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Standard Specification for Electrodeposited Coatings of Tin-Lead Alloy (Solder Plate)[1]

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

1. Scope

1.1 This specification covers the requirements for electrodeposited tin-lead coatings on fabricated articles of iron, steel, copper, and copper alloys, to protect them against corrosion (Note 1), to improve and preserve solderability over long periods of storage, and to improve anti-galling characteristics.

NOTE 1—Some corrosion of tin-lead coatings may be expected in outdoor exposure. In normal indoor exposure, tin-lead is protective on iron, copper, and copper alloys. Corrosion may be expected at discontinuities (pits or pores) in the coating. Porosity decreases as the thickness is increased. A primary use of the tin-lead coating (solder) is with the printed circuit industry as a solderable coating and as an etch mask material.

1.2 This specification applies to electrodeposited coatings containing a minimum of 50 % and a maximum of 70 % tin. The specification applies to mat, bright, and flow-brightened tin-lead coatings.

NOTE 2—Tin-lead plating baths are composed of tin and lead fluoborates and of addition agents to promote stability. The final appearance may be influenced by the addition of proprietary brighteners. Without brighteners, the coatings are mat; with brighteners, they are semibright or bright. Flow-brightened coatings are obtained by heating mat coatings to above the melting point of tin-lead for a few seconds and then quenching; palm oil, hydrogenated oils, or fats are used as a heat-transfer medium at a temperature of 260 ± 10°C (500 ± 20°F), but other methods of heating are also in use. The maximum thickness for flow-brightening is about 7.5 µm (0.3 mil); thicker coatings tend to reflow unevenly. The shape of the part is also a factor; flat surfaces tend to reflow more unevenly than wires or rounded shapes (Note 3).

NOTE 3—Volatile impurities in tin-lead coatings will cause bubbling and foaming during flow-brightening resulting in voids and roughness. The impurities can arise from plating solution addition agents and from improper rinsing and processing.

1.3 This specification does not apply to sheet, strip, or wire in the unfabricated form or to threaded articles having basic major diameters up to and including 19 mm (0.75 in.).

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
B281 Practice for Preparation of Copper and Copper-Base Alloys for Electroplating and Conversion Coatings
B322 Guide for Cleaning Metals Prior to 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
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
E105 Practice for Probability Sampling of Materials
E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process

[1] This specification is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.06 on Soft Metals.

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[2] 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.

2.2 *Other Standards:*
MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes[3]
MIL-STD-414 Sampling Procedures and Tables for Inspection by Variables for Percent Defective[3]

3. Classification and Service Condition

3.1 Orders for articles to be plated in accordance with this specification shall specify, in addition to the ASTM designation number and year of issue, the classification notation indicating the basis metal and thickness of tin-lead coating required, or the service condition number indicating the severity of service required for the coating. In addition, when specifying a tin-lead coating composition, the first number shall refer to the tin content in percent.

3.1.1 *Classification Notation:*

Symbol	Classification
Fe/	Iron or steel basis metals
Cu/	Copper or copper alloy basis metals
/Sn-Pb	Tin-lead coating and its composition number, when required; for example, Sn60-Pb40
Number (5 to 50)	Minimum coating thickness in micrometres
Suffix Letter	
f	flow-brightened
b	bright
m	mat

An example of complete classification notation is as follows: Cu/Sn60-Pb40/5F

3.1.2 *Service Condition Number:*

No.	Service Condition
4	very severe exposure
3	severe exposure
2	moderate exposure
1	mild exposure

NOTE 4—See Appendix X1 for additional description of exposure conditions and examples of typical end uses. The coating thicknesses given for each service condition are guidelines and are not intended to be absolute values.

4. Significant Surfaces

4.1 Significant surfaces are defined as those surfaces normally visible (directly or by reflection) that are essential to the appearance or serviceability of the article when assembled in normal position; or those surfaces that can be the source of corrosion products that will deface visible surfaces on the assembled article. When necessary, the significant surfaces shall be indicated on the drawing of the part, or by the provision of suitably marked samples.

NOTE 5—When significant surfaces include areas on which the specified thickness of deposit cannot readily be controlled, such as threads, holes, deep recesses, bases of angles, and similar areas, the purchaser and the manufacturer should recognize the necessity for either thicker deposits on the more accessible surfaces or for special racking. Special racks may involve the use of conforming, auxiliary bipolar electrodes, or nonconducting shields.

5. Materials and Manufacture

5.1 Defects in the surface of the basis metal, such as scratches, porosity, nonconducting inclusions, roll and die marks, cold shuts, and cracks, may adversely affect the appearance and the performance of coatings applied thereto despite the observance of the best plating practices. Accordingly, the plater's responsibility for defects in the coating resulting from such conditions shall be waived, except when he is also in the position of prime contractor supplying plated parts.

NOTE 6—In order to minimize problems of this sort, the specifications covering the basis material or the item to be plated should contain appropriate limitations on such basis metal conditions.

5.2 When required the basis metal shall be subjected to such polishing or buffing operations as are necessary to yield deposits with the desired final appearance (Section 6).

5.3 Proper preparatory procedures and thorough cleaning of the basis metal surface are essential in order to assure satisfactory adhesion and corrosion performance of the coating. Accordingly, it is suggested that the following Practices for the preparation of various basis metals for electroplating be followed when appropriate: B183, B281, and B322 and Guide B242.

5.4 When necessary, preliminary samples showing the finish shall be supplied to and approved by the purchaser. Where rack marks are inevitable, their location shall be the subject of agreement between supplier and purchaser.

[3] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

6. Physical Composition

6.1 *Composition*—The tin-lead coating composition shall be as follows (Note 7):

Element	Weight, %
Tin (Sn)	50 to 70
Lead (Pb)	remainder

6.1.1 The tin percentage is calculated as follows:

$$\text{Tin}, \% = 134.1 \times (L/A - 1) \quad (1)$$

where:

L = weight of lead coating, g, and
A = weight of alloy coating, g.

NOTE 7—Only the tin content need be determined. Lead is usually determined by difference. A sample of the deposit can be obtained by plating on a stainless steel panel from which the coating can be peeled or by employing any recognized stripping method. The alloy composition of the deposit can be determined by methods such as gravimetric or volumetric analysis, density measurements, atomic absorption spectrophotometry, X-ray fluorescence, and beta backscatter.

In addition, the alloy composition produced by a plating solution may be obtained by comparing the weight of a tin-lead coating deposited by a given number of ampere-hours to the weight of lead coating produced in a lead fluoborate coulometer in series with the plating bath.

6.2 *Appearance*—The tin-lead coating shall be smooth, fine grained, continuous, adherent, and shall be free of visible blisters, pits, nodules, indications of burning, excessive build-up, staining, and other defects. Flow-brightened coatings shall not have dewetted areas or beads, and shall be free of the oil used in the fusion process.

6.3 *Thickness*—The thickness of the coating on significant surfaces shall conform to the requirements in Table 1 and Table 2.

6.3.1 *Thickness Measurements*—Tin-lead alloy thickness measurements shall be made on those areas of the significant surfaces where the coating would be expected to be thinnest. The method of determining the thickness shall be agreed upon by the manufacturer and purchaser. Several methods are available depending upon the thickness of coating, the shape of the article, and the basis metal. They include beta backscatter, coulometric, magnetic, microscopical, and X-ray fluorescence test methods. The methods are outlined in 9.1.

NOTE 8—Thicknesses determined by beta backscatter, coulometry, and X-ray fluorescence are a function of the composition as well as the thickness of the coating.

6.4 *Adhesion*—The adhesion of the coating shall be adequate to pass the tests described in 9.2.

6.5 *Solderability:*

6.5.1 When specified by the purchaser, the coating shall be tested by one of the methods described in 9.2. The results shall be evaluated in accordance with each procedure described in that section.

6.5.2 When specified by the purchaser, the coating on copper and copper alloys shall, before solderability testing, be subjected to the preliminary artificial aging treatment described in 9.3.6 to determine if they may be expected to retain their solderability during periods of storage.

NOTE 9—See Appendix X2 for design considerations that have an effect on the selection of thickness of the coating and, ultimately, on the solderability of the electrodeposits.

7. Hydrogen Embrittlement

7.1 High-tensile strength steels, and severely cold-worked steels, are susceptible to embrittlement by hydrogen in both cleaning and plating operations. The embrittling hydrogen shall be removed by heat treatment. Procedures for baking to minimize embrittlement before and after plating are covered in Sections 2 and 7 of Guide B242.

TABLE 1 Tin-Lead Alloy Coatings on Steel

Service Condition	Classification Number	Minimum Thickness	
		µm	mil
SC4[A]	Fe/SnPb 30	30	1.2
SC3[A]	Fe/SnPb 20	20	0.8
SC2	Fe/SnPb 10	10	0.4
SC1	Fe/SnPb 5	5	0.2
SC1	Fe/SnPb 5f[B]	5	0.2

[A] An undercoat of 2.5 µm (0.1 mil) copper is recommended for SC3 and SC4.
[B] f = flow brightened or
m = mat or
b = bright