AEROSPACE MATERIAL SPECIFICATION

AMS2419	REV. D

Issued 1966-03
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Revised 2015-01

Superseding AMS2419C

(R) Plating, Cadmium-Titanium

RATIONALE

AMS2419D results from a Five Year Review and update of this specification.

NOTICE

ORDERING INFORMATION: The following information shall be provided to the plating processor by the purchaser.

1. Purchase order shall specify not less than the following:

   - AMS2419D
   - Plating thickness desired (See 3.6.1)
   - Basis metal to be plated
   - Tensile strength or hardness of the basis metal
   - Preplate stress relief to be performed by plating processor (time and temperature) if different from 3.3.2
   - Special features, geometry or processing present on parts that requires special attention by the plating processor
   - Hydrogen embrittlement relief to be performed by plating processor (parameters or reference document) if different from 3.6.4
   - Quantity of pieces to be plated

2. Parts manufacturing operations such as heat treating, forming, joining and media finishing can affect the condition of the substrate for plating, or, if performed after plating, could adversely affect the plated part. The sequencing of these types of operations should be specified by the cognizant engineering organization or purchaser and is not controlled by this specification.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS2419D

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

This process has been used typically to provide corrosion resistance to high strength steel for use in fracture critical applications such as aircraft landing gear and naval arrestor hooks at temperatures below 450 °F (232 °C) by limiting the generation of hydrogen and potential hydrogen embrittlement, but usage is not limited to such applications.

1.3 Safety-Hazardous Materials

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

1.4 WARNING

This document includes cadmium as a plating material. The use of cadmium has been restricted and/or banned for use in many countries due to environmental and health concerns. The user should consult with local officials on applicable health and environmental regulations regarding its use.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA, www.sae.org.

AMS2750 Pyrometry

AMS2759/9 Hydrogen Embrittlement Relief (Baking) of Steel Parts

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM B117 Operating Salt Spray (Fog) Apparatus

ASTM B253 Preparation of Aluminum Alloys for Electroplating

ASTM B487 Measurement and Oxide Coating Thicknesses by Microscopical Examination of Cross Section

ASTM B499 Measurement of Coating Thicknesses by the Magnetic Method; Nonmagnetic Coating on Magnetic Basis Metals

ASTM B504 Measurement of Thickness of Metallic Coatings by the Coulometric Method

ASTM B567 Measurement of Coating Thickness by the Beta Backscatter Method

ASTM B568 Measurement of Coating Thickness by X-Ray Spectrometry

ASTM B571 Qualitative Adhesion Testing of Metallic Coatings

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

ASTM F326 Electronic Measurement for Hydrogen Embrittlement From Cadmium-Electroplating Processes

ASTM F519 Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments

3. TECHNICAL REQUIREMENTS

3.1 Materials

Materials used in plating cadmium-titanium are as follows:

Cadmium ball anodes
Cadmium oxide
Sodium cyanide
Sodium hydroxide
Titanium additive compound
Hydrogen Peroxide-35% Technical Grade
Filter Aid, Diatomaceous

3.2 Equipment

3.2.1 The rectifier shall be either generated or rectified DC current. Ripple value shall not exceed 10% as measured by dividing the Root Mean Square of the AC voltage component by the DC voltage (See 8.10).

3.2.2 Tanks shall be resistant to the operating temperature and the chemical environment.

3.2.2.1 The cadmium plating tanks shall be of 300 series stainless steel, carbon steel with a rigid PVC lining, or other suitable non-metallic material which has been determined to be compatible with cadmium-titanium plating solutions.

3.2.3 The plating tanks to be operated at the temperatures other than room temperature shall be equipped with automatic temperature indicating and regulating devices.

3.2.4 An ammeter shall be placed in series with the cadmium-titanium tank cathode. The ammeter shall have sufficient shunts and switches to provide a full-scale reading equal to the maximum capacity of the power source, and an accuracy of ±10% of the current being measured.

3.2.5 If conventional ball anodes are used, carriers may be made of either titanium or stainless steel. Cadmium bar anodes may be used if they are cast with no central steel spline and titanium or stainless steel hooks are used. Auxiliary or internal anodes must be of cadmium or 300 series stainless steel.

3.2.6 This process requires a continuously filtered bath. The filter (See 8.8) must be of a type that permits introduction of the titanium paste mixture on the filter cloth. The filter must have a plate area of 40 to 120 square feet per 1000 gallons (0.98 to 2.95 m^2/kL) of plating solution. The filtration equipment must be 300 series stainless steel or have an approved type of lining such as rigid PVC or other unplasticized material. The filter cloth material should be of a high-grade chemical resistant fabric. Cotton cannot be used in this system. In addition, hydrogen peroxide additions are required (See 8.7 and 8.8).

3.2.7 A blast cabinet shall be located near the plating line and be encapsulated. The size of the cabinet shall be adequate to enclose the parts to be plated. Air lines shall be suitably trapped and filtered to prevent in-process contamination of the parts to be cleaned.

3.2.8 An oven conforming to AMS2750 for embrittlement relief shall be located near the plating line.

3.3 Preparation

3.3.1 Unless otherwise specified parts shall be within drawing dimension limits before plating. All machining, forming, welding and shot peening shall be completed prior to plating.

3.3.2 Stress Relief Treatment

3.3.2.1 All steel parts having a hardness of 40 HRC and above and that are machined, ground, cold formed or cold straightened after heat treatment shall be cleaned to remove surface contamination and thermally stress relieved before plating. (Residual tensile stresses have been found to be damaging during electroplating.) Furnaces used for stress relief shall be controlled per AMS2750; the minimum requirements shall be Class 5, with Type D Instrumentation. Temperatures to which parts are heated shall be such that stress relief is obtained while still maintaining hardness of parts within drawing limits. Unless otherwise specified, the following treatment temperatures and times shall be used:

3.3.2.1.1 For parts, excluding nitrided parts, having a hardness of 55 HRC and above, and for carburized and induction hardened parts, stress relieve at 275 °F ± 25 (135 °C ± 14) for 5 to 10 hours.

3.3.2.1.2 For parts having a hardness less than 55 HRC, and for nitrided parts, stress relieve at 375 °F ± 25 (191 °C ± 13) for a minimum of 4 hours. Higher temperatures shall be used only when specified or approved by the cognizant engineering organization.

3.3.2.1.3 For peened parts: If stress relief temperatures above 375 °F (191 °C) are elected, the stress relieve shall be performed prior to peening or the cognizant engineering organization shall be consulted and shall approve the stress relief temperature.

3.3.3 Parts shall be handled such that a minimum of contamination occurs during masking and racking.

3.3.4 Any specified residual compressive stress-inducing operations, such as shot peening, shall follow stress-relieving but precede plating. In the event of multiple plating operations cadmium/titanium shall be the final operation. The cognizant engineering authority shall specify additional stress relief if other coatings were ground or machined.

3.3.5 Parts shall have clean surfaces, free of water breaks, prior to immersion in the plating solution.

3.3.5.1 Alkaline cleaning of steel parts may be done with anodic current, but steel parts shall not be cathodically cleaned.

3.3.5.2 All parts shall be cleaned by dry blasting using 80 to 180 grit aluminum oxide. Elapsed time between completion of cleaning and immersion in plating bath shall not exceed 60 minutes. Acid pickling or cleaning using reducing acids is not allowed.

3.3.6 Except for barrel plating, electrical contact points shall be as follows. For parts which are to be plated all over, location shall be acceptable to purchaser; for parts which are not to be plated all over, locations shall be in areas on which plating is not required.

3.4 Procedure

3.4.1 Parts shall be plated by electrodeposition of cadmium/titanium from a suitable plating solution (See 8.9).

3.4.1.1 Spotting-in is not permitted.

3.4.2 The cadmium/titanium shall be deposited directly on the basis metal without a strike coating of other metal except in the case of parts made wholly of corrosion resistant steel or similarly passive materials, on which a preliminary strike of nickel or other suitable metal is permissible.

3.4.3 Aluminum alloys may be zincate treated in accordance with ASTM B253.

3.4.4 Following plating the parts shall be rinsed in cold and hot water.

3.4.5 After rinsing in water and without allowing the parts to dry, unless otherwise specified, plated parts shall be chemically treated by a process that has been demonstrated to prevent the formation of white corrosion products. If trivalent chromium treatment is elected, it may be applied prior to hydrogen embrittlement thermal treatment (See 3.5) without subsequent reactivation retreatment, provided it has demonstrated acceptable corrosion resistance (See 3.6.3). When plated parts specifying a traditional type of supplementary treatment, such as hexavalent chromate, require post thermal treatment as in 3.5, surface reactivation and supplementary treatment shall follow hydrogen embrittlement relief.

3.5 Hydrogen Embrittlement Relief

Treatment of steel parts shall be in accordance with AMS2759/9 using the parameters for cadmium.

3.6 Properties

The plating shall conform to the following requirements:

3.6.1 Thickness

Shall be as specified on the drawing, determined on representative parts or, when permitted by purchaser, test panels in accordance with ASTM B487, ASTM B499, ASTM B504, ASTM B567, ASTM B568, ASTM E376, or other method acceptable to purchaser.

3.6.1.1 Plate thickness may be specified by AMS2419 and a suffix number as shown in Table 1A or 1B normally designating the minimum thickness in ten-thousandths of an inch (0.0025 mm); except as indicated in Table 1A or 1B, the maximum plate thickness shall be 0.0002 inch (0.0051 mm) greater than the minimum. When flash plating is specified it shall be approximately 0.0001 inch (0.0025 mm).

Table 1A – Plate thickness and salt spray corrosion resistance requirements, inch/pound units

AMS2419 Thickness Designation Specified	External Threads Thickness Inch	External Threads Salt Spray Resistance Hours, min	Nuts, Washers, and Unthreaded Surfaces of Parts Externally Threaded Thickness Inch	Nuts, Washers, and Unthreaded Surfaces of Parts Externally Threaded Salt Spray Resistance Hours, min	Parts Not Externally Threaded Except Nuts and Washers Thickness Inch	Parts Not Externally Threaded Except Nuts and Washers Salt Spray Resistance Hours, min
2419	0.0001 to 0.0004	100	0.0002 to 0.0005	150	0.0003 to 0.0005	400
2419-1	0.0001 to 0.0003	100	0.0002 to 0.0004	150	0.0001 to 0.0003	100
2419-2	0.0001 to 0.0004	100	0.0002 to 0.0004	150	0.0002 to 0.0004	150
2419-3	0.0002 to 0.0005	150	0.0003 to 0.0005	400	0.0003 to 0.0005	400
2419-4	0.0003 to 0.0006	400	0.0004 to 0.0006	450	0.0004 to 0.0006	450
2419-5	0.0004 to 0.0007	450	0.0005 to 0.0007	500	0.0005 to 0.0007	500

Note: For thickness designations when AMS2419-X is greater than 5, plate thickness in ten-thousandths of an inch shall be X to X +2 except on external threads where the plate thickness shall be X-1 to X+2; such parts shall withstand salt spray for not less than 250 hours.

Table 1B – Plate thickness and salt spray corrosion resistance requirements, SI units

AMS2419 Thickness Designation Specified	External Threads Thickness Millimeter	External Threads Salt Spray Resistance Hours, min	Nuts, Washers, and Unthreaded Surfaces of Parts Externally Threaded Thickness Millimeter	Nuts, Washers, and Unthreaded Surfaces of Parts Externally Threaded Salt Spray Resistance Hours, min	Parts Not Externally Threaded Except Nuts and Washers Thickness Millimeter	Parts Not Externally Threaded Except Nuts and Washers Salt Spray Resistance Hours, min
2419	0.003 to 0.010	100	0.005 to 0.013	150	0.008 to 0.013	400
2419-1	0.003 to 0.008	100	0.005 to 0.010	150	0.003 to 0.008	100
2419-2	0.003 to 0.010	100	0.005 to 0.010	150	0.005 to 0.010	150
2419-3	0.005 to 0.013	150	0.008 to 0.013	400	0.008 to 0.013	400
2419-4	0.008 to 0.015	400	0.010 to 0.015	450	0.010 to 0.015	450
2419-5	0.010 to 0.018	450	0.013 to 0.018	500	0.013 to 0.018	500

Note: For thickness designations when AMS2419-X is greater than 5, plate thickness in millimeters shall be 0.0025X to 0.0025 (X+2) except on external threads where the plate thickness shall be 0.0025 (X-1) to 0.0025 (X+2); such parts shall withstand salt spray for not less than 250 hours.

3.6.1.2 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.

3.6.1.3 Thickness requirements apply to surfaces that can be touched by a sphere 0.75 inch (19 mm) in diameter. Other areas, such as surfaces of holes, recesses, internal threads, or contact areas of parts plated all over, where a controlled deposit cannot be obtained under normal plating conditions, shall show evidence of plating.

3.6.2 Adhesion

Plating shall be firmly and continuously bonded to the basis metal and shall not show internal delamination of the plating.

3.6.2.1 Plating adhesion shall be tested using one of the following methods:

3.6.2.1.1 The plating shall be scraped through to the basis metal with a sharp knife to expose the basis metal and examined at approximately 5X magnification for evidence of flaking or separation.

3.6.2.1.2 Test adhesion using the bend test, burnishing test, draw test, or heat quench test of ASTM B571.

3.6.2.2 Adhesion testing is not required for parts that are post treated by heating to at least 375 °F (191 °C), quenched, and examined for blisters or other signs of lack of adhesion.

3.6.3 Corrosion Resistance

Ferrous metal parts or representative test panels (See 4.3.3) shall show no visual evidence of corrosion of the basis metal after being subjected for a time specified in Table 1A or 1B to continuous salt spray corrosion testing conducted in accordance with ASTM B117.

3.6.4 Hydrogen Embrittlement

The plating process shall not cause hydrogen embrittlement in ferrous metals. Testing in accordance with the requirements of ASTM F519 Type 1a using notched round specimens, unless a different specimen is specified by the purchaser, stressed in tension under sustained load is required. For test purposes, plating thicknesses shall be 0.0005 to 0.0007 inch (0.0127 to 0.0178 mm) thick measured on the smooth section of the specimen, but with visible plating at the root of the notch. Testing beyond the 200 hour test period is not required.

3.6.4.1 Alternatively, when approved by purchaser hydrogen gauge testing in accordance with ASTM F326 and an approved company operating procedure may be used.

3.6.5 Composition

Titanium content of the plating shall be 0.07 to 0.5% by weight determined by a method acceptable to the purchaser. An alternative method is to measure the content in the plating solution.

3.7 Quality

Plating shall be smooth, continuous, free of delamination within the plating, uniform in appearance, and free of imperfections detrimental to usage of the plating. Plating shall be visually free from frosty areas, pinholes, porosity, blisters, nodules, and pits. Slight discoloration or staining is permitted.

3.7.1 The finished plating color shall range from an iridescent yellow or gold to brown to olive drab. If the chrome acid solution (See 3.4.5) is used for the supplementary coating, the resultant coating may be gray.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The processor shall supply all specimens for processor's test and shall be responsible for the performance of all required tests. Where parts are to be tested, such parts shall be supplied by purchaser. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that processing conforms to the specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

Thickness (3.6.1) and Quality (3.7) are acceptance tests and shall be performed to represent each lot.

4.2.2 Periodic Tests

Composition (3.6.5), Corrosion-Resistance (3.6.3) and Embrittlement, (3.6.4) and tests of cleaning and plating solutions to ensure that the deposited metal will conform to specified requirements (See 8.4) are periodic tests and shall be performed at a frequency not less than 30 days. Adhesion (3.6.2) is a periodic test that shall be performed no less than daily for each generic class of alloy as defined by AS2390 processed during that day.

4.2.3 Preproduction Test

All technical requirements are preproduction tests and shall be performed prior to or on the initial shipment of plated parts to a purchaser, when a change in material and/or processing requires approval by the cognizant engineering organization (See 4.4.2), and when purchaser deems confirmatory testing to be required.

4.3 Sampling and Testing

Shall not be less than the following

A lot shall be all parts of the same part number, plated to the same range of plate thickness in the same set of solutions, in each consecutive 24 hours of operation, and presented for processor's inspection at one time.

4.3.1 Sample Configuration

Nondestructive testing shall be performed wherever practical and authorized herein. Except as noted actual parts shall be selected as samples for tests.

4.3.1.1 Thickness

Separate test panels of same generic class of alloy as the parts, distributed throughout the lot, cleaned, plated, and post treated with the parts represented shall be used when plated parts are of such configuration or size as to be not readily adaptable to the specified tests or when nondestructive testing is not practical on actual parts, or it is not economically acceptable to perform destructive tests on actual parts.

4.3.1.2 Corrosion Test

Panels shall be low carbon steel approximately 0.032 x 4 x 6 inches (0.8 x 102 x 152 mm) or bars approximately 0.5 inches (13 mm) in diameter and 4 inches (102 mm) long, having surface roughness not exceeding 40 microinches (1 µm).

4.3.1.3 Adhesion Tests

Specimens shall be made of the same generic class of alloy as defined by AS2390 processed. The test specimens shall be 0.025 inch (0.6 mm) minimum thickness and not less than 1 x 4 inches (25 x 102 mm).

4.3.2 For acceptance tests

Test samples shall be selected from all parts in the lot, unless purchaser specifies a sampling plan; the minimum number of samples shall be as shown in Table 2.

Table 2 –Sampling for acceptance tests

Number of Parts In Lot	Quality	Thickness
1 to 6	All	3
7 to 15	7	4
16 to 40	10	4
41 to 110	15	5
111 to 300	25	6
301 to 500	35	7
501 to 700	50	8
701 to 1200	75	10
Over 1200	125	15

4.3.3 For Periodic Tests

Frequency of testing shall be at the discretion of the processor unless a test frequency is specified by the purchaser. Tests for hydrogen embrittlement are applicable only when parts having hardness of 36 HRC or higher are plated. For adhesion tests, four test specimens of each generic class of alloy, as defined by AS2390, that have been processed through the same cleaning and plating operations as the parts that they represent. These adhesion test specimens shall be processed prior to the first production lot of parts or with the first production lot of parts.

4.4 Approval

4.4.1 The process and control factors, a preproduction sample plated part, or both, whichever is specified shall be approved by the cognizant engineering organization before production parts are supplied.

4.4.2 The processor shall make no significant change to materials, processes, or control factors from those on which approval was based, unless the change is approved by the cognizant engineering organization. A significant change is one that, in the judgment of the cognizant engineering organization, could affect the properties or performance of the parts.