

AEROSPACE MATERIAL SPECIFICATIONS

AMS 2401

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Issued 7-15-63
Revised

CADMIUM PLATING Low Hydrogen Content Deposit

1. ACKNOWLEDGMENT: A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.
2. APPLICATION: To provide corrosion resistance to steel parts, primarily those heat treated to tensile strengths of 180,000 psi and higher and used at temperatures not higher than 450 F (230 C). For plating of other basis metals and of steels which are carburized or are heat treated to lower strength levels, AMS 2400 should be specified.
3. PREPARATION:
 - 3.1 All brazing or welding or both shall be completed before parts are plated.
 - 3.2 Parts shall be stress relieved before plating if they have been subjected to any of the following operations after heat treatment: machining, grinding, straightening or other cold deformation (except residual compressive stress-inducing operations such as shot peening), and proof testing. Parts stress relieved before application of a prior plate such as chromium or nickel shall not be stress relieved again unless they have, following such plating, been subjected to any of the operations listed above. Temperatures to which parts are heated and time of heating shall be such that maximum stress-relief is obtained without reducing hardness of parts below that specified on the drawing.
 - 3.3 Any residual compressive stress-inducing operation such as shot peening shall follow stress-relieving.
 - 3.4 Unless otherwise specified, parts shall be within limits specified on the drawing before plating, except as specified in 3.4.1.
 - 3.4.1 All engine and propeller utility parts having part numbers with the prefix MS or AS and required to be plated in accordance with this specification shall be made to such dimensions that parts will be within drawing limits after plating. Undercutting before plating shall not be permitted unless specifically authorized by specifications referenced on drawing.
 - 3.5 Before placing parts in the plating solution, they shall have chemically clean surfaces prepared with minimum erosion, pitting, or unintended abrasion. Parts shall not be cleaned with inorganic acids (hydrochloric or sulfuric) unless specifically approved. If parts are cleaned by abrasive blasting, blasting with dry abrasive is preferred.

Section 8.3 of the SAE Technical Board rules provides that: "All technical reports, including standards approved and practices recommended, are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no obligation to conform to or be guided by any technical report, in formulating and approving technical reports, the Board and its Committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against liability for infringement of patents."

3.5.1 Following cleaning, parts shall be immersed in an alkaline cyanide solution until transferred, after rinsing but without drying, to the plating solution. Parts cleaned by abrasive blasting shall be agitated in the solution to remove residual abrasive. Parts may be held in the solution for up to 4 hr before being transferred to the plating solution.

4. PROCEDURE:

4.1 The plating process consists of electrodeposition of cadmium from a cadmium cyanide, cadmium fluoborate, or cadmium sulfamate solution. The cadmium shall be deposited directly on the basis metal, 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, on which a preliminary flash of nickel or other suitable metal is permissible.

4.1.1 If parts require plating to two thicknesses in different areas and thickness of the thinner plate is not greater than 0.0005 in., parts shall be plated to the thinner requirement and areas on which this thickness is required shall be masked. Parts shall then be anodically cleaned in alkaline cleaning solution, rinsed, and plated to the greater plate thickness.

4.2 Post Plate Treatment: Unless otherwise specified on the drawing, parts, before heating as in 4.3, shall be dipped with agitation in a 3 - 5% solution of chromic acid. After a chromic acid dip, parts shall be given a final rinse.

4.3 After rinsing plated and treated parts in water, the parts should be immersed in hot water at a temperature not lower than 180 F (82 C) for approximately 15 min. and shall then be treated as follows; heating shall be in air, preferably in a circulating air furnace.

4.3.1 Parts heat treated to minimum tensile strength of 220,000 psi or higher but not higher than 260,000 psi and all externally threaded parts heat treated to minimum tensile strength of 180,000 psi or higher but not higher than 260,000 psi shall be heated at $375\text{ F} \pm 10$ ($190.6\text{ C} \pm 5.6$) for 23 hours.

4.3.2 Parts, other than externally threaded parts, heat treated to minimum tensile strength of 180,000 psi or higher but not higher than 220,000 psi shall be heated at $375\text{ F} \pm 10$ ($190.6\text{ C} \pm 5.6$) for 8 hours.

4.3.3 Parts heat treated to minimum tensile strength of over 260,000 psi shall be treated as agreed upon by purchaser and vendor.

4.4 Parts rejected for defective plating shall be stripped in 10% ammonium nitrate solution before replating. Double plating except as specified in 4.1.1 and spotting-in after plating shall be causes for rejection. Parts which have been stripped shall be heated at not lower than 375 F (190 C) for not less than 4 hr after stripping and before recleaning for plating.

5. THICKNESS: Thickness of cadmium plate shall be as specified in Table I except as specified in 5.1 and 5.2. When plate thickness is specified by AMS 2401 and a suffix number, the suffix number will normally designate the minimum thickness in ten-thousandths of an inch; the maximum thickness shall be 0.0002 in. greater than the minimum, unless otherwise specified. Thus, AMS 2401-1 designates a thickness of 0.0001 - 0.0003 in., AMS 2401-6 designates a thickness of 0.0006 - 0.0008 in., etc.
- 5.1 No requirements are established for minimum thickness of plate for holes, recesses, 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. in diameter unless otherwise noted on drawings.
- 5.1.1 If internal surfaces as defined in 5.1 are required to be plated to a specified thickness, notes on the drawing will so specify.
- 5.2 Where cadmium flash is specified, the thickness of cadmium shall be approximately 0.0001 inch.
6. THICKNESS DETERMINATION: Thickness of plate, shall be determined by one of the following methods, as applicable, on representative parts or on separate specimens representing parts and plated simultaneously with them.
- 6.1 When possible, thickness shall be determined on plated parts by the drop test method. The drop test method consists of allowing an aqueous solution containing 200 g of chromic acid and 27 ml of sulfuric acid (sp gr 1.84) per liter at a temperature of 70 - 80 F (21.1 C - 26.7 C) to drop at a uniform rate of 100 drops \pm 5 per min. directly upon properly cleaned surfaces of plated parts until the basis metal is exposed. The dropping apparatus may be a 250 ml laboratory separatory funnel equipped with a stopcock to regulate the solution flow and having the discharge orifice of the outlet tube constricted to deliver drops approximately 0.05 ml each. Plated parts shall be supported so that the surface to be tested is at an angle of 45 deg from the horizontal and about 7/8 in. below the discharge orifice. Plating which meets specified thickness requirements shall not be perforated in less than the time specified in Table I.
- 6.2 When plated parts are of such form that they are not adaptable to determination of plate thickness by the drop test method, thickness may be determined, by drop test or micrometer measurement, on steel strip specimens approximately 1/32 x 1 x 4 in. in the case of still plating, or on cylindrical specimens with cross-sectional areas approximately equal to those of the parts in the case of barrel plating, which are processed simultaneously with the parts through the complete cleaning and plating cycle.
- 6.3 Magnetic methods or other methods may be used for determining plate thickness if the results are dependably accurate.
- 6.4 The strip test method using ammonium nitrate as the stripping agent may be used for determining the plate thickness.

7. QUALITY:

- 7.1 Plated cadmium shall be smooth, continuous, adherent, uniform in appearance, and not coarsely crystalline, and shall be free from pin holes, porosity, blisters, nodules, pits, and other harmful imperfections. Slight staining or discoloration will not be cause for rejection.
- 7.2 The salt spray corrosion resistance of the plate may be determined by subjecting representative plated parts or test panels representing parts to continuous salt spray corrosion test conducted in accordance with the issue of ASTM B117 listed in the latest issue of AMS 2350. Plate shall be capable of withstanding salt spray for the minimum time specified in Table I for the respective thicknesses or thickness designations, without definite rusting, pitting, or other visible damage to the basis metal. Slight stain or discoloration which readily washes off without damage to the plate, when scrubbed with a cloth or bristle brush, is permissible. Salt spray corrosion test shall be applicable only to parts when thickness is specified as other than "flash."
- 7.3 Steel strip specimens approximately $1/32 \times 1 \times 4$ in., when cleaned and plated simultaneously with parts, shall withstand rapid bending at room temperature through an angle of 180 deg around a diameter equal to the thickness of the specimen, without showing separation from the basis metal at the interface when examined at approximately 4 diameters magnification. The formation of cracks which do not result in flaking or blistering of the plate shall not be considered as non-conformance to this requirement. Specimens may be the same ones used for determination of thickness.
- 7.4 Room Temperature Notched Stress-Rupture Test: Notched tensile test specimens of the same material as the parts, heat treated to the same strength level as the parts, and completely processed with the parts, shall be capable of withstanding for 200 hr without rupture a stress of 75% of the tensile strength of duplicate unprocessed specimens.
- 7.4.1 For qualification of new or revised plating procedures, specimens shall be made of AMS 6415 heat treated to tensile strength of 260,000 - 280,000 psi. Specimens shall have 60 deg V-notch with area at root of Vee approximately equal to half the area of the full section of specimen and 0.005 in. \pm 0.0005 radius of curvature at base of notch, shall be stress relieved as specified in 3.2, plated to plate thickness not lower than 0.0005 in., dipped in chromic acid as in 4.2, and heated as in 4.3.

8. APPROVAL:

- 8.1 To assure adequate performance characteristics, plated parts shall be approved by purchaser before parts for production use are supplied, unless such approval be waived.
- 8.2 Vendor shall use the same manufacturing procedures, processes, and methods of inspection for conformance to this specification for production parts as for approved sample parts. If necessary to make any change in processing which could unfavorably affect any characteristics of the deposit, vendor shall obtain written permission from purchaser prior to incorporating such change.
9. REJECTIONS: Parts on which plating does not conform to this specification or to authorized modifications will be subject to rejection.