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

Standard Practice for Preparation of and Electroplating on Stainless Steel¹

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This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 Various metals are electrodeposited on stainless steel for color matching, lubrication during cold heading, spring-coiling and wire-drawing operations, reduction of scaling at high temperatures, improvement of wettability (as in fountain pens), improvement of heat and electrical conductance, prevention of galling, jewelry decoration, and prevention of superficial rusting.

1.2 This practice is presented as an aid to electroplaters and finishing engineers, confronted with problems inherent in the electrodeposition of metals on stainless steel. It is not a standardized procedure but a guide to the production of smooth adherent electrodeposits on stainless steel.

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:

A 380 Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems²

3. Nature of Stainless Steel

3.1 Because previous metal treatment may have a more pronounced effect on the final finish when stainless steel is being electroplated, the metal finisher should become acquainted with the fabrication procedure, grade, and mill finish of the stainless steel with which he is working before outlining his electrodeposition procedure (see Appendix X1).

3.2 Stainless steel surfaces are normally resistant to a wide variety of corrosive elements. This property is the result of a thin transparent film of oxides present on the surface. Because this film rapidly reforms after it has been stripped off or

penetrated, it protects stainless steel against corrosion. An adherent electrodeposit cannot be obtained over the oxide film normally present on stainless steel. However, once this film is removed by surface activation and kept from reforming while the surface is covered with an electrodeposit, any of the commonly electroplated metals may be electrodeposited successfully on stainless steel.

3.3 Where the finished product is to be subjected to severe exposure, the deposit produced by the proposed electroplating sequence should be tested under similar exposure conditions before adoption, to determine whether the natural corrosion resistance of the stainless steel has been impaired by the presence of the electrodeposit.

4. Nature of Cleaning

4.1 The preparation of stainless steel for electroplating involves three basic steps in the following order:

4.1.1 Removal of scale. If scale removal is necessary, one of the methods outlined in Appendix X2 may be used (Note 1). See also Practice A 380.

4.1.2 Removal of oil, grease, or other foreign material by cleaning, and

4.1.3 Activation immediately before electroplating.

4.2 *Precleaning*—Removal of fabricating lubricants and finishing compounds from the stainless steel may have to be undertaken immediately following the fabrication or finishing operation (Note 2).

4.3 *Electrocleaning*—Anodic cleaning is generally preferred (Note 3).

4.4 *Metal Lubricants*—Metal lubricants such as copper, lead, or cadmium, applied to stainless steel wire for cold heading, wire drawing, or spring forming are removed by immersion in a solution of 200 mL of concentrated, 67 mass %, nitric acid (density 1.40 g/mL) diluted to 1 L at 50 to 60°C. See Practice A 380.

NOTE 1—Oil, grease or other fabricating lubricants should be removed by cleaning before heat treating.

NOTE 2—Spray cleaning with a nozzle pressure of 200 to 400 kPa (30 to 60 psi) in a power washer, using an alkaline or emulsion-type cleaner, is the generally preferred method, especially for the removal of heavy drawing, buffing, or polishing compounds. Soak cleaning or vapor degreasing may also be used. Extreme examples of such compounds are

¹ This practice 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.

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² *Annual Book of ASTM Standards*, Vol 01.03.

drawing or stamping lubricants containing unsaturated oils, which if left on the surface, form by air-oxidation tenacious films that are very difficult to remove.

NOTE 3—When brightness is important, alkalinity, current density, and temperature should be kept as low as the part will permit. This is an essential requirement when cleaning work on racks bearing auxiliary lead anodes or when high chromium alloys (such as UNS Types S44200 and S44600) are being cleaned.

5. Cleaning Solutions

5.1 The types of solution control, electrodes, heating coils, and rinse tanks normally used for cleaning carbon steel are satisfactory for stainless steel. Equipment previously used for the cleaning or processing of carbon steel should not be used. See Practice A 380.

6. Racking

6.1 The general principles of good racking as used in chromium electroplating processes apply. However, the high electrical resistance of stainless steel requires rack construction methods that minimize potential contact problems and increase the number of contact points.

NOTE 4—Because of the high electrical resistance of stainless steel, especially in fine-coiled wire articles such as watch bands, chains, jewelry, etc., it is necessary to provide a larger number of contacts. As an example, a watch band 110 mm long made of 1.0-mm diameter wire has been found to require at least three contacts.

7. Activation

7.1 After the cleaning operation and before the electroplating operation, the parts must be completely activated, that is, the thin transparent film of oxides must be removed from the surface to be electroplated (Note 5). This film will reform if the parts are allowed to dry or are exposed to oxygen-containing solutions. For this reason, the shortest interval practicable should elapse between the time the parts are removed from the activating solution and covered by the electrodeposit, unless a simultaneous activation-electroplating procedure is used.

NOTE 5—The etching practice may be more severe for nondecorative applications than for decorative applications.

7.2 The following activating procedures have been used. The procedure selected will depend upon the nature of the part and preceding or subsequent processes (see 7.7). In the following solution formulas, the concentrations are expressed on a volume basis as follows:

Liquids: as volume per litre of solution

Solids: as mass per litre of solution

7.3 The commercial grade acids and salts used in the formulas include:

Sulfuric acid: 93 mass %; density 1.83 g/mL

Hydrochloric acid: 31 mass %; density 1.16 g/mL

Nickel chloride: $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$

Copper sulfate: $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$

NOTE 6—**Precaution:** Sulfuric acid should be slowly added to the approximate amount of water required with rapid mixing, and then after cooling, diluted to exact volume.

7.4 Cathodic Treatments:

7.4.1	Sulfuric acid	50 to 500 mL/L
	Water	to 1 L
	Temperature	room
	Time	1 to 5 min
	Current density	0.54 A/dm ²
	Anodes	pure lead
7.4.2 ^A	Hydrochloric acid	50 to 500 mL/L
	Water	to 1 L
	Temperature	room
	Time	1 to 5 min
	Current density	2.15 A/dm ²
	Anodes	electrolytic nickel strip or nickel bar

^A See Patent No. 2,133,996.

7.4.3 After immersion in a solution containing 100 to 300 mL/L of hydrochloric acid diluted to 1 L at room temperature for 30 to 60 s, treat cathodically in:

Sulfuric acid	50 to 500 mL/L
Water	to 1 L
Temperature	room
Current	0.54 to 2.7 A/dm ²
Anodes	pure lead

7.5 Immersion Treatments:

7.5.1 Immerse in a solution of sulfuric acid containing 200 to 500 mL of acid diluted to 1 L at 65 to 80°C (with the higher temperature for the lower concentration) for at least 1 min after gassing starts. If gassing does not start within 1 min after the parts have been immersed, touch them with a carbon-steel bar or rod. This activation treatment will produce a dark, adherent smut that is removed in the electroplating bath. A cathodic current of at least 0.54 A/dm² may be used to accelerate activation. Lead anodes are suitable for this solution.

7.5.2 Immerse in the following solution:

Hydrochloric acid	1 mL
Sulfuric acid	10 mL
Water	to 1 L
Temperature	room
Time	26 s

NOTE 7—This practice has been used with success for chromium electroplating on stainless steel automobile parts in a conveyORIZED process. It is not recommended before copper or nickel electroplating.

7.6 Simultaneous Activation-Electroplating Treatments:

7.6.1	Nickel chloride ^A	240 g
	Hydrochloric acid	85 mL
	Iron	should not exceed 7.5 g/L
	Water	to 1 L
	Temperature	room
	Electrodes	nickel

^A See U. S. Patent No. 2,285,548-9.

7.6.1.1	Anodic Treatment:	
	Current density	2.2 A/dm ²
	Time	2 min

7.6.1.2	Followed by Cathodic Treatment:	
	Current density	2.2 A/dm ²
	Time	6 min

7.6.2	Nickel chloride ^A	240 g
	Hydrochloric acid	126 mL
	Water	to 1 L
	Electrodes	nickel
	Temperature ^B	room
	Current density (cathodic)	5.4 to 21.5 A/dm ²
	Time	2 to 4 min

^A See U. S. Patent No. 2,437,409.

^B Bath may require cooling or reduction in hydrochloric acid content if temperature exceeds 30°C.

7.6.3	Nickel chloride	30 to 300 g/L
	Hydrochloric acid	15 to 160 mL/L
	Water	to 1 L

	Electrodes	nickel
	Temperature	room
	Current density	0.55 to 10.75 A/dm ²
	Time	½ to 5 min
7.6.4	Hydrochloric acid	undiluted commercial grade (7.2)
	Copper sulfate	0.4 g/L
	Electrodes	nickel
	Temperature	room
	Current density	4.5 to 6.6 A/dm ²
	Time	1 to 5 min

NOTE 8—Nickel anode materials containing greater than 0.01 % sulfur are not recommended for use in acid nickel strike baths operated at pH 0.5, or lower, to avoid oxidation of sulfides by hydrochloric acid (see section 7.6.1, section 7.6.2, section 7.6.3, section 7.6.4, and 7.7).

7.7 A combination of more than one type of treatment may be necessary to ensure a high degree of adhesion. For example, the following has been used in the automotive industry for nickel plating on UNS Type S30200 stainless steel:

	Sulfuric acid	650 mL
	Water	to 1 L
	Potential (cathodic)	10 V
	Electrodes	lead
	Temperature	room
	Time	2 min

Followed by:

	Nickel chloride	240 g
	Hydrochloric acid	120 mL
	Water	to 1 L
	Electrodes	nickel
	Temperature	room
	Time	2 min
	Current density (cathodic)	16.2 A/dm ²

This is followed by transfer without rinsing to a Watts (or higher chloride) nickel bath with a pH of 1.5 to 2.0.

8. Rinsing

8.1 The parts should be transferred to the cold-water rinse and to the plating solution as rapidly as practicable after the activating procedure; otherwise the surface will passivate itself and the electrodeposit will not be adherent.

8.1.1 The rinse water should be kept slightly acid (approximately pH of 2.5 to 3.5). The acid carryover from the activation operation will maintain this pH in many instances.

8.1.2 In conveyORIZED operations where trace contamination of plating solutions with chloride and sulfate from activating solutions will produce an unsatisfactory electrodeposit, spray-rinse operations subsequent to the activation treatment will remove these contaminants.

8.1.3 If the simultaneous activation-plating procedure is employed and nickel plating follows, the intermediate rinse need only be superficial and the length of transfer time is not so important.

9. Electroplating

9.1 An adherent electrodeposit of commonly electroplated metals (cadmium, copper, brass, chromium, gold, nickel, or silver) may be electrodeposited directly on stainless steel provided the surface of the stainless steel is active.

NOTE 9—Nickel may be electrodeposited at normal current densities directly on properly activated stainless steel from standard nickel-electroplating solutions if the pH of the solution is between 2 and 4. A pH of 2 is preferred.

NOTE 10—When a chromium-electroplating solution containing 400 g/L of chromic acid is used for decorative chromium electroplating, better coverage and a wider bright range is obtained by operating at a current density of 16.2 A/dm² and 49°C.

NOTE 11—A bright nickel electroplate under chromium, preceded by one of the simultaneous activation-electroplating treatments, may often be used to advantage for better color matching and elimination of chromium buffing.

9.2 Where practical, the parts should have the current applied during entry into the electroplating solution.

10. Stripping

10.1 Nitric acid is the preferred stripping solution.

10.2 Decorative chromium electrodeposits have been stripped in a solution of 500 mL of concentrated, 31 mass % hydrochloric acid (density 1.16 g/mL) diluted to 1 L at 45 to 50°C for 1 min.

NOTE 12—Overstripping will result in etching.

NOTE 13—Decorative chromium electrodeposits may also be stripped anodically in any alkaline solution.

10.3 Cadmium is stripped successfully without current by immersion in a solution of 120 g/L of ammonium nitrate.

11. Post Electroplating Operations

11.1 Post electroplating operations such as stress relieving, buffing or coloring, and forming or drawing may be applied to stainless steel in the same manner as to any other basis metal, as long as the natural differences in the characteristic of the stainless steel are taken into consideration. The stainless steel supplier should be consulted for guidance in regard to these characteristics.

12. Test Methods

12.1 The methods of testing for thickness, hardness, and adhesion of electrodeposits applied with the usual basis metals may be employed for similar tests on stainless steel.

NOTE 14—An exception to this is the determination of the thickness of chromium on stainless steel by the hydrochloric acid drop method. Because gassing continues after the chromium coating has been penetrated, the accuracy of this method may be questionable for this application.