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SUPERSEDING
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MILITARY SPECIFICATION

LEAD-TIN ALLOY COATING
(Electrodeposited)

This specification is approved for use by all Departments and Agencies of the Department of Defense

1. SCOPE

1.1 Scope. This specification covers an electrodeposited lead-tin alloy coating for metal bearings.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this specification to the extent specified herein.

STANDARDS

FEDERAL

Fed. Test Method Std. No. 151 - Metals; Test Methods

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes

(Copies of specifications, standards, handbocks, drawings, and publications required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, US Army Materials and Mechanics Research Center, ATTN: DRXMR-SMS, Watertown, MA 02172 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

NO DELIVERABLE DATA REQUIRED BY THIS DOCUMENT

/ AREA MFFP /

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

B487 - Metal and Oxide Coating Thickness by Microscopical Examination of a Cross-Section, Method of Measuring

B499 - Coating Thicknesses by the Magnetic Method; Non-magnetic Coatings on Magnetic Basic Metals, Method of Measuring of

E8 - Tension Testing of Metallic Materials

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.)

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

3.1 Materials. The materials used for electroplating shall produce a coating which meets the requirements of this specification.

3.2 Basis material. The basis material shall be free from defects that will be detrimental to the utility, form, fit, function, or protective value of the plating.

3.3 Preplating operations. Unless otherwise specified in the contract or order, the plating shall be applied after all machining, brazing, welding, forming and perforating of the article has been completed.

3.4 Processing bath. Unless otherwise specified in the contract or order, the plating shall be electrodeposited in a lead-tin fluoborate bath. One suggested process is outlined in section 6.

3.5 Composition. The composition of the bearing coating shall be as follows:

93 percent lead, minimum
6 percent tin, minimum

3.6 Post plating removal of plating residues. The bearing alloy plating shall not be applied to assemblies which will entrap the plating solution in edges, joints or recesses where it cannot be removed. Such parts shall be plated prior to assembly. Plating residues shall be removed from plated articles after plating by soaking for a minimum of 3 minutes in clean hot water (93° to 100°C) (200° to 212°F).

3.7 Equipment and process. The articles to be plated shall be subject to such cleaning, pickling, and plating procedures as are necessary to yield a coating as hereinafter specified. Acid pickling on high strength steels is prohibited.

3.8 Stress relief treatment. All steel parts shall be given a stress relief treatment at a minimum of 191° ± 14°C (375° ± 25°F) for 3 hours or more prior to cleaning and coating if they contain or are suspected of having residual tensile stresses caused by machining, grinding or cold forming operations. Parts which are cold straightened are considered to contain damaging residual tensile stresses. The temperature and time at temperature shall be such that maximum stress relief is obtained without reduction in hardness to less than the specified minimum.

3.9 Hydrogen embrittlement relief. All steel parts having a hardness of Rockwell C40 and higher shall be baked at 191° ± 14°C (375 ± 25°F) for 3 hours or more, within four hours after plating to provide hydrogen embrittlement relief. Parts subject to flexure shall not be flexed prior to the baking operation. When specified (see 6.2) the parts shall be tested for embrittlement relief in accordance with 4.5.3. When examined after test the parts shall show no cracks or fracture.

3.10 Thickness of plating. Unless otherwise specified in the contract or order, the thickness of the plating shall be as shown on the drawing(s) (see 6.2).

3.11 Adhesion. The adhesion of the plating shall be such that when examined at a magnification of four diameters, it does not show separation from the basis metal at the interface when subjected to the test specified in 4.5.2. The interface between the bearing plating and the basis metal is the surface of the basis metal before plating. The formation of cracks in the basis metal or plate which do not result in flaking, peeling, or blistering of the plate shall not be cause for rejection.

3.12 Workmanship. In bi-metal bearings, the bearing plating shall be firmly and continuously bonded to the basis metal. Die castings to be plated or polished shall be reasonably free, on significant surfaces, from die marks, finds, and ejector pin depressions. Die castings shall not be soldered, impregnated or plugged, to hide defects or to salvage defective parts. The bearing plate shall be free from any defects which are detrimental to the utility, form, fit or function of the part.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Lot. A lot shall consist of plated articles of the same class and of approximately the same size, form and shape and plated under similar conditions, submitted for inspection at one time.

4.3 Sampling.

4.3.1 Visual inspection and nondestructive thickness measurement. Representative samples from each lot shall be selected in accordance with MIL-STD-105, inspection level II, with acceptable quality level equal to 1.5 percent defective to verify compliance with all requirements of this specification for visual examination and nondestructive tests for plating thickness.

4.3.2 Destructive tests for plating thickness, adhesion and hydrogen embrittlement. A random sample of four items shall be selected from each lot or four separately plated specimens shall be prepared to represent the lot for each destructive test. If the number of items in the inspection lot is 4 or less, the number of items in the sample shall be determined by the procuring activity. Separate specimens shall not be used for thickness measurements unless a need has been demonstrated. The articles or specimens used for the destructive thickness test, if of suitable size and form, may be used as the specimens for the adhesion test. Failure of any sample to conform to the applicable tests shall reject the lot represented.

4.3.3 Specimen preparation. When the plated articles are of such form, shape, size and value as to prohibit use thereof, or are not readily adaptable to the 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 includes chemical composition, grade, heat treated condition and finish of surface prior to plating. 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 plated. These specimens shall be introduced into a lot at regular intervals prior to the cleaning operation preliminary to plating and shall not be separated therefrom until after completion of plating. Conditions affecting the plating of specimens including the spacing and positioning in respect to anodes and to other objects being plated shall correspond as nearly as possible to those affecting the significant surfaces of the articles represented.

4.3.3.1 For thickness and adhesion tests. If separate specimens for thickness and adhesion tests are required, they shall be strips approximately 4 inches long, 1 inch wide and 0.04 inch thick.

4.3.3.2 For embrittlement relief. When hydrogen embrittlement relief testing is specified (see 6.2) for those parts which will be subjected to a sustained tensile load in use, separate specimens, if required, shall be prepared. They shall be round notched specimens with the axis of the specimen (load direction) perpendicular to the short transverse grain flow direction. The configuration shall be in accordance with figure 8 of ASTM E8 for rounded specimens. Specimens shall have a 60 degree V-notch located approximately at the center of the gage length. The cross section area at the root of the vee shall be approximately equal to half the area of the full cross section area of the specimen's reduced section. The vee shall have a 0.010 $\pm$ 0.0005 inch radius of curvature at the base of the notch.

4.4 Inspection.

4.4.1 Visual inspection. The number of items indicated in 4.3.1 shall be taken at random from the lot to be inspected and examined visually to insure compliance with the requirements of 3.12. If the number of nonconforming items in any sample exceeds the acceptance number for that sample, the lot represented by that sample shall be rejected.

4.5 Test methods.

4.5.1 Thickness tests. Measurements should be made in accordance with ASTM method B487 or method B499. At the option of the supplier, instruments which use the principal of beta radiation backscatter may also be employed for thickness measurements. Thickness measurements by the beta radiation backscatter method depend on the mass (density) of the coating and basis metal and the instrument should be calibrated with standards identical to the test specimens to be measured.

4.5.2 Adhesion test. Wherever possible, the test shall be made on a specimen representing the basis material which can be bent 180°. The test specimens shall be bent repeatedly through an angle of 180° until fracture of the basis metal occurs. Following fracture of the basis metal, it shall not be possible to detect separation from the basis metal at the interface when examined at magnification of four diameters in the area of the coating with a sharp instrument.

4.5.2.1 When the plated articles are not readily adaptable to the bend test, adhesion may be determined on the plated article or on a plated sample representative of the plated article (see 4.3.2) by cutting the plating from the basis metal at the interface in a continuous path. The plate shall then be examined at four diameters magnification to determine whether removal has been caused by the cutting away of an adherent plate or by the lifting of a non-adherent plate.

4.5.3 Embrittlement relief. When specified (see 6.2), parts for determining compliance with 3.9 shall be taken as specified in 4.3.2. The

selected samples shall be subjected to a sustained tensile load equal to 115 percent of the maximum design load for which the part was designed. Parts which require special fixtures, extreme loads to comply with the above requirements or where the maximum design load is not known, may be represented by separate specimens prepared in accordance with 4.3.2 and 4.3.3 (see 6.2). The notched specimens shall be subject to a sustained tensile load equal to 75 percent of the ultimate notch tensile strength of the material. Unless otherwise specified, the articles, parts or specimens shall be held under load for at least 200 hours and then examined visually for cracks or fractures.

4.5.4 Composition. The composition of the lead-tin coating shall be checked for compliance with 3.5 by either method 111, 112 or 514 of Fed. Test Method No. 151.

5. PACKAGING

5.1 Packaging requirements. There are no packaging, packing or marking requirements applicable to this specification.

6. NOTES

6.1 Intended use. The electrodeposited lead-tin alloy is used for bearing purposes.

6.2 Ordering data. Procurement documents should specify the following:

(a) Title, number and date of this specification.
(b) Thickness of plating (see 3.10).
(c) Whether embrittlement relief test is required (see 3.9 and 4.5.3).

6.3 The manufacturer of the basis metal parts should provide the plating facility with the following data:

(a) Hardness of steel parts (see 3.9).
(b) Whether heat treatment for stress relief has been performed or is required (see 3.8).
(c) Ultimate use.
(d) Tensile loads and time required for embrittlement relief test.
(e) Separate specimens for embrittlement relief testing (see 4.3.3.2) if required.

6.4 Process. A suggested fluoborate process is outlined below, however, the Government assumes no responsibility for the acceptance of articles claimed to be plated by this process. Acceptance is based on compliance with the requirements of section 3.

6.4.1 Materials. The bath composition may be as indicated in table I.

TABLE I. Bearing metal bath

Bath Composition	oz./gal.
Stannous tin	0.80
Lead	11.8
Free fluoboric acid	13.4-26.8
Peptone	0.67
Anodes: Composition: 93 percent lead--7 percent tin	

6.4.2 Typical bath. Table II indicates the amounts of the various ingredients that should be used in making up 100 gallons of this bath, using the concentrates indicated in table I.

TABLE II. Bath ingredients

Ingredients	Quanitity Gal.	Lbs.
Stannous fluoborate concentrate 51% Sn $(BF_4)_2$	1.8	24.1
Lead fluoborate concentrate 51% Pb $(BF_4)_2$	18.1	264
Fluoboric acid (49%)	14.6	168
Boric acid	-	18.0
Peptone	-	4.2
Water (approximate)	65.1	530

6.4.3 Equipment. Tank linings, pump linings or filter chamber shall be constructed from P.V.C., butyl rubber, Lucite, polypropylene or other plastics not attacked by the solution.

6.4.3.1 Anode bags and filter spools. These shall be made of Dynel or polypropylene. Before using, leach Dynel or polypropylene anode bags or filter spools in hot (150°F) (65.5°C) water to remove organic agents used in their manufacture.

6.4.4 Racks and other equipment. Titanium racks or equipment shall not be used. Also, glass or other silicated materials shall not be used. The material specified in 6.4.3 is the only material that shall be permitted.

6.4.5 Operating conditions. The operating conditions specified in table III shall apply.

TABLE III. Operating conditions

Cathode current density	30 to 60 amp./sq. ft.
Temperature	60° - 100°F
Agitation	Mild (cathode rod)[1]
Alloy anodes	Pure lead and tin
Anode to cathode ratio	2:1[2]

[1]Air agitation cannot be used as it will oxidize the tin. Agitation should not be vigorous as excessive agitation will decrease the tin in the deposit. Adequate agitation may be had on a moving work rod. An outside pump may be used.

[2]It will be noted that the lead and tin content of the anode is the same as that desired in the deposit. If under certain conditions of operation, the resulting deposit does not have the desired composition, correction is made by a suitable adjustment of the bath composition, the anode composition being maintained as indicated.

Custodians:
Army - MR
Navy - SH
Air Force - 11

Review Activities:
Army - AR, AL, AT

Preparing activity:
Army - MR

Project No. MFFP-0160

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1 DOCUMENT NUMBER	2 DOCUMENT TITLE

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5 PROBLEM AREAS

a. Paragraph Number and Wording

b Recommended Wording

c Reason/Rationale for Recommendation

6 REMARKS

7a NAME OF SUBMITTER *(Last, First, MI)* – Optional	b WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
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