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Standard Specification for Coatings of Cadmium-Tin Mechanically Deposited[1]

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1. Scope

1.1 This specification covers the requirements for a coating that is a mixture of cadmium and tin mechanically deposited on metal products. The coating is provided in various thicknesses up to and including 12 µm.

1.2 Mechanical deposition greatly reduces the risk of hydrogen embrittlement and is suitable for coating bores and recesses in many parts that cannot be conveniently plated electrolytically. (See Appendix X1.)

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *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.* For specific hazards statements, see Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B117 Practice for Operating Salt Spray (Fog) Apparatus
B183 Practice for Preparation of Low-Carbon Steel for Electroplating
B201 Practice for Testing Chromate Coatings on Zinc and Cadmium Surfaces
B242 Guide for Preparation of High-Carbon Steel for Electroplating
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
B567 Test Method for Measurement of Coating Thickness by the Beta Backscatter Method
B571 Practice for Qualitative Adhesion Testing of Metallic Coatings
B602 Test Method for Attribute Sampling of Metallic and Inorganic Coatings
B697 Guide for Selection of Sampling Plans for Inspection of Electrodeposited Metallic and Inorganic Coatings
B762 Test Method of Variables Sampling of Metallic and Inorganic Coatings
E87 Methods for Chemical Analysis of Lead, Tin, Antimony, and Their Alloys (Photometric Methods) (Withdrawn 1983)[3]
E396 Test Methods for Chemical Analysis of Cadmium
F1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection

2.2 *U.S. Federal Standard:*

FED-STD-141 Paint, Varnish, Lacquer, and Related Materials; Methods of Inspection, Sampling and Testing[4]

2.3 *U.S. Military Standard:*

MIL-L-7808J Lubricating Oil, Aircraft Turbine Engine, Synthetic Base[4]

3. Classification

3.1 *Classes*—Cadmium-tin coatings are classified on the basis of thickness, as follows:

Class	Minimum Thickness, µm
12	12
8	8
5	5

3.2 *Types*—Cadmium-tin coatings are identified by types on the basis of supplementary treatment required, as follows:

3.2.1 *Type I*—As coated, without supplementary chromate treatment (see X1.1).

3.2.2 *Type II*—With supplementary chromate treatment (see X1.2).

[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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

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

4. Ordering Information

4.1 To make the application of this specification complete, the purchaser needs to supply the following information to the supplier in the purchase order or other governing document:

4.1.1 Class, including a maximum thickness, if appropriate, type, and need for supplemental lubricant (3.1, 3.2, and 5.2.4.2).

4.1.2 Nature of substrate, for example, high-strength steel, need for stress-relief, and cleaning precautions to be followed (5.2.2).

4.1.3 Significant surfaces (5.3).

4.1.4 Requirements and methods of testing for one or more of the following requirements: need for and type of test specimens (8.1), composition (8.2), thickness (8.4), adhesion (8.6), and absence of hydrogen embrittlement and the waiting period prior to testing and testing loads (8.8) and lubricating resistance (S2).

4.1.5 Sampling plan for each inspection criterion and responsibility for inspection, if necessary (Section 6 and Supplementary Requirement S1).

4.1.6 Requirements for certified report of test results (Section 10).

5. Requirements

5.1 *Nature of Finish*—The coating shall be 45 to 75 mass % cadmium, the remainder tin.

5.2 *Process:*

5.2.1 *Stress Relief Treatment*—All steel parts that have ultimate tensile strength of 1000 MPa and above and that contain tensile stresses caused by machining, grinding, straightening, or cold forming operation shall be given a stress relief heat treatment prior to cleaning and metal deposition. The temperature and time at temperature shall be 190 ± 15°C for a minimum of 3 h so that maximum stress relief is obtained without reducing the hardness below the specified minimum.

5.2.2 High-strength steels that have heavy oxide or scale shall be cleaned before application of the coating in accordance with Guide B242. In general, non-electrolytic alkaline, anodic-alkaline, and some inhibited acid cleaners are preferred to avoid the risk of producing hydrogen embrittlement from the cleaning procedure.

5.2.3 For preparation of low-carbon steels, see Practice B183. For cleaning, useful guidelines are also given in Guide B322.

5.2.4 *Supplementary Treatments:*

5.2.4.1 Chromate treatment for Type II shall be done in a solution containing hexavalent chromium. This solution shall produce a bright or semi-bright continuous, smooth, protective film. This film may have a slight yellowish or iridescent color. The absence of color shall not be considered evidence of the absence of a Type II film or as a basis for rejection of the parts. Only post treatments that contain salts that yield films containing hexavalent chromium are permitted as treatments for producing Type II coatings.

5.2.4.2 Waxes, lacquers, or other organic coatings may be used to improve lubricity, and the need for them should be supplied in the purchase order or other governing document (4.1.1). Such supplemental lubrication treatments shall not be used to ensure conformance to the salt spray corrosion resistant requirements or to enhance the test results of the lead acetate spot test (8.5.2).

5.3 *Thickness:*

5.3.1 The thickness of the coating everywhere on the significant surfaces shall be at least that of the specified class as defined in 3.1.

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

NOTE 1—The thickness of mechanically-deposited coatings varies from point-to-point on the surface of a product, characteristically tending to be thicker on flat surfaces and thinner at exposed edges, sharp projections, shielded or recessed areas, interior corners and holes, with such thinner areas often being exempted from thickness requirement.

5.3.3 When significant surfaces are involved on which the specified thickness of deposit cannot readily be controlled, the purchaser and manufacturer should recognize the necessity for either thicker or thinner deposits. For example, to reduce buildup in thread roots, holes, deep recesses, bases of angles, and similar areas, the deposit thickness on the more accessible surfaces will have to be reduced proportionately.

NOTE 2—The coating thickness requirement of this specification is a minimum requirement; that is, the coating thickness is required to equal or exceed the specified thickness everywhere on the significant surfaces. Variation in the coating thickness from point to point on a coated article is an inherent characteristic of mechanical deposition 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. Thus, in most cases, the average coating thickness on an article will be greater than the specified value; how much greater is largely determined by the shape of the article and the characteristics of the deposition process. In addition, the average coating 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 coating thickness for the production lot as a whole will be greater than the average necessary to ensure that a single article meets the requirement.

5.4 *Adhesion*—The cadmium-tin coating shall be sufficiently adherent to the basis metal to pass the tests specified in 8.6.

5.5 *Corrosion Resistance:*

5.5.1 The presence of corrosion products visible to the unaided eye at normal reading distance at the end of the specified test period as stated in Table 1 shall constitute failure, except that corrosion products at the edges of specimens shall not constitute failure. Slight "wisps" of white corrosion, as opposed to obvious accumulations, shall be acceptable.

NOTE 3—The hours given in Table 1 are the minimums required to guarantee satisfactory performance. Longer periods before the appearance of white corrosion products and rust are possible, but salt spray resistance does not vary in exact proportion with increased plating thickness. The hours given for Type II reflect the added protection of chromate treatments without requiring impractical testing periods.

TABLE 1 Minimum Hours to Failure (White Corrosion and Red Rust for Cadmium-Tin Coatings on Iron and Steel)[A]

Type	Class 12		Class 8		Class 5	
	White Corrosion	Rust	White Corrosion	Rust	White Corrosion	Rust
I	not applicable	144	not applicable	120	not applicable	60
II	96	168	96	168	96	168

[A] Corrosion products are those visible to the unaided eye at normal reading distances after gentle washing to remove salt deposits.

5.5.2 There are no requirements for corrosion of base metals other than steels.

NOTE 4—Mechanical deposition is exclusively a barrel-finishing process. It is recognized that mechanical deposition on parts may therefore produce surfaces which have a different characteristic from those on parts which are finished exclusively by racking. Similarly, corrosion testing of actual parts may produce different results from those on test panels. Salt spray requirements that are appropriate to indicate the technical quality with which a process is carried out may be impractical for acceptance of actual parts. In such cases the purchaser should indicate his requirements on the purchase order (see 4.1.4).

NOTE 5—In many instances, there is no direct relation between the results of an accelerated corrosion test and the resistance to corrosion in other media, because several factors that influence the progress of corrosion, such as the formation of protective films, vary greatly with the conditions encountered. The results obtained in the test should not, therefore, be regarded as a direct guide to the corrosion resistance of the tested materials in all environments where these materials may be used. Also, performance of different materials in the test cannot always be taken as a direct guide to the relative corrosion resistance of these materials in service.

5.6 *Absence of Hydrogen Embrittlement*— Steel springs and other high-strength steel parts subject to flexure shall be held for a minimum of 48 h at room temperature after coating, before being loaded, flexed, or used. Such parts shall be free from hydrogen embrittlement. When specified in the purchase order, freedom from embrittlement shall be determined by the test specified herein (see 4.1.4 and 8.8).

5.7 *Workmanship*—The coating shall be uniform in appearance and substantially free of blisters, pits, nodules, flaking and other defects that can adversely affect the function of the coating. The coating shall cover all surfaces as stated in 5.3, including thread roots, thread peaks, corners, recesses, and edges. The coating shall not be stained or discolored throughout to an extent that would adversely affect appearance as a functional requirement. However, superficial staining that results from rinsing or drying, and variations in color or luster shall not be cause for rejection.

NOTE 6—The nature of the mechanical plating process is such that coatings characteristically will not be as smooth or as bright as some electroplated coatings.

5.8 *Surface Defects*—Defects and variations in appearance in the coating that arise from surface conditions of the substrate (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 7—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 product provide limits for these defects. A metal finisher can often remove defects through special treatments, such as grinding, polishing, abrasive blasting, chemical treatments, and electropolishing. However, these are not normal in the treatment steps preceding the application of the finish. When desired, they must be specified on the purchase order (see 4.1.2).

6. Sampling

6.1 The purchaser and producer are urged to employ statistical process control in the coating process. Properly performed, statistical process control will assure coated products of satisfactory quality and will reduce the amount of acceptance inspection. The sampling plan used for the inspection of the quality coated article shall be agreed upon between the purchaser and producer.

6.1.1 When a collection of coated articles (inspection lot, see 6.2) is examined for compliance with the requirements placed on the articles, a relatively small number of the articles (sample) is selected at random and is inspected. The inspection lot is then classified as complying with the requirements based on the results of the inspection of the sample. The size of the sample and the criteria for compliance are determined by the application of statistics. The procedure is known as sampling inspection. Test Method B602, Guide B697, and Test Method B762 contain sampling plans that are designed for sampling inspection of coatings.

6.1.2 Test Method B602 contains four sampling plans, three for use with tests that are nondestructive and one when they are destructive. Test Method B602 provides a default plan if one is not specified.

6.1.3 Guide B697 provides a large number of plans and also gives guidance in the selection of a plan. Guide B697 provides a default plan if one is not specified.

6.1.4 Test Method B762 can be used only for coating requirements that have a numerical limit, such as coating thickness. The test must yield a numeric value and certain statistical requirements must be met. Test Method B762 contains several plans and also gives instructions for calculating plans to meet special needs. Test Method B762 provides a default plan if one is not specified.

6.1.5 Guide F1470 can be used for fasteners such as internally threaded, externally threaded and nonthreaded fasteners and washers. This guide provides for two plans: one designated the "detection process" and one designated the "prevention process." The purchaser and producer shall agree on the plan to be used.

6.2 An inspection lot shall be defined as a collection of coated articles that are the same kind, that have been produced to the same specification, 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.

7. Hazards

7.1 **Warning—**Cadmium is toxic and must not be used in a coating for articles that can come into contact with food or

beverages, or for dental or other equipment that can be inserted into the mouth. Consult appropriate agencies for regulations in this connection.

7.2 **Warning—**Because of the toxicity of cadmium vapors and cadmium oxide fumes, cadmium-tin coated articles must not be used at temperatures of 165°C and above. They must not be welded, spot-welded, soldered, or otherwise strongly heated, without adequate ventilation that will efficiently remove all toxic fumes. (See X4.2.)

8. Test Methods

8.1 *Test Specimens:*

8.1.1 Test specimens may be used to represent the coated articles in a test if the articles are of a size, shape, or material that is not suitable for the test, or if it is preferred not to submit articles to a destructive test because, for example, the articles are expensive or few. The permission or the requirement to use test specimens, their number, the material from which they shall be made, and their shape and size shall be stated in the purchase order or other governing document.

8.1.2 The test specimen shall duplicate those characteristics of the article that influence the property being tested, and it shall be processed with the article through those process steps that influence the property.

8.1.2.1 The test specimen used to represent an article in an adhesion, corrosion resistance, or appearance test shall be made of the same material, shall be in the same metallurgical condition, and shall have the same surface condition as the article it represents. It shall be placed in the production lot of and be processed along with the article it represents.

8.1.2.2 A test specimen used to represent an article in a coating thickness test shall be introduced into the process at the point where the coating or coatings are applied and it shall be carried through all steps that have a bearing on the coating thickness.

8.1.2.3 When a test specimen is used to represent a coated article in a thickness test, the specimen will not necessarily have the same thickness and thickness distribution as the article unless the specimen and the article are of the same general size and shape. Therefore, before coated articles may be accepted on the basis of a thickness test performed on test specimens, the relationship between the thickness on the specimen and the thickness on the part shall be established. The criterion of acceptance shall be that thickness on the specimen that corresponds to the required thickness on the article.

8.2 *Composition*—Chemical composition of the cadmium-tin coating shall be determined when required on the purchase order by procedures given in Methods E87 or Test Methods E396, or by other methods specified on the purchase order (see 4.1.4) as long as they can determine composition to within the desired limits.

8.3 *Workmanship*—The quality of workmanship shall be determined by the unaided eye at normal reading distance.

8.4 *Thickness:*

8.4.1 The thickness of the coating shall be determined by the microscopical method (Test Method B487), the magnetic method (Test Method B499), or the beta backscatter method (Test Method B567), as applicable. Other methods may be used if it can be demonstrated that the uncertainty of the measurements with these methods is less than 10 %.

8.4.1.1 The composition of the deposit shall be considered when selecting standards for calibrating beta backscatter instruments.

8.4.2 The thickness of the coating shall be measured at the location or locations on the significant surfaces of the product where the coating would be expected to be the thinnest or at such locations as specified on the purchase order (see 4.1.3 and 5.3.2).

8.4.3 Thickness measurements of Type II deposits shall be made after application of the supplementary treatment.

NOTE 8—The process by which Type II coatings are produced dissolves a small amount of the cadmium-tin. For this reason the thickness requirement to be checked refers to the thickness of the deposit after the application of the Type II coating.

NOTE 9—The thickest chromate film (olive drab) is approximately 1.5 µm thick.[5] If this significantly affects the accuracy of the thickness measuring method used (for example, Test Method B567) the Type II coating should be removed from the test area. Removal should be done by using a very mild abrasive (a paste of levigated alumina or magnesium oxide rubbed on gently with the finger).

8.5 *Presence of Chromate:*

8.5.1 Chromate conversion coatings of cadmium-tin both have an essentially silvery-white appearance. In the absence of a definitive method for distinguishing a Type II coating from a lacquer or other non-chromate film, the salt spray test shall be used to verify the presence of a Type II coating, in terms of hours to white corrosion product.

8.5.2 Frequently, the presence of a chromate coating on a product is tested for by a diphenyl carbazide test, and the quality of the coating is assessed by a lead acetate test. The reliability of these tests has been questioned because the diphenyl carbazide test merely tests for the presence of chromate ions, which may or may not be in the form of a coating, and because the lead acetate test will not distinguish between chromate and other kinds of coatings. Therefore, these tests have value as controls of an in-house process but are of less value in the evaluation of a purchased product whose processing is neither under the control nor the cognizance of the purchaser. The lead acetate test is described in Practice B201. The diphenyl carbazide test is described in Annex A1 of this specification.

8.6 *Adhesion*—Adhesion of the cadmium-tin deposit to the basis metal shall be tested in a manner that is consistent with the service requirements of the coated article. The ability to separate the coating from the substrate by peeling, as distinct from flaking caused by rupture of the deposit or of the base metal, shall be evidence of failure. One of the following methods for determining adhesion shall be used:

8.6.1 The part shall be plastically deformed, if possible, to rupture as specified on the purchase order (see 4.1.4).

[5] Biestek and Weber, *Electrolytic and Chemical Conversion Coatings*, Portcullis Press, Redhill, Surrey, U.K., 1976.