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Standard Specification for Electrodeposited Coatings of Cadmium[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 cadmium coatings on products of iron, steel, and other metals.

NOTE 1—Cadmium is deposited as a coating principally on iron and steel products. It can also be electrodeposited on aluminum, brass, beryllium copper, copper, nickel, and powder metallurgy parts.

1.2 The coating is provided in various thicknesses up to and including 25 µm either as electrodeposited or with supplementary finishes.

1.3 Cadmium coatings are used for corrosion resistance and for corrosion prevention of the basis metal part. The as-deposited coating (Type I) is useful for the lowest cost protection in a mild or noncorrosive environment where early formation of white corrosion products is not detrimental or harmful to the function of a component. The prime purpose of the supplementary chromate finishes (Types II and III) on the electroplated cadmium is to increase corrosion resistance. Chromating will retard or prevent the formation of white corrosion products on surfaces exposed to various environmental conditions as well as delay the appearance of corrosion from the basis metal.

1.4 Cadmium plating is used to minimize bi-metallic corrosion between high-strength steel fasteners and aluminum in the aerospace industry. Undercutting of threads on fastener parts is not necessary as the cadmium coating has a low coefficient of friction that reduces the tightening torque required and allows repetitive dismantling.

1.5 Cadmium-coated parts can easily be soldered without the use of corrosive fluxes. Cadmium-coated steel parts have a lower electrical contact resistance than zinc-coated steel. The lubricity of cadmium plating is used on springs for doors and latches and for weaving machinery operating in high humidity. Corrosion products formed on cadmium are tightly adherent. Unlike zinc, cadmium does not build up voluminous corrosion products on the surface. This allows for proper functioning during corrosive exposure of moving parts, threaded assemblies, valves, and delicate mechanisms without jamming with debris.

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 The following standards form a part of this document to the extent referenced herein.

2.2 *ASTM Standards:*[2]

A165 Specification for Electrodeposited Coatings of Cadmium on Steel (Withdrawn 1987)[3]
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
B253 Guide for Preparation of Aluminum Alloys for Electroplating
B254 Practice for Preparation of and Electroplating on Stainless Steel
B281 Practice for Preparation of Copper and Copper-Base Alloys for Electroplating and Conversion Coatings
B320 Practice for Preparation of Iron Castings for Electroplating
B322 Guide for Cleaning Metals Prior to Electroplating
B343 Practice for Preparation of Nickel for Electroplating with Nickel
B374 Terminology Relating to Electroplating

[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.

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
B507 Practice for Design of Articles to Be Electroplated on Racks
B558 Practice for Preparation of Nickel Alloys for Electroplating
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
B571 Practice for Qualitative Adhesion Testing of Metallic Coatings
B602 Guide for Attribute Sampling of Metallic and Inorganic Coatings
B697 Guide for Selection of Sampling Plans for Inspection of Electrodeposited Metallic and Inorganic Coatings
B849 Specification for Pre-Treatments of Iron or Steel for Reducing Risk of Hydrogen Embrittlement
B850 Guide for Post-Coating Treatments of Steel for Reducing the Risk of Hydrogen Embrittlement
E8 Test Methods for Tension Testing of Metallic Materials [Metric] E0008_E0008M
F519 Test Method for Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments

2.3 *Federal Standard:*
QQ-P-416 Plating, Cadmium (Electrodeposited)[4]

2.4 *International Standard:*
ISO 2082 Metallic Coatings—Electroplated Coatings of Cadmium on Iron or Steel[5]

2.5 *Military Standard:*
MIL-STD-1312 Fasteners, Test Methods[6]

3. Terminology

3.1 *Definitions*—Definitions of terms used in this specification are in accordance with Terminology B374.

4. Classification

4.1 *Classes*—Electrodeposited cadmium coatings shall be classified on the basis of thickness as follows:

Class	Minimum Thickness, µm
25	25
12	12
8	8
5	5

NOTE 2—Cadmium coatings thicker than 12 µm are normally not economical.

4.2 *Types*—Electrodeposited cadmium coatings shall be identified by types on the basis of supplementary treatment required as follows:

4.2.1 *Type I*—As electrodeposited without supplementary treatment.

4.2.2 *Type II*—With supplementary colored chromate treatment.

4.2.3 *Type III*—With supplementary colorless chromate treatment.

NOTE 3—It is strongly recommended that production items be processed as either Type II or Type III.

5. Ordering Information

5.1 In order to make the application of this specification complete, the purchaser needs to supply the following information to the seller in the purchase order or other governing document:

5.1.1 The name, designation, and date of issue of this specification.

5.1.2 Deposit by class and type (4.1 and 4.2).

5.1.3 Composition, metallurgical condition, and tensile strength of the substrate to be coated. Application to high-strength steel parts (6.2), pretreatment (6.3) and post treatment (6.7).

5.1.4 Heat treatment for stress relief, whether it has been performed or is required (6.3).

5.1.5 Additional undercoat, if required (6.5).

5.1.6 Plating process variation, if required (6.6).

5.1.7 Exception to stress relief heat treatment prior to plating (6.3).

5.1.8 Baking requirements after plating, if any (6.7).

5.1.9 Desired color of the Type II film (6.8.2).

5.1.10 Location of significant surfaces (7.1.2).

5.1.11 Coating luster (7.5).

5.1.12 Whether non-destructive or destructive tests are to be used in cases of choice (Note 14).

5.1.13 Configuration, procedures, and tensile load for hydrogen embrittlement relief test (9.4, 10.6, Supplementary Requirements S2, and S3).

5.1.14 Whether certification is required (Section 12).

5.1.15 Whether supplementary requirements are applicable.

6. Materials and Manufacture

6.1 *Nature of Coating*—The coating shall be essentially pure cadmium produced by electrodeposition usually from an alkaline cyanide solution.

6.2 *High Tensile Strength Steel Parts*—Steel parts having an ultimate tensile strength greater than 1650 MPa (approximately 50 HRC) shall not be plated by electrodeposition unless authorized by the purchaser.

6.3 *Pretreatment of Iron or Steel for the Purpose of Reducing the Risk of Hydrogen Embrittlement*—Steel parts having an ultimate tensile strength greater than 1000 MPa (31 HRC) that contain tensile stresses caused by cold forming or cold straightening which have not been heat treated after the cold forming process, shall be heat treated for stress relief to reduce the risk of hydrogen embrittlement in the part before clean and electroplate processes. If these heat treatments are not required,

[4] Available from U.S. Government Printing Office, Washington DC 20402.
[5] Available from American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.
[6] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

the purchaser shall specify in the ordering information their exception. If the purchaser does not specify an exception to heat treatment, then the plater shall use Table 1 in Specification B849 to determine the appropriate heat treatment for the steel based on its tensile strength.

6.4 *Preparatory Procedures*—The basis metal shall be subjected to such cleaning procedures as necessary to ensure a surface satisfactory for subsequent electroplating. Materials used for cleaning shall have no damaging effects on the basis metal resulting in pits, intergranular attack, stress corrosion cracking, or hydrogen embrittlement. If necessary, cleaning materials for steel parts should be evaluated in accordance with Method F519.

NOTE 4—For basis metal preparation, the following standards should be employed depending upon the metallurgical composition: Practices B183, B242, B253, B254, B281, B320, B322, B343, and B558.

6.5 *Substrate*—Cadmium shall be deposited directly on the basis metal part without an undercoat of another metal except when the part is either stainless steel or aluminum and its alloys. An undercoat of nickel is permissible on stainless steel. With aluminum and aluminum alloys, the oxide layer shall be removed and replaced by a metallic zinc layer in accordance with Guide B253. For better adherence, a copper strike or a nickel coating may be applied to the zinc layer before electroplating with the cadmium.

6.6 *Plating Process*—The plating shall be applied after all basis metal heat treatments and mechanical operations, such as machining, brazing, welding, forming, and perforating of the article, have been completed.

6.7 *Hydrogen Embrittlement Relief*—Electroplated steel parts having a tensile strength greater than 1200 MPa (39 HRC) as well as surface hardened parts, shall be baked to reduce the risk of hydrogen embrittlement. Baking of electroplated steel parts with tensile strength 1200 MPa (39 HRC) or less is not mandatory.

6.7.1 Steel parts having a tensile strength greater than 1200 MPa (39 HRC) as well as surface hardened parts, shall be baked to reduce the risk of hydrogen embrittlement. For such parts, purchasers shall specify the baking requirements in the ordering information. Purchasers are directed to the appropriate ER Class in Guide B850 Table 1.

6.7.2 A purchaser wishing to specify baking requirements, irrespective of tensile strength, shall specify such requirements in the ordering information. Purchasers are directed to Guide B850 Table 1.

6.7.3 Any baking treatment done under this section shall begin within 4 h of removal from the electroplating process.

6.7.4 Electroplated springs and other parts subject to flexure shall not be flexed before the hydrogen embrittlement relief treatment.

NOTE 5—For high-strength steels, greater than 1300 MPa or approximately 40 HRC, it is strongly recommended that the baking time be extended to 23 h or more to ensure hydrogen embrittlement relief.

NOTE 6—Electroplated steel parts, passivated by the baking operation for hydrogen embrittlement relief, require reactivation before the chromate treatment. This application, immersion in a dilute acid solution, should be done as soon as practical. If the chromating solution contains sulfuric acid, then the reactivating solution should be 1 part of sulfuric acid (sp gr 1.83) by volume added to 99 parts of water. If the chromating solution contains hydrochloric acid, then the reactivating solution should be 1 part of hydrochloric acid (sp gr 1.16) by volume added to 99 parts of water. Duration of immersion should be as brief as is consistent with the nature of the work. Separately racked items can be reactivated in approximately 5 s, whereas a perforated container of barrel-plated parts requires approximately 15 s.

6.8 *Chromate Treatment:*

6.8.1 Chromate treatments for Types II and III shall be done in or with special aqueous acidic solutions composed of hexavalent chromium along with certain anions that act as catalyst or film-forming compounds to produce a continuous smooth protective film. Chromic acid and nitric acid bright dips shall not be used for treatment to produce chromate coatings. When proprietary materials are used for this treatment, the instructions of the supplier should be followed.

6.8.2 The Type II film color shall range from an iridescent yellow or a thicker, more protective iridescent bronze or brown to the heavier olive drab. It may also be dyed to a desired color. When necessary, the color of the film shall be indicated by the purchaser and specified by the provision of a suitably colored sample or indicated on the drawing for the part.

6.8.3 The absence of color shall not be considered as evidence of lack of Type III film or as a basis for rejection. Presence of clear Type III film shall be determined by a spot test as specified in 10.4.

6.8.4 Waxes, lacquers, or other organic coatings shall not be used as a substitute for, nor may they be used in conjunction with, supplementary treatments when the purpose is to ensure conformance to the salt spray requirements. Waxes and the like, may be used to improve lubricity.

7. Coating Requirements

7.1 *Thickness:*

7.1.1 The thickness of the coating everywhere on the significant surfaces shall conform to the requirements of the specified class, as defined in 4.1.

7.1.2 Significant surfaces are 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 will deface visible surfaces on the assembled article. When necessary, the significant surfaces shall be indicated by the purchaser on applicable drawing of the article, or by the provision of suitably marked samples.

NOTE 7—As heavier coatings are required for satisfactory corrosion resistance than Class 5, allowance should be made in the fabrication of most threaded articles, such as nuts, bolts, and similar fasteners with complementary threads for dimensional tolerances to obtain necessary coating build-up. Flat surfaces and certain shielded or recessed areas, such as root-diameter of threads, have a tendency to exhibit lack of build-up and to be heavier at exposed edges and sharp projections with electrodeposited coatings. This trend is also found with vacuum-deposited cadmium coatings and is in direct contrast with mechanically deposited coatings.

NOTE 8—The coating thickness requirements of this specification is a minimum requirement. Variation in thickness from point to point on an article is inherent in electroplating. Therefore, the 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. Hence, in most cases, the average coating thickness of an article will be greater than the specified value; how much greater is largely determined by the shape