

CADMIUM-TITANIUM PLATING
1. SCOPE:

- 1.1 **Purpose:** This specification covers the engineering requirements for electrodeposition of cadmium-titanium on metal parts and the properties of the deposit.
- 1.2 **Application:** Primarily to provide corrosion resistance to steel parts heat treated to tensile strength of 180,000 psi (1241 MPa) and higher, used at not higher than 450°F (230°C), and requiring essential freedom from hydrogen embrittlement.

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 Thickness of Metallic Coatings by the Coulometric Method

ASTM E290 - Semi-Guided Bend Test for Ductility of Metallic Materials

ASTM E376 - Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Test Methods

ASTM F519 - Hydrogen Embrittlement Testing of Aerospace 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.

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- 3.1.2 Parts shall be stress relieved before plating if they have been subjected to any of the following operations after heat treatment: machining, grinding, proof testing, straightening, or other cold deformation (except residual compressive stress-inducing operations, such as shot peening). Parts stress relieved before application of a prior plate, such as chromium or nickel, shall not be stress relieved again unless, following such plating, they have 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 mechanical properties of parts below those specified on the applicable drawing.
- 3.1.3 Residual compressive stress-inducing operations such as shot peening, if specified, shall follow stress relieving.
- 3.1.4 Parts shall be within dimensional limits specified on the drawing before plating, except as specified in 3.1.4.1.
- 3.1.4.1 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 the applicable drawing.
- 3.1.5 Parts shall have chemically clean surfaces prepared with minimum erosion, pitting, or abrasion prior to immersion in the plating solution. Except as provided in 3.1.5.1, parts shall not be cleaned with inorganic acids (hydrochloric, nitric, or sulfuric) unless approved by purchaser. If parts are cleaned by abrasive blasting, dry alumina or silica should be used. Parts heat treated to minimum tensile strength of 180,000 psi (1241 MPa) or higher shall be cleaned only by solvent degreasing and abrasive blasting with size 100 - 180 alumina or silica grit.
- 3.1.5.1 Following cleaning, parts shall be immersed in an alkaline cyanide solution until transferred, after rinsing in clean water but without drying, to the plating solution. Abrasively cleaned parts shall be agitated in the alkaline solution to remove residual abrasive. Parts may be held in the solution for not more than 4 hr before being transferred to the plating solution. An immersion for not more than 30 sec in a 2 - 4% by volume hydrochloric or fluoboric acid solution followed by thorough rinsing may be used as an activation dip prior to transferring parts into the plating solution. Parts so treated are not required to be immersed in a cyanide holding bath providing delays are not experienced.
- 3.1.6 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. For parts to be plated all over, contact points, except in case of barrel plating, shall be located where specified or where agreed upon by purchaser and vendor. For parts 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: Parts shall be plated by electrodeposition of a cadmium-titanium alloy containing approximately 0.1 - 0.5% by weight titanium from a cadmium-titanium cyanide solution. The cadmium-titanium alloy shall be deposited directly on the basis metal without a 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 steels or similarly inactive metals, on which a preliminary flash of nickel or other suitable metal is permissible. Brightening additives shall not be used in the plating bath.

3.3 Post Treatment:

- 3.3.1 After plating, parts heat treated to specified minimum tensile strength of 150,000 psi (1034 MPa) or higher shall be rinsed in water at room temperature, immersed and agitated in a bath containing
 ∅ 1 - 5% chromic acid for approximately 1 min., rinsed in hot water at not lower than 180°F (82°C) for not less than 10 min., air dried, and baked at 375°F ± 25 (190°C ± 15) for not less than the following time:

Specified Minimum Tensile Strength		Time, hr
psi	(MPa)	
150,000 to 180,000, excl	(1034 to 1241, excl)	3
180,000 to 200,000, excl	(1241 to 1379, excl)	6
200,000 to 220,000, excl	(1379 to 1517, excl)	8
220,000 and over	(1517 and over)	23

- 3.3.1.1 After baking, parts shall be placed in a chromating bath for sufficient time to deposit approximately 40 mg per sq ft (430 mg/m²) of chromate, rinsed in water not hotter than 160°F (70°C) for 1/2 - 2 min., and air dried.
- 3.3.1.2 Magnetic particle inspection shall be conducted subsequent to bake but prior to chromate supplementary treatment.
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- 3.3.2 Parts heat treated to tensile strengths below 150,000 psi (1034 MPa) shall be rinsed in water at room temperature, immersed in a chromating bath, rinsed, and air dried, as described in 3.3.1.1.
- 3.3.2.1 Magnetic particle inspection, if required, shall be conducted prior to chromate supplementary treatment.
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3.4 Properties: The deposited plating shall conform to the following requirements:

- 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, ASTM E376 or other method agreed upon by purchaser and vendor.
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- 3.4.1.1 Plate thickness may be specified by AMS 2419 and a suffix number normally designating the minimum thickness in ten-thousandths of an inch (2.5 μm); except as indicated in Table I, the maximum plate thickness shall be 0.0002 in. (5 μm) greater than the minimum. Thus, AMS 2419-2 designates a thickness of 0.0002 - 0.0004 in. (5 - 10 μm) and AMS 2419-6 designates a thickness of 0.0006 - 0.0008 in. (15 - 20 μm).
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- 3.4.1.1.1 Plate thickness, when specified by AMS 2419 and a suffix number, shall be as specified in Table I for the specified suffix number and type of part or surface.
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- 3.4.1.2 Where "cadmium-titanium 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.
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- 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 parts, the resultant thickness shall be considered only when such surfaces can be touched by a sphere 0.75 in. (19 mm) in diameter.
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- 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.
- 3.4.2 Composition: Samples of the deposit, when analyzed by a method capable of quantitatively determining titanium with 100 ppm accuracy, shall contain not less than 0.10% titanium by weight.
- 3.4.3 Adhesion: Specimens as in 3.4.4 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 nominal thickness of the specimen. Formation of cracks which do not result in flaking or blistering of the plating is acceptable.
- 3.4.4 Corrosion Resistance: Except as specified in 3.4.4.1, ferrous metal parts or representative test panels 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.
- 3.4.4.1 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."
- 3.4.5 Hydrogen Embrittlement: The plating shall be non-embrittling, determined in accordance with ASTM F519 except that, when approved by purchaser, a suitable electronic meter or gauge may be used.
- 3.5 Quality: Plated cadmium-titanium alloy shall be smooth, continuous, adherent to basis metal, uniform in appearance, and essentially free from pin holes, porosity, blisters, nodules, pits, and other imperfections detrimental to performance of the plated parts. Slight staining or discoloration is permissible. Standards for acceptance shall be as agreed upon by purchaser and vendor.
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 the processing conforms to the requirements of this specification.
- 4.2 Classification of Tests:
- 4.2.1 Acceptance Tests: Tests to determine conformance to requirements for thickness (3.4.1), adhesion (3.4.3), and quality (3.5) are classified as acceptance tests and shall be performed on each lot.
- 4.2.2 Periodic Tests: Tests to determine conformance to requirements for composition (3.4.2), corrosion resistance (3.4.4), and hydrogen embrittlement (3.4.5) 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 and shall be performed at a frequency selected by the plating processor unless frequency of testing is specified by purchaser.
- 4.2.3 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests and shall be performed on the initial shipment of plated parts to a purchaser, when a change in bath composition or in processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.
- 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; a lot shall be all parts of one size and shape plated in one bath to the same specified coating thickness range(s) within one 24-hr period and submitted for vendor's inspection at one time.

4.3.1 Acceptance Tests:

4.3.1.1 Thickness and Adhesion: Three parts for each requirement for each 8 hr of operation of the same set of solutions, except as specified in 4.3.4.

4.3.1.2 Quality: As agreed upon by purchaser and vendor.

4.3.2 Periodic Tests: As agreed upon by purchaser and vendor and as follows:

4.3.2.1 For sustained load hydrogen embrittlement control, three specimens in accordance with ASTM F519 and as approved by purchaser.

4.3.2.2 For hydrogen embrittlement control using an electronic meter or gage, sampling shall be as approved by purchaser.

4.3.3 Preproduction Tests: As agreed upon by purchaser and vendor and as follows:

4.3.3.1 For preproduction tests of new or revised plating procedures, ASTM F519.

4.3.4 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 they represent may be used. For adhesion tests, such specimens shall be panels of annealed, low-carbon steel approximately 0.032 x 1 x 4 in. (1 x 25 x 100 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 3 in. (75 mm) wide by 4 in. (100 mm) long.

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 in an aqueous solution of 9 - 11% ammonium nitrate, baked at 375° F ± 10 (190°C ± 5) for not less than 4 hr, replated, post-treated, and retested.