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Standard Guide for Chromium Electroplating on Steel for Engineering Use[1]

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1. Scope

1.1 This standard 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 much thicker than decorative deposits.

1.2 This specification 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 steel base. Requirements for chromium electrodeposits on ferrous surfaces are defined in Specification B 650.

1.3 *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:*

B 183 Practice for Preparation of Low-Carbon Steel for Electroplating[2]
B 242 Practice for Preparation of High-Carbon Steel for Electroplating[2]
B 322 Practice for Cleaning Metals Prior to Electroplating[2]
B 487 Test Method for Measurement of Metal and Oxide Coating Thicknesses by Microscopical Examination of a Cross Section[2]
B 499 Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals[2]
B 504 Test Method for Measurement of Thickness of Metallic Coatings by the Coulometric Method[2]
B 507 Practice for Design of Articles to Be Electroplated on Racks[2]
B 571 Test Methods for Adhesion of Metallic Coatings[2]
B 578 Test Method for Microhardness of Electroplated Coatings[2]
B 602 Test Method for Attribute Sampling of Metallic and Inorganic Coatings[2]
B 630 Practice for Preparation of Chromium for Electroplating with Chromium[2]
B 650 Specification for Electrodeposited Engineering Chromium Coatings on Ferrous Surfaces[2]
B 697 Guide for Selection of Sampling Plans for Inspection of Electrodeposited Metallic and Inorganic Coatings[2]
B 762 Test Method of Variables Sampling of Metallic and Inorganic Coatings[2]

2.2 *Military Standard:*

MIL-S-13165B Shot Peening of Metal Parts[3]

3. Nature of Steel

3.1 *High Strength Steel*—Since steel of high strength is susceptible to cracking, the tensile strength of the steel should not exceed 1000 MPa (150 000 psi) or a hardness of 32 HRC unless the steel has been stress-relieved (3.4). Before electroplating, heat-treated parts should be examined for cracks by suitable techniques such as the fluorescent dye or magnetic powder methods. It is important that the hardness of the steel base be sufficient to withstand the service load without deformation and consequent stress fracturing of the chromium deposit.

3.2 *Smoothness*—The smoothness of the steel 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 steel 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, 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

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[2] *Annual Book of ASTM Standards*, Vol 02.05.

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

consideration, the use of mechanical methods such as shot peening (see MIL-S-13165C) or autofrettage to compressively stress the surfaces can increase the fatigue strength. This should be done after all stress relieving heat treatments.

3.4 *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, will require one of the following stress reliefheat treatments (Table 1) prior to electroplating. In all cases, the duration of the heat treatment 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.

3.4.1.1 Parts having surface hardened areas that would suffer an unacceptable reduction in hardness by treatment in accordance with Table 1 shall be heat-treated 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 steel surface between the final operations of mechanical preparation and electroplating. 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 The parts to be electroplated may be racked at any convenient stage in the preparatory process but preferably prior to the final cleaning and etching.

4.2 See Practice B 507 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 steel 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 bars.

4.2.3 There must be uniform current distribution on the parts to be electroplated. This often requires anodes of special shapes conforming to the shape of the part or area to be electroplated.

4.2.4 It may be necessary to use thieves, robbers, or guards, which are auxiliary metallic conductors placed near points of abnormally high current density to attract the current away from such points; and shields, which are parts made of nonconductive materials and placed to disperse the current in areas where it tends to concentrate unduly.

4.2.5 It is important to protect areas that are to remain free of any chromium electroplate by the use of masks made of rigid, nonconductive materials placed against the substrate, or stop-offs, which are especially compounded nonconductive tapes, waxes, lacquers, or plastics for the protection of such substrates. Lead tape will provide a sharp line of demarcation between coated and uncoated areas with a minimum of buildup.

4.2.6 Plugs (conducting and nonconducting) may be used in holes not requiring electroplating to produce a sharp edge without grooves around the periphery of the holes.

4.2.7 It is very important to remember that improperly applied stop-off materials or poorly designed racks can entrap acids that can cause corrosion of the basis metal, contamination of the solutions used in subsequent operations, or both.

4.2.8 Construction materials must be used that are sufficiently insoluble and noncontaminating to provide the desired rack life.

4.2.9 Components must be placed in such positions that gas from the parts, rack, thieves, masks, and anodes escapes freely and does not become entrapped so as to prevent electroplating on areas that should be electroplated.

4.3 *Anodes*—Lead anodes containing 4 to 6 % antimony, 4 to 7 % tin, or 1 % silver, or a combination thereof, are satisfactory. Chemical lead is also satisfactory where hardness and rigidity are not important. However, it tends to form greater quantities of scale that may fall on the work and cause pitting or roughness. Lead wire used for small anodes should contain 0.25 % antimony to obtain the best relationship between rigidity and ductility in close tolerance areas. Lead sheathed steel, copper, or silver may be used when indicated by the requirement for strength or conductivity. Platinum, platinum clad titanium, platinum clad niobium, or even iron, steel rods, or wire may be used for internal electroplating of small holes, but the latter will contaminate the bath with iron. If the anode contains little or no lead, the reoxidation of trivalent chromium to the hexavalent will not take place or will be seriously impaired, which will lead to trivalent buildup in the plating solution and poor results.

4.3.1 Some proprietary baths may require special anodes, which should be recommended by the supplier.

5. Cleaning

5.1 Parts to be electroplated may be cleaned in accordance with Practices B 183, B 242 or B 322.

5.2 Mechanical methods of cleaning prior to electroplating, including abrasive blasting or light grinding, are also suitable. If parts have been shot peened to develop a compressively stressed surface, it is important to avoid removing that surface by excessive grinding.

TABLE 1 Stress Relief Treatments

Class	Temperature (°C)	Time (h) min	Tensile Strength (Rm) MPa
SR-1	200 to 230	24	over 1800
SR-2	190 to 220	24	over 1800
SR-3	200 to 230	18	1401 to 1800
SR-4	190 to 220	18	1450 to 1800
SR-5	177 to 205	3	1034 or greater
SR-6	200 to 230	3	1000 to 1400
SR-7	190 to 220	1	1050 to 1450
SR-8	130 to 160	8	surface hardened parts≤ 1400