



Designation: B699 – 86 (Reapproved 2015)

Standard Specification for Coatings of Cadmium Vacuum-Deposited on Iron and Steel¹

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1. Scope

1.1 This specification covers the requirements for a cadmium coating vacuum-deposited on iron and steel basis metals. The coating is especially beneficial to those ferrous metals, heat treated to 46HRC and higher or having an ultimate tensile strength greater than 1500 MPa, wherein protection against corrosion and appearance are important (see [Appendix X1](#)).

1.2 Vacuum-deposited production items are normally free of hydrogen embrittlement, a danger when using electroplating processes for deposition. Vacuum deposition can handle large high-strength parts that cannot be conveniently mechanically plated in the rotating barrels.

1.3 The coating is provided in various thicknesses up to and including 12 μm ([3.1](#)) either in the as-deposited condition or with a supplementary finish ([3.2](#)).

1.4 The following precautionary caveat pertains only to the test methods portion, Section 9, of this specification: *This standard does not purport to address all of the safety problems, 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

- [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](#)
- [B254 Practice for Preparation of and Electroplating on Stainless Steel](#)

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.

- [B320 Practice for Preparation of Iron Castings for Electroplating](#)
- [B322 Guide for Cleaning Metals Prior to Electroplating](#)
- [B440 Specification for Cadmium](#)
- [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](#)
- [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 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](#)
- [E396 Test Methods for Chemical Analysis of Cadmium](#)
- [F519 Test Method for Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments](#)

3. Classification

3.1 *Classes*—Vacuum-deposited cadmium coatings shall be classified on the basis of thickness, as follows:

Class	Minimum Thickness, μm
12	12
8	8
5	5

3.2 *Types*—Vacuum-deposited cadmium coatings shall be identified by types on the basis of supplementary treatment required, as follows:

3.2.1 *Type I*—As-vacuum-deposited without supplementary chromate treatment (see [Appendix X1](#)).

3.2.2 *Type II*—With supplementary chromate treatment (see [Appendix X2](#)).

NOTE 1—It is strongly recommended that Type II should be used rather than Type I on production items.

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 The designation number and year of issue of this document.
- 4.1.2 Class and type (3.1 and 3.2),
- 4.1.3 Hardness or tensile strength of the steel parts (5.2),
- 4.1.4 Heat treatment for stress relief, whether it has been performed or is required,
- 4.1.5 Undercoating, if required (5.5),
- 4.1.6 Test of coating composition, if required (6.1),
- 4.1.7 Significant surfaces (6.2.2),
- 4.1.8 Luster (6.6),
- 4.1.9 Sampling, if other than specified (Section 7),
- 4.1.10 Certification (11.1), and
- 4.1.11 Supplementary requirements, if applicable.

5. Materials and Manufacture

5.1 *Nature of Finish*—The cadmium metal for the production of the coating and the resultant coating shall conform to the composition requirements of Specification B440 and shall contain not less than 99.95 mass % cadmium.

5.2 *Stress Relief*—Steel parts that have an ultimate tensile strength of 1000 MPa and above and that have been machined, ground, cold-formed, or cold-straightened shall be heat-treated at a minimum of 190°C for 3 h or more for stress relief before cleaning and coating.

5.3 *Cleaning of Basis Metal*—Proper preparatory procedures and thorough cleaning of the basis metal are essential to ensure satisfactory adhesion and corrosion resistance performance of the coating. The basis metal shall not be exposed to treatments such as cathodic cleaning, and acid treatments involving release of hydrogen on the surface of parts; nor shall materials be used for cleaning that will have damaging effects on the metal, such as pits, intergranular attack, and hydrogen embrittlement. If necessary, cleaning materials for surface preparation should be evaluated in accordance with Method F519. The basis metal shall be abrasive dry-blasted, using new materials or materials that have not been used on other metals. All loose particles shall be removed by air blasting the parts thoroughly, using clean dry oil-free compressed air. Following air blasting, the basis metal may be outgassed by subjecting it to an electron bombardment with high-energy positive ions in a glow discharge unit. The following practices, where appropriate for precleaning to remove oil, grease, and other foreign materials should be used: B183, B242, B254, B320, and B322.

NOTE 2—Parts may be cleaned by blasting with 120-mesh aluminum oxide or 100-mesh garnet grit with a nozzle pressure of 410 to 620 kPa to remove scale, oxides, or other contamination. Blasted surfaces should not be rougher than the specified finish for the part. When necessary to achieve the proper surface roughness, finer grit may be used, but aluminum oxide coarser than 120-mesh or garnet grit coarser than 100-mesh should not be used. Following air blasting, stainless steel parts should be passivated.

5.4 *Deposition Process*—Cadmium vacuum deposition shall be conducted in a vacuum of 1.33×10^{-4} to 3.3 Pa with an evaporation rate of 0.8 to 1.7 mg/s.

5.5 *Substrate*—Unless otherwise specified, cadmium shall be deposited directly on the basis metal without a preliminary undercoating of another metal. A preliminary undercoating of nickel is permissible with parts made of stainless steel.

5.6 Chromate Treatment (Type II):

5.6.1 Chromate treatment for Type II shall be done in or with special aqueous acid solutions composed of hexavalent chromium along with certain anions that act as a catalyst or film forming compound to produce a continuous, smooth, protective film.

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

5.6.3 Waxes, lacquers, or other organic coatings shall not be permitted as a substitute, nor shall they be used in conjunction with Type II coatings, in order to ensure the conformance to the salt spray or abrasion resistance test requirements. Waxes, etc., may be used to improve lubricity.

6. Coating Requirements

6.1 *Coating Composition*—When specified, the chemical composition of the coating shall be determined (see X1.3).

6.2 Thickness:

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

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

6.2.3 On nonsignificant visible surfaces, the minimum allowable thickness for Class 12 shall be Class 8 (8 µm), for Class 8 it shall be Class 5 (5 µm), and for Class 5 it shall be 4 µm.

6.3 *Adhesion*—The cadmium coating shall be sufficiently adherent to the basis metal to pass the tests in 9.3. When examined at a magnification of approximately 4 diameters, the coating shall not show separation from the basis metal. The formation of cracks in the coating caused by rupture of the basis metal that does not result in flaking, peeling, or blistering of the cadmium coating shall not be considered as nonconformance to this requirement.

6.4 *Abrasion Resistance*—The supplementary chromate film (Type II) on the cadmium coating shall be adherent, non-powdery, and shall resist abrasion when tested as detailed in 9.4.

6.5 *Corrosion Resistance*—Cadmium coatings with Type II treatment shall show neither white corrosion products of cadmium nor basis metal corrosion products at the end of 96 h test period, when tested by continuous exposure to salt spray in