MIL-A-63576A (AR)
6 December 1985
SUPERSEDING
MIL-A-63576 (AR)
13 August 1982

MILITARY SPECIFICATION

ALUMINUM OXIDE COATINGS, LUBRICATIVE, FOR ALUMINUM AND ALUMINUM ALLOYS

This specification is approved for use by the U.S. Army Armament Research and Development Center, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the requirements for an electrochemical process for building a lubricative anodic coating on aluminum and aluminum alloys. The unsealed anodic coating is impregnated with polytetrafluoroethylene (PTFE) or coated with a resin bonded material containing PTFE.

1.2 Classification. Lubricative anodic coatings shall be of the following types, as specified (see 6.2).

Type I. Anodic coating with the unsealed surface asperities impregnated with PTFE.

Type II. Anodic coating which has the unsealed surface coated with a thermoplastic resin containing PTFE.

Type III. Anodic coating which has the unsealed surface coated with a thermosetting resin containing PTFE.

2. APPLICABLE DOCUMENTS

2.1 Government Documents.

2.1.1 Specifications and Standards. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document, should be addressed to Commander, US Army Armament, Research and Development Center, ATTN SMCAR-ESC-AS, Dover, New Jersey 07801-5001 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter

AMSC N/A AREA MFFP

SPECIFICATIONS

FEDERAL

QQ-A-250/4	- Aluminum Alloy 2024, Plate and Sheet
QQ-A-250/11	- Aluminum Alloy 6061, Plate and Sheet
QQ-A-250/12	- Aluminum Alloy 7075, Plate and Sheet

MILITARY

MIL-C-5541	- Chemical Films and Chemical Film Materials for Aluminum and Aluminum Alloys
MIL-A-8625	- Anodic Coatings, for Aluminum and Aluminum Alloys

STANDARDS

FEDERAL

Fed. Test Method Std. No. 141	- Paint, Varnish, Lacquer, and Related Materials; Methods of Inspection, Sampling and Testing
Fed. Test Method Std. No. 151	- Metals; Test Methods

MILITARY

MIL-STD-105	- Sampling Procedures and Tables for Inspection by Attributes

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity).

2.2 Other publications. The following document(s) form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS shall be the issue of the nongovernment documents which is current on the date of the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 117	- Method of Salt Spray (Fog) Testing
ASTM B 244	- Measuring Thickness of Anodic Coating on Aluminum with Eddy Current Instruments

(Application for copies should be addressed to ASTM, 1916 Race Street, Philadelphia, PA 19103).

(Nongovernment standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services).

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Materials. The materials used shall be such as to produce coatings which meet the requirements of this specification.

3.1.1 Basis metal. The basis metal shall be sufficiently free from surface defects, caused by machining, cutting, scratching, polishing, buffing, roughening, bending, stretching, deforming, rolling, sandblasting, vaporblasting, etching, and inclusions, which will be detrimental to the functional use of the coating. It shall be subjected to such cleaning, etching, anodizing and sealing procedures as are necessary to yield coatings meeting all requirements of this specification (see 6.5).

3.2 Equipment and processes. The equipment and processes employed shall be such as to produce coatings which meet the requirements of this specification. Unless otherwise specified in the contract, order, or applicable drawing (see 6.2), process operating conditions shall be at the option of the supplier, subject to approval of the procuring activity.

3.3 General.

3.3.1 Unless otherwise specified in the contract, order, or applicable drawing, parts and assemblies shall be anodized after all heat treatment, machining, welding, forming, and perforating have been completed.

3.3.2 Parts which contain non-aluminum materials, such as steel, brass or organic substances, which would be attacked by chemical or electrolytic brightening (chemical or electropolishing) or anodizing solutions or would prevent the uniform formation of the anodic coatings on the aluminum surfaces or cause attack of the aluminum alloy, shall not be anodized as assemblies unless the non-aluminum surfaces are masked or electrically insulated in a manner which produces satisfactory anodized parts.

3 3 3 Parts shall be so handled during all pretreatments, anodizing, and post treatments that mechanical damage or contamination will be avoided Soiled parts shall be cleaned with such materials which will remove the soil without damaging the part or coatings

3 3 4 Unless otherwise specified in the contract or purchase order, the aluminum and aluminum alloys shall be cleaned before subsequent anodic treatment Alkaline cleaners when used shall be of the non-etching or inhibited type Where an uninhibited alkaline etching solution is permitted in the fabrication of aluminum and aluminum alloy parts for the chemical removal or milling of excess metal, the basis metal shall then be treated in an acid deoxidizing bath to remove any characteristic surface smut The basis metal shall be rinsed thoroughly with water prior to application of the anodic coatings Abrasives containing iron such as steel wool, iron oxide rouge, and steel wire, which may become embedded in the metal and accelerate corrosion of aluminum and aluminum alloys, are prohibited as a means of mechanical cleaning, prior to anodizing (see 6 2)

3 3 5 Parts shall be free of all foreign substances, oxides, and soils such as greases, oil, paint, and welding flux Parts shall have oxide and other interfering film removed by the use of proper cleaning procedures so as to be cleaned and have water break-free surfaces

3 3 6 Unless otherwise specified in the contract, order, or applicable drawing, anodic coatings shall not be applied to assemblies which will entrap the electrolyte in joints or recesses. Anodic coatings shall not be used for assemblies where the electrolyte cannot be removed When authorized by the contract, order, or applicable drawings, edges shall be masked to prevent electrolyte entry Spot welded assemblies are examples of assemblies requiring edge masking Residual electrolytes, especially sulphuric acid baths, will engender corrosion of aluminum Where coating of assemblies is not authorized, parts of assemblies shall be anodic coated before assembling

3.3 7 When approved by the procuring activity, mechanically damaged areas from which the anodic coating has been removed may be repaired, using chemical film materials and treatments meeting the requirements of MIL-C-5541 by Grade B (brush) application

3 4 Types of coating The anodic coating to be impregnated or coated shall meet the requirements of an unsealed Type III, Class 1 coating as specified in MIL-A-8625

3 4 1 Type I coating Type I coatings shall be the result of impregnating PTFE into the unsealed surface asperities of the anodic coating

3.4 2 Type II coating Type II coatings shall be the result of applying by dipping, spraying, or brushing a thermoplastic resin containing PTFE to the unsealed anodic surfaces The resin is air cured

3.4 3 Type III coating Type III coatings shall be the result of applying by spraying, dipping, or brushing a thermosetting resin containing PTFE to the unsealed anodic surface and then curing at 177° Celsius for 1 hour.

3 5 Thickness Thickness of the coatings shall be as specified in the contract, order, or applicable drawing The coatings may vary in thickness from 0 0001 (0.1 mil) to more than 0 008 inch (8 mils) If a definite thickness is not specified in the contract, order, or applicable drawing, the nominal thickness of the coating shall be 0 002 inch (2 mils) for the anodic coating prior to impregnation with the lubricant Unless otherwise specified, the thickness of the coating shall not vary by more than ±10 percent. Type I coatings will normally add less than 0 0001 inch (0 1 mil) to the anodic thickness If not otherwise specified, Type I coating thickness shall be 0 0020± 0 0002 inch (2 0 ±0 2 mils) for the total anodic plus PTFE coating Type II and Type III coatings can add from 0 0002 (0 2 mil) to 0.0007 inch (0 7 mil) to the anodic coatings Unless otherwise specified on the drawing or order, the Type II or Type III coating thickness shall be 0 0025 ± 0 00025 inch (2 5 ± 0 25 mils) for the total anodic plus resin coatings.

3 6 Detail requirements

3 6 1 Corrosion resistance Coatings shall be capable of protecting the substrate metal when specimens or items are subject to the corrosion resistance test specified in 4 6 2 (see 6 3) The specimen panels or finished products shall show no more than a total of 15 isolated spots or pits, none larger than 1/32 inch in diameter, in a total of 150 square inches of test area grouped from five or more test pieces, nor more than 5 isolated spots or pits, none larger than 1/32 inch in diameter, in a total of 30 square inches from one or more test pieces, except those areas within 1/16 inch from identification markings and electrode contact marks remaining after processing. When specified in the contract, order, or applicable drawing, the corrosion resistance shall be determined (see 6 2).

3 6.2 Thickness of coating Anodic coating thickness, prior to impregnation with the lubricant, shall conform to the specified thickness requirements when tested in accordance with 4 6 1 (see 3 5)

3.6.3 Abrasion resistance The coatings applied by any process shall have an abrasion resistance anodic finish The items or separate specimens anodized, but without lubricant impregnation, shall be subject to the abrasion test specified in 4 6 3 For 2024 aluminum alloy and other copper bearing alloys, the anodic coating loss shall not exceed 40 milligrams Anodic coating loss of all other aluminum alloys shall not exceed 20 milligrams when subjected to the abrasion test

3.7 Dimensions of coated items For Type I coatings, items or parts shall comply with the dimensional requirements of the applicable drawings after the application of the anodic coating For Type II and Type III coatings, items or parts shall comply with the dimensional requirements of the applicable drawings after the application of the anodic coating but shall allow for the additional application of the resin coating

3 8 Workmanship The anodic coating shall be continuous, smooth, adherent, uniform in appearance and shall be free from powdery areas, loose films, discontinuities such as breaks and scratches, or other damage The size and number of contact marks shall be at a minimum consistent with good practice The location of contact marks shall be in areas of minimum exposure to service environmental conditions when important to the function of the part

4. QUALITY ASSURANCE PROVISIONS

4 1 Responsibility for inspection Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the procuring activity The procuring activity reserves the right to perform any of the inspections set forth in the specifications where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements

4 2 Quality conformance tests. The quality conformance inspection shall consist of an examination for the acceptability of the quality control methods used by the supplier and an examination and testing of the quality conformance samples as specified under 4 6

4 2 1 Control The supplier should maintain a permanent record of the history of each processing bath, showing all additions of chemicals to the bath, the results of all analysis performed, and the quantity of parts of each kind anodized in the bath. Upon request of the procuring activity, such records shall be made available to the procuring activity

4 2 1 1 Process control The equipment, procedures, and operations employed by the supplier shall be capable of producing high quality anodic coatings on aluminum and aluminum alloys as specified in this document Upon request of the procuring activity, such capability shall be demonstrated by the supplier

4 2 1 2 Frequency of tests The tests listed in Table I for process control shall be made once each month or more frequently if required by the procuring activity. In all cases, the results of tests made to determine conformance of anodic coatings on aluminum and aluminum alloys to the requirements of this specification for definite contracts or purchase orders are acceptable as evidence of the properties being obtained with the equipment and procedures employed

4 2 1 3 Process control specimens Test specimens for process control shall be prepared in accordance with 4 4 2 1, 4 4 2 2, and 4 4 2 3 as applicable, for tests detailed in Table I

Table I. Process control tests and specimens for Types I, II, and III

Test	Alloy for specimen	Conforming to	Requirement paragraph	Reference paragraph
Corrosion resistance	2024-T3 or production parts (see 4 2 1.2)	QQ-A-250/4	3 6.1	4.6 2
Coating thickness	2024-T3, 6061-T4, 7075-T6, or production parts (see 4 2 1 2)	QQ-A-250/4, QQ-A-250/11, QQ-A-250/12	3.6.2	4 6.1
Abrasive resistance			3.6.3	4 6.3

4 3 Lot. A lot shall consist of all articles, items, parts, or components with anodic coatings of the same type, approximately the same size, shape, and thickness submitted for acceptance at one time The lot size shall not exceed the number of parts, articles, items or components resulting from one 8-hour production

4 4 Sampling. Unless otherwise specified, sampling plans and procedures in the determination of the acceptability of coated parts and articles submitted by a supplier shall be in accordance with the provisions set forth in MIL-STD-105

4 4 1 Quality conformance samples

4 4 1 1 Visual examination and dimensions of coated articles. Samples for visual examination and dimensions of coated articles shall be selected from each lot of coated parts and articles in accordance with the provisions of MIL-STD-105 Acceptance criteria shall be Inspection Level II, Acceptable Quality Level (AQL) of 1.5 percent defective.

4 4.1.2 Finished products Random samples for thickness, corrosion resistance, and abrasion resistance shall be selected from each lot of coated parts and articles in accordance with MIL-STD-105, Inspection Level S-2, acceptance number of zero for tests of 4 6.

4 4 2 Quality conformance specimen preparation When the work or articles are of such form, size, and value as to prohibit use thereof, or are not readily adaptable to the test specified herein, specimens of the same composition

and heat treatment as the work being inspected shall be anodized concurrently and on the same anodizing rack or hook with the articles represented, to be used for required tests Where aluminum alloy castings are being coated, the specimens may be cut from scrap castings or cast as separate specimens If wrought alloys are processed, separate panels in accordance with 4 4 2 1, 4 4 2 2, and 4 4 2 3 may be used

4 4 2 1 Specimens for thickness If separate specimens for thickness are required, they shall be aluminum alloy panels not less than 3 inches in length and width, with a nominal thickness of 0 032 inch, and of the same composition and temper as the production work and anodized concurrently

4 4 2 2 Specimens for corrosion resistance If separate specimens for corrosion resistance tests are required, they shall be aluminum alloy panels, not less than 10 inches in length and 3 inches in width with a nominal thickness of 0 032 inch Specimens shall be of an alloy of the same composition and temper as the production work and anodized concurrently

4 4 2 3 Specimens for abrasion resistance test If separate specimens for abrasion resistance test are required, they shall be aluminum alloy panels 4 inches by 4 inches, and with a nominal thickness of 0 032 inch, similar in composition and temper to the production work and anodized concurrently These samples shall be anodized but not impregnated with lubricant

4 5 Quality conformance examination

4 5 1 Coated articles Samples selected in accordance with 4 4 1 1 shall be inspected and visually examined for compliance with the requirements of 3 1 1 before anodizing, unless otherwise specified, and of 3 8 after anodizing and sealing

4 5 2 Dimensional examination Samples selected in accordance with 4 4 1 1 shall be inspected for dimensional requirements for compliance with 3 7, unless otherwise specified by the procuring activity

4 6 Quality conformance tests

4 6 1 Anodic coating thickness If the surface face is suitable, random items or separate specimen panels prepared in accordance with 4 4 2 1, shall be selected in accordance with 4 4 1 2 from each lot The separate items or prepared specimen panels shall be tested for anodic coating thickness in accordance with ASTM B 244 or Method 520 or Method 521 of Fed Test Method Std No 151, at the option of the supplier, to determine conformance to the requirements of 3 6 2 If either ASTM B 244 or Method 520 of Fed Test Method Std No 151 is used, the thickness shall be computed as the average of not less than eight measurements If one or more of the items or panels fails to meet the specified thickness range for the coatings (see 3 5) the lot represented shall be rejected In case of dispute, anodic coating thickness shall be determined by measurement of a perpendicular cross section of the anodized specimen using a metallographic microscope with a calibrated eyepiece

4.6.2 Corrosion resistance When processed parts are such that they may be conveniently adapted for the corrosion resistance test, the actual parts may be selected for test in accordance with 4.4.1 2 in lieu of separate test panels prepared in accordance with 4 4.2.2 of sheet samples. The selected items or specimen test panels shall be tested for corrosion resistance in accordance with the method specified in 4.6.2.1

4,6.2.1 Method. Specimens shall be washed in distilled or deionized water, dried with a soft cloth, and then subjected to a 5 percent salt spray test in accordance with Method 811 of Fed. Test Method Std. No. 151 or ASTM B 117, except that the significant surface shall be inclined approximately 6° from the vertical. Specimens shall be exposed for 1,000 hours. After exposure, specimens shall be examined and compared with unexposed specimens for the effects of corrosion to determine compliance with 3 6 1. Corrosion on the specimen in excess of that permitted by 3 6.1 shall be cause for rejection of the lot.

4.6.3 Abrasion resistance of the anodic coating without impregnation When processed parts are such that they may be conveniently adapted for the abrasion test, the actual part may be selected for test in accordance with 4.4.1.2 in lieu of separate test panels prepared in accordance with 4.4.2 3. The selected items or specimen test panels shall be tested in accordance with Method 6192 of Fed. Test Method Std. No. 141 using CS-17 wheels with 1000 gram load The wheels shall revolve on the anodic coating at a speed of 70 revolutions per minute for 10,000 cycles. After abrading, the specimens shall be weighed to the nearest milligram and the weight loss obtained to determine compliance with the requirements of 3.6 3. If the amount of the anodic coating abraded is more than specified, the coating shall be considered unsatisfactory and the lot represented by the specimens shall be rejected.

5. PACKAGING

5.1 The requirements of section 5 are not applicable to this specification

6. NOTES

6.1 Intended use These coatings are intended to provide wear and abrasion resistance surfaces with improved corrosion protection due to greater thickness, weight, and surface treatment than the conventional anodic coatings. These coatings may reduce fatigue strength and this factor should be considered in proposed use of parts subjected to cyclic loads Generally, these coatings should not be used on parts or portions of parts which normally during rework would require restoring of dimensional tolerances because of wear of coated surfaces. They are used in such applications as valves, sliding parts, hinge mechanisms, cams, gears, swivel joints, pistons, etc

6 2 Ordering data Requisitions, contracts and purchase orders should specify the following·

a Title, number, and date of this specification

b Type of coating, (see 1 2)

c Special process operating conditions, if applicable (see 3 2)

d. Special cleaning and fabrication requirements (see 3 3.1, 3 3.4, and 3 3 6)

e. Special sampling plans (see 4 4)

f Whether corrosion resistance test is required (see 4 6 2)

6 3 Definition of term "capable of" The term "capable of" as used in this specification means that the test need not be performed by the supplier of the anodic coating. However, should subsequent testing by the procuring activity establish the material does not meet these requirements the anodic coated articles will be rejected (see 3.6 1)

6 4 Electrolytic action Severe attack by the electrolyte on castings or welds may be occasioned either by unsound castings, improper welding practice, difference in composition between the weld and the basis metal or, particularly in the case of the sulfuric acid process, the retention of the solution in cracks, crevices, or irregular surfaces. Severe attack by the electrolyte may also be caused by contaminants in the electrolyte, particularly chlorides, or by improper racking of the parts

6.5 Defects If harmful defects are revealed as a result of anodizing, this condition should be brought to the attention of the procuring activity

6 6 Design information

6 6 1 Surface dimension of parts On specifying the thickness of coatings allowance must be made for dimensional increase Both a machining dimension and a coated dimension should be placed on applicable drawings An increase in dimension, equal to one half of the thickness of the applied coating, can be expected for the anodic coatings prior to impregnation due to surface growth For example, for a 0 004 inch (4 mils) coating on close tolerance parts, a premachining allowance of 0 002 inch (2 mils) per surface must be made prior to hard coating If close fits are specified in design drawings, buildup in thickness may result in interference on assembly Type I and Type III coatings have an additional buildup due to the application of the resins

6 6 1 1 In the case of small blind holes and tapped holes, coating thickness can vary from no film to a full normal coating Unless otherwise specified, any tapped hole or non-tapped hole 1/4 inch or less in diameter may be furnished free of the coating

6.6.2 Thread dimensions. All anodic coatings will affect thread dimensions for external and internal threads; the major and minor diameter will be increased 2 times the amount of growth (see 6.6.1). The pitch diameter for threads having an including angle of 60° will increase 4 times the amount of growth. For threads having an including angle other than 60° the pitch diameter will increase 2 times the amount of growth (see 6.6.1) divided by the sine 1/2 the included angle.

6.6.3 Fabrication. Successful use of these coatings depends on proper product design. Because of the manner of formation, anodic coatings will develop voids at sharp corners and edges. Sharp edges and corners are difficult to anodize satisfactorily and in general should be avoided. All edges and inside corners should be radiused prior to anodizing. Chamfering should not be used unless resulting sharp edges are radiused. In general, to avoid any uncoated edges or inside corners, the piercing and blanking operations should comply with the radii of curvature for nominal coating thicknesses as in Table II.

6.7 Coefficient of friction. Initial static coefficient of friction will be about 0.16 and should not exceed 0.20. This can be lowered to 0.04 to 0.08, depending on how it is measured, by burnishing the coatings as a secondary operation.

Table II Thickness vs. edge and corner curvature.

Nominal coating thickness inch	Radius of curvature on edge and inside corner
0.001	approximately 1/32 inch
0.002	approximately 1/16 inch
0.003	approximately 3/32 inch
0.004	approximately 1/8 inch

6.8 Previous issue. MIL-A-63576 (AR) was for US Army Armament Research and Development Center internal use only and was not forwarded to the Naval Publications and Forms Center for publication.

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Preparing activity.
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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-A-63576A (AR)	Aluminum Oxide Coatings, Lubricative, For Aluminum And Aluminum Alloys

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR
b. ADDRESS *(Street, City, State, ZIP Code)*	☐ USER
	☐ MANUFACTURER
	☐ OTHER *(Specify)* _____

5 PROBLEM AREAS

a. Paragraph Number and Wording.

b Recommended Wording

c Reason/Rationale for Recommendation

6 REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

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