Designation: B879 – 17 (Reapproved 2022)

Standard Practice for Applying Non-Electrolytic Conversion Coatings on Magnesium and Magnesium Alloys[1]

This standard is issued under the fixed designation B879; 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 practice covers a guide for metal finishers to clean and then provide a paint base for the finishing of magnesium and magnesium alloys using chemical conversion coatings. Where applicable (for example, aerospace) secondary supplementary coatings (for example, surface sealing) can be used (see Appendix X1).

1.2 Although primarily intended as a base for paint, chemical conversion coatings provide varying degrees of surface protection for magnesium parts exposed to indoor atmosphere either in storage or in service under mild exposure conditions. An example is the extensive use of the dichromate treatment (see 5.2) as a final coating for machined surfaces of die cast magnesium components in the computer industry.

1.3 The traditional numbering of the coating is used throughout.

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

1.5 *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.*

1.6 *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 The following documents form a part of this practice to the extent referenced herein.

2.2 *ASTM Standards:*[2]

D1732 Practices for Preparation of Magnesium Alloy Surfaces for Painting

2.3 *SAE Standard:*[3]

AMS 2475 Protective Treatments—Magnesium Alloys

2.4 *Military Specifications:*[4]

MIL-M-3171 Magnesium Alloy, Processes for Pretreatment and Prevention of Corrosion on

DTD 911 (British), Protection of Magnesium-Rich Alloys Against Corrosion

DTD 5562 (British), Clear Baking Resin for Surface Sealing Magnesium

DTD 935 (British), Surface Sealing of Magnesium Rich Alloys

3. Significance and Use

3.1 The processes described in this practice clean and provide a paint base for the finishing of magnesium and magnesium alloys. Service conditions will determine, to some degree, the specific process to be applied.

4. Reagents

4.1 The chemicals that are used to formulate and control the processing solutions are listed in Table 1. Commercial grade chemicals are satisfactory. The concentrations stated for chemicals that are normally supplied at less than a nominal 100 % strength are those typically available. Other strengths may be used in the proportions that yield the specified processing concentrations. Unless otherwise stated all solutions are made up using water.

5. Types of Coating

5.1 *Chrome Pickle (Traditional Number 1) Treatment (See Practices D1732):*

[1] This practice is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.07 on Conversion Coatings.

Current edition approved May 1, 2022. Published June 2022. Originally approved in 1997. Last previous edition approved in 2017 as B879 – 17. DOI: 10.1520/B0879-17R22.

[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] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

[4] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://dodssp.daps.dla.mil.

TABLE 1 Processing Chemicals

Acetic acid glacial, (CH_3COOH)
Aluminum sulfate ($Al_2 [SO^3]_3 \cdot 14H_2O$)
Ammonium bifluoride (NH_4HF_2)
Ammonium hydroxide (NH_4OH), 30 %
Ammonium phosphate monobasic ($NH_4H_2PO_4$)
Ammonium sulfate ($[NH_4]_2SO_4$)
Ammonium sulfite ($[NH_4]_2SO_3 \cdot H_2O$)
Calcium chromate ($CaCrO_4$)
Calcium fluoride (CaF_2)
Calcium sulfate ($CaSO_4 \cdot 2H_2O$)
Chromic acid (CrO_3)
Ferric nitrate ($Fe[NO_3]_3 \cdot 9H_2O$)
Glycolic acid ($HOCH_2COOH$), 70 %
Hydrofluoric acid (HF), 60 %
Magnesium fluoride (MgF_2)
Magnesium nitrate ($Mg[NO_3]_2 \cdot 6H_2O$)
Magnesium sulfate ($MgSO_4 \cdot 7H_2O$)
Manganese sulfate ($MnSO_4 \cdot 5H_2O$)
Nitric acid (HNO_3), sp gr 1.42
Phosphoric acid (H_3PO_4), 85 %
Potassium fluoride (KF)
Potassium bifluoride (KHF_2)
Sodium bifluoride ($NaHF_2$)
Sodium bisulfate ($NaHSO_4$)
Sodium carbonate (Na_2CO_3)
Sodium dichromate ($Na_2Cr_2O_7 \cdot 2H_2O$)
Sodium hydroxide (NaOH)
Sodium metasilicate (Na_2SiO_3, or $Na_2SiO_3 \cdot 4H_2O$)
Sodium nitrate ($NaNO_3$)
Sulfuric acid (H_2SO_4), sp gr 1.84

5.1.1 With slight variations this treatment can be applied to all alloys and forms of magnesium. The treatment removes up to 15 µm of metal per surface, 30 µm per diameter. Therefore, it may not be applicable to machined surfaces with close tolerances. Parts with steel inserts may be processed, but some slight etching of the steel surface may occur.

5.1.2 The color, luster, and etch produced by the treatment will vary with the age and usage of the solution, alloy composition, and heat treatment of the alloy. The most desirable paint base is a matte grey to yellow-red, iridescent coating which exhibits a pebbled etch finish when viewed under low magnification (5 to 10×). Bright brassy coatings, showing a relatively smooth surface with only occasional rounded pits under low magnification are unsatisfactory as a paint base but are acceptable for protection during shipping and storage.

5.2 *Dichromate (Traditional Number 7) Treatment (see Practices D1732):*

5.2.1 This treatment provides an improved paint base compared with the chrome pickle treatment, and for temporary protection on all standard alloys except, EK41A, HM31A, HM21A, HK31A, WE54, WE43, and M1A on which the coating does not form. The treatment causes no appreciable dimensional changes, is normally applied after machining, and is suitable for close clearance parts. Parts containing inserts of bronze, brass, steel, or cadmium plated steel should not be treated unless the dissimilar metals are masked or it is demonstrated that the treatment will not adversely affect them. For assemblies containing aluminum inserts or rivets, the acid fluoride treatment (see 7.2.3) should replace the hydrofluoric acid treatment in part preparation.

5.2.2 Coatings vary from light to dark brown depending upon the alloy. On AZ91C-T6 and AZ92A-T6 castings the coating is grey.

5.3 *Galvanic Chromate (Traditional Number 9) Treatment (see Practices D1732):*

5.3.1 This treatment can be used for all alloys and is specifically used for those alloys which do not react or form satisfactory conversion coatings in other baths. The treatment requires no external current but utilizes the relatively high potential difference between suitably racked magnesium components and steel tank walls or other cathodes. As with the dichromate treatment, a prior immersion in acid fluoride solution is required to condition the magnesium surface. The galvanic chromate treatment causes no appreciable dimensional change and is normally applied after machining.

5.3.2 Properly applied coatings vary from dark brown to a dense black color depending on the alloy. The treatment is particularly useful for application to optical equipment requiring a nonreflective black coating.

5.4 *Chromic Acid Brush-On (Traditional Number 19) Treatment:*

5.4.1 This treatment can be applied to parts that require touch up. It is generally used in refinishing procedures or where parts or assemblies are too large to be immersed. It is effective on most alloys and causes negligible dimensional changes.

5.4.2 Coatings produced by this treatment can vary from a brassy iridescence to a dark brown depending upon treatment time. Prolonged treatment produces powdery coatings. For best adhesion, dark brown coatings are preferred.

5.5 *Chromate Treatment (see DTD 911):*

5.5.1 This treatment is suitable for all magnesium alloys. The treatment causes no dimensional change and is normally applied after machining. The pickling procedures and the composition of the treating solution generally vary with the alloy being processed.

5.5.2 The coating will vary from dark brown to light reddish-brown depending on the alloy.

5.6 *Chrome-Manganese Treatment:*

5.6.1 This treatment provides an improved paint base compared with the chrome pickle treatment and protection on all standard alloys except EK41A, HM31A, HM21A, HK31A, and M1A on which the coating does not form. The treatment causes no appreciable dimensional change, and normally is applied after machining. It is suitable for close clearance parts. Parts containing inserts of bronze, brass, steel, or cadmium plated steel should not be treated unless the dissimilar metals are masked or it is demonstrated that the treatment will not adversely affect them.

5.6.2 The bath generally gives dark brown to black films on both cast and wrought magnesium alloys. Treatment of aluminum containing alloys may require bath temperatures above 50°C.

5.7 *SemiBright Pickle (Traditional Number 21) Treatment*—This treatment provides a semibright silvery surface on magnesium parts that prevents tarnishing and corrosion for indoor storage up to six months in non-air-conditioned environments. Extended storage times can be obtained by using air conditioning. This process causes negligible dimensional change. It is a simple, economical way to apply an attractive shelf-life finish and is a good base for clear lacquers. The treatment greatly reduces or eliminates "filiform or worm-tracking" corrosion usually experienced when clear paints are used directly over polished metal surfaces.

5.8 *Phosphate Treatment:*

5.8.1 Phosphate treatments can provide a satisfactory paint base on magnesium for many applications when it is necessary to avoid the use of chromates. Commercial iron phosphate treatments applied by spray or dipping have been successfully used on magnesium die castings for automotive and other consumer product applications. The suitability of a particular phosphatizing process for magnesium should be verified by testing. Iron phosphate treatments containing nickel or copper salts as accelerators are detrimental to the corrosion resistance of magnesium and should not be used.

5.8.2 Phosphate treatments do not provide interim stand-alone protection against atmospheric oxidation and tarnish equal to that provided by some chromate conversion coatings.

5.9 *Plasma Electrolytic Oxidation (PEO)*—This process is a combination of the co-deposition on Magnesium and Magnesium alloys from an electrolyte and the oxidation of the surface of the metals in question with a plasma. Short pulses of plasma discharges result in the metals being processed to oxidize and then melt the generated Magnesium oxides onto the surface of the metals being treated. The melting seals up any holes in the surface oxides to prevent corrosion, increase ware and provide for a surface that will accept secondary organic coatings (that is, commercial paints).

5.10 *All Organic Hydrocarbon Acid*—This process chemically reacts the Magnesium or Magnesium alloy, or both, in question with various organic acids that then attach themselves to the surface of the metal in question, seals the surface of the metal to prevent any oxidation and produces a surface that will easily accept applied secondary coatings (that is, commercial paints).

6. Part Preparation

6.1 *Cleaning—General:*

6.1.1 Before considering the use of solvent degreasing, consult federal and state safety and environmental laws and regulations. Many of the commonly used solvents are now being banned from use. Exposure to their vapor (VOC) is being strictly regulated for health, safety, and environmental reasons. Obtain current safe exposure levels for various solvents before use. Follow all federal, state, and local regulations for the disposal of solvents.

6.1.2 *Solvent Cleaning*—Grease or oil may be removed by means of vapor degreasing, ultrasonic cleaning, solvent washing, or an emulsion cleaning process that utilizes a mineral oil distillate and an emulsifying agent. Chlorinated solvents, petroleum spirits, naphths, lacquer thinner, and similar solvents that do not attack magnesium may be used. Methyl alcohol (CH_3OH) should not be used because it may react with the magnesium surface.

6.1.3 *Mechanical Cleaning*—Mechanical cleaning may consist of sand, shot, pumice, grit or vapor blasting, sodium carbonate slurry, sanding, hard bristle brushing, grinding and rough polishing. Sand, shot, or grit blasting leaves surface contamination that will greatly increase the corrosion rate of the magnesium on exposure to salt water or humid environment. If these methods are used, specific pickling procedures must be employed after blasting (see 6.4.2).

6.1.4 *Alkaline Cleaning*—Cleaning prior to application of treatments other than the chrome pickle treatment (see 5.1), when used for protection during shipment or storage, should be done in an alkaline cleaner recommended for steel or in a cleaning solution as specified in 6.1.4.1. Maintain the solution pH above 8.0. Alkaline cleaning prior to the application of the chrome pickle treatment (see 5.1), when used for protection during shipment and storage only, may be omitted provided the parts are free of grease, oil, and other deleterious deposits at the time of application. Alkaline cleaning solutions containing more than 2 % sodium hydroxide will etch ZK60A, ZK60B, and some other magnesium alloys producing a change in dimensions. If such a dimensional change is undesirable, use cleaners with lower alkali content.

6.1.4.1 Alkaline cleaning may be carried out in solutions of proprietary cleaners. In this case the operating conditions should be as specified by the supplier. In no case should a cleaner having pH lower than 8.0 be used. Most recommended cleaners are used by simple immersion. After alkaline cleaning, rise parts thoroughly in cold running water. No water breaks should be observed in the rinse.

6.1.5 *Electrolytic Cleaning*—Use of anodic current for cleaning is not generally recommended because of the possible formation of oxide films, pitting of the magnesium surface, or both. However, electrolytic cleaning using cathodic current at 1 to 4 A/dm^2 may be carried out in properly formulated cleaners.

6.2 *Graphite Lubricant Removal:*

6.2.1 Remove graphite-based lubricants from hot formed magnesium sheet parts by soaking the parts for 10 to 20 min in 100 g/L sodium hydroxide maintained at 88 to 100 °C. The pH should be above 13.0. Add wetting agent (0.75 g/L), if needed, for the removal of heavy films of mineral oil. Then rinse parts thoroughly in cold water and immerse for 3 min in a chromic-nitrate pickle as specified in 6.5.2. Repeat the cycle until all parts are clean.

6.2.2 Because of the difficulty of removing graphite from chrome pickled sheet, such sheet should not be used for forming unless the chrome pickle is removed as outlined in 6.3 before forming.

6.3 *Previously Applied Chemical Finishes:*

6.3.1 Magnesium base alloys are often supplied with a chrome pickle treatment to protect them during shipment, storage, and machining. The coating from this treatment remaining on unmachined areas will impair the film produced by any subsequent chromate treatment and therefore must be removed.

6.3.2 Previously applied coatings may be removed with the alkaline cleaners recommended in 6.1.4.

6.3.3 If the finish is difficult to remove, immerse the part in the chromic acid pickle given in 6.5.1. Alternate immersion in the alkaline cleaner and the chromic acid pickle may be