



Standard Guide for Preparation of Zinc Alloy Die Castings for Electroplating and Conversion Coatings¹

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1. Scope

1.1 This guide is intended as an aid in establishing and maintaining a procedure for preparing zinc alloy die castings for electroplating and conversion coatings. It is primarily intended for the preparation of Alloys UNS Z33521 (AG-40A) and UNS Z35530 (AC-41A) (Specification B 86) for electroplating with copper, nickel, and chromium (Specification B 456).

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.*

2. Referenced Documents

2.1 ASTM Standards:²

B 6 Specification for Zinc

B 86 Specification for Zinc and Zinc-Aluminum (ZA) Alloy Foundry and Die Castings

B 456 Specification for Electrodeposited Coatings of Copper Plus Nickel Plus Chromium and Nickel Plus Chromium

2.2 Military Standard:

MIL-S-13165C Shot Peening of Metal Parts³

3. Summary of Practice

3.1 The normal sequence of preparation steps is as follows: (1) smoothing of parting lines; (2) smoothing of rough or defective surfaces, if necessary; (3) buffing, if necessary; (4) precleaning and rinsing; (5) alkaline electrocleaning and rinsing; (6) acid dipping and rinsing; and (7) copper striking.

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 Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

4. Significance and Use

4.1 The performance and quality of electroplated or conversion-coated zinc alloy die casting depends upon the surface cleanliness and condition. Various metals are electroplated or conversion coatings are established on zinc alloys for decorative or engineering finish. The common electroplates applied are usually copper, nickel, and chromium for decorative and functional uses. The common conversion coatings applied are phosphates, chromates, and anodized coatings. Electroplated zinc die castings and conversion coatings on zinc die castings are used in many industries such as the marine, automotive, plumbing fixtures, and appliance industries.

5. Composition and Characteristics of Zinc Alloy Die Castings

5.1 The alloys used in the manufacture of zinc alloy die castings are made with special high-grade zinc conforming to Specification B 6, alloyed with about 4 % of aluminum, 0.04 % of magnesium, and either 0.25 (max) or 1.0 % copper (Alloys UNS Z33521 and UNS Z35530). Impurities such as lead, cadmium, tin, and iron are held at or below the specified low levels in Specification B 86.

5.2 Die castings made of Alloys UNS Z33521 and UNS Z35530 are usually dense and fine grained but do not always have smooth surfaces. Defects sometimes encountered in the surface layers include cracks, crevices (cold shut), skin blisters, and hemispherical pores. Burrs are usually left at parting lines where fins and gates are removed by die trimming.

5.3 Cast surfaces are frequently contaminated with parting compounds applied at frequent intervals to die surfaces to facilitate the ejection of the castings and with water-soluble oils added to quenching tanks for corrosion inhibition.

5.4 Zinc alloy die castings are chemically active and are dissolved or etched during prolonged contact with concentrated solutions of many mineral or organic acids or strongly alkaline solutions with a pH greater than 10. Immersion periods in such solutions should be of short duration to avoid roughening.

6. Smoothing of Parting Lines

6.1 Parting lines are smoothed by (1) mechanical polishing with abrasive-coated wheels or belts, (2) tumbling with abrasive media, or (3) vibration with abrasives.

6.2 Abrasives with a size range of 220 to 300 mesh glued on cloth wheels or continuous cloth belts that run over flexible back-up wheels are usually used for mechanical polishing of parting lines. Wheel diameters range from 5 to 40 cm, depending on the complexity of the shape. Wheels are rotated with a minimum peripheral speed of 2500 m/min. A peripheral speed of 2100 m/min should not be exceeded with belts. Lower speeds of the order of 1100 to 1400 m/min are fairly common for small die castings polished on small diameter wheels. Abrasive belts should not be used dry but should be lubricated with a small amount of grease. Die castings usually are handled individually to polish parting lines smooth. This may require 30 s or less for small castings, and sometimes 5 or 6 min for larger ones.

6.3 Tumbling in horizontal barrels, loaded with abrasive stones such as limestone, preformed and fused aluminum oxide, ceramic shapes or abrasive-loaded plastic chips, and a lubricant such as soap or detergent solution, removes parting-line burrs from die castings in 4 to 12 h. The barrels may be rotated at 4 r/min. Higher speeds reduce the time cycles and costs, but also increase the danger of impingement of parts against zinc surfaces. A hexagonal barrel with a capacity of 0.5 m³ can be loaded with 450 kg of abrasive stones or chips and 90 kg of zinc die castings.

6.4 Vibration in a bed of resin-bonded abrasive chips removes parting-line burrs, typically in 1 to 4 h. Frequencies range from 700 to 2100 cpm and amplitudes from 0.8 to 6.4 mm. A vibrating tub with a capacity of 0.5 m³ can be loaded with about 900 kg of abrasive media and 180 kg of zinc die castings. A dilute solution of detergent or soap is continuously metered through the bed of media and parts to keep their surfaces clean and maximize surface smoothing. Parting lines may be mechanically polished before vibratory processing when a large amount of flash must be removed.

7. Smoothing of Rough or Defective Surfaces

7.1 Rough or defective surfaces are smoothed by (1) mechanical polishing on rotating wheels or continuous, abrasive-coated belts, (2) spin finishing, (3) vibratory finishing, or (4) controlled shot peening. Fissures, skin blisters, and other defects with a depth of 25 to 50 µm can usually be erased with these metal-removal methods. Deeper defects are infrequent.

7.2 Mechanical polishing for smoothing rough or defective surfaces is similar to mechanical polishing for smoothing parting line areas (see 6.2). Parting lines and rough or defective surfaces are frequently polished by the same operator. If polishing is mechanized to advance die castings attached to a conveyor through successive belts or wheels to polish different areas, a manual operation may be required later to complete the smoothing of parting lines if they are too curved. The finish ranges from 0.2 to 0.6 µm, depending on the abrasive and the pressure.

7.3 Smoothing by spinning in abrasives is accomplished by attaching die castings to spindles or drums rotated with a

peripheral speed of about 600 m/min in a slurry of abrasive material such as ground corn cobs or nut shells mixed with a small amount of grease or other lubricant. Times usually range from 5 to 10 min and the finish from 0.1 to 0.2 µm, depending on the abrasive.

7.4 Vibrating tubs loaded with plastic chips (such as polyurethane) impregnated with an abrasive (such as aluminum oxide) smooth the surfaces of die castings in 2 to 4 h when frequencies are in the range of 1700 to 2100 cpm and amplitudes are adjusted to 3.2 to 6.4 mm. Vibratory machines produce a finish of 0.15 to 0.25 µm, with a cutting rate of 5 µm/h. A smoother finish of 0.075 to 0.125 µm can be obtained with plastic media containing finer abrasive, which removes metal at a slower rate. Media and zinc parts are usually loaded with a ratio of 5:1 or 6:1. Surface gouges may occur with a smaller ratio.

7.5 Controlled shot peening will plastically deform and densify the casting surface and near-surface layers. Shot peening can seal surface pores, which can create problems in electroplating and conversion coating. The process is described in MIL-S-13165C. The process is also effective in removing fins, burrs, and flash from the surface. The casting configuration, including the smallest size radii and wall thickness, as well as the required finish and contamination limits, will dictate the proper selection of peening media, shot size, intensity, and coverage, as is detailed in MIL-S-13165C.

8. Buffing

8.1 Die castings are buffed to produce a mirror-like finish, suitable for plating with conventional solutions, when good leveling plating solutions are not available. Buffing can be omitted, however, for die castings which have good surfaces or which can be uniformly polished to a finish of 0.25 µm, if solutions with good leveling power are used for plating copper and nickel.

8.2 Die castings are buffed on cloth wheels rotated at a peripheral speed not exceeding 2150 m/min. Slower speeds, of the order of 1100 to 1600 m/min, are used for small die castings. Buffing compounds should be made with a binder that is readily emulsified or saponified during alkaline cleaning. The abrasive may be tripoli (amorphous silica) or lime, mixed with about 25 % of tallow or other lubricants. Compounds suspended in a liquid are preferred for automatic buffing machines that advance die castings through a succession of buffs of varying diameter and width, which individually smooth different surface areas. Buffs are usually made of cloth with a thread count of 34 to 37/cm. A finish of 0.025 to 0.05 µm can be produced by buffing. The smoothing rate is influenced by the temperature of the metal surface (faster at approximately 150°C than at lower temperatures).

8.3 After buffing, surfaces with impacted buffing compound can be improved by passing them over a dry wheel to remove buffing compound. This will reduce the demand placed on the precleaning solution.

9. Precleaning and Rinsing

9.1 It is strongly recommended that the preliminary removal of most of the buffing compound and other soil in a precleaning operation be done as soon as possible after buffing and

polishing. Most buffing compounds become substantially more difficult to remove after aging several days.

9.2 There are several methods by which soils can be removed from zinc die castings prior to final alkaline electrocleaning. Generally speaking, these fall into three main classes: solvent degreasing, emulsion cleaning, and cleaning with aqueous base detergents.

9.2.1 *Solvent Degreasing*—Before considering the use of solvent degreasing, federal and state safety and environmental laws and regulations should be consulted. Many of the commonly used solvents are now being banned from use. Exposure to their vapors (VOC) is being strictly regulated for health, safety, and environmental reasons. Current safe exposure levels for various solvents should be obtained before use. Cold solvents, such as mineral spirits, methylene chloride, trichloroethylene, perchloroethylene and trichloroethane, are used with brushing to loosen packed buffing compound, but this method usually is not practical for mass production conditions. Simple dipping in cold solvent is often ineffective. Vapor degreasing⁴ with trichloroethylene or perchloroethylene is widely practiced. Often the buffed die castings are sprayed with, or immersed in, hot solvent for mechanical removal of heavy soil deposits. This is followed by condensation of hot, clean solvent vapors on the work; this removes the last traces of grease and compound. The method is very effective, provided adequate measures are taken to remove the very fine abrasive and metallic particles from the work. Trichloroethylene and perchloroethylene are nonflammable as used in vapor degreasing and still must be used in systems designed to protect personnel from inhalation of vapors. Suppliers of solvents should be consulted as to the safety of a given installation.

9.2.1.1 All federal, state, and local regulations for the disposal of solvents should be followed.

9.2.2 *Emulsion Cleaning*:

9.2.2.1 Impacted buffing compound may be loosened, and to some extent removed, by immersion in various hydrocarbon-water emulsions. These emulsions are available in several forms, including unstable emulsions (diphase cleaners), invert type emulsions, mixtures of emulsions and alkaline cleaners, and stable emulsions. Such emulsion cleaners usually have a suitable hydrocarbon base such as kerosene or a higher flashpoint solvent to which is added emulsifiers, soaps, and inhibitors to prevent etching of the die castings. The pH of the emulsion cleaner should be kept between 7 and 10 to avoid damage to the castings.

9.2.2.2 These emulsions normally are used hot, about 80°C, as a soak, sometimes with agitation, for about 2 to 5 min. A warm water spray rinse should follow the emulsion soak cleaning. Buffing compound not removed in the emulsion soak is sufficiently softened so that it is easily removed in an alkaline spray wash operation that normally follows.

9.2.2.3 Emulsion cleaning is an effective method for removing buffing compound. Its principal disadvantage is the danger of carryover of hydrocarbon solvent into plating baths because

of incomplete rinsing. For this reason, it is very important that proper alkaline cleaning and rinsing follow to ensure solvent removal from blind holes, defects in rack coatings, and recesses.

9.2.2.4 All federal, state, and local regulations for the use and disposal of solvents should be followed.

9.2.3 *Aqueous Base Detergents*—In recent years, hot mixtures of emulsifiers and surfactants (wetting agents), sometimes combined with mild alkaline phosphates or borates, are used for soak cleaning to soften and remove buffing compound. Combining soak cleaning with ultrasonics is particularly effective on impacted buffing compound. Such detergent soaks should be followed by spray cleaning with an alkaline cleaner. If a spray cleaning step is not needed, then the soak cleaning step should be followed by a spray rinse with warm water before electrocleaning. Sometimes conventional alkaline soak cleaners are used for precleaning die castings with little or no buffing compound on them. These alkaline cleaners must be mild and inhibited since strong alkali will attack the castings.

9.3 *Power Spray Alkaline Washing*—Alkaline spray cleaners are widely used, during the initial cleaning operation or following initial presoaks in emulsions, solvents, or detergents. This is accomplished with conveyerized units equipped with washing, draining, rinsing, and draining sections. The solution heated to a temperature range of 50 to 80°C is sprayed with a pressure of 170 to 205 kPa through nozzles on 20 to 30 cm centers in the washing area. A typical solution may contain 10 g/L of mixed alkalis such as trisodium phosphate, sodium tripolyphosphate, sodium metasilicate, and sodium bicarbonate and not more than 1 g/L sodium hydroxide. The solution should also contain not more than 0.2 g/L of a low-foaming or non-foaming surfactant. In a typical precleaning cycle, a 1 to 2 min washing period is followed with a ½ to 1 min draining period, a ½ to 1 min water rinse with spray nozzles and a final draining period of ½ to 1 min. Proprietary alkaline spray cleaners are available for this application.

10. Alkaline Electrocleaning and Rinsing

10.1 Electrocleaning is necessary for completing the removal of oil, grease, and soil, and to ensure good electroplate adhesion. Anodic cleaning is usually selected for zinc alloys in preference to cathodic cleaning. Anodic current densities usually range from about 1.6 to 3.2 A/dm². Time cycles vary from 25 to 45 s.

10.2 A typical solution for anodic cleaning contains 30 to 40 g/L of mixed alkalis such as trisodium phosphate and sodium metasilicate, 0.5 g/L of a low-foaming surfactant, and not more than 0.5 g/L of sodium hydroxide and is heated to 70 to 82°C. Proprietary products for anodic cleaning are available. Lower temperatures may be required if time cycles must be prolonged for more than 45 s, or if the transfer time from the electrocleaner to the first rinse is more than about 30 s. Operating an anodic electrocleaner at too dilute concentrations may over etch the castings.

10.3 A cycle including a warm water rinse, a cold water rinse, and a water spray rinse is recommended after alkaline electrocleaning. The rinses should be agitated with air to dilute, as much as possible, the concentration of alkaline solution in blind holes, grooves, and other surface indentations and

⁴ ASTM Committee D26 *Manual on Vapor Degreasing*, MNL2, ASTM, Philadelphia, PA.

cavities. Alkaline solution entrapped in surface crevices and pores will become sites for process blisters if alkaline cleaner concentrations are not reduced to very low levels by agitated cold water rinsing. Rinse water containing a high concentration of dissolved minerals should be avoided.

10.4 Electrocleaning may not be required for the application of conversion coatings.

11. Acid Dipping and Rinsing

11.1 An acid dip must follow alkaline cleaning, to remove zinc oxidation products and trace amounts of alkaline compounds carried over from the cleaning operations due to the inadequate rinsing. The strength must be adjusted to the time of immersion. A solution containing 0.25 to 0.75 % by weight of sulfuric acid is frequently used for time cycles of 25 to 45 s, at room temperature. A solution of citric acid is a safe alternative. All acids used should be removed by thorough rinsing before electroplating or applying a conversion coating. Excessive exposure to stronger acid solutions can cause etching and dissolution of the metal.

11.2 The acid dip should remove all traces of black films or loosely adherent smut. For die castings prone to smut, including alloys containing more than about 0.25 % copper, the acid solution can be ultrasonically agitated; this effectively prevents the retention of smut on the surface.

11.3 A succession of two agitated overflow rinses and a water spray rinse is suggested after acid dipping. A final water rinse should use deionized spray water, which can be recycled for use in an initial rinsing stage. Acid solution must be completely removed from crevices and pores, to avoid blisters that may otherwise occur during or soon after plating. Crevices and pores in grooves and other surface indentations are common sites for process blisters if rinsing after acid dipping is incomplete.

11.4 Electrocleaning may not be required for the application of conversion coatings.

12. Copper Striking

12.1 A copper strike applied in a cyanide copper solution is normally the first plating step for all die castings to be electroplated with nickel and chromium. The thickness of the strike should be at least 1.0 μm for die castings that will be

subsequently plated with bright copper in high-temperature cyanide solutions and at least 5.0 μm for die castings that will be plated with nickel after copper striking. A thickness of 3.0 to 4.0 μm is recommended for die castings that will be subsequently electroplated with bright, leveling copper in copper sulfate-sulfuric acid solutions.

12.2 Solutions containing 20 to 25 g/L of copper cyanide, 10 to 20 g/L of free sodium cyanide, and 15 to 75 g/L of sodium carbonate are customary for strike solutions. A few formulations include the molar equivalents of potassium cyanide in place of sodium cyanide. Others contain 3.8 to 7.5 g/L of sodium hydroxide in addition to the major constituents. In many of the formulations, use is made of addition agents that reduce hexavalent chromium, aid in anode corrosion, and refine the grain structure. Cathode current densities normally range from 2.7 to 6.5 A/dm² and solution temperatures from 50 to 57°C. Cyanide solutions containing a higher concentration of copper cyanide and operated at a higher temperature should be avoided because of the danger of blister formation.

12.3 The average cathode current density must be balanced with the free sodium cyanide and the temperature of the solution to prevent burning at edges and other high-current-density areas. With an average cathode current density of 2.7 A/dm², the cathode current efficiency varies from 30 to 60 % for strike plating. A high temperature, a high copper cyanide concentration, and a low-free cyanide concentration, within the limits given in 12.2, favor high efficiency. Ultrasonic agitation has been proposed for increasing cathode efficiency, the covering power in recessed areas, and improving the density of the copper deposit. Ultrasonic agitation has been reported as an important condition for copper striking in cyanide-free solutions prepared with potassium pyrophosphate, copper pyrophosphate and potassium citrate, prior to bright copper plating in acid sulfate solutions.⁵

12.4 High-purity copper anodes are recommended for copper cyanide strike solutions. Solutions should be continuously filtered to avoid the inclusion of small particles that nucleate nodules during subsequent plating operations.

⁵ Safranek, W. H., and Miller, H. R., "Copper Plating on Zinc Die Castings," *Plating*, 1968, pp. 233–237.

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