



AEROSPACE MATERIAL SPECIFICATION

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

AMS 2488

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Revised

ANODIC TREATMENT OF TITANIUM AND TITANIUM ALLOYS

1. SCOPE:

1.1 Purpose: This specification establishes the engineering requirements for producing an electrolytic conversion (anodize) coating on titanium and titanium alloys and the properties of the coating.

1.2 Application: Type 1 is used primarily as a lubricating and antigalling coating for elevated-temperature forming of titanium and titanium alloys. Type 2 is used primarily for protection against galling and galvanic corrosion, for improved wear resistance, and for pretreatment in the application of dry film lubrication.

1.3 Classification: Coatings are classified by end-product application, as follows:

Type 1 - As a coating for elevated-temperature forming.

Type 2 - As an anti-galling coating without additional lubrication or as a pretreatment for dry film lubricants. Such coatings also are compatible with hypergolic propellants such as hydrazine-unsymmetrical-dimethylhydrazine and nitrogen tetroxide, and are electrically semiconductive.

1.3.1 Type 2 shall be furnished unless type 1 is specified.

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.

AMS 2350 - Standards and Test Methods

AMS 3084 - Solid Film Lubricant, Space Application, Minimal Outgassing

AMS 4911 - Titanium Alloy Sheet, Strip, and Plate, 6Al - 4V, Annealed

AMS 4928 - Titanium Alloy Bars and Forgings, 6Al - 4V, Annealed, 120,000 psi (827 MPa) Yield Strength

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 D2714 - Calibration and Operation of the Alpha Model LFW-1 Friction and Wear Testing Machine

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

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2.3.1 Military Specifications:

- MIL-L-8937 - Lubricant, Solid Film, Heat Cured, Corrosion Inhibiting
- MIL-P-26539 - Propellant, Nitrogen Tetroxide
- MIL-P-27402 - Propellant, Hydrazine-uns-Dimethylhydrazine (50% N_2H_4 - 50% UDMH)
- MIL-L-81329 - Lubricant, Solid Film, Extreme Environment

2.3.2 Military Standards:

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

3. TECHNICAL REQUIREMENTS:

3.1 Solutions:

- 3.1.1 Electrolyte: Shall be an alkaline solution with pH of 13 or greater.

3.2 Equipment:

- 3.2.1 Tanks: Shall be of unlined steel.
- 3.2.2 Fixtures: Wire, hooks, clamps and racks used to suspend parts shall be of titanium or titanium alloys. Protection at the air/liquid interface is not required.

3.3 Preparation:

- 3.3.1 Cleaning: Parts shall be thoroughly cleaned to ensure that all surfaces are free from grease, oil, soap, alkali, or other contaminants which would cause unacceptable coatings. The use of halogenated solvents is prohibited.
- 3.3.2 Racking: Direct current (DC) processing shall be used. Parts shall be suspended on one electrode with the tank serving as the other electrode.
 - 3.3.2.1 Racks and clamps should have any anodic film removed from contact areas before being reused.
- 3.3.3 Attachment and Contact: Parts shall be firmly attached to the racks. Contact areas shall be kept as small as possible and, when practicable, shall be on surfaces not required to be coated. When parts are to be coated all over, contacts shall be located in areas indicated on the drawing. Parts shall, insofar as practicable, be hung so as to avoid gas entrapment during processing.

3.4 Procedure:

- 3.4.1 Processing: The cleaned and racked parts shall be immersed in the electrolyte. The parts shall be the anode, and the tank shall serve as the cathode. Direct current shall be applied, with the voltage being raised manually or automatically to maintain the required current density. Completion of the process is indicated by total decay of the amperage (zero amperage).
 - 3.4.1.1 Complex parts should be agitated while totally immersed in the electrolyte in order to minimize entrapment of air in pockets and blind holes and should be repositioned periodically to bring the electrolyte into contact with uncoated areas and to prevent attack at the electrolyte/air interface of such pockets and blind holes.

3.4.2 Rinsing and Drying: After anodizing, parts shall be rinsed thoroughly in cold, running tap water; rinsed in clean, hot water; and dried.

3.5 Properties:

3.5.1 Coating Thickness:

3.5.1.1 Type 1: Shall be such that the dimensional increase will be 0.0002 - 0.0004 in. (5 - 10 μ m) per surface, determined by measuring at the same locations with micrometers accurate to 0.0001 in. (2.54 μ m) before and after anodizing, and dividing by two if opposite surfaces are anodized.

3.5.1.2 Type 2: Shall be such that there is no measurable dimensional change.

3.5.2 Corrosion Resistance: Anodized parts or test specimens shall withstand exposure for 336 hr to salt spray test conducted in accordance with ASTM B117 without showing corrosion on significant surfaces or more than a few scattered corrosion pits visible without magnification on other surfaces.

3.5.3 Wear Resistance (Type 2): LFW-1 rings and blocks made of AMS 4928 titanium alloy (See 8.1) anodized in accordance with this specification and coated with 0.0003 - 0.0005 in. (8 - 13 μ m) of AMS 3084, MIL-L-8937, or MIL-L-81329 solid film lubricant shall have an average life of 75,000 oscillatory cycles, determined in accordance with 4.5.1.

3.5.4 Propellant Compatibility: When specified, the anodic coating shall not react, dissolve, disperse, change propellant color, or show any other evidence of deterioration during and after 30 days exposure to MIL-P-27402 hydrazine-unsymmetrical dimethylhydrazine and MIL-P-26539 nitrogen tetroxide in accordance with 4.5.2. Persistent gas escape or continuous streaming of bubbles from the anodic coating which results in a pressure increase exceeding 50 psi (345 kPa) when immersed in non-agitated propellant shall be evidence of incompatibility.

3.6 Quality: Anodic coating shall be continuous, smooth, adherent to basis metal, uniform in texture and appearance, and free from burned or powdery areas, loose films, discontinuities such as breaks or scratches, except at contact points, or other damage or imperfections detrimental to performance of parts.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The coating vendor shall supply all samples and shall be responsible for all required tests. Results of such tests shall be reported to the purchase as required by 4.6. Purchaser reserves the right to perform such confirmatory testing as he deems necessary to ensure that the coating conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to coating thickness (3.5.1), corrosion resistance (3.5.2), and quality (3.6) requirements are classified as acceptance tests.

4.2.2 Qualification Tests: Tests to determine conformance to all technical requirements of this specification are classified as qualification tests.

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

4.3 Sampling: Shall be as follows; a lot shall be all parts made of the same material, processed in the same solution under the same conditions, and presented for vendor's inspection at one time.

- 4.3.1 Acceptance Tests: Sufficient parts or test specimens shall be prepared to permit duplicate determinations of coating thickness and corrosion resistance on each lot.
- 4.3.1.1 Corrosion resistance test specimens, when required, shall be AMS 4911 titanium alloy sheet 0.020 - 0.063 in. (0.51 - 1.60 mm) thick, and approximately 3 in. (75 mm) wide by 6 in. (150 mm) long.
- 4.3.2 Qualification Tests: Sufficient parts or representative test specimens shall be prepared to permit duplicate determinations of wear resistance of Type 2 coatings and of propellant compatibility.
- 4.4 Approval:
- 4.4.1 Parts coated in accordance with this specification shall be approved by purchaser before parts for production use are supplied, unless such approval be waived.
- 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 coated parts, test specimens, or both. Production parts coated by the revised procedure shall not be shipped prior to receipt of reapproval.
- 4.5 Test Methods:
- 4.5.1 Wear Resistance:
- 4.5.1.1 Equipment: An Alpha model LFW-1 lubricant tester calibrated and operated in accordance with ASTM D2714.
- 4.5.1.2 Procedure: Mount an anodized and dry-film-lubricated AMS 4928 LFW-1 ring on the LFW-1 tester and torque to 225 lb-in. (45N·m) by means of a retaining nut. Mount an anodized and dry-film-lubricated AMS 4928 LFW-1 block in the block holder. Place 21 lb (9.5 kg) of weight on the bale rod and, within one minute after the machine has been started, settle gently onto the lever system, thereby exerting the required 630 lb (2800 N) of normal force. Use a friction cutoff of 0.20 as the failure point. Repeat the room temperature test twice using new anodized and lubricated LFW-1 blocks and rings in each test.
- 4.5.2 Propellant Compatibility:
- 4.5.2.1 Test Specimens: Shall be AMS 4911 titanium alloy sheet 0.063 in. \pm 0.006 (1.60 mm \pm 0.15) thick, approximately 3/4 in. (20 mm) wide by 3 in. (75 mm) long.
- 4.5.2.2 Procedure:
- 4.5.2.2.1 50% N₂H₂ - 50% UDMH Compatibility: Place each anodized test specimen in a clean glass tube capable of being tightly closed and provided with a pressure relief and monitoring system. Cover the test specimen with approximately 3 oz (85 g) of MIL-P-27402 propellant. Close the test tube and heat to 160° F \pm 5 (71° C \pm 3). Examine each working day for noticeable color change, excessive pressure buildup, solubility, or other evidence of deterioration.
- 4.5.2.2.2 Nitrogen Tetroxide Compatibility: Shall be determined as in 4.5.2.2.1 except that the test tube shall be maintained at 75° F \pm 15 (24° C \pm 8) and the test specimen shall be covered with approximately 3 oz (85 g) of MIL-P-26539 propellant.