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400 COMMONWEALTH DRIVE WARRENDALE PA 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 2488A

Superseding AMS 2488

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ANODIC TREATMENT OF TITANIUM AND TITANIUM ALLOYS

1. SCOPE:

1.1 Purpose: This specification establishes the engineering requirements for producing an eletrolytic 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 antigalling 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 SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

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 (825 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 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

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 miminize 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: Coating shall conform to the following requirements:

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 µm) per surface, determined by measuring at the same locations with micrometers accurate to 0.0001 in. (2.5 µm) 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: When specified, anodized parts or test specimens as in 4.3.1.1 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 8.2) anodized in accordance with this specification and coated with 0.0003 - 0.0005 in. (7.5 - 12.5 µm) 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, Type 2 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, determined in accordance with 4.5.2 (See 8.3). 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 incompatability.

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 the coating.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The coating vendor shall supply all samples for vendor's tests and shall be responsible for performing all required Ø tests. Results of such tests shall be reported to the purchaser as required by 4.6. Purchaser reserves the right to sample and to perform any confirmatory testing deemed 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 requirements for Ø coating thickness (3.5.1.1) of Type 1, corrosion resistance (3.5.2) when specified, and quality (3.6) are classified as acceptance tests and shall be performed on each lot.

4.2.2 Preproduction Tests: Tests to determine conformance to all technical Ø requirements of this specification are classified as preproduction tests and shall be performed prior to or on the first-article shipment of coated parts to a purchaser, when a change in material or processing, or both, requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.2.1 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 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 set of solutions under the same conditions, and presented for vendor's inspection at one time:

4.3.1 For Acceptance Tests: Sufficient anodized parts shall be selected at Ø random from each lot or representative test specimens shall be prepared to perform all required tests. The number of determinations for each requirement shall be as specified in the applicable test procedure or, if not specified therein, not less than two.

4.3.1.1 Corrosion resistance test specimens, when required, shall be AMS 4911 titanium alloy sheet 0.020 - 0.063 in. (0.50 - 1.60 mm) thick, and approximately 3 in. (75 mm) wide by 6 in. (150 mm) long.

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

4.4 Approval:

4.4.1 Parts coated in accordance with this specification shall be approved by Ø purchaser before parts for production use are supplied, unless such approval by waived by purchaser. 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 necessary to make any change 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 (See 8.2):

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. (45 N·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 Propellent Compatibility:

4.5.2.1 Test Specimens: Shall be AMS 4911 titanium alloy sheet 0.063 in. ± 0.006 (1.60 mm ± 0.15) thick, approximately 3/4 in. (20 mm) wide by 3 in. (75 mm) long.

4.5.2.2 Procedure (See 8.3):

4.5.2.2.1 50% N_2H_4 - 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 ± 5 (70°C ± 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 ± 15 (25°C ± 8) and the test specimen shall be covered with approximately 3 oz (85 g) of MIL-P-26539 propellant.

4.6 Reports: The vendor of coated parts shall furnish with each shipment three copies of a report showing the purchase order number, AMS 2488A, material specification number and its revision letter if any, contractor or other direct supplier of part and coating materials, part number, and quantity. When material for making parts or the coating material is produced or purchased by the coated parts vendor, that vendor shall inspect each lot of material to determine conformance to the applicable material specification and shall include in the report either a statement that the materials conform or copies of laboratory reports showing the results of tests to determine conformance. This report shall also include the results of tests to determine that the coating conforms to the acceptance test requirements of this specification.

4.7 Resampling and Retesting: If any part or 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 parts or specimens for each original nonconforming part or specimen. Except as specified in 4.7.1, failure of any retest part or 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.

4.7.1 If any part fails to meet the specified requirements, either on the original sampling as in 4.3 or upon resampling as in 4.7, the parts in that lot may be stripped by a method approved by purchaser which does not roughen, pit, or embrittle the basis metal, reprocessed, and retested.

5. PREPARATION FOR DELIVERY:

5.1 Packaging: