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Standard Guide for Preparation of Aluminum Alloys for Electroplating[1]

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

1. Scope

1.1 This guide covers cleaning and conditioning treatments used before metal deposition (Section 5), and immersion deposit/strike procedures (Section 6) that enhance the adhesion of metals that are subsequently applied to aluminum products by electrodeposition or by autocatalytic chemical reduction.

1.2 The following immersion deposit/strike procedures are covered:

1.2.1 Zinc immersion with optional copper strike (6.3).

1.2.2 Zinc immersion with neutral nickel strike (6.4).

1.2.3 Zinc immersion with acetate-buffered, nickel glycolate strike (6.5).

1.2.4 Zinc immersion with acid or alkaline electroless nickel strike.

1.2.5 Tin immersion with bronze strike (6.6).

1.3 From the processing point of view, these procedures are expected to give deposits on aluminum alloys that are approximately equivalent with respect to adherence. Corrosion performance is affected by many factors, however, including the procedure used to prepare the aluminum alloy for electroplating.

1.4 This guide is intended to aid electroplaters in preparing aluminum and its alloys for electroplating.

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

1.6 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 7 and Appendix X1.

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B85 Specification for Aluminum-Alloy Die Castings
B179 Specification for Aluminum Alloys in Ingot and Molten Forms for Castings from All Casting Processes
B209/B209M Specification for Aluminum and Aluminum-Alloy Sheet and Plate
B221 Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
B221M Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)
B322 Guide for Cleaning Metals Prior to Electroplating
B432 Specification for Copper and Copper Alloy Clad Steel Plate
E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

3. Significance and Use

3.1 Various metals are deposited on aluminum alloys to obtain a decorative or engineering finish. The electroplates applied are usually chromium, nickel, copper, brass, silver, tin, lead, cadmium, zinc, gold, and combinations of these. Silver, tin, or gold is applied to electrical equipment to decrease contact resistance or to improve surface conductivity; brass, copper, nickel, or tin for assembly by soft soldering; chromium to reduce friction and obtain increased resistance to wear; zinc for threaded parts where organic lubricants are not permissible; tin or lead is frequently employed to reduce friction on bearing surfaces. Nickel plus chromium or copper plus nickel plus chromium is used in decorative applications. Nickel plus brass plus lacquer or copper plus nickel plus brass plus lacquer is also used for decorative finishes, sometimes with the brass oxidized and relieved in various ways.

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[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.

3.1.1 Electroless nickel may be applied as a barrier layer prior to other deposits, or for engineering purposes.

3.2 The preparation of aluminum and aluminum alloy mandrels for electroforming is described in Practice B432.

4. Nature of Aluminum and Its Influence on Preparation

4.1 *Microstructure*—It is difficult to find a preplating procedure that is equally satisfactory for all types and tempers of aluminum alloys because the various alloys and products behave differently electrochemically due to their different compositions and metallurgical structures. When elements are added for alloying purposes, they may appear in an aluminum alloy in several different forms: that is, they may be in solid solution in the aluminum lattice, be present as microparticles of the elements themselves, or be present as particles of intermetallic compounds formed by combination with the aluminum. The several solid solution matrices and the 20 or more microconstituents that may occur in commercial alloys may have different chemical reactivities and electropotentials and their surfaces may not respond uniformly to various chemical and electrochemical treatments. In addition, the response may be influenced by variations in the microstructure of different lots of products of the same alloy. In some cases, these variations may be introduced or aggravated by preparation processes; for example, the heat generated in buffing. The electroplater needs to know the aluminum alloy that is to be processed in order to select the best electroplating procedure. In the absence of this information, there are so-called universal procedures that may be used. However these will not necessarily be the best or the most economical procedures for the alloy.

4.2 *Oxide Film*—In addition to differences in microstructure that may affect response to preplating treatments, all aluminum products have an ever-present natural oxide film. This oxide film can be removed by various acid and alkaline treatments and even though it reforms immediately on contact with aqueous solutions or air, it then is usually thinner and more uniform than the original film. The newly formed oxide film provides a more suitable surface for deposition of the first metallic layer.

5. Cleaning and Conditioning Treatments

5.1 To obtain consistent results for electroplating on aluminum alloys, it is essential that the various cleaning and conditioning treatments provide a surface of uniform activity for the deposition of the initial metallic layer. First, the surface should be free of any oil, grease, buffing compound, or other foreign material. For removing oil, grease, or buffing compound, use vapor degreasing,[3] solvent washing, or solvent emulsion cleaning. For removing buffing compound, specially formulated detergent type or modified detergent type buffing compound removers may also be used. If the deposits of soil are relatively light and fairly uniformly distributed, a mild etching type cleaner may also be used. A convenient one is a hot, aqueous carbonate-phosphate solution (Appendix X1.1). Other types of cleaners are used; for example, mildly alkaline or acidic soak cleaners are used to remove gross soils. Also available are a wide range of proprietary cleaners of the "non-etching" type. Some of these are actually buffered mixtures, similar to the carbonate-phosphate mixture (Appendix X1.1) where the so-called non-etching characteristics are obtained by buffering the solution to pH levels where the etching action becomes minimal. Others are truly non-etching types where etching is prevented by using silicate inhibitors, such as sodium metasilicate (Na_2SiO_3). These inhibitors always leave a film of aluminum silicate on the surface. When these materials are used, subsequent deoxidizing solutions should contain controlled amounts of fluoride salts to insure complete removal of the film.

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

5.2 After cleaning, a conditioning treatment of the surface is generally required. For this to be effective, it must accomplish two things: (*1*) remove the original oxide film and (*2*) remove any microconstituents that may interfere with the formation of a continuous deposited metallic layer or that may react with subsequent electroplating solutions.

5.2.1 An effective conditioning treatment is immersion of the work in a warm sodium hydroxide solution (Appendix X1.3) followed by water rinsing and immersion in a nitric acid-bifluoride desmutting solution (Appendix X1.4). An alternative desmutting solution is sulfuric acid-hydrogen peroxide (Appendix X1.5).

NOTE 2—When an unmodified sodium hydroxide solution is used, etching may become nonuniform and heavy concrete-like scales may form on tank walls and heating surfaces, their development becoming more rapid as the concentration of dissolved aluminum increases. The incorporation of controlled amounts of deflocculating complexors such as sodium gluconate, sodium glucoheptonate, certain sugar derivatives, and certain substituted sugar amines will eliminate this problem. Many proprietary etching materials are so modified.

NOTE 3—The universal acid mixture (Appendix X1.9) is applicable to almost all alloys, and is especially desirable for use with alloys containing magnesium.

5.2.2 For heat-treated alloys (alloys in a "T" temper), it is important to remove the relatively thick, heat-treated oxide film before proceeding with subsequent conditioning treatments. Normally, heat-treated films are removed by machining, or by the polishing action on metal surfaces that are buffed.

5.2.2.1 In the absence of machining or buffing, controlled abrasive blasting may be used to remove this oxide. Fine abrasives such as aluminum oxide, ceramic beads, or glass beads may be used. Silicon carbide abrasives should be avoided. If aluminum oxide, or glass beads are used, subsequent treatments should include the use of an acid fluoride to ensure that any embedded aluminum oxide or silica is removed. However, surfaces of heat-treated alloys that are not machined or buffed should have the heat-treated film removed with a deoxidizing etch to obtain uniform electroplating results. An effective deoxidizing etch is a hot sulfuric-chromic acid solution (Appendix X1.2). Suitable proprietary deoxidizing etches including some with no chromates are available. They should be used as recommended by the manufacturer.

[3] For details on the proper operation and safety precautions to be followed in vapor degreasing, see *Handbook of Vapor Degreasing, ASTM STP 310*, ASTM, 1976.