



## Standard Guide for Preparation of High-Carbon Steel for Electroplating<sup>1</sup>

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### 1. Scope

1.1 This guide is intended as an aid in establishing and maintaining a preparatory cycle for electroplating on high-carbon steel (**Note 1**) producing a minimum of hydrogen embrittlement and maximum adhesion of the electrodeposited metal. For the purpose of this guide, steels containing 0.35 % of carbon or more, and case-hardened low-carbon steel, are defined as high-carbon steels. There is no generally recognized definite carbon content dividing high from low-carbon steels for electroplating purposes.

**NOTE 1**—Electroplating of plain high-carbon steel introduced problems not found in similar operations on low-carbon steel. During the cleaning and electroplating cycle, high-carbon steel differs from low-carbon steel in regard to its greater tendency to become embrittled and the greater difficulty in obtaining maximum adhesion of the electrodeposit. The preparation of low-carbon steel for electroplating is covered in Practice **B183**.

1.2 This guide does not apply to the electroplating of alloy steel. For methods of chromium electroplating directly on steel see Guide **B177**.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *This standard does not purport to address all of the safety problems 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.* For a specific hazards statement, see **3.1**.

### 2. Referenced Documents

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

**B177** Guide for Engineering Chromium Electroplating

**B183** Practice for Preparation of Low-Carbon Steel for Electroplating

**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

### 3. Reagents

3.1 *Purity of Reagents*—All acids and chemicals used in this practice are technical grade. Acid solutions are based upon the following assay materials:

Hydrochloric acid (HCl) 31 mass %, density 1.16 g/mL

Nitric acid (HNO<sub>3</sub>) 67 mass %, density 1.40 g/mL

Sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) 93 mass %, density 1.83 g/mL

**(Warning)**—Dilute sulfuric acid by slowly adding it to the approximate amount of water required with rapid mixing. After cooling, bring the mixture to exact volume.)

3.2 *Purity of Water*—Use ordinary industrial or potable water for preparing solutions and rinsing.

### 4. Nature of Steel

4.1 *Hardness*—High hardness is a major cause of cracking of the steel during or after electroplating. The recommended maximum hardness range for classes of products depends on their geometry and service requirements (**Note 2**). Parts hardened by heat treatment should be inspected before electroplating for the presence of cracks by a suitable method, such as magnetic or fluorescent powder inspection.

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<sup>2</sup> 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.

NOTE 2—Some examples of parts and Rockwell hardness ranges are as follows:

|  |                              |
|--|------------------------------|
| Springs  | Rockwell Hard-<br>ness Range |
| Spring washers   | C45 to C48                   |
| Small instrument parts                                     | C45 to C53                   |
| Parts to be chromium electroplated<br>—for engineering use | C52 to C55<br>C57 to C62     |
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| Spring washers   | C45 to C48                   |
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4.2 *Hydrogen Embrittlement*—Difficulties resulting from hydrogen embrittlement increase with increasing hardness, whether produced by heat treatment or cold work. Difficulties, during or after electroplating of hardened high-carbon steel parts, may in some cases be minimized without material change in hardness by baking before final pretreatment. For a listing of such hydrogen embrittlement relief bake cycles, consult Guide **B850**.

4.3 *Surface Oxidation*—In order that subsequent treatments be facilitated, every reasonable precaution should be taken throughout the processing to limit oxidation or scale formation. In particular cases pre-electroplating with copper to a minimum thickness of 13  $\mu\text{m}$  may assist in maintaining a preferred surface through the heat treatment. A nonoxidizing atmosphere should be maintained in the furnace. This copper shall be removed prior to the regular electroplating cycle. Care should be used in oil-quenching parts heat treated in a salt bath, to prevent the charring effect that can be caused by salt-bath drag-out. Proper lead-bath quenching results in only slight oxidation.

4.4 *Steel Quality*—The quality of the steel should be characteristic of the requirement of the product and the electroplating operation. The steel should be free of injurious surface defects, and of at least average cleanliness.

## 5. Preparation of Steel, General

5.1 *Preparatory Treatments*—A wide variety of surface conditions are encountered in high-carbon steel articles to be electroplated. The surface may require the removal of one or more of the following contaminants: grease, oil or drawing compounds, burned-in oil scale, light to heavy treatment scale, permeable oxide films, emery and fine steel particles resulting from the grinding operation. The removal of such contaminants is accomplished by one or more of the following pretreatment procedures where applicable:

5.1.1 Substantial removal of oil, grease, and caked-on dirt by precleaning before the part enters the electroplating cycle (applicable in all cases).

5.1.2 Mechanical treatment of the surface by tumbling, sand or grit blasting, vapor blasting, or grinding (optional).

5.1.3 Final and complete anodic cleaning in an electrolytic alkali cleaner.

5.1.4 Acid treatment in HCl to remove the last trace of oxide and scale. This should be avoided for spring temper and case-hardened parts. This treatment also removes residual traces of lead that may be present following proper lead-bath quenching.

5.1.5 Smut removal by cyanide dipping or by anodic treatment in cyanide or alkali.

5.1.6 Final preparation for electroplating may be accomplished by an anodic etching treatment in  $\text{H}_2\text{SO}_4$  (used whenever possible in the interest of high yield and adhesion).

5.1.7 Conditioning of the surface to be electroplated may be accomplished, where necessary for the electroplating process, by a short dip or rinse in a solution equivalent to the electroplating solution without its metallic content.

5.2 *Rinsing*—Inadequate rinsing after each solution treatment step is the recognized cause of a large portion of electroplating difficulties. Not enough rinsing is characteristic of most pretreatment cycles.

5.3 *Pretreatment Time*—All processing steps involving hydrogen generation must be designed to operate for a minimum length of time, to avoid hydrogen embrittlement of the high-carbon steel.

5.4 *Control*—All pretreatment steps should be carried out with solutions that are maintained in good working condition by control of composition and contaminants, and used under conditions of time, temperature and current density specified to meet the requirement of the work being processed.

5.5 *Pretreatment Cycle Design*—Depending upon the requirements for the particular high-carbon steel parts to be electroplated, a minimum cycle should be selected from the general steps listed in 5.1. Different classes of materials require selected process steps combined into pretreatment cycles of greater or less complexity according to the condition and properties of the material. The minimum number of steps necessary to accomplish the electroplating satisfactorily is recommended.

## 6. Preliminary Pretreatment Procedures

6.1 *Application*—Degreasing and mechanical surface treatment are necessary only where the high-carbon steel parts are contaminated to such an extent that otherwise the burden imposed on the pretreatment cycle would impair its efficiency, increase