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Standard Specification for Coatings of Cadmium Mechanically Deposited[1]

This standard is issued under the fixed designation B696; 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 a coating of cadmium 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 electroplated (see Appendix X3).

1.3 Cadmium coatings are usually applied to provide engineering properties and corrosion resistance. The performance of a cadmium coating depends largely on its thickness and the kind of environment to which it is exposed. Without proof of satisfactory correlation, accelerated tests such as the salt spray (fog) test cannot be relied upon to predict performance in other environments, nor will these serve as comparative measures of the corrosion resistance afforded by coatings of different metals. Thus, although there is a marked superiority of cadmium coatings over zinc coatings of equal thickness in the salt spray test, this is often not the case under conditions of use, so that further testing in the service environment should be conducted.

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 precautionary statements, see 1.5 and 1.6.

1.5 **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.

1.6 **Warning—**Because of the toxicity of cadmium vapors and cadmium oxide fumes, cadmium-coated articles must not be used at temperatures of 320°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.

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
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
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
F1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection

3. Classification

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

Class	Minimum Thickness, µm
12	12
8	8
5	5

[1] This specification is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatingsand 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.

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

Type I—As coated without supplementary chromate treatment (Appendix X2.1).

Type II—With colored chromate conversion treatment (Appendix X2.2).

4. Ordering Information

4.1 To make the application of this standard complete, the purchaser should supply the following information to the seller in the purchase order or other governing document:

4.1.1 Class, including a maximum thickness, if appropriate, Type, and for Type II, color and need for supplemental lubricant (see 3.1, 3.2, and 6.2.4.2),

4.1.2 Nature of substrate (for example, high-strength steel), needed for stress relief (6.2.1), and cleaning precautions to be followed 6.2.2 and 6.2.3),

4.1.3 Significant surfaces (6.3),

4.1.4 Requirements for and methods of testing for one or more of the following, if required: need for and type of test specimens (8.1), thickness (6.3 and 8.3), adhesion (6.4 and 8.4), corrosion resistance (6.5 and 8.5), absence of hydrogen embrittlement, and the waiting period before testing and testing loads (6.6 and 8.6),

4.1.5 Inspection responsibility (Supplementary Requirement S1) and sampling plan for each inspection criterion (Section 7).

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

5. Workmanship

5.1 The coating shall be uniform in appearance and 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 6.3 including roots of threads, 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 1—The nature of the mechanical plating process is such that coatings characteristically will not be as smooth or as bright as some electroplated coatings.

6. Requirements

6.1 *Appearance*—The coating as deposited shall have a uniform silvery appearance, and a matte to medium-bright luster.

6.2 *Process:*

6.2.1 *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.

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

6.2.3 For low-carbon steels see Practice B183. Useful guidelines are also given in Practice B322.

6.2.4 *Supplementary Treatments:*

6.2.4.1 *Colored Chromate Conversion Treatments (Type II)*—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 with a uniform color that may range from yellow through bronze and olive drab to brown and black including olive drab and that may be dyed to a desired color. Post treatments that do not contain salts that yield films containing hexavalent chromium are not permitted as treatments for producing Type II coatings.

6.2.4.2 Waxes, lacquers, or other organic coatings may be used to improve lubricity, and the need for them shall be supplied in the purchase order or other governing document (4.1.1). Supplemental lubrication treatment shall not be used to ensure conformance to the salt spray corrosion resistance requirements.

6.2.5 *Surface Defects*—Defects and variations in appearance in the coating that arise from surface conditions of the substrate (scratches, pores, roll marks, inclusions, and so forth) and that persist in the finish despite the observance of good metal finishing practices shall not be cause for rejection.

NOTE 2—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 (4.1.2).

6.3 *Thickness:*

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

6.3.2 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 that 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 for the article, or by the provision of suitably marked samples.

NOTE 3—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 requirements.

6.3.3 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 4—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. Hence, 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.

6.4 *Adhesion*—The cadmium coating shall be sufficiently adherent to the basis metal to pass the tests specified in 8.4.

6.5 *Corrosion Resistance:*

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

NOTE 5—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.

6.5.2 There are no requirements for corrosion of basis metals other than steels.

NOTE 6—Mechanical deposition is exclusively a barrel-finishing process. It is recognized that mechanical deposition on parts may therefore produce surfaces that have a different characteristic from those on parts that 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 purchaser order (4.1.4).

NOTE 7—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.

TABLE 1 Minimum Hours to Failure (White Corrosion Products and Red Rust for Mechanically Deposited Cadmium Coatings on Iron and Steel)

Type				
		White Corrosion		
	Class:	12	8	5
I		no requirement		
II		72 for all		
		Red Rust		
	Class:	12	8	5
I		144	96	36
II		144	96	72

6.5.3 On parts with Type II coatings, the greater number of hours for either white corrosion products or rust shall apply. For example, for Type II, Class 5, the test shall be continued until the 72-h requirement is met for white corrosion products; similarly, for Type II, Class 8, if no white corrosion products appear before 72 h, the test shall be continued until the 96-h requirement for basis metal corrosion is met (8.5.2).

6.6 *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 high-strength steel parts shall be free of hydrogen embrittlement. When specified in the purchase order, freedom from embrittlement shall be determined by the test specified herein (4.1.4 and 8.6).

7. Sampling

7.1 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.

7.1.1 When a collection of coated articles (inspection lot, see 7.2) 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.

7.1.2 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.

7.1.3 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.

7.1.4 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.

7.1.5 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.