Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

# AEROSPACE MATERIAL SPECIFICATION

AMS 2402F
Superseding AMS 2402E
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## ZINC PLATING

1. SCOPE:

1.1 Purpose: This specification covers the engineering requirements for electrodeposition of zinc and the properties of the deposit.

1.2 Application: Primarily to provide corrosion resistance to metal parts.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM B117 - Salt Spray (Fog) Testing
ASTM B487 - Measurement of Metal and Oxide Coating Thicknesses by Microscopical Examination of a Cross Section
ASTM B499 - Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals
ASTM B504 - Measurement of the Thickness of Metallic Coatings by the Coulometric Method
ASTM E290 - Semi-Guided Bend Test for Ductility of Metallic Materials

2.3 Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Standards:

MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing Of

3. TECHNICAL REQUIREMENTS:

3.1 Preparation:

3.1.1 All forming, machining, heat treating, brazing, and welding shall be completed before parts are plated.

3.1.2 Parts shall be within drawing dimension limits before plating, except as specified in 3.1.2.1.

3.1.2.1 Undercutting before plating shall not be permitted unless specifically authorized by specifications referenced on the applicable drawing.

3.1.3 Parts having hardness higher than 40 HRC and which have been ground after heat treatment shall be suitably stress-relieved before cleaning for plating, unless otherwise specified. Temperatures to which parts are heated shall be such that maximum stress relief is obtained without reducing hardness of parts below drawing limits.

3.1.4 Residual compressive stress-inducing operations such as shot peening shall follow stress relieving.

3.1.5 Parts shall have chemically clean surfaces, prepared with minimum abrasion, erosion, or pitting, prior to immersion in the plating solution.

3.1.6 Parts having hardness of 33 HRC or higher and parts roll-threaded after heat treatment shall not be cleaned with hydrochloric or sulfuric acids, unless specifically approved. Cleaning of other parts with inorganic acids is not prohibited but permission to use such method on a particular part shall first be obtained from purchaser. In either case, a momentary dip in acid after alkaline cleaning is permissible.

3.1.7 Electrical contacts between the parts and power source shall be made in such a manner as will ensure that neither chemical or immersion deposition nor electrical arcing or overheating will occur. If parts are to be plated all over, contact points shall be located where specified or where agreed upon by purchaser and vendor. If parts are not required to be plated all over, contact points shall be located in areas on which plating is not required or is optional.

3.2 Procedure:

3.2.1 Parts shall be plated by electrodeposition of zinc from a zinc cyanide solution. The zinc shall be deposited directly on the metal part, without a prior flash coating of other metal, such as copper or nickel underneath, except in the case of parts, assemblies, and weldments made wholly or in part of corrosion-resistant steel or similarly inactive materials, on which a preliminary flash of nickel or other suitable metal is permissible.

3.2.2 The plated parts shall be removed from the plating solution, thoroughly rinsed, and dried.

3.3 Post Treatment:

3.3.1 After plating, rinsing, and drying, steel parts shall be post treated as in 3.3.1.1, 3.3.1.2, 3.3.1.3, or 3.3.1.4, as applicable, unless otherwise permitted, to minimize the effects of hydrogen embrittlement; heating shall be in air, preferably in a circulating air furnace:

3.3.1.1 Springs and other parts having hardness of 45 HRC or higher shall be heated to 450°F ± 15 (230°C ± 8) and held at heat for not less than 2 hours.

3.3.1.2 Parts, including roll-threaded parts, cold worked after being heat treated by hardening and tempering; parts having hardness of 33 HRC - 45 HRC; and springs and other parts having hardness of 45 HRC or higher which will decrease in hardness or be otherwise deleteriously affected by heating to 450°F (230°C) shall be heated to 375°F ± 15 (190°C ± 8) and held at heat for not less than 3 hours.

3.3.1.3 Parts and assemblies, including carburized parts, which will decrease in hardness or be otherwise deleteriously affected by heating to 375°F (190°C) shall be heated to 275°F ± 15 (135°C ± 8) and held at heat for not less than 5 hours.

3.3.1.4 Parts requiring special handling shall be post treated as agreed upon by purchaser and vendor.

3.3.2 Zinc plated parts, after the embrittlement relief treatment, shall, unless otherwise specified, be treated by a process which has been demonstrated to prevent formation of white corrosion products after 100-hr salt spray test in accordance with the procedure specified in 3.4.3.

3.4 Properties:

3.4.1 Thickness: Shall be as specified on the drawing, determined on representative parts or test panels in accordance with ASTM B487, ASTM B499, ASTM B504, the drop test of 3.4.1.5, or other suitable methods agreed upon by purchaser and vendor. When thickness is determined by the drop test method, plating shall not be perforated in less time than specified in Table I.

3.4.1.1 Plate thickness may be specified by AMS 2402 and a suffix number normally designating the minimum thickness in ten-thousandths of an inch; except as indicated in Table I, the maximum plate thickness shall be 0.0002 in. (5 μm) greater than the minimum. Thus, AMS 2402-2 designates a thickness of 0.0002 - 0.0004 in. (5 - 10 μm) and AMS 2402-6 designates a thickness of 0.0006 - 0.0008 in. (15 - 20 μm).

3.4.1.1.1 Plate thickness, when specified by AMS 2402 and a suffix number, shall be as specified in Table I for the specified suffix number and type of part or surface.

3.4.1.2 Where "zinc flash" is specified, plate thickness shall be approximately 0.0001 in. (2.5 μm).

3.4.1.3 The plate shall be substantially uniform in thickness on significant surfaces except that slight build-up on exterior corners or edges will be permitted provided finished drawing dimensions are met.

3.4.1.4 No requirements are established for minimum plate thickness for surfaces of holes, recesses, internal threads except as specified in Table I, contact areas of parts plated all over, and other areas where a controlled deposit cannot be obtained under normal plating conditions but such areas shall not be masked to prevent plating. Except as specified in Table I for externally threaded sections, the resulting thickness shall be considered only when such surfaces of parts can be touched by a sphere 0.75 in. (19 mm) in diameter.

3.4.1.4.1 If internal surfaces as defined in 3.4.1.4 are required to be plated to a specified thickness, notes on the drawing will so specify.

3.4.1.5 Drop Test for Thickness Determination: Allow an aqueous solution of 200 g of chromic acid and 27 mL of sulfuric acid (sp gr 1.84) per litre to drop at a uniform rate of 100 drops ± 5 per min. directly upon properly cleaned surfaces of parts until the basis metal is exposed. The solution shall be maintained at a temperature within the range 70° - 80°F (21° - 26°C). The dripping apparatus may be a laboratory separatory funnel equipped with a stopcock to regulate solution flow. The discharge orifice of the outlet tube shall be constructed to deliver drops of 0.045 - 0.055 mL each. The surface to be tested shall be supported at an angle of 45 deg ± 5 to the horizontal and placed approximately 7/8 in. (20 mm) below the discharge orifice.

3.4.2 Adhesion: Specimens as in 4.3.3 shall not show separation of the plating from the basis metal, when examined at approximately 4X magnification, after being bent rapidly, in accordance with ASTM E290, through an angle of 180 deg around a diameter equal to the thickness of the specimen. Formation of cracks which do not result in flaking or blistering of the plating is acceptable.

3.4.3 Corrosion Resistance: Except as specified in 3.4.3.1, ferrous metal parts or representative specimens as in 4.3.3 shall show no visual evidence of corrosion of the basis metal after being subjected for a time not less than specified in Table I to continuous salt spray corrosion test conducted in accordance with ASTM B117.

3.4.3.1 Salt spray corrosion tests shall not apply to plated parts made of austenitic corrosion-resistant steels, to parts made of any corrosion-resistant steel or alloy when not plated all over, and to parts made of any steel when thickness is specified as "flash".

3.5 Quality: Plated zinc shall be smooth, continuous, adherent to basis metal, uniform in appearance, and not coarsely crystalline and shall be essentially free from pin holes, porosity, blisters, nodules, pits, and other imperfections detrimental to performance of parts. Slight staining or discoloration is permissible. Standards for acceptance shall be as agreed upon by purchaser and vendor.

3.5.1 Double plating and spotting-in after plating are not permitted, unless otherwise specified.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The processing vendor shall supply all samples and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.5. Purchaser reserves the right to perform such confirmatory testing as he deems necessary to ensure that processing conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to thickness (3.4.1) and quality (3.5) requirements are classified as acceptance tests.

4.2.2 Periodic Tests: Tests to determine conformance to adhesion (3.4.2) and corrosion-resistance (3.4.3) requirements and of cleaning and plating solutions to ensure that the deposited metal will conform to the requirements of this specification are classified as periodic tests.

4.2.3 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests.

4.2.3.1 For direct U.S. Military procurement, substantiating test data and, when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, the contracting officer, or the request for procurement.

4.3 Sampling: Shall be not less than the following:

4.3.1 Acceptance Tests:

4.3.1.1 Thickness: Three parts for each consecutive 8 hr of operation of the same set of solutions, except as specified in 4.3.3.

4.3.1.2 Quality: As agreed upon by purchaser and vendor.

4.3.2 Periodic Tests and Preproduction Tests: As agreed upon by purchaser and vendor.

4.3.3 When plated parts are of such configuration or size as to be not readily adaptable to the specified tests, separate test specimens cleaned, plated, and post-treated with the parts represented may be used. For adhesion tests, such specimens shall be panels of annealed low-carbon steel approximately 0.032 x 4 x 1 in. (1 x 100 x 25 mm) and for thickness and quality tests shall be panels of the same size and type or shall be bars approximately 0.5 in. (10 mm) in diameter and 4 in. (100 mm) long. For corrosion resistance tests, specimens shall be panels 0.062 - 0.125 in. (1.5 - 3 mm) in nominal thickness and not less than 4 in. (100 mm) long by 3 in. (75 mm) wide.

4.4 Approval:

4.4.1 Plated parts shall be approved by purchaser before parts for production use are supplied, unless such approval be waived. Results of tests on production parts shall be essentially equivalent to those on the approved sample parts.

4.4.2 Vendor shall use manufacturing procedures, processes, and methods of inspection on production parts which are essentially the same as those used on the approved sample parts. If any change is necessary in type of equipment or in established composition limits and operating conditions of process solutions, vendor shall submit for reapproval of the process a statement of the proposed changes in processing and, when requested, sample plated parts, test panels, or both. Production parts plated by the revised procedure shall not be shipped prior to receipt of reapproval.

4.5 Reports: The vendor of plated parts shall furnish with each shipment three copies of a report stating that the parts have been processed and tested in accordance with the requirements of this specification and that they conform to the acceptance test requirements. This report shall include the purchase order number, this specification number and its revision letter, part number, and quantity.

4.6 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, disposition of the parts may be based on the results of testing three additional specimens for each original nonconforming specimen. Except as specified in 4.6.1, failure of any retest specimen to meet the specified requirements shall be cause for rejection of the parts represented and no additional testing shall be permitted. Results of all tests shall be reported.

4.6.1 If any part fails to meet the specified requirements, either on the original sampling as in 4.3 or upon resampling as in 4.6, the parts in that lot may be stripped by a method approved by purchaser which does not roughen, pit, or embrittle the basis metal, replated, post-treated, and retested.

5. PREPARATION FOR DELIVERY:

5.1 Parts shall be handled and packaged in such a manner as will ensure that the required physical characteristics and properties of the plating are preserved.

5.2 Packages of parts shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the plated parts to ensure carrier acceptance and safe delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

5.3 For direct U.S. Military procurement, packaging shall be in accordance with MIL-STD-794, Level A or Level C, as specified in the request for procurement. Commercial packaging as in 5.1 and 5.2 will be acceptable if it meets the requirements of Level C.

6. ACKNOWLEDGMENT: A vendor shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders.

7. REJECTIONS: Parts on which the plating does not conform to this specification or to authorized modifications will be subject to rejection.

8. NOTES:

8.1 Marginal Indicia: The phi (Ø) symbol is used to indicate technical changes from the previous issue of this specification.

8.2 For direct U.S. Military procurement, purchase documents should specify not less than the following:

Title, number, and date of this specification
Plate thickness desired
Quantity of pieces to be plated
Quality standards
Applicable level of packaging (See 5.3)

8.3 Similar Specifications:

8.3.1 This specification exceeds the minimum requirements of Federal QQ-Z-325B, Type II, Class 2, Amendment 3, dated 28 November 1972.

8.3.2 Federal QQ-Z-325 is listed for information only and shall not be construed as an acceptable alternate unless all requirements of this AMS are met.