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Standard Specification for Electrodeposited Engineering Chromium Coatings on Ferrous Substrates[1]

This standard is issued under the fixed designation B650; 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 U.S. Department of Defense.

1. Scope

1.1 This specification covers the requirements for electrodeposited chromium coatings applied to ferrous alloys for engineering applications.

1.2 Electrodeposited engineering chromium, which is sometimes called "functional" or "hard" chromium, is usually applied directly to the basis metal and is much thicker than decorative chromium. Engineering chromium is used for the following:

1.2.1 To increase wear and abrasion resistance,

1.2.2 To increase fretting resistance,

1.2.3 To reduce static and kinetic friction,

1.2.4 To reduce galling or seizing, or both, for various metal combinations,

1.2.5 To increase corrosion resistance, and

1.2.6 To build up undersize or worn parts.

1.3 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *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 *ASTM Standards:*[2]

B117 Practice for Operating Salt Spray (Fog) Apparatus

[1] This specification is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.03 on Engineering Coatings.

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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.

B177 Guide for Engineering Chromium Electroplating
B183 Practice for Preparation of Low-Carbon Steel for Electroplating
B242 Guide for Preparation of High-Carbon Steel for Electroplating
B320 Practice for Preparation of Iron Castings for Electroplating
B374 Terminology Relating 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
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
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
B762 Guide of Variables Sampling of 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
D3951 Practice for Commercial Packaging
E8 Test Methods for Tension Testing of Metallic Materials [Metric] E0008_E0008M
F1459 Test Method for Determination of the Susceptibility of Metallic Materials to Hydrogen Gas Embrittlement (HGE)

2.2 *Other Standard:*
MIL-S-13165 Shot Peening of Metal Parts[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *significant surfaces*—all surfaces upon which a deposit of controlled thickness is required.

3.1.1.1 *Discussion*—
When a controlled deposit is required in holes, corners, recesses, and similar areas, special racking, auxiliary anodes or shielding, or both, will be necessary. With the best practices there will be areas where a controlled deposit is impossible.

3.2 Definitions used in this specification are in accordance with Terminology B374.

4. Classification

4.1 Electrodeposited chromium coatings in accordance with this specification are classified by the thickness of the coating as follows:

Class No.	Chromium Thickness, µm	Typical Application
1	2.5 to 25	reduce friction; anti-galling, light wear resistance
2	>25 as specified	buildup to dimension specified for salvage or as required for severe wear resistance

4.2 Unless otherwise specified by suitably marked drawings or samples, only those surfaces that can be touched with a 20-mm diameter ball shall be considered significant. In holes, corners, recesses, and other areas where a controlled deposit cannot be obtained under normal electroplating conditions, the thickness of the deposit may be that which results from control on the significant surfaces.

5. Ordering Information

5.1 The purchaser shall exercise the desired options of this standard. Ordering documents shall specify the following information:

5.1.1 Title, ASTM designation, and issue date of this specification,

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

5.1.2 Alloy and metallurgical condition of the product to be chromium plated,

5.1.3 Ultimate tensile strength of the material to be plated,

5.1.4 Heat treatment required for stress relief and whether it has been performed or is required,

5.1.5 The significant surfaces if different from the 20 mm ball rule (see 3.1.1),

5.1.6 Thickness of the deposit or class (see 4.1),

5.1.7 Control record requirements,

5.1.8 Preproduction test specimens, if required,

5.1.9 Sampling plan, if different from that specified in Test Method B602 (see Section 8),

5.1.10 The number of test specimens for destructive testing (see 7.1),

5.1.11 Thickness, adhesion, porosity, and hydrogen embrittlement tests required (see Section 6),

5.1.12 Whether separate test specimens will be used (see 7.1 and 7.5),

5.1.13 Where required, any special requirements for parts that are subsequently ground to size,

5.1.14 Where required, the base metal finish in terms of center line average (CLA) or arithmetic average (AA), and

5.1.15 Where required, dimensional tolerances allowed for the specified coating thickness or class.

5.2 The manufacturer of the parts to be electroplated shall provide the electroplating facility with test specimens (see Section 7) to be electroplated for conformance tests as requested for preparation, control, inspection, and lot acceptance unless other arrangements have been made between the purchaser and the electroplating facility.

6. Coating Requirements

6.1 The appearance of the chromium coating on the significant surfaces of the product shall be smooth and free of visual defects such as blisters, pits, roughness, cracks, burned deposits, uncoated areas, or macrocracking of the deposit that is visible without magnification. The boundaries of electroplating that cover only a portion of the surface shall, after finishing as indicated on the drawing, be free of beads, nodules, jagged edges, or other irregularities that will interfere with the functioning of the plated part. Imperfections and variations that arise from surface conditions of the basis metal (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 1—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, which are not normal in the treatment steps preceding the application of the finish and will add to the cost. When they are desired, they are the subject of a special agreement between the purchaser and the seller.

6.2 In cases where design for maximum fatigue life is a consideration the parts should be shot peened (see MIL-S-13165C) or given an alternate mechanical treatment to compressively stress the surface.

6.3 *Stress Relief Treatment* (See headnote at the beginning of this specification.):

6.3.1 All steel parts having an ultimate tensile strength of 1000 MPa (150 000 psi—approximately 32 HRC) or greater, that may contain residual stress caused by various fabrication operations such as machining, grinding, straightening, or cold forming, will require one of the stress relief heat treatments prescribed in Specification B849 prior to electroplating. In all cases, the duration of heat treatment shall commence from the time at which the whole of each part attains the specified temperature.

6.3.1.1 The treatment selected, of necessity, must be based upon experience with the part or empirical test data. Therefore, Class SR-0 treatment is provided for parts that the purchaser wishes to exempt from treatment. However, many, if not most, steels with a tensile strength in excess of 1000 MPa will become embrittled when plated with chromium. The stress relief and hydrogen embrittlement relief treatments are essential for the safe performance of chromium plated items fabricated from those steels. Selection of Class SR-0 or ER-0 requires thorough knowledge of the embrittlement susceptibility of the specific steel employed. When the purchaser specifies Class SR-0 or ER-0, the purchaser assumes sole responsibility for any embrittlement failure of the part. The relative susceptibility of a steel can be determined by subjecting it to the Disk Rupture Test of Test Method F1459. When no stress relief treatment is specified by the purchaser then Class SR-1 shall be applied.

6.3.2 Parts having surface hardened areas that would suffer an unacceptable reduction in hardness by treatment in accordance with Specification B849 shall be heat-treated at a lower temperature but not less than 130 °C for a minimum period of 8 h. This treatment is applicable for parts made of steel with an actual tensile strength below 1400 MPa. The purchaser may require that the heat-treatment temperature shall not reduce the surface hardness. Shorter times at higher temperatures may be used, if the resulting loss of surface hardness is acceptable.

6.3.3 If stress relief is given after shot peening or other cold working processes to introduce beneficial compressive stresses, the temperature shall not exceed 230 °C.

6.4 *Hydrogen Embrittlement Relief:*

6.4.1 Heat treatment appropriate for the tensile strength of the electroplated part (see Specification B850) shall be performed to reduce the risk of hydrogen embrittlement. In all cases, the duration of the heat treatment shall commence from the time at which the whole part attains the specified temperature. See 6.3.1.1 for important embrittlement relief information regarding the selection of ER-0. When no embrittlement relief treatment is specified by the purchaser then Class ER-1 shall be applied.

6.4.2 Begin the embrittlement relief heat-treatment as soon as practical following the plating process but no longer than ~~1.5 h.~~ 1.5 h.

6.4.3 Parts or representative specimens shall be tested for compliance in accordance with 7.5.

6.5 *Thickness*—The thickness of the coating everywhere on the significant surface(s) shall conform to the requirements of the specified class as defined in Section 3 (see 7.2).

NOTE 2—The coating thickness requirements of this specification are a minimum requirement, that is, the coating thickness is required to equal or exceed the specified thickness everywhere on the significant surfaces (see 4.1). Variation in the coating thickness from point to point on a coated article is an inherent characteristic of electroplating processes. Therefore, the coating thickness must exceed the specified value at some point 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 (see Practice B507) and the characteristics of the electroplating 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 within 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. This may not apply to parts that are ground after plating.

6.6 *Adhesion*—The coating shall be sufficiently adherent to the basis metal to pass the adhesion test specified (see 7.3). These tests are, with the possible exception of the heat quench test, all destructive and therefore, in most cases, should be performed on test panels.

NOTE 3—Adhesion may be influenced by the method of pretreating the base metal and the type of steel used as a basis metal. Helpful information is given in Practices B177, B183, B242, and B320.

6.7 The coating shall be sufficiently free of pores to pass the porosity test specified (see 7.4).

6.8 *Workmanship*—Adding to (spotting in) or double electroplating, unless evidence of a satisfactory bond is established, shall be cause for rejection. Stripping and replating is permitted but parts having an ultimate tensile strength greater than 1000 MPa or a hardness greater than 32 HRC that are acid stripped shall be rebaked (see 6.3) before plating. Baking after stripping is not necessary if the parts are stripped anodically in an alkaline solution.