Designation: B 242 – 99

Endorsed by American
Electroplaters' Society
Endorsed by National
Association of Metal Finishers

Standard Guide for Preparation of High-Carbon Steel for Electroplating[1]

This standard is issued under the fixed designation B 242; 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.

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 highfrom 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 B 183.

1.2 This guide does not apply to the electroplating of alloy steel. For methods of chromium electroplating directly on steel see Guide B 177.

1.3 *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:*

B 177 Practice for Chromium Electroplating on Steel for Engineering Use[2]

B 183 Practice for Preparation of Low-Carbon Steel for Electroplating[2]

B 849 Specification for Pre-Treatments of Iron or Steel for Reducing the Risk of Hydrogen Embrittlement[2]

B 850 Specification for Post-Coating Treatments of Iron or Steel for Reducing the Risk of Hydrogen Embrittlement[2]

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_3) 67 mass %, density 1.40 g/mL
Sulfuric acid (H_2SO_4) 93 mass %, density 1.83 g/mL

Caution—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.

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

	Rockwell Hardness Range
Springs	C45 to C48
Spring washers	C45 to C53
Small instrument parts	C52 to C55
Parts to be chromium electroplated for engineering use	C57 to C62

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 Specification B 850.

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 µm may assist in maintaining a preferred surface through the heat treatment. A nonoxidizing atmosphere

[1] This guide is under the jurisdiction of ASTM Committee B-8 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.02 on Substrate Preparation.

Current edition approved Oct. 10, 1999. Published December 1999. Originally published as B 242 – 49 T. Last previous edition B 242 – 54 (1990).

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

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 H_2SO_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 its complexity, and tend to prevent the attainment of the required quality of the deposit. The overall cost of the electroplating process is usually reduced by using the preliminary treatments where applicable. Oil, grease, dirt, drawing compounds, burnt-in oil, heavy scale, and emery and steel particles are typical of the gross contaminants encountered.

6.2 *Precleaning*—Solvent-degreasing with clean solvent, spray-washing, or emulsion-cleaning, followed by electrolytic or soak-alkali cleaners are recommended. The former types are preferred to reduce the burden on the alkali treatments. Soak-alkali cleaning is usual for parts that are to be barrel electroplated. Electrolytic cleaning should always be anodic where the control of embrittlement is a problem.

6.3 *Stress Relief Treatment*—It is recommended that hardened high-carbon steel parts receive a stress-relief bake before the parts are mechanically pretreated or enter the final pretreatment cycle, or both. For a listing of typical stress-relief bakes, consult Specification B 849.

6.4 *Mechanical Treatment*—The purpose of mechanical treatment is to reduce subsequent acid pickling to a minimum. Where mechanical treatment has been accomplished with precision, it is sometimes possible to eliminate acid pickling entirely, thus improving the control of hydrogen embrittlement. When required, mechanical treatment of small parts is best effected by tumbling. All scaled and nearly all oil-quenched materials require mechanical cleaning such as by tumbling with or without abrasive, or by sand, grit, or vapor blasting. These operations should be carried out so as to avoid severe roughening of the surface with accompanying notch effect. One resorts to grinding in certain cases where the surface smoothness or dimensions of the parts are of critical importance, for example, in chromium electroplating for engineering use.

7. Final Pretreatment Procedures

7.1 *Application*—Final cleaning, oxide removal, and anodic acid treatment are fundamental steps required for preparing high-carbon steel for electroplating. These pretreatment steps are designed to assist in the control of hydrogen embrittlement and in securing the maximum adhesion of the electroplated coating.

7.2 *Electrolytic Anodic Cleaning*:

7.2.1 All work, except work to be barrel electroplated, should preferably be cleaned in an electrolytic anodic alkaline cleaner. Anodic cleaning is recommended to avoid hydrogen embrittlement that is likely to result from cathodic cleaning. An exception is barrel work which, because of the work size, is