



## Standard Guide for Engineering Chromium Electroplating<sup>1</sup>

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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 guide provides information about the deposition of chromium on steel for engineering uses. This is sometimes called “functional” or “hard” chromium and is usually applied directly to the basis metal and is usually thicker than decorative deposits.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 This guide is not intended as a standardized procedure, but as a guide for obtaining smooth, adherent coatings of chromium of a desired thickness while retaining the required physical and mechanical properties of the base metals. Specified chromium electrodeposits on ferrous surfaces are defined in Specification **B650**.

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.*

1.5 *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.*

<sup>1</sup> This guide 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. Referenced Documents

#### 2.1 *ASTM Standards:*<sup>2</sup>

- B183** Practice for Preparation of Low-Carbon Steel for Electroplating
- B242** Guide for Preparation of High-Carbon Steel for Electroplating
- B244** Test Method for Measurement of Thickness of Anodic Coatings on Aluminum and of Other Nonconductive Coatings on Nonmagnetic Basis Metals with Eddy-Current Instruments
- 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
- B481** Practice for Preparation of Titanium and Titanium Alloys for 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

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

- B558** Practice for Preparation of Nickel Alloys for Electroplating
  - B568** Test Method for Measurement of Coating Thickness by X-Ray Spectrometry
  - B571** Practice for Qualitative Adhesion Testing of Metallic Coatings
  - B578** Test Method for Microhardness of Electroplated Coatings
  - B602** Test Method for Attribute Sampling of Metallic and Inorganic Coatings
  - B630** Practice for Preparation of Chromium for Electroplating with Chromium
  - B650** Specification for Electrodeposited Engineering Chromium Coatings on Ferrous Substrates
  - 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
  - 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
  - B851** Specification for Automated Controlled Shot Peening of Metallic Articles Prior to Nickel, Autocatalytic Nickel, or Chromium Plating, or as Final Finish
  - F519** Test Method for Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments
- 2.2 *Military Standard*:<sup>3</sup>  
**MIL-S-13165B** Shot Peening of Metal Parts

### 3. Substrates

3.1 Engineering chromium may be plated directly to the surface of a number of commonly used engineering metals such as aluminum, nickel alloys, cast iron, steels, copper, copper alloys, and titanium. The bond strengths of the chromium varies with metallic substrate. Nevertheless, if the procedures cited in the appropriate references are followed, the bond strength is such that grinding and honing can be conducted without delamination of the coating.

3.2 *Smoothness*—The smoothness of the material surface to be electroplated should be adequate to meet the requirements of the finished product. Chromium electrodeposits do not exhibit leveling, and consequently the surface roughness of the electrodeposit will always be greater than that of the substrate. Any mechanical operations that can result in grinding checks or glazing of the metal are detrimental and should be eliminated. The required surface smoothness may be obtained by suitable chemical, mechanical, or electrochemical procedures. Depending upon the thickness of the electrodeposit and the smoothness required of the electrodeposit, grinding of the electrodeposit may be required.

3.3 *Fatigue Considerations*—Cracking that can occur in chromium electrodeposits either as a function of the plating

bath chemistry or the plating conditions, or both, or as a result of grinding of the electrodeposit can lead to a reduction in the fatigue life of the electroplated part. If this is a design consideration, the use of mechanical methods such as shot peening (see Specification **B851** or MIL-S-13165C, or both) or autofrettage to compressively stress the surface can increase the fatigue strength. This should be done after any stress-relieving heat treatment.

#### 3.4 *High-Strength Steel Stress Relief*:

3.4.1 All steel parts having an ultimate tensile strength of 1000 MPa [150 000 psi, approximately 32 HRC] or greater, which may contain residual stress caused by various fabrication operations such as machining, grinding, straightening, or cold-forming, usually will require one of the stress relief bakes prescribed in Specification **B849** prior to electroplating. In all cases, the duration of the bake shall commence from the time at which the whole of each part attains the specified temperature. This stress relief is essential if hydrogen embrittlement from subsequent operations is to be avoided.

3.4.2 Parts having surface-hardened areas that would suffer an unacceptable reduction in hardness by baking in accordance with Specification **B849** may be baked at a lower temperature but not less than 130°C for a minimum period of 8 h. Shorter times at higher temperatures may be used, if the resulting loss in surface hardness is acceptable.

3.5 *Oxidation*—All possible precautions should be taken to prevent oxidation of the metal surface between the final operations of mechanical preparation and electroplating, particularly with steel substrates. Materials such as aluminum and titanium have an inherent oxide film on the surface that can only be removed or minimized just prior to the electroplating process (see 6.1.1 and 6.1.2). When conditions are especially unfavorable, definite steps must be taken to meet this important requirement, including storage in a noncorrosive environment, or the use of a suitable coating to exclude air and moisture.

### 4. Racks and Anodes

4.1 Steel, cast iron, and stainless steel parts to be electroplated may be racked at any convenient stage in the preparatory process but preferably prior to the final cleaning and etching. Aluminum, titanium, and certain nickel alloys may need to have cleaning and etching operations done before racking due to entrapment of cleaning and etching solutions in the plating rack which can result in adhesion failures due to seepage during chromium electroplating.

4.2 See Practice **B507** for guidance on rack design, but note that while the general principles of good racking as used in other electroplating processes apply, the use of much higher current densities and the desirability of securing coatings of uniform thickness and quality on desired areas require rack construction designs and methods that are much more exacting. The design of racks for chromium electroplating on the various base metals previously mentioned for functional use should provide for the following to the greatest possible extent.

4.2.1 There must be sufficient current-carrying capacity of both cathode and anode circuits to all parts of the rack.

4.2.2 There must be positive electrical contact to the parts to be electroplated, to the anodes, and to the tank contact bus bars.

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