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MILITARY SPECIFICATION

ANODIC COATINGS, FOR ALUMINUM AND ALUMINUM ALLOYS

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the requirements for four types and two classes of electrolytically formed anodic coatings on aluminum and aluminum alloys for non-architectural applications.

1.2 Classification. Anodic coatings for aluminum and aluminum alloys shall be of the following types and classes, as specified (see 6.2.1):

1.2.1 Types

Type I - Chromic acid anodizing, conventional coatings produced from chromic acid bath, (see 3.4.1)
Type IB - Chromic acid anodizing, low voltage process, 20V, (see 3.4.1)
Type II - Sulfuric acid anodizing, conventional coatings produced from sulfuric acid bath, (see 3.4.2)
Type III - Hard Anodic Coatings (see 3.4.3)

1.2.2 Classes. The coating types specified in 1.2.1 shall be of the following classes:

Class 1 - Non-dyed, natural, including dichromate sealing, (see 3.5.)
Class 2 - Dyed, (see 3.6.)

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, and standards. The following specifications and standards form a part of this specification to the extent specified herein. 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: Systems Engineering and Standardization Department (Code 53), Naval Air Engineering Center, Lakehurst, NJ 08733-5100, 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

MILITARY

MIL-C-5541	-	Chemical Conversion Coatings On Aluminum and Aluminum Alloys
MIL-C-81706	-	Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys

STANDARDS

FEDERAL

FED-STD-141	-	Paint, Varnish, Lacquer, and Related Materials: Method For Sampling and Testing
FED-STD-151	-	Metals; Test Methods
FED-STD-595	-	Color

MILITARY

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

(Copies of specifications and standards 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 documents 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
ANSI/ASTM B 137	-	Weight of Coating on Anodically Coated Aluminum, Measurement of
ASTM B 244	-	Thickness of Anodic Coatings on Aluminum and of Other Nonconductive Coatings on Nonmagnetic Basis Metals with Eddy Current Instruments, Measurement of
ASTM D 822	-	Light and Water Exposure Apparatus (Carbon-Arc Type) for Testing Paint, Varnish, Lacquer and Related Products, Standard Practice for Operating
ASTM D 2244	-	Color Differences of Opaque Materials, Instrumental Evaluation of
ASTM G 23	-	Standard Practice for Operating Light Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Non-metallic Materials
ASTM G 26	-	Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Non-metallic Materials

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

(Nongovernment standards and other publications are normally available from the organizations which prepare or which distibute 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 Base metal. The base metal shall be sufficiently free from surface defects, caused by machining, cutting, scratching, polishing, buffing, roughening, bending, stretching, deforming, rolling, sandblasting, vaporblasting, etching, heat treatment condition, alloy chemistry imbalance and inclusions, that will cause test panels or parts not to meet all applicable requirements for the type and class of anodize required. It shall be subjected to such cleaning, etching, anodizing and sealing procedures as necessary to yield coatings meeting all requirements of this specification.

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 6.2.1), process operating conditions shall be at the option of the supplier, subject to approval of the acquiring activity.

3.3 General.

3.3.1 Anodizing of parts and assemblies.

3.3.1.1 Anodizing of parts. Unless otherwise specified in the contract, order or applicable drawing (see 6.2.1), parts shall be anodized after all heat treatment, machining, welding, forming and perforating have been completed.

3.3.1.2 Anodizing of assemblies. 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. When anodizing of assemblies is authorized by the contract, order or applicable drawings, edges shall be masked to prevent electrolyte entry. Spot welded assemblies are examples requiring edge masking. Assemblies which contain non-aluminum parts such as steel, brass or organic substances, which would be attacked by pretreatment or anodizing solutions or would prevent uniform formation of the anodic coating, shall not be anodized as assemblies, unless the non-aluminum surfaces are masked or electrically insulated in a manner which produces satisfactory anodized parts. Where coating of assemblies is not authorized, the separate components shall be anodized before assembling. Post cleaning of anodized parts to be used in assemblies shall be accomplished with slightly acidic or deionized water in order to allow for proper anodic seal.

3.3.2 Handling and cleaning. Parts shall be so handled during all pretreatments, anodizing and post treatments that mechanical damage or contamination will be avoided. 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 films removed by the use of proper cleaning procedures so as to be clean and have water break free surfaces. 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. If special cleaning requirements are required they shall be specified in the contract or order (see 6.2.1).

3.3.3 Reflective surfaces. When specified in the contract or order (see 6.2.1), parts fabricated to produce a highly reflective surface shall be chemically or electrochemically brightened, prior to anodic coating (see 6.9).

3.3.4 Repair. Unless otherwise specified by the procuring activity, mechanically damaged areas from which the anodic coating has been removed may be repaired using chemical conversion materials approved on QPL-81706 for Class 1A coatings and the applicable method of application. For Type III coatings, repair shall only be allowed in areas which will not be subjected to abrasion (see 6.1.1). The repair area shall not exceed 5 percent of total item surface area. If the repair area exceeds 5 percent, specific approval must be obtained from the procuring activity before the area can be repaired.

3.4 Coatings. Conventional anodic coatings as specified in the contract, order or applicable drawings (see 6.2.1), shall be prepared by any process or operation to produce the specified coating on aluminum and aluminum alloys. The applied anodic coating shall be uniform in appearance, free from breaks, scratches and other defects which will reduce the serviceability of anodized parts or assemblies (see 3.13).

3.4.1 Type I and IB coatings. Type I and IB coatings shall be the result of treating aluminum and aluminum alloys electrolytically in a bath containing chromic acid to produce a uniform anodic coating on the metal surface. Unless otherwise specified in the contract, order or applicable drawing, Type I coatings shall not be applied to aluminum alloys with a nominal copper content in excess of 5.0 percent; nominal silicon contents in excess of 7.0 percent; or when the total allowable contents of nominal alloying elements exceed 7.5 percent. Heat treatable alloys which are to receive a Type I or IB coating shall be in a temper obtained by heat treatment, such as -T4 or -T6, prior to anodizing. Parts having complex shapes in which the bath solution may be entrapped shall be processed by a Type I or IB process.

3.4.2 Type II coatings. Type II coatings shall be the result of treating aluminum and aluminum alloys electrolytically in a bath containing sulfuric acid to produce a uniform anodic coating on the metal surface. Heat treatable alloys shall be in a temper obtained by heat treatment, such as -T4 or -T6, prior to anodizing.

3.4.3 Type III coatings. Type III coatings shall be the result of treating aluminum and aluminum alloys electrolytically to produce a uniform anodic coating on the metal surface. Type III coatings, as specified in accordance with the contract, order or applicable drawing, shall be prepared by any process operation to produce a heavy dense coating of specified thickness on aluminum alloys (see 3.7.2.1). Unless otherwise specified in the contract, order or applicable drawing, Type III coatings shall not be applied to aluminum alloys with a nominal copper content in excess of 5 percent or a nominal silicon content in excess of 8.0 percent. Alloys with a nominal silicon content higher than 8.0 percent may be anodized subject to approval of the procuring activity, provided data is submitted by the supplier which shows that such coatings are equivalent to those obtained on alloys of lower silicon contents. Heat treatable alloys shall be in a temper obtained by heat treatment, such as -T4 or -T6, prior to anodizing.

3.5 Class 1. When class 1 is specified in the contract or order,(see 6.2.1), the anodic coating shall not be dyed or pigmented. Any natural coloration resulting from anodic treatment with the various alloy compositions shall not be considered coloration. The characteristic color imparted by the dichromate sealing technique shall also be considered as non-dyed.

3.6 Class 2. When class 2 is specified in the contract or order,(see 6.2.1), the anodic coating shall be uniformly dyed or pigmented by exposure to a solution of a suitable type dye or stain. The color on wrought alloys shall be uniform. Cast alloys may exhibit dye bleed-out or lack of color associated with the inherent porosity of the casting. The various dyes and pigments used shall not be damaging to the anodic coatings.

3.6.1 Dye color. When dyed or pigmented coatings are required, the color shall be as specified by the contract, order or applicable drawing (see 6.2.1).

3.6.1.1 Casting alloys. Dyed casting alloys may show a slight lack of uniformity. The degree of non-uniformity that is acceptable shall be established by the procuring activity (see 6.2.1).

3.7 Detail requirements.

3.7.1 Types I, IB and II coatings.

3.7.1.1 Weight of coating. After sealing, Type I, IB and II coatings shall conform to the minimum weight requirements of Table I when tested in accordance with 4.5.2 (see 6.10.6). When Type II, Class 2, coatings are specified for identification purposes on parts such as rivets to be mechanically deformed, the minimum coating weight for Type II, Class 1, coatings shall apply.

TABLE I. Types I and II anodic coating weights.

Type	Milligrams per square foot (minimum)	
	Class 1	Class 2
I and IB	200	500
II	600	2500 1/

1/ For wrought alloys of the 2000 series (such as 2011, 2014, 2017, 2219, 2024, etc.) where copper is the major alloying element and for casting alloys with a nominal copper content of 1.0 percent or greater (such as 213.0, 222.0, 242.0, 296.0, 333.0 and 852.0 etc.), the minimum coating weights shall be 1400 milligrams per square foot.

3.7.1.2 Corrosion resistance. Sealed anodic coatings shall protect the substrate metal when subjected to the corrosion resistance test specified in 4.5.3. When visually examining for corrosion resistance, test specimens shall show no more than a total of 15 isolated spots or pits, none larger than .031 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 .031 inch in diameter, in a total of 30 square inches from one or more test pieces; except those areas within .062 inch from identification markings, edges and electrode contact marks remaining after processing.

3.7.1.3 Light fastness resistance. Class 2, dyed anodic coatings, shall show no more fading or discoloration than would be equivalent to a Delta (E) value of 3 when subjected to the light fastness resistance test, see 4.5.4. Light fastness resistance shall be determined when specified in the contract, order or applicable drawing, (see 6.2.1).

3.7.2 Type III coatings.

3.7.2.1 Thickness of coating. Type III coatings shall conform to the specified thickness requirements when tested in accordance with 4.5.1. Thickness of Type III coatings shall be as specified in the contract, order, or applicable drawing (see 6.2.1). If a definite thickness is not specified, the nominal thickness of the coating shall be 0.002 inch (2 mils). Unless otherwise specified, the thickness of the coating shall not vary by more than plus or minus 20 percent for coatings up to 0.002 inches thick (2 mils). Coatings over 0.002 inches (2 mils) shall not vary by more than plus or minus 0.0004 inches (0.4 mils) in thickness (see 6.10.4). A typical Type III coating thickness range is shown in Table IV.

3.7.2.1.1 Weight of coating. The coating weight may be determined in lieu of the coating thickness (see 3.7.2.1), at the option of the procuring activity. Unsealed Type III coatings shall have a minimum coating weight of 4320 milligrams per square foot for every 0.001 inch of coating when tested in accordance with 4.5.2 (see 6.2.1).

3.7.2.2 Abrasion resistance. All unsealed Type III coatings shall have a hard abrasion resistant finish when tested in accordance with 4.5.5. For aluminum alloys having a nominal copper content of 2 percent or higher (see 6.14), anodic coating loss shall not exceed 35 milligrams. Anodic coating loss for all other alloys shall not exceed 15 milligrams.

3.8 Sealing.

3.8.1 Types I, IB and II. All Types I, IB and II anodic coatings shall be completely sealed, unless otherwise specified in the contract, order or applicable drawing (see 6.2.1). They shall be sealed as specified in 3.8.1.1 or 3.8.1.2, whichever is applicable. If wetting agents are used they must be of the non-ionic type.

3.8.1.1 Class 1. When class 1 is specified, sealing shall be accomplished by immersion in a sealing medium such as a 5 percent aqueous solution of sodium dichromate (pH 5.0 to 6.0) for 15 minutes at 90°C to 100°C (194°F to 212°F), in boiling deionized water, or other suitable chemical solutions.

3.8.1.2 Class 2. When class 2 is specified, sealing shall be accomplished after dyeing by immersion in a sealing medium, such as a hot aqueous solution containing 0.5 percent nickel or cobalt acetate (pH 5.5 to 5.8), boiling deionized water, duplex sealing with hot aqueous solutions of nickel acetate and sodium dichromate (see 6.11), or other suitable chemical solutions

3.8.2 Type III. Type III coatings shall not be sealed where the main function of application is to obtain the maximum degree of abrasion or wear resistance. Where Type III coatings are used for exterior non-maintained applications requiring corrosion resistance but permitting reduced abrasion resistance, the contract or purchase order shall specify that sealing is required. Sealing for such Type III coatings shall be accomplished by immersion in a medium, such as boiling deionized water, in a hot aqueous 5 percent sodium dichromate solution, in a hot aqueous solution containing nickel or cobalt acetate or other suitable chemical solutions (see 6.2.1). When Type III coatings are provided unsealed, parts shall be thoroughly rinsed in cold, deionized clean water and dried after anodizing.

3.9 Dimensions of coated articles. Articles or parts shall comply with the dimensional requirements of the applicable drawings after application of the anodic coating. (For interference in close fits of parts or assemblies see 6.10.5).

3.10 Toxicity. The coatings and electrical/chemical processes used to develop these anodic coatings shall have no adverse effect on the health of personnel when used for their intended purposes and within the realm of known industrial practices. Questions pertinent to this effect shall be referred by the contracting activity to the appropriate departmental medical service who will act as an advisor to the contracting agency.

3.11 Painting. When primary painting operations are not performed on fresh, uncontaminated, anodized parts within 48 hours of the anodizing process, the parts shall be stored in a manner that will avoid contamination. If the parts become contaminated, they shall be cleaned in a manner that will not be detrimental to the anodic coating or the basis metal, (see 6.3).

3.12 Dyeing or coloring. Anodic coatings shall not be allowed to dry before dyeing or coloring. Items to be dyed or colored should be preferably coated by the Type II anodizing treatment (see 6.12). Dyed or colored coatings shall not be allowed to remain in rinse waters for more than 5 minutes before sealing.

3.13 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 contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of Section 3. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.2 Classification of inspection. The inspection requirements specified herein are classified as follows:

a. Process control inspection (see 4.3).

b. Quality conformance inspection (see 4.4).

4.3 Process control inspection.

4.3.1 Process control records. The processor shall maintain a record of the history of each processing bath, showing all chemicals or treatment solutions added to the baths and the results of all chemical analysis performed. Chemical analysis shall be performed at least once every week, unless otherwise specified by the procuring activity. Upon request of the procuring activity, such records, as well as reports of the test results, shall be made available. These records shall be maintained for not less than one year after completion of the contract or purchase order.

4.3.2 Process control tests. To assure continuous control of the process, specimens shall be tested in accordance with Table II. Process control tests are conducted to determine conformance of the anodic coatings with the requirements of this specification and are acceptable as evidence of the properties being obtained with the equipment and procedures employed.

4.3.2.1 Frequency of tests. Process control tests shall be conducted once every month. In addition, the intervals between each monthly test shall not exceed 35 days. If production in accordance with this specification is not performed for a period of one month or longer, process control tests shall be conducted at the start of production.

TABLE II. Process control tests and specimens.

Test	Applicable type	Number of specimens to be tested	Paragraph		
			Specimen Preparation	Requirement	Test Method
Coating weight	I, IB and II III 1/	3	4.3.2.2.1 4.3.2.2.1	3.7.1.1 3.7.2.1.1	4.5.2 4.5.2
Coating thickness	III 1/	3	4.3.2.2.1	3.7.2.1	4.5.1
Corrosion resistance	I, IB and II	A minimum of 5	4.3.2.2.2	3.7.1.2	4.5.3
Light fastness	I, IB and II Class 2 only	3	4.3.2.2.2	3.7.1.3	4.5.4
Abrasion resistance	III	2	4.3.2.2.3	3.7.2.2	4.5.5

1/ For Type III coatings, the coating weight may be chosen in lieu of the coating thickness at the option of the procuring activity (see 3.7.2.1.1).

4.3.2.2 Test specimens. The test specimens for the process control inspection shall be prepared in accordance with 4.3.2.2.1 through 4.3.2.2.3, as applicable, for the anodic coating weight, coating thickness, corrosion resistance, light fastness resistance and abrasion resistance. If more than one aluminum alloy is being processed at the same time, the alloy representing the largest percentage of current production shall be used for process control testing. That is, all tests may be conducted with specimens made from that alloy and it is not necessary to test specimens of every alloy being processed. All test specimens shall be anodized in the same manner as the actual hardware, including all pretreatment processes.

4.3.2.2.1 Specimens for thickness and anodic coating weight. Actual hardware shall be selected in lieu of separate specimen panels if it can be conveniently adapted to the coating weight test, (see 4.5.2), and/or coating thickness test, (see 4.5.1). If separate specimen panels are required, they shall be aluminum alloy panels 3 inches in length and width having a minimum nominal thickness of 0.032 inch .

4.3.2.2.2 Specimens for corrosion resistance and light fastness tests. Actual hardware shall be selected in lieu of separate specimen panels if it can be conveniently adapted to the corrosion resistance test, (see 4.5.3), and/or the lightfastness resistance test, (see 4.5.4). If separate specimen panels are required, they shall be aluminum alloy panels 10 inches in length, 3 inches in width and have a minimum nominal thickness of 0.032 inches.

4.3.2.2.3 Specimens for abrasion resistance test. Actual hardware shall be selected in lieu of separate specimen panels if it can be conveniently adapted to the abrasion resistance test in 4.5.5. If separate specimen panels are required, they shall be aluminum alloy panels 4 inches in length and width having a minimum nominal thickness of .063 inches.

4.3.3 Failure. Failure to conform to any of the process control requirements shall result in immediate halt of production. All lots anodized after the failed process control specimens were taken shall not be acceptable. The reason for failure shall be determined and corrected before production resumes. Process control tests shall be reconducted at the start of production.

4.4 Quality conformance (ie. lot acceptance) inspection. Quality conformance inspection shall consist of visual (see 4.4.2.1) and dimensional (see 4.4.2.2) examinations.

4.4.1 Lot. A lot shall consist of all articles, items, parts or components with anodic coatings of the same type and class, approximately the same size, shape, thickness and color submitted for inspection at one time. The lot size shall not exceed the number of parts, articles, items or components resulting from one eight-hour production period.

4.4.2 Samples for visual and dimensional examinations. Unless otherwise specified in the contract or order (see 6.2.1), samples for visual and dimensional examinations of coated articles shall be selected from each lot of anodized parts and articles in accordance with the provisions of MIL-STD-105, Inspection Level II with an Acceptable Quality Level (AQL) of 1.5 percent defective.

4.4.2.1 Visual examination. Samples selected in accordance with 4.4.2 shall be inspected and visually examined for compliance with 3.13 after anodizing and sealing.

4.4.2.2 Dimensional examination. Samples, selected in accordance with 4.4.2, shall be dimensionally inspected for compliance with 3.9, unless otherwise specified by the procuring activity (see 6.10.5).

4.4.3 Failure. Failure to conform to any of the quality conformance requirements shall result in rejection of the represented lot

4.5 Process control test methods.

4.5.1 Anodic coating thickness. Test specimens prepared in accordance with 4.3.2.2.1, shall be tested for anodic coating thickness in accordance with ASTM B 244, Method 520 or Method 520.1 of FED-STD-151, at the option of the contractor, to determine conformance to the requirements of 3.7.2.1. If either ASTM B 244 or Method 520 of FED-STD-151 is used, the thickness shall be computed as the average of not less than eight measurements. 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.

4.5.2 Anodic coating weight. Test specimens prepared in accordance with 4.3.2.2.1 shall be tested for anodic coating weight either in accordance with ANSI/ASTM B 137, or the method specified in 4.5.2.1, at the option of the contractor. Type I, IB and II coatings shall be tested for conformance with the requirements of 3.7.1.1. If the procuring activity chooses to have coating weight tested in lieu of the coating thickness for Type III hard anodized coatings, it shall be tested for conformance with 3.7.2.1.1.

4.5.2.1 Method. Anodic-coating weight determinations shall be accomplished in the following manner:

a. Test specimens shall be weighed following the anodizing treatment. An analytical balance or other instrument sensitive at least to 10 percent of the net anodic-coating weight on the panel or specimen of material shall be used. Specimens shall be cleaned and dried for a minimum of 30 minutes at 93° ± 6°C (200° ± 10°F) and allowed to cool to room temperature before weighing.

b. Immediately following weighing, the test specimens shall be stripped by immersion in a phosphoric-chromic acid solution for a minimum of 5 minutes, (not to exceed 6 minutes), at 100° ± 6°C (212° ± 10°F). The solution shall consist of the following:

Phosphoric acid, 85 percent	35 milliliters
Chromic acid (CrO_3)	20 grams
Water to make	1,000 milliliters

The test specimens shall be removed from the solution, washed in distilled water, dried, and weighed. The 5-minute exposure shall be repeated until the coating is completely removed, which is indicated by the panel or specimen's weight remaining constant. The stripping solution shall be discarded after 1 liter of the solution has dissolved 5 grams of the anodic coating.

c. After final weighing, the total surface area of the test specimen shall be accurately determined.

d. The unit film weight shall be determined by subtracting the weight in milligrams of the stripped specimen from its weight in milligrams prior to stripping and dividing by the surface area expressed in square feet.

4.5.3 Corrosion resistance.

4.5.3.1 Method. Test specimens, prepared in accordance with 4.3.2.2.2, 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 ASTM B 117, except that the significant surface shall be inclined 6 degrees from the vertical. Specimens with Types I, IB and II coatings shall be exposed for 336 hours. After exposure, specimens shall be examined and compared with unexposed specimens for the effects of corrosion to determine compliance with 3.7.1.2.

4.5.4 Light fastness resistance (Class 2 only). Test specimens, prepared in accordance with 4.3.2.2.2, shall be tested for light fastness resistance by exposure to ultraviolet radiation in accordance with either ASTM G 23, ASTM D 822 or ASTM G 26, for a period of 200 hours, except that the specimens will be exposed continuously to light without water spray. After exposure, specimens shall be compared with duplicate specimens not exposed to a light source for the same period of time to determine the Delta (E) value in accordance with ASTM D 2244. The Delta (E) value shall be used to determine conformance with 3.7.1.3.

4.5.5 Abrasion resistance. Test specimens, prepared in accordance with 4.3.2.2.3, shall be tested in accordance with Method 6192 of FED-STD-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 (RPM) for 10,000 cycles. The test specimens shall be weighed to the nearest milligram before, (W1), and after, (W2), abrading . The weight loss obtained by subtracting the final weight from the initial weight, (W1 - W2), shall be used to determine compliance with the requirements of 3.7.2.2.

5. PACKAGING (Not applicable to this specification)

6. NOTES

6.1 Intended use.

6.1.1 Types I, IB and II. The conventional Types I, IB and II anodic coatings are intended to improve surface corrosion protection under severe service conditions or as a base for paint systems. Anodic coatings can be colored with a large variety of dyes and pigments. Types I, IB and II coatings provide better corrosion protection at higher cost than the chromate chemical conversion systems (MIL-C-5541). Repair of mechanically damaged areas by the use of materials conforming to MIL-C-81706, (see 3.3.4), will not restore abrasion resistance but will provide an effective means of reestablishing corrosion resistance.

6.1.2 Type III. Type III coatings are intended to provide wear and abrasion resistant surfaces with improved corrosion protection due to greater thickness and weight than the conventional anodic coatings. Sealing of Type III coatings is not recommended unless corrrosion resistance is also a factor. Wear resistance is reduced by sealing. Anodic coatings form an excellent base for most types of paint systems, adhesives and dry film lubricants. Hard coatings may reduce fatigue strength. These factors should be considered in proposed use of parts subjected to cyclic loads. Generally, these hard 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 hard coated surfaces.

6.1.2.1 Applications. Type III coatings are used in such applications as valves, sliding parts, hinge mechanisms, cams, gears, swivel joints, pistons, rocket nozzles, insulation plates, blast shields, etc.

6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number and date of this specification.

b. Type of anodic coating (see 1.2.1).

c. Class of anodic coating (see 1.2.2).

d. Special process operating conditions, if applicable (see 3.2).

e. Special cleaning and fabrication requirements (see 3.3.1, 3.3.2, and 3.3.3).

f. Type III coating thickness, if applicable (see 3.7.2.1).

g. Color of Class 2 coating, if applicable (see 3.6.1 and 3.12).

h. Light fastness resistance, if applicable (see 3.7.1.3).

i. Coating weight for thickness, Type III, if substituted (see 3.7.2.1.1).

j. Special sealing requirements (see 3.8).

k. Special sampling plans (see 4.4.2).

l. Degree of non-uniformity of dyed casting alloys (see 3.6.1.1).

6.2.2 Exceptions to drawings for types I, IB and II anodic coatings. When the anodic coating type is not specified on the drawing, Type I, IB or II may be furnished within the limits of this specification, at the option of the contractor. When the coating class is not specified on the drawing, either Class 1 or Class 2 shall be supplied within the limits of this specification, at the option of the contractor.

6.3 Painting. When anodized coatings are required to be painted, the parts should be dried and painted as promptly as possible, during which time, exposure to contamination should be kept to a minimum. Prior to painting anodized or sealed parts, wiping, buffing or mechanical operations should be kept to a minimum. This may damage the relatively soft outside layer of the anodic coating make it susceptible to subsequent paint adhesion failures.

6.4 Electrolytic action. Severe attack by the electrolyte on castings or welds may be occasioned either by unsound castings, improper welding practice, a difference in composition between the weld and the base 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 Anodizing rate. Aluminum and aluminum alloys may be conveniently grouped by anodizing rate, especially in the case of the chromic acid process (Type I) for conventional coatings. However, either the chromic (Type I) or the sulfuric acid process (Type II) will anodize mixed loads satisfactorily, depending upon local processing preference. Suppliers are cautioned that, especially in the sulfuric acid process, the anodizing time will have to be sufficiently long to assure that the slower anodizing alloys have at least a minimum coating thickness. In some cases, this may result in improper coatings on the fast anodizing alloys.

6.6 Color match. FED-STD-595 may be used as a guide for specifying color of anodic coatings. The color standards in FED-STD-595 are intended for paint finishes and should be used for approximate comparison only with the anodic coatings. (see 6.2.1).

6.7 Lapping. The Type III anodic coatings generally have increased surface roughness as well as having the property of being softer on the top surface than in the core of the coating toward the base metal. Such coatings may be processed oversized and then lapped or honed down to the final desired dimension.

6.8 Coating baths. For information, it should be noted that processes providing other coating electrolytes for the conventional coatings may be aqueous solutions containing oxalic acid, boric acid plus ammonium borate and nitrides. There are proprietary processes requiring coating electrolytes, other than sulfuric acid, for the Type III coatings; for example, the various Alumilites, the Martin Hard Coat, the Sanford, the Hardas and others. One of the Alumilite processes requires an aqueous solution containing both sulfuric and oxalic acids for the bath. Other baths used less frequently and for special purposes employ sulfosalicylic, sulfamic or sulfophthalic acid solutions.

6.9 Chemical brightening and polishing. Chemical brightening can be beneficial by improving the appearance and corrosion resistance, in smoothing the metallic surface by removing certain contaminants and in enhancing the continuity of the anodic coatings on aluminum alloys (see 3.3.3).

6.10 Design information.

6.10.1 Surface dimension of parts. On specifying the thickness of coatings, especially for the Type III 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 each surface coated due to surface growth. For example, for a 0.004 inch (4 mils) coating on close tolerance parts, a pre-machining 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 caused by anodic coatings, especially Type III, may result in interference on assembly.

6.10.1.1 Holes. In the case of small holes and tapped holes, coating thickness can vary from no film to a full normal coating. Holes, both tapped and not tapped, over 1/4 inch should be anodized. Parts with Type II coatings, external or internal, with a total tolerance of 0.0004 inch or less, if lapped, honed or stoned to size after anodizing, should be subsequently treated with QPL-81706 materials to provide surface protection. Discoloration on the surface that has been sized is acceptable (see 6.6). The designer is cautioned to require adequate thread and hole sealing operations in subsequent assemblies as may be required to produce the necessary corrosion resistance.

6.10.2 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 6.10.1). The pitch diameter for threads having an included angle of 60° will increase 4 times the amount of growth. For threads having an included angle, other than 60°, the pitch diameter will increase 2 times the amount of growth (see 6.10.1) divided by the sine of 1/2 the included angle.

6.10.3 Fabrication. Successful use of anodic coatings, especially the hard Type III, 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 III.

TABLE III. Radii of curvature for nominal coating thickness.

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

6.10.4 Coating thickness. Thickness of the heavy Type III coating can be controlled to extremely close tolerances. Anodized coating can be obtained with tolerances of as little as ± 0.0001 inch (0.1 mil). With all anodizing processes used primarily for engineering rather than for decorative purposes, a number of highly specialized techniques are used for operation control. One method that may be employed is to carefully measure the coated part while still wet and replace it in the bath for a fixed period of treatment. Calculations based upon a calculated rate of coating per unit of processing time may be used as the basis for determining the exact duration of processing required for the specific alloy being coated.

6.10.5 Coating dimensions. Table IV gives thickness ranges of anodic coatings that can be applied on aluminum and aluminum alloys. All anodic coatings are harder than the substrate material. If interference is required for assembly, and is accomplished by force fitting, Type I, IB and some Type II coatings are too thin, too soft and too brittle to withstand abrasive damage during such assembly. With Type III coatings, however, assembly may be accomplished by grinding, lapping or otherwise removing the surplus coating. Coatings of all types are brittle and may crack and spall due to force fittings.

6.10.6 Coating weight - thickness relationship.

6.10.6.1 Thickness. Table V gives typical minimum thicknesses in inches of anodic coatings formed on some wrought and cast alloys that could comply with the minimum coating weight requirements in accordance with Table I for Types I, IA and II, Class 1.

6.10.6.2 Type II. For exterior surfaces processed from sulfuric acid electrolytes (Type II) that are cleaned regularly, a thickness of at least 0.0004 inch (approximately 2450 milligrams per square foot) will assure high resistance to weathering. For exterior parts that are handled frequently or kept without maintenance, a minimum thickness of 0.0007 inch (approximately 3890 milligrams per square foot) should be required. For ordinary applications for interior service, coatings 0.0004 inch thick are ample. Where abrasion resistance is not a factor and parts are not normally handled, thickness of 0.00013 to 0.00025 inch (900 to 1700 milligrams per square foot) may be adequate.

TABLE IV. Thickness ranges of anodic coatings on aluminum and aluminum alloys

Coating Type	Thickness range, inch
I and IB	0.00002 to 0.0003
II	0.00007 to 0.0010
III	0.0005 to 0.0045

TABLE V. Minimum thickness (typical) in inch of anodic coatings.

Alloy designation	Thickness of coating, inch	
	Type I and IB	Type II
1100	0.000029	0.000093
2024-T4	-	0.000125
2024-T6	0.000044	-
3003	0.000035	0.000103
5052	0.000033	0.000098
5056	0.000021	-
6061-T6	0.000034	0.000099
7075-T6	0.000040	-
Alclad 2014-T6	0.000045	-
Alclad 7075-T6	0.000041	-
295-T6	-	0.000107
356-T6	-	0.000102
514	-	0.000086

6.10.7 Effect on fatigue. The fatigue properties of aluminum alloys can be severely reduced by anodic coatings. The amount of reduction varies with the process. As a general rule, the thicker the coating the greater the effect will be.

6.11 Duplex sealing. The corrosion resistance of dyed parts, especially those anodized in a sulfuric acid bath, Type II, may be enhanced by treatment in a sodium dichromate solution either during or after conventional sealing with nickel acetate. This treatment can cause slight changes in the color of the dye. Paint systems adhere very satisfactorily to duplex sealed dyed coatings. However, where any objection with such duplex sealing application is warranted because of a firmly desired coloration, the dual process for sealing should not be used.

6.12 Dyeing or coloring Type I and IB coatings. Because Type I and IB coatings have a different pore structure and a thinner anodized layer than Type II coatings, they are the most difficult to dye. As a result, Type I or IB black anodized is not readily obtainable.

6.13 High copper content alloys. Aluminum alloys having a nominal copper content of 2 percent or higher include all 2xxx series alloys, 7050 and 7178.

6.14 Subject term (key word) listing.

Anodic coatings
Aluminum
Aluminum alloys

6.15 Supersedure data. Type I, conventional chromic acid anodizing, referenced throughout this specification is the same as the Type IA designated in the D revision and the Type I in all versions preceding the D revision.

6.16 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodian:
Army - MR
Navy - AS
Air Force - 20

Review activities:
Army - AR, AV, MI
Navy - EC, OS, SH
Air Force - 70, 71, 80, 82, 99

User activities:
Army - AT, CR, GL, ME

Preparing activity:
Navy - AS
(Project no. MFFP-0368)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-A-8625E	ANODIC COATINGS, 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)*

DD FORM 82 MAR 1426

PREVIOUS EDITION IS OBSOLETE.