Designation: B 200 – 85 (Reapproved 2004)

Standard Specification for Electrodeposited Coatings of Lead and Lead-Tin Alloys on Steel and Ferrous Alloys[1]

This standard is issued under the fixed designation B 200; 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.

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

1. Scope

1.1 This specification covers the requirements for electrodeposited coatings of lead and lead-tin alloys on steel and ferrous alloys. The coatings of lead-tin alloys are those that range in tin content up to but not exceeding 15 mass %. The coatings ranging between 3 and 15 mass % in tin content are known also as "terne" metallic electrodeposits.

1.2 This specification does not apply to sheet, strip, or wire in the unfabricated form.

1.3 The following precautionary caveat pertains only to the test method portion, Section 11, of this specification: *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:* [2]

B 117 Practice for Operating Salt Spray (Fog) Apparatus
B 183 Practice for Preparation of Low-Carbon Steel for Electroplating
B 242 Practice for Preparation of High-Carbon Steel for Electroplating
B 320 Practice for Preparation of Iron Castings for Electroplating
B 322 Practice for Cleaning Metals Prior to Electroplating
B 339 Specification for Pig Tin
B 374 Terminology Relating to Electroplating
B 487 Test Method for Measurement of Metal and Oxide Coating Thicknesses by Microscopical Examination of a Cross Section
B 499 Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals
B 504 Test Method for Measurement of Thickness of Metallic Coatings by the Coulometric Method
B 507 Practice for Design of Articles to Be Electroplated on Racks
B 567 Test Method for Measurement of Coating Thickness by the Beta Backscatter Method
B 568 Test Method for Measurement of Coating Thickness by X-Ray Spectrometry
B 571 Practice for Qualitative Adhesion Testing of Metallic Coatings
B 602 Test Method for Attribute Sampling of Metallic and Inorganic Coatings
B 697 Guide for Selection of Sampling Plans for Inspection of Electrodeposited Metallic and Inorganic Coatings

3. Terminology

3.1 *Definitions*—Definitions of the terms used in this specification are in accordance with Terminology B 374.

4. Classification

4.1 The coating designation shall comprise the following:

4.1.1 The chemical symbol for the basis metal.

4.1.2 The chemical symbol for the undercoating of copper or nickel, if used.

4.1.3 The chemical symbol Pb representing lead or the symbol Pb Sn for the lead-tin alloy. When tin is present, the tin content of the coating will appear before the symbol Sn. For example, Pb 5 Sn refers to a coating having the minimum composition 5 mass % tin, remainder lead.

4.1.4 A number indicating the minimum thickness of the coating in micrometres (µm). This minimum thickness shall be 6, 12, 25, or 40 µm, and shall apply to all significant surfaces specified in 8.2.2 and 8.3.1.

4.2 *Examples*:

4.2.1 Fe-Pb-5-Sn-40 represents a lead-tin alloy coating having 5 mass % tin content, remainder lead, on a ferrous basis metal. The thickness is 40 µm minimum.

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[1] This specification is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.08.04 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.

4.2.2 Fe-Cu-Pb-6 represents a lead coating on a ferrous basis metal with a copper strike. The thickness is 6 µm minimum.

5. Sampling

5.1 *Lot*—An inspection lot is defined as a collection of finished articles that are of the same kind, that have been produced to the same specification, that have been coated by a single supplier at one time or at approximately the same time under essentially identical conditions, and that are submitted for acceptance or rejection as a group.

5.2 *Selection*—A random sample of the size required by Test Method B 602 shall be selected from the inspection lot (see 5.1). The articles in the lot shall be inspected for conformance to the requirements of this specification and the lot shall be classified as conforming or nonconforming to each requirement according to the criteria of the sampling plans in Test Method B 602.

NOTE 1—Test Method B 602 contains three sampling plans that are to be used with nondestructive test methods and a fourth to be used 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. The purchaser should 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.

NOTE 2—When both destructive and nondestructive tests exist for the measurement of a characteristic, the purchaser needs to state which is to be used so that the proper sampling plan is selected. Also, a test may destroy the coating in a noncritical area; or, although it destroys the coating, the tested article might be reclaimed by stripping and recoating. The purchaser needs to state whether the test is to be considered destructive or nondestructive.

5.3 *Separate Specimens*—If separate specimens are to be used to represent the finished articles in a test, the specimens shall be of the nature, size, number, and be processed as required in 6.1, 6.2, 6.3 and 6.4.

6. Specimen Preparation

6.1 *Electroplated Parts or Separate Specimens*—When the electroplated parts are of such form, shape, size, and value as to prohibit use thereof, or are not readily adaptable to a test specified herein, or when destructive tests of small lot sizes are required, the test shall be made by the use of separate specimens plated concurrently with the articles represented. The separate specimens shall be of a basis metal equivalent to that of the articles represented. "Equivalent" basis metal incudes chemical composition, grade, condition, and finish of surface prior to electroplating. For example, a cold-rolled steel surface should not be used to represent a hot-rolled steel surface. Due to the impracticality of forging or casting separate test specimens, hot-rolled steel specimens may be used to represent forged and cast-steel articles. The separate specimens may also be cut from scrap castings when ferrous alloy castings are being electroplated. These separate specimens shall be introduced into a lot at regular intervals before the cleaning operations, preliminary to electroplating of specimens, including the spacing, plating media, bath agitation, and temperature, in respect to other objects being electroplated, shall correspond as nearly as possible to those affecting the significant surfaces of the articles represented. Unless a need can be demonstrated, separately prepared specimens shall not be used in place of production items for nondestructive and visual examinations.

6.2 *Thickness and Adhesion Specimens*— If separate specimens for thickness and adhesion tests are required, they shall be strips approximately 25 mm wide, 100 mm long, and 1 mm thick.

6.3 *Corrosion Resistance Specimens*— If separate specimens for corrosion resistance tests are required, they shall be panels not less than 150 mm long, 100 mm wide, and approximately 1 mm thick.

6.4 *Hydrogen Embrittlement Specimens*— If specimens are required, the configuration shall be that specified by the purchaser.

7. Significance and Use

7.1 Electrodeposits of lead and lead-tin alloys on steel and ferrous alloys are produced where it is desired to obtain atmospheric corrosion resistance. Deposits of lead and lead-tin alloys on steel have shown to have excellent corrosion protective qualities in atmospheric exposure, especially when undercoated by a thin deposit of copper (or nickel). Applications of lead and lead-tin alloy deposits include the following: protection from dilute sulfuric acid; lining of brine refrigeration tanks; chemical apparatus; and parts for storage batteries; and for coating bearing surfaces. In this last application, lead is electroplated alone, or as an alloy and coated with another metal, such as indium. The indium may be diffused into the lead or lead alloy by heat treatment. See Appendix X1.

8. Ordering Information

8.1 When ordering articles to be electroplated in accordance with this specification, the purchaser shall state the coating designation (see Section 4), the minimum thickness on significant surfaces, in addition to the ASTM designation number and year of issue.

8.2 If necessary, the purchaser shall include on his part, drawings, or purchase order the following:

8.2.1 Electroplating application to high-strength steel, if specified (see 9.2.2).

8.2.2 Location of significant surfaces, to be shown on part drawing, or by the provision of a suitably marked sample.

8.2.3 Hydrogen embrittlement test, if required (see 6.4).

8.2.4 Sample size for inspection, if other than specified (see Section 5).

8.2.5 Supplementary requirements, if applicable (see Supplementary Requirements).

8.2.6 Separate test specimens, if permitted (see 6.1).

8.2.7 Certification, if required (see Section 13).

8.3 The manufacturer of the basis metal parts should provide the supplier of the coating facility, with the following data:

8.3.1 Hardness or tensile strength of steel parts (see 9.2.2 and 9.2.3).

8.3.2 Heat treatment for stress relief, whether or not it has been performed or is required.

9. Coating Requirements

9.1 *Composition*—The coating compositions shall be as specified in Table 1.

9.2 *Process*—Lead and lead-tin alloy coatings shall be produced by electrodeposition in aqueous solution of salts. For the preparation of ferrous metal surfaces necessary to assure good deposit, adhesion, and quality, see Practices B 183, B 242, B 320, and B 322.

9.2.1 A copper or nickel strike, 2.5 µm thick, may be employed and is desirable (see X1.1.2).

9.2.2 Steel parts with ultimate tensile strengths greater than 1050 Mpa (approximately 32 HRC) and that have been machined, ground, cold-formed, or cold-straightened shall be stress relieved before processing by heat treating for 5 h at 190 ± 15°C. Steel parts having an ultimate tensile strength greater than 2350 MPa (approximately 50 HRC) shall not be coated with lead or lead-tin alloys by electrodeposition.

9.2.3 Steel parts with ultimate tensile strengths greater than 1125 MPa (approximately 35 HRC) and greater, shall be heat treated within 4 h after plating to remove hydrogen embrittlement. The heat treatment shall be at least for 3 h at 190 ± 15°C.

9.2.4 Defects and variations in appearance in the finish that arise from surface conditions of the substrate (for example, scratches, pores, roll marks, inclusions, etc.) and that persist in the finish despite the observance of good metal-finishing practices shall not be cause for rejection.

NOTE 3—Applied finishes generally perform better in service when the substrate over which they are applied is smooth and free of torn metal, inclusions, pores, and other defects. It is recommended that the specifications covering the unfinished products provide limits for these defects. A metal finisher can often remove defects through special treatments such as grinding, polishing, abrasive blasting, chemical etching, and electropolishing. However, these are not normal in the treatment steps preceding the application of the finish. When they are desired they shall be the subject of agreement between the buyer and the seller.

9.3 *Thickness*—The minimum thickness on significant surfaces shall be 6, 12, 25, or 40 µm, as designated by the purchaser (see 8.1).

9.4 *Significant Surfaces*—Significant surfaces are defined as those normally visible (directly or by reflection) or are essential to the serviceability or function of the article; or can be the source of corrosion products or tarnish films that interfere with the function or desirable appearance of the article. When necessary, the significant surfaces shall be indicated on the drawings of the parts, or by the provision of suitably marked samples.

NOTE 4—When significant surfaces are involved on which the specified thickness of finish cannot be readily controlled, it will be necessary to apply greater thickness on the more accessible surfaces, to use special racking, or both. The thickness requirements of this specification are minimum, (see Table 2). Variation in the finish thickness from point to point on a coated article is inherent in electroplating. Therefore, the finish thickness will have to exceed the specified value at some points on the significant surfaces to ensure that it equals or exceeds the specified value at all points. In most cases, the average finish 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 B 507) and the characteristics of the plating process. In addition, the average finish 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 finish thickness for the production lot as a whole will be greater than the average necessary to assure that a single article meets the requirement.

9.5 *Corrosion Resistance*—Lead and lead-tin coatings shall show neither corrosion products of lead (or lead-tin) nor basis metal corrosion products at the end of the test period, (see Table 2), when tested by continuous exposure to salt spray in accordance with 11.4. The appearance of corrosion products visible to the unaided eye at normal reading distance shall be cause for rejection except that corrosion products at the edges of specimens shall not constitute failure.

NOTE 5—Corrosion is defined as the presence of more than 66 rust spots per square metre, or more than two rust spots in an area less than 3 square decimetres, or rust spots larger than 1.6 mm in diameter.

10. Workmanship, Finish, and Appearance

10.1 The surface of the electroplated article shall be uniform in appearance and free of visible coating defects, such as blisters, pits, roughness, nodules, burning, cracks, or unplated areas, and other defects that will affect the function of the coating. However, superficial staining that results from rinsing or slight discoloration from any drying or baking operation to relieve hydrogen embrittlement, shall not be cause for rejection. On articles where a visible contact mark is unavoidable, its position shall be that chosen by the purchaser. The electroplated articles shall be clean and free of damage.

11. Test Methods

11.1 *Composition*—The lead-tin alloy coating deposit may be weighed and then analyzed for one of the metals. Lead content may be determined and the tin calculated by difference, for 1 g sample:

$$\text{Tin \%} = \frac{(1 - L)}{A} \times 100 \quad (1)$$

$$\text{Mass \% Tin} = \left(W - \frac{L}{W} \right) \times 100 \quad (2)$$

where:

L = weight of lead in sample, and

A = weight of lead-tin alloy in sample.

W = 1 g

TABLE 1 Lead-Tin Alloy Coating Composition

Element	Mass %
Tin (Sn)	Up to 15 max
Lead (Pb)	Remainder
Other metals and nonmetallics	1.0 max
Lead Coating Composition	
Lead	99.0
Other metals and nonmetallics	1.0 max

TABLE 2 Lead and Lead-Tin Alloy Coatings on Ferrous Alloys

Thickness, min µm	Salt Spray Resistance, h
40	200
25	96
12	48
6	24

11.1.1 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 coating deposited by a given number of ampere-hours to the weight of a lead coating produced in a lead coulometer in series with the plating bath.

11.2 *Thickness*—The thickness of the coating may be determined by Test Methods B 487, B 499, B 504, B 567, and B 568. The method used shall be applicable for the coating material and thickness specified.

NOTE 6—The thickness range of some of these methods may not include the specified thickness or the method may require the knowledge of the coating composition or density.

11.2.1 Other methods may be used if it can be determined that the uncertainty of the measurement is less than 10 %.

11.3 *Adhesion*—Determine adhesion by any suitable procedure in accordance with Practice B 571.

11.4 *Corrosion Resistance*—When specified in 8.2, determine the corrosion resistance in accordance with Test Method B 117. Subject the selected samples to the salt spray test; the length of time to be applicable for the coating thickness shall be in accordance with the requirements of Table 2.

11.5 *Hydrogen Embrittlement Relief*— When specified in the contract or purchase order, prepare and test the satisfactory behavior of parts to indicate freedom from hydrogen embrittlement.

11.6 *Visual Examination*—Examine material for compliance with the requirements of Section 10 after electroplating.

12. Rejection and Rehearing

12.1 Articles that fail to conform to the requirements of this Specification may be rejected. Rejection shall be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of a test, the producer or supplier may make a claim for a hearing.

13. Certification

13.1 The purchaser may require in the purchase order or contract that the producer or supplier give to the purchaser certification that the finish was produced and tested in accordance with this Specification and found to meet the requirements. The purchaser may similarly require that a report of the test results be furnished.

14. Keywords

14.1 electrodeposited coatings, lead and lead-tin alloys; lead/lead-tin alloy on steel/ferrous alloys

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirement shall apply only when specified by the purchaser as part of the purchaser's order or contract and for all agencies of the United States government.

S1. Responsibility for Inspection

S1.1 The producer or supplier shall be responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein unless disapproved by the purchaser. The purchaser retains the right to perform any of the inspections and tests set forth in this specification where such inspections and tests are deemed necessary to ensure that supplies and services conform to the prescribed requirements.

APPENDIXES

(Nonmandatory Information)

X1. GUIDE TO SELECTION OF COATING THICKNESS

X1.1 *Corrosion Protection:*

X1.1.1 The results of atmospheric exposure tests on unalloyed lead coatings are given in Table X1.1. Tests completed under the auspices of ASTM[3] show that a 19-µm coating of lead, electroplated directly on steel, has a life expectancy greater than 9 years under industrial conditions. Under marine conditions, for example, at the lot at Kure Beach, life expectance of a 19-µm coating with a copper strike is 4 to 6 years. Under rural conditions, life expectancy of a 19-µm coating (with copper strike) is 7.5 to 9.5 years. Tests conducted at ASTM sites for the International Lead Zinc Research Organization, Inc., on lead coatings produced from a lead fluoborate electrolyte with hydroquinone as an addition agent, showed comparable results and also confirmed the beneficial effect of a copper strike.

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[3] DuRose, A. H., "Atmospheric Exposure of Electroplated Lead Coatings on Steel," *Symposium on Properties, Tests and Performance of Electrodeposited Metallic Coatings, ASTM STP 197,* ASTM, 1956.

TABLE X1.1 Atmospheric Exposure Tests on Lead-Plated Steel[A] (Expected Life in Years)

Coating	Coating Thickness		Industrial	Marine	Rural	Reference[B]
	µm	mil				
Lead	6.5	0.25	<2	<2	<2	1
1.3 µm (0.05 mil) Cu strike plus lead	6.5	0.25	>1–2	3–4	3–4	1
Lead	6.5	0.25	6–>9	<0.8–1.5	<0.8–1.0	2
0.25 µm (0.01 mil) Cu stbike plus lead	6.5	0.25	7–>9	1.3–3.0	1.3–3.0	2
0.25 µm (0.01 mil) Cu strike plus lead	13	0.50	9–>9	3.3–4.0	2.0–4.0	2
0.38 µm (0.015 mil) Cu strike plus lead	13	0.50	>9	3.5–4.0	5.0–7.0	2
Lead	19	0.75	>9	3.5–4.0	5.0–7.6	2
0.38 µm (0.015 mil) Cu strike plus lead	19	0.75	>9	4.0–6.0	7.5–9.5	2
Lead	25	1.00	>9	4.0–7.0	6.0–8.4	2
0.38 µm (0.015 mil) Cu strike plus lead	25	1.00	>9	5.0–10.0	>10	2
Hot-dipped Pb	10	0.40	7–9	0.8–4.0	1.0–8.0	2
Lead	25	1.0	>5	>5	>5	3
Lead	50	2.0	>5	>5	>5	3

[A] Additions of tin up to 15 % do not adversely affect the corrosion resistance of the coatings.

[B] Ref 1—Program of the International Lead Zinc Research Organization, Inc.—5 years exposure. The ILZRO investigation was based on the use of fluoborate electrolytes with the addition agent hydroquinone.

Ref 2—ASTM program, 1944 Exposure Tests—Plated lead coatings.

Ref 3—ILZRO test in progress.

X1.1.2 The effect of a copper strike on atmospheric corrosion protection is shown by the data in Table X1.1. In industrial, marine, and rural atmospheres, there is a significant improvement in corrosion resistance if a copper strike of minimum thickness 0.25 µm is used.

X1.1.3 Exposure to sulfuric acid and other aggressive industrial chemicals may require coating thicknesses of 40 µm and greater. Where there are exceptionally aggressive conditions or where mechanical damage is possible, then lead coating thicknesses between 125 and 250 µm may be required.

X1.1.4 Resistance to corrosion from less severe atmospheric conditions than those considered in X1.1.1 can be achieved with lead coatings 12 µm thick. Coatings less than 12 µm thick will normally be used in conjunction with paint coatings, etc., where exposure to an aggressive atmosphere is anticipated. The use, for corrosion protection, of coatings less than 12 µm thick is limited to indoor applications or to special situations owing to the possibility of damage during handling and possible increased porosity.

X1.1.5 The atmospheric corrosion resistance of lead-tin alloy coatings is not adversely affected by additions of tin up to 15 mass %.

X1.2 Where a nickel strike is employed, overheating during any joining operation may cause hot shortness and cracking of the nickel coating, from contamination by the lead and in the lead or lead-tin alloy plate.

X1.3 Lead-tin alloy (93 % Pb − 7 % Sn) is used for coating bearing surfaces.

X2. SUGGESTIONS FOR MEETING THE SPECIFICATIONS AS TO THICKNESS AND QUALITY OF THE COATINGS

X2.1 Ensure that the basis metal is properly cleaned.

X2.2 Use anodes of high purity such as 99.99 % of lead for lead plating. Grade A tin (see Specification B 339) and high-purity lead for the alloy anodes.

X2.3 Alloy anodes should not be left in the bath unless current is flowing. If this precaution is not observed, tin will be deposited from the bath onto the anode, and subsequently, it will flake off to cause roughness in deposition.

X2.4 To avoid buildup of impurities, work pieces should not remain in the bath unless current is flowing.

X2.5 Filteration should be continuous.

X2.6 Agitation should be employed. Lead baths should be agitated continuously to prevent concentration and temperature gradients in the solution.

X2.7 A carbon treatment during bath preparation is recommended to remove organic impurities.

X2.8 Demineralized (or deionized) water should be used for the last rinse prior to plating to prevent chloride and sulfate contamination.

X2.9 When hydroquinone is used as an addition agent, about 48 h are required at room temperature to allow an equilibrium between quinone and hydroquinone to be established. If this is not done, there may not be adequate grain refinement, and treeing may be excessive with thick deposits.

X2.10 Maintain regular control of all solutions and inspect the equipment at regular intervals, paying special attention to electrical contacts and accuracy of instruments.

X2.11 Maintain an inspection department, using the test methods prescribed in this specification in order to trace immediately the source of irregularities. On jobs running continuously over any length of time, the quality of the coatings on each part should be checked at least twice every shift after initial difficulties have been overcome.

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