurements of Electrical Conductivity⁵
 F 519 Method for Mechanical Hydrogen Embrittlement
 Testing of Plating Processes and Aircraft Maintenance
 Chemicals⁶

3. Terminology

3.1 *Definitions*—Many of the terms used in this specification are defined in Terminologies B 374 or B 542.

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 B 507) 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 $\mu\text{-in.}$) 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—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

⁵ Annual Book of ASTM Standards, Vol 03.03.

⁶ Annual Book of ASTM Standards, Vol 15.03.

ASTM standards are recommended: Practices B 183, B 242, B 252, B 254, B 281, B 322, B 343, B 481, and B 482, and Guide B 253.

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 B 849 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 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 B 850 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 B 602 or Method B 762 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 B 602 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 B 602 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 B 602 do not serve the needs, additional ones are given in Guide B 697 which provides a large number of plans and also gives guidance in the choice of a plan. When Guide B 697 is specified, the buyer and seller need to agree on the plan to be used.

NOTE 8—Method B 762 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 B 762 contains several plans for special needs. Buyer and seller may agree on the plan or plans to be used; if not, Method B 762 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.

7.2 An inspection lot shall be defined as a collection of coated articles that are of the same kind, that have been produced to the same specifications, that have been coated by a single supplier at one time or approximately the same time under essentially identical conditions, and that are submitted for acceptance or rejection as a group.