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# Standard Specification for Electrodeposited Coatings of Tin[1]

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

ε[1] NOTE—Paragraphs 1.3 and 4.1 were editorially corrected in March 2001.

## 1. Scope

1.1 This specification covers the requirements for electrodeposited (electroplated) coatings of tin applied to metallic articles. Tin coatings are used to provide a low contact-resistance surface, to protect against corrosion (see 1.2), to facilitate soldering, to provide anti-galling properties, and to be a stopoff coating in the nitriding of high-strength steels.

1.2 Some corrosion can be expected from tin coatings exposed outdoors. In normal indoor exposure, tin is protective on iron, steel, nickel, copper, and their alloys. Corrosion can be expected at discontinuities in the coating (such as pores) due to galvanic couples formed between the tin and the underlying metal through the discontinuities, especially in humid atmospheres. Porosity increases as the coating thickness decreases, so that minimum thicknesses must be specified for each application. Parts coated with tin can be assembled safely in contact with iron and steel, tin-coated aluminum, yellow chromated zinc, cadmium, and solder coatings. (See X5.2 for oxidation and corrosion properties.)

1.3 This specification applies to electroplated coatings of not less than 99 % tin (except where deliberately alloyed for special purposes, as stated in X6.3) obtained from any of the available tin electroplating processes (see 4.3).

1.4 This specification does not apply to hot-dipped tin or other non-electrodeposited coating; it also does not apply to mill products. For mill products, refer to Specifications A 623 or A 623M.

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

1.6 *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 *ASTM Standards:*

A 623 Specification for Tin Mill Products, General Requirements[2]

A 623M Specification for Tin Mill Products, General Requirements (Metric)[2]

B 32 Specification for Solder Metal[3]

B 183 Practice for Preparation of Low-Carbon Steel for Electroplating[4]

B 242 Practice for Preparation of High-Carbon Steel for Electroplating[4]

B 246 Specification for Tinned Hard-Drawn and Medium-Hard-Drawn Copper Wire for Electrical Purposes[5]

B 281 Practice for Preparation of Copper and Copper-Base Alloys for Electroplating and Conversion Coatings[4]

B 320 Practice for Preparation of Iron Castings for Electroplating[4]

B 322 Practice for Cleaning Metals Prior to Electroplating[4]

B 374 Terminology Relating to Electroplating[4]

B 487 Test Method for Measurement of Metal and Oxide Coating Thicknesses by Microscopical Examination of a Cross Section[4]

B 499 Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals[4]

B 504 Test Method for Measurement of Thickness of Metallic Coatings by the Coulometric Method[4]

B 507 Practice for Design of Articles to be Electroplated on Racks[4]

B 542 Terminology Relating to Electrical Contacts and Their Use[6]

B 558 Practice for Preparation of Nickel Alloys for Electroplating[4]

B 567 Test Method for Measurement of Coating Thickness by the Beta Backscatter Method[4]

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[2] *Annual Book of ASTM Standards*, Vol 01.06.

[3] *Annual Book of ASTM Standards*, Vol 02.04.

[4] *Annual Book of ASTM Standards*, Vol 02.05.

[5] *Annual Book of ASTM Standards*, Vol 02.03.

[6] *Annual Book of ASTM Standards*, Vol 03.04.

B 568 Test Method for Measurement of Coating Thickness by X-Ray Spectrometry[4]
B 571 Test Methods for Adhesion of Metallic Coatings[4]
B 602 Test Method for Attribute Sampling of Metallic and Inorganic Coatings[4]
B 659 Guide for Measuring Thickness of Metallic and Inorganic Coatings[4]
B 678 Test Method for Solderability of Metallic-Coated Products[4]
B 697 Guide for Selection of Sampling Plans for Inspection of Electrodeposited Metallic and Inorganic Coatings[4]
B 762 Method of Variables Sampling of Metallic and Inorganic Coatings[4]
B 765 Guide to the Selection of Porosity Tests for Electrodeposits and Related Metallic Coatings[4]
B 809 Test Method for Porosity in Metallic Coatings by Humid Sulfur Vapor ("Flowers-of-Sulfur")[4]
B 849 Specification for Pre-Treatments of Iron or Steel for Reducing the Risk of Hydrogen Embrittlement[4]
B 850 Specification for Post-Coating Treatments of Iron or Steel for Reducing the Risk of Hydrogen Embrittlement[4]
B 851 Specification for Automated Controlled Shot Peening of Metallic Articles Prior to Nickel, Autocatalytic Nickel, or Chromium Plating, or as a Final Finish[4]
D 3951 Practice for Commercial Packaging[7]

## 3. Terminology

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

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

3.1.2 *significant surface*—that portion of the surface of a coated article at which the coating is required to meet all of the requirements of the coating specification for that article; significant surfaces are usually those that are essential to the serviceability or function of the article, or that can be a source of corrosion products or tarnish films that interfere with the function or desirable appearance of the article; significant surfaces shall be indicated on the drawings of the parts or by the provision of suitably marked samples.

3.1.3 *undercoating (see* 3.1.4)—also called an *underplate* in the electronics industry.

3.1.4 *underplating*—application of a metallic coating layer between the basis metal or substrate and the topmost metallic coating or coatings. The thickness of such an undercoating is usually greater than 0.8 µm (30 µin.). This is in contrast to strikes or flashes, whose thicknesses are generally much smaller.

## 4. Classification

4.1 *General*—Orders for articles to be plated in accordance with this specification shall specify the service class (4.2) (and underplating, if required), indicating the severity of service required for the coating. Other coatings variations, such as surface appearance type (4.3) or alloy composition (Appendix X6), are optional.

4.2 *Service Class*:

| Class | Minimum Thickness | Typical Applications |
|---|---|---|
| A | 2.5 µm (100 µin.) | Mild service conditions, particularly where the significant surface is shielded from the atmosphere (as in electronic connector housings). To provide corrosion and tarnish resistance where greater thicknesses may be detrimental to the mechanical operation of the product (for example, small electrical spring contacts and relays). Class A is often used for tin coatings that are not to be soldered, but must function as low-resistance electrical contact surfaces. |
| B | 5 µm (200 µin.) | Mild service conditions with less severe requirements than Class C (below). Applications are as follows: precoating on solderable basis metals to facilitate the soldering of electrical components; as a surface preparation for protective painting; for antigalling purposes; and as a stopoff in nitriding. Also found on baking pans after reflow. |
| C | 8 µm (320 µin.), (10 µm (400 µin.) for steel substrates) | Moderate exposure conditions, usually indoors, but more severe than Class B. Examples are electrical hardware (such as cases for relays and coils, transformer cans, screened cages, chassis, frames, and fittings) and for retention of the solderability of solderable articles during storage. |
| D | 15 µm (600 µin.) (20 µm (800 µin.) for steel substrates) | Severe service, including exposure to dampness and mild corrosion from moderate industrial environments. Examples are fittings for gas meters, automotive accessories (such as air cleaners and oil filters), and in some electronic applications. |
| E | 30 µm (0.0012 in.) | Very severe service conditions, including elevated temperatures, where underlying metal diffusion and intermetallic formation processes are accelerated. Thicknesses of 30 to 125 µm (0.0012 to 0.005 in.) may be required if the coating is subjected to abrasion or is exposed to slowly corrosive liquids or corrosive atmospheres or gases. Thicker coatings are used for water containers, threaded steel couplings of oil drilling strings, and seacoast atmospheres. Coatings subject to mild etchants are included. |
| F | 1.5 µm (60 µin.) | Similar to Class A, but for shorter-term contact applications and short shelf-life requirements, subject to purchaser approval. |

4.3 *Surface Appearance Type (Electroplating Process)*:

4.3.1 *Matte Tin Electrodeposits*—Coatings with a matte appearance are obtained from tin plating baths (stannate, sulfate, methylsulfonate, and fluoborate) used without the addition of any brightening agents. However, all matte baths (except for stannate baths) do require the addition of grain-refiners, and often of other additives in order to produce the desired matte finish.

4.3.2 *Bright Tin Electrodeposits*—Bright coatings are obtained when proprietary brightening agents are used in specific bright tin plating baths.

4.3.3 *Flow-Brightened Electrodeposits*—Flow-brightened coatings are obtained by heating the matte coating above the melting point of tin for a few seconds, followed by quenching; palm oil and hydrogenated oils and fats are used as heat-transfer medium at a temperature of 260 ± 8°C (500 ± 14°F), but other heating methods also are in use, such as hot air. The maximum thickness for flow-brightening is, in most cases,

[7] *Annual Book of ASTM Standards*, Vol 15.09.

approximately 8 µm (300 µin.); thicker coatings tend to dewet. The shape of the part is also a factor; flat surfaces dewet more readily than wires or rounded shapes.

NOTE 1—Terms commonly used in soldering, such as *dewet*, are described in soldering textbooks **(1)**[8] or reviews of solderability testing **(2)**. Some examples are given in Appendix X6.

## 5. Ordering Information

5.1 In order to make the application of this specification complete, the purchaser must supply the following information to the seller in the purchase order and drawings:

5.1.1 Title, ASTM designation number, and year of issue of this specification;

5.1.2 Deposit by classification (4.1), including thickness or service class (4.2);

5.1.3 Composition and metallurgical condition of the substrate to be coated (6.1);

5.1.4 Additional underplating, if required (6.8);

5.1.5 Surface-appearance type (for example, matte, flow-brightened, or bright), if required (4.3 and 6.2);

5.1.6 Location of significant surfaces (3.1.2);

5.1.7 Hydrogen embrittlement relief, if required (Supplementary Requirement S2); and

5.1.8 Any other items needing agreement (for example, 6.5.2 and 8.5).

## 6. Coating Requirements

6.1 *Substrate*—The metal substrate shall be subjected to such surface preparation, cleaning, and electroplating procedures as are necessary to yield deposits with the desired quality.

NOTE 2—Careful preparation of metal surfaces is necessary in order to assure good adhesion and quality. For suitable methods, see Practices B 183, B 242, B 281, B 320, B 322, and B 558. Also see 6.6.

6.2 Electroplating shall be applied after all basis metal heat treatments and mechanical operations have been completed.

6.3 *Appearance*—Tin coatings shall have the characteristic appearance, including surface texture (4.3), for the process used. The appearance shall be uniform throughout, insofar as the basis metal will permit. They shall be adherent and visually free of blisters, pits, peeled areas, cracks, nodules, and unplated areas. They shall not be stained or discolored. Flow-brightened coatings shall be free of dewetted areas and beads. All surfaces shall be substantially free of grease or oil used in the flow-brightening process.

6.4 All tin-coated articles shall be clean and undamaged. When necessary, preliminary samples showing the finish shall be supplied to and approved by the purchaser. Where a contact mark is inevitable, its location shall be subject to agreement between the supplier and the purchaser.

6.5 *Thickness of Coatings*—Tin coatings on articles shall conform to the thickness requirements specified in 4.2 as to the minimum thickness on significant surfaces.

6.5.1 *Local Thickness*—The thickness values specified in 4.2 are the minimum local thicknesses measured by one or more of the methods given in Practice B 659 at any number of desired spots on the significant surface.

6.5.2 *Mean Thickness*—When specified by the purchaser, instead of being a local minimum requirement, the thickness requirement can be a minimum (arithmetic) mean thickness.

NOTE 3—Specification of the coating thickness in terms of the mean is normally made when the coated articles are small and relatively simple, such as connector pins and terminals.

NOTE 4—Thickness of electrodeposited coatings varies from point to point on the surfaces of a product (see Practice B 507). The thickness is less in interior corners and holes. Such surfaces are normally exempt from the thickness requirement. If the full thickness is required on these surfaces, the electroplater will have to use special techniques that probably will increase the cost of the process.

NOTE 5—When articles are plated by mass plating techniques (such as barrel plating), such measurement methods as “strip and weigh” or “weigh before and after plating” may be used to determine the mean thickness.

6.6 *Adhesion*—Adhesion of the coating shall be tested by one of the methods given in Appendix X2. The coating should adhere to the basis metal when subjected to the agreed test; flaking or blistering of the coating is to be taken as evidence of unsatisfactory adhesion.

6.7 *Integrity of the Coating*:

6.7.1 *Gross Defects/Mechanical Damage*—Coatings shall be free of visible mechanical damage and similar gross defects when viewed at up to 4× magnification. 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 significant surfaces (also see 6.7.2).

6.7.2 *Porosity*—Almost all as-plated electrodeposits contain some porosity. 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 significant surfaces, their presence can often be tolerated. Such acceptance (or pass-fail) criteria, if required, should be part of the product specification for the particular article or coating requiring the porosity test. See 8.5 for porosity testing.

6.8 *Underplating*:

6.8.1 For tin coatings in Class A and Class F (4.2) that will not be exposed to solder temperatures (especially those that must function as electrically conductive surfaces), a nickel underplate or undercoating of at least 1.3 µm (50 µin.) shall be applied before tin plating.

6.8.2 To prevent zinc migration and impairment of solderability during service or storage, substrates of brass or other copper alloys containing more than 5 % zinc must have a copper undercoating of at least 2.5 µm (100 µin.), or a nickel undercoating of at least 1.3 µm (50 µin.), prior to tin plating. A thicker coating of nickel may be required in some situations for additional retardation.

6.9 *Hydrogen Embrittlement Relief*—High-tensile strength steels and severely cold-worked steels are susceptible to embrittlement by hydrogen in both cleaning and electroplating operations. See Supplementary Requirements S1 and S2 for details.

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

## 7. Sampling

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

NOTE 6—The procedure for sampling is accomplished by selecting a relatively small number of the finished articles at random. These articles (the inspection lots) are inspected and classified as complying or not complying with the requirements of the specification. The size of the sample and the criteria of compliance are determined by the application of statistics. The procedure is known as sampling inspection. Three standards, Test Method B 602, Guide B 697, and Method B 762, contain sampling plans that are designed for the sampling inspection of coatings.

Test Method B 602 contains four sampling plans, three for use with tests that are non-destructive and one for use when they are destructive. The buyer and seller may agree on the plan or plans to be used. If they do not, Test Method B 602 identifies the plan to be used.

Guide B 697 provides a large number of plans and also provides guidance in the selection of a plan. When Guide B 697 is specified, the buyer and seller must agree on the plan to be used.

Method B 762 can be used only for coating requirements that have a numerical limit, such as coating thickness. The test must yield a numerical value, and certain statistical requirements must be met. Guide B 762 contains several plans and also provides instructions for calculating plans to meet special needs. The buyer and seller may agree on the plan or plans to be used. If they do not, Guide B 762 identifies the plan to be used.

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

7.3 *Special Test Specimens*—It may be preferable to use special test specimens to represent product in process control or in acceptance inspection when, for example, destructive tests are used and it is desirable not to destroy product or if the test specimen is better adapted to the test. The use of special test specimens, their number, the material from which they are made, their size and shape, and the conditions of their coating shall be as agreed upon by the purchaser and the seller.

## 8. Test Methods

8.1 *Deposit Purity*—Atomic absorption or energy dispersion spectrophotometry, or any other methods with a demonstrated uncertainty of less than 10 % of the component measured, may be used to determine impurities. Initial scanning should be conducted for all elements in order to detect any unknown or unexpected impurities. Determine deposit purity by subtracting the total impurities from 100 %.

NOTE 7—Deposit purity is best determined on samples of the actual product (see Section 7). If special test specimens are used (7.3), care must be taken to arrange the specimens so as to electroplate them under the same conditions as typical production pieces.

8.2 *Thickness*:

8.2.1 *Standard Thickness*—The coating thickness shall be measured at locations on significant surfaces by one of the following test methods: Test Methods B 487, B 499 (magnetic substrates only), B 504, B 567, and B 568. Practice B 659 may be consulted to determine the most appropriate test method.

8.2.1.1 When Methods B 504 and B 568 are used with tin platings that have been alloyed with more than 0.5 % of lead, bismuth, or antimony to reduce whiskering (see X6.3.2.5), the standard shall have the same composition as the coating. When Test Method B 567 is used to measure these types of coatings, the measuring instrument shall be calibrated with thickness standards that have the same substrate and same composition of coating as the product.

8.2.2 *Mean Thickness*—If the entire surface of the article is a significant surface, the mean thickness can also be determined by the method described in Appendix X1. Also see Note 5.

8.3 *Adhesion*—Adhesion of the coating shall be tested by one of the recommended methods of Test Methods B 571 (see Appendix X2).

8.4 *Solderability*—For coatings that must be solderable, the method by which solderability is tested shall be specified. Three test methods are described in Appendix X3, while a simple dip test is given in Test Method B 678. The purchaser shall specify whether the tested articles are to receive an artificial aging treatment, such as that given in Test Method B 678, so as to demonstrate whether the articles may be expected to retain their solderability during long storage periods.

8.5 *Porosity and Gross Defects Testing*:

8.5.1 Coatings on articles of steel (or iron) having a local thickness of 10 µ (0.4 mil) or greater should be subjected to the test given in Appendix X5.

8.5.2 For coatings on articles made from copper or copper alloy as the basis metal, the following tests should be used:

8.5.2.1 To determine mechanical damage or gross defects only, subject samples to the sodium polysulfide immersion test outlined in Specification B 246. Black spots or lines are evidence of mechanical damage or gross defects.

8.5.2.2 To determine all porosity that penetrates down to the copper substrate, especially for coatings in Service Class A, the humid sulfur vapor test (Test Method B 809) shall be used. Blackening at pores will be evidence of porosity.

## 9. Rejection and Rehearing

9.1 Articles that fail to conform to the requirements of this specification may be rejected. Rejection shall be reported to the seller promptly and in writing. In cases of rejection, the seller may make a claim for a rehearing. Product that shows coating imperfections in subsequent manufacturing operations may be rejected.

## 10. Keywords

10.1 electrodeposited tin; electroplated tin; tin; tin coatings