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Standard Guide for Preparation of Magnesium and Magnesium Alloys for Electroplating¹

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1. Scope

1.1 This guide describes two processes used for plating on magnesium and magnesium alloys: direct electroless nickel plating and zinc immersion. Some users report that the direct electroless nickel procedure does not produce quite as high a level of adhesion as zinc immersion.

1.2 *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.* For specific hazard statements, see 5.1.1 and 5.2.9.2.

2. Referenced Documents

2.1 *ASTM Standards:*²

B322 Guide for Cleaning Metals Prior to Electroplating

3. Significance and Use

3.1 Metals are electroplated on magnesium for various purposes: solderability, RF grounding, hermetic sealing, wear resistance, corrosion resistance, appearance, and electrical conductivity, for example. Because magnesium is covered with a naturally occurring oxide film, usual procedures for the preparation of metals for autocatalytic or electrolytic plating cannot be used.

4. Reagents

4.1 *Purity of Reagents*—All acids and chemicals used in this guide are of technical grade. Acid and base solutions are based on the following assay materials:

Ammonium hydroxide (NH ₄ OH)	30 mass %, density 0.895 g/L
Nitric acid (HNO ₃)	67 mass %, density 1.16 g/L
Sulfuric acid (H ₂ SO ₄)	93 mass %, density 1.40 g/L

¹ This guide is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.02 on Pre Treatment.

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² 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.

Hydrofluoric acid (HF)	70 mass %, density 1.258 g/L
Phosphoric acid (H ₃ PO ₄)	85 mass %, density 1.689 g/L

4.2 *Purity of Water*—All water used for solutions, whether new or recycled, should be monitored for cations, anions, and organic matter that are known to interfere with the plating process.

5. Processes

5.1 Procedures:

5.1.1 Wheel polish and buff parts for smooth, highly polished surfaces. Tumble and burnish small parts. Acid pickle the parts after use of wire brushing or steel wool. (**Warning**—Because of the high flammability of powdered magnesium, special precautions against fire are important. Polishing and buffing lathes should be kept scrupulously clean. Dust from grinding in and around lathes should be swept up and placed in closed containers for proper disposal. Exhaust systems should be cleaned frequently and the residues handled similarly. If abrasives are used in tumble finishing, similar precautionary techniques should be used for the solids from the abrasive slurry.)

5.1.2 *Chemical*—Remove oil and grease in an alkaline soak cleaner. Remove other soils and coatings in suitable acid pickling solutions.

NOTE 1—General information on the cleaning of metals is given in Practice B322.

5.2 General Electroplating Procedure:

5.2.1 Remove oil, grease, and other soils left from preplating procedures by soak cleaning in an alkaline cleaner suitable for magnesium.

5.2.2 Rinse in cold water.

NOTE 2—As generally used in rinsing terminology, cold water refers to water from an unheated water supply as opposed to heated water used for drying or other purposes. In some areas, particularly in water, ambient water temperatures may be too low for effective rinsing. In those instances, the rinse water may need to be heated. A minimum temperature of 16°C is recommended for effective rinsing.

5.2.3 Electroclean parts in an alkaline electrocleaner suitable for magnesium. Make the magnesium cathodic at 7.5 to 13 A/dm² and 85°C.

5.2.4 Rinse in cold water.

5.2.5 Pickle in one of the following solutions:

5.2.5.1 *Ferric Nitrate Pickle:*³

Chromic acid (CrO ₃)	180 g/L
Ferric nitrate (Fe(NO ₃) ₃ ·9H ₂ O)	40 g/L
Potassium fluoride (KF)	3.5 g/L
Temperature	16 to 38°C
Time	15 s to 3 min

NOTE 3—This pickle removes metal from a surface at the rate of 3 µm/min at 38°C. Where no dimensional change can be tolerated, use of the chromic acid pickle in 5.2.5.2 is recommended.

5.2.5.2 *Chromic Acid Pickle:*³

Chromic acid (CrO ₃)	180 g/L
Temperature	16 to 93°C
Time	2 to 10 min

NOTE 4—The use of chromic acid pickles may leave chromate films on the surface that will reduce the adhesion of the subsequently deposited coating.

5.2.6 Rinse in cold water.

5.2.7 Activate in the following solution:³

Phosphoric acid, (H ₃ PO ₄)	20 % by vol
Ammonium bifluoride (NH ₄ HF ₂)	105 g/L
Temperature	16 to 38°C
Time	15 s to 2 min

5.2.8 Rinse in cold water.

5.2.9 Zinc coat in the following solution:

Zinc sulfate (ZnSO ₄ ·H ₂ O)	30 g/L
Tetrasodium pyrophosphate (Na ₄ P ₂ O ₇)	120 g/L
Sodium fluoride (NaF) or	5 g/L or
Lithium fluoride (LiF)	2 g/L
Sodium carbonate (Na ₂ CO ₃)	5 g/L

5.2.9.1 Because of the low solubility of the tetrasodium pyrophosphate, it is generally necessary to mix this solution in an elevated temperature from 70 to 85°C. It is also advantageous to alternately add portions of the zinc sulfate and pyrophosphate. When these ingredients are completely dissolved, add and dissolve the balance of the ingredients in the order given.

NOTE 5—Either sodium fluoride or lithium fluoride may be used as a constituent of this bath. Sodium fluoride is widely used, but requires careful control. Potassium fluoride is too hygroscopic and should not be used because the variation in water content makes it impossible to be sure of how much is being added. Lithium fluoride has been found highly desirable because it is soluble only to the proper concentration level and is self-regulating. Thus, the use of lithium fluoride eliminates the need for fluoride analysis. During bath makeup, 3 g/L lithium fluoride is added. This small quantity saturates the solution, and an excess suspended in the bath in a canvas or nylon anode bag automatically replaces any fluoride consumed during the operation.

5.2.9.2 Immerse the parts for 3 to 10 min in the solution operated at 79 to 85°C and agitate mildly. Do not use glass or fiberglass equipment of any kind. Careful control is essential for best results. Maintain the pH between 10.2 and 10.4 electrometric (glass electrode) measured at 25°C. (**Warning**—The glass electrode must be used with caution. Do not allow the electrode to remain in contact with the zincate solution for prolonged periods. Inspect and test the electrode regularly to ensure that no change has occurred from contact with fluoride ion. Colorimetric (paper) methods may be used. However, the colorimetric readings may vary ±0.5 pH units.)

5.2.10 Rinse thoroughly in cold water.

NOTE 6—For alloys M1660, M13120, M13312, or M13310, a double zinc immersion is required. After step 5.2.10, steps 5.2.7-5.2.10 are repeated followed by step 5.2.11. It is advisable to use separate solutions for steps 5.2.7 and 5.2.9 when the double zinc immersion technique is practiced.

5.2.11 Copper strike in either of the following:

Bath 1:

Copper cyanide (CuCN)	38 to 42 g/L
Potassium cyanide (KCN)	64.5 to 71.5 g/L
Potassium fluoride (KF)	28.5 to 31.5 g/L
Free potassium cyanide	7 to 8 g/L
pH	9.6 to 10.4
Temperature	54 to 60°C

Bath 2:

Copper cyanide (CuCN)	38 to 42 g/L
Sodium cyanide (NaCN)	50 to 55 g/L
Rochelle salt (KNaC ₄ H ₄ O ₆ ·4H ₂ O)	40 to 48 g/L
Free sodium cyanide	7 to 8 g/L
pH	9.6 to 10.4
Temperature	54 to 60°C

5.2.11.1 Plate the parts about 6 min. Cathode rod agitation is suggested. With either bath make electrical contact quickly with initial current 5 to 10 A/dm², then lower current to 1 to 2.5 A/dm².

5.2.12 Rinse thoroughly in cold water.

5.2.13 Dip in diluted acid (1 % by vol sulfuric acid + 99 % by vol water).

5.2.14 Rinse in cold water.

5.2.15 Apply subsequent electrodeposits or autocatalytic nickel in accordance with standard commercial electroplating practice.³ Use plastisol-coated racks that are fitted with stainless steel or phosphor-bronze rack tips.

5.3 *Autocatalytic Nickel Plating Magnesium:*

5.3.1 *Surface Conditioning*—See 5.1.1 and 5.1.2, and 5.2.1-5.2.4.

5.3.2 *Pickling*—Pickle in (1) chromic acid³ as directed in 5.2.5.2 or in (2) phosphoric acid³ (90 % by vol phosphoric acid + 10 % by vol water) using a lead, glass, ceramic, or rubber-lined tank of polyethylene, polypropylene, or other suitably corrosion resistant material.

5.3.3 Rinse in cold water.

5.3.4 Chemical etch in one of the following:

Etch 1—For Alloys Containing Aluminum:³

Chromic acid (CrO ₃)	120 g/L
Nitric acid (HNO ₃)	(11 % by vol nitric acid + 89 % by vol water) to make 1 L

Etch 2—For Other Magnesium Alloys:³

Chromic acid (CrO ₃)	60 g/L
Nitric acid (HNO ₃)	(9 % by vol nitric acid + 91 % by vol water) to make 1 L

Stainless steel tank or tank lined with glass, ceramic, polyvinyl chloride, polyethylene, or other suitably resistant plastic material.

Immerse parts 20 to 60 s in solution at room temperature. Rinse thoroughly and proceed immediately to hydrofluoric acid dip.

NOTE 7—Use the chromic acid pickle where dimensional change cannot be tolerated. Do not use on alloys containing thorium. For thorium-containing alloys and on other alloys where dimensional change

³ *Magnesium Finishing*, The Dow Metal Products Co., Midland, MI.