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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 three 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 IA	-	Conventional coatings produced from chromic acid bath (see 3.4.1)
Type IB	-	Low voltage chromic acid arodizing (20V)
Type II	-	Conventional coatings produced from sulfuric acid bath (see 3.4.2)
Type III	-	Uniform Anodic Coatings (see 3.4.3)

1.2.2 Classes.

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

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation, form a part of this specification to the extent specified herein.

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 93), 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.

NO INFORMATION REQUIREMENTS 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.

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

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

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

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, Recommended Practice for Operating.
ASTM D 2244	-	Color Differences of Opaque Materials, Instrument Evaluation.
ASTM G 23	-	Standard Practice for Operating Light Exposure Apparatus (Carbon-arc Type) with and without Water

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

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 (see 3.9).

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. 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. Assemblies which contain non-aluminum parts 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.

3.3.2 Handling and cleaning. Parts shall be so handled during all pretreatments, anodizing and post treatments that mechanical damage or contamination will be avoided. The base metal shall be thoroughly cleaned prior to anodizing. 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 6.2.1).

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. 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 sulfuric acid from Type II baths, will engender corrosion of aluminum. Where coating of assemblies is not authorized, parts of assemblies shall be anodic coated before assembling. Post cleaning of anodized surfaces of these parts of assemblies shall be accomplished with slightly acidic or deionized water in order to allow for proper anodic seal.

3.3.5 Rework. Unless otherwise specified by the acquiring activity, mechanically damaged areas from which the anodic coating has been removed may be repaired, using chemical film materials meeting the requirements of MIL-C-5541, Class 1A, brush application (MIL-C-81706, Method B). The reworked area shall not exceed 1/2 inch in the longest dimension; or 5% of total surface area, whichever is less.

3.4 Coatings. Conventional anodic coatings as specified in the contract, order or applicable drawings, 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 coatings. Type I 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 IA coating 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. For 7000 series alloys, Type IB coatings should be used. Heat treatable alloys which are to receive a Type I coating should be in a temper obtained by heat treatment, such as -T4 or -T6, prior to anodizing. Parts having complex shapes in which solution may be entrapped shall be processed by Type I 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.

3.4.3 Type III coating. Type III coatings shall be the result of treating aluminum and aluminum alloys electrolytically to produce a uniform anodic coating on the metal surface. Coatings conforming to Type III classification, 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 3.5). Type III coating processes may be used to produce Type II coatings.

3.5 Thickness. Thickness of Type III coatings shall be as specified in the contract, order, or applicable drawing. Hard coatings may vary in thickness from 0.0005 inch (0.5 mil) to more than 0.004 inch (4 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). Unless otherwise specified, the thickness of the coating shall not vary by more than plus or minus ten percent (see 6.14.4).

3.6. Nominal content. Unless otherwise specified in the contract, order or applicable drawing, Type I coatings produced from the anodizing baths shall not be applied to aluminum alloys with a nominal copper content in excess of 5.0 percent or a nominal silicon content in excess of 8.0 percent. Alloys with a higher nominal silicon content than 8.0 percent may be anodized subject to approval of the acquiring activity, provided data is submitted by the supplier which shows that such coatings are equivalent to those obtained on alloys of lower silicon contents.

3.7 Class 1 coatings. Class 1 anodic coatings of Types I, II and III 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 coatings.

3.8 Class 2 coatings. Class 2 anodic coatings of Types I, II, and III 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 shall not be damaging to the anodic coatings.

3.8.1 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).

3.8.2 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).

3.9 Defects. If variations in color patterns, pitting, brazing or other defects are revealed as a result of anodizing, this condition must be brought to the attention of the acquiring activity.

3.10 Detail requirements.

3.10.1 Types I and II coatings.

3.10.1.1 Weight of coating. After sealing, Types I and II coatings shall conform to the minimum weight requirements of Table I when tested in accordance with 4.3.3 (see 6.11.6). 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.

3.10.1.2 Corrosion resistance. Sealed anodic coatings shall protect the substrate metal when specimens or items are subject to the corrosion resistance test specified in 4.5.3. When examining the specimen panels for corrosion resistance, the specimen panels shall show no more than a few pits visible without magnification. 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, edges and electrode contact marks remaining after processing.

3.10.1.3 Light fastness resistance. Items or separate specimens with Class 2 dyed anodic coatings shall show no more fading or discoloration than would be equivalent to a color difference of 3 units when subjected to the light fastness resistance test specified in 4.5.4. When specified in the contract, order or applicable drawing, light fastness resistance shall be determined (see 6.2.1).

3.10.1.4 Thickness. The requirements for thickness for Type I and Type II castings are specified in Tables III, IV, and V.

3.10.2 Type III coatings.

3.10.2.1 Thickness of coating. Type III coatings shall conform to the specified thickness requirements when tested in accordance with 4.5.1 (see 3.7.1). Type III coating thickness range is specified in Table IV.

3.10.2.1.1 Weight of coating. The weight of coating may be determined in lieu of the thickness of coating (see 3.10.2.1), at the option of the acquiring activity. For Type III unsealed coatings, 4320 milligrams per square foot is equivalent to 0.001 inch thickness when tested in accordance with 4.5.2 (see 6.2.1).

3.10.2.2 Abrasion resistance. The anodized coatings, applied by any process for unsealed Type III coating, shall have a hard abrasion resistance finish. The items or separate specimens shall be subject to the abrasion test specified in 4.5.5. 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 subject to the abrasion test.

3.11 Sealing.

3.11.1 Types I and II. All Types I and II anodic coatings shall be completely sealed, unless otherwise specified in the contract, order or applicable drawing, by oxide hydration or absorption of metallic salt inhibitors. If wetting agents are used they must be of the non-ionic type. (see 6.2.1).

3.11.1.1 Class 1. Sealing shall be accomplished by immersion in a sealing medium such as a 5 percent aqueous solution of sodium dichromate (pH 5.0 to 6.5) for 15 minutes at 90°C to 98°C (200° to 210°F), boiling deionized water, or other suitable chemical solutions. If not otherwise specified, sealing shall be in a water solution of the sodium dichromate heated at 90°C to 98°C (200° to 210°F) for enhancing corrosion resistance of the anodic coating.

3.11.1.2 Class 2. 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 or other suitable chemical solutions (see 6.12).

3.11.2 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 coatings shall be sealed. Sealing for such Type III coatings shall be accomplished by immersion in a medium, such as boiling deionized water, in hot aqueous 5 percent sodium dichromate, in a hot aqueous solution containing nickel or cobalt acetate or other suitable chemical solutions (see 6.2.1). Unless otherwise specified in the contract, order or applicable drawing, Type III anodic coatings shall be furnished unsealed as Class 1 only. When unsealed, parts shall be thoroughly rinsed in cold, deionized clean water and dried after anodizing.

3.12 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 6.11.5).

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.

3.14 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 its intended purpose 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.

3.15 Painting. Primary painting operations should be performed on fresh, uncontaminated, anodized parts within 48 hours of the anodizing process.

3.16 Dyeing or coloring. Anodic coatings for Class 2 application should not be allowed to dry before dyeing or coloring. Anodic coatings to be dyed or colored should be preferably coated by the Type II anodizing treatment. Dyed or colored coatings should not be allowed to remain in rinse waters for more than 5 minutes before sealing.

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.

4.2 Classification of inspection. The inspection requirements specified herein are classified as quality conformance inspections and shall consist of the following:

a. Process control inspection (see 4.3).

b. Lot sampling inspection (see 4.4).

4.3 Process control inspection.

4.3.1 Control records. The processor shall maintain a record of the history of each processing bath, showing all chemicals or treatment solutions added to the unit, the results of all chemical analyses performed and the quantity of parts coated during operation. Upon request of the acquisition 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 Analytical inspection. Analytical inspections of the process shall be conducted and documented as may be appropriate (but not less than weekly) for the processing method to assure that the equipment, procedures, and operations employed by the processor shall be capable of producing high quality anodic coatings on aluminum and aluminum alloys as specified in this document.

4.3.3 Process control tests.

4.3.3.1 Frequency of tests. To assure continuous control of the process, specimens shall be prepared and tested in accordance with Table II and 4.3.3. The test specimens shall be prepared in accordance with 4.3.3.2 through 4.3.3.2.3, as applicable. The tested specimens shall conform to the requirements of this specification. These tests shall be conducted at least once a month or more frequently if required by the procuring activity. These 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.

4.3.3.2 Test specimens. The test specimens for the process control inspection shall be prepared in accordance with 4.3.3.2.1 through 4.3.3.2.3, as applicable, for the anodic coating weight, corrosion resistance, light resistance and abrasion resistance. If more than one aluminum alloy is being processed at the same time, the alloy representing the largest part of current production shall be used for process control inspection specimens, that is, all tests may be conducted with specimens made from that alloy. It is not necessary to test specimens of every alloy being processed at one time.

4.3.3.2.1 Specimens for thickness and anodic coating weight. Random items (if the surface area is measurable) or separate specimen panels, prepared as specified herein, shall be selected at least once a week for determination of coating weight. If separate specimens are required, they shall be aluminum alloy panels not less than 3 inches in length and width, 0.032 inch nominal thickness, and of the same composition and temper as the production work and anodized concurrently. The selected items or prepared specimen panels shall be tested for anodic coating weight either in accordance with ANSI/ASTM B 137, Weight of Coating on Anodically Coated Aluminum, or the method specified in 4.5.2.1, at the option of the contractor, to determine conformance to the requirements of 3.10.1.1, for the specified minimum weight of the Type I or Type II coatings. The item or separate specimen panel shall be considered defective if the coating weight fails to meet the specified minimum weight and no further work shall be processed until adjustments have been made to bring the coating weight up to the required minimum. However, if production in accordance with this specification is not performed for a period of one week or longer, these tests shall be conducted at the beginning of production start-up.

4.3.3.2.2 Specimens for corrosion resistance and light fastness tests. If separate specimens for corrosion resistance and light fastness tests are required, they shall be aluminum alloy panels not less than 10 inches in length and 3 inches in width. Specimens shall be of an alloy of the same composition and temper as the production work and anodized concurrently.

4.3.3.2.3 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, similar in composition and temper to the production work and anodized concurrently.

4.4 Lot sampling inspection.

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 Coated articles. Samples selected in accordance with 4.4.4.1 shall be inspected and visually examined for compliance with 3.13 after anodizing and sealing.

4.4.3 Dimensional examination. Samples selected in accordance with 4.4.4.1 shall be inspected for dimensional requirements for compliance with 3.12, unless otherwise specified by the acquiring activity (see 6.11.5).

4.4.4 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.

4.4.4.1 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, Inspection Level II with an Acceptable Quality Level (AQL) of 1.5 percent defective.

4.5 Tests.

4.5.1 Anodic coating thickness. The separate items or prepared specimen panels shall be tested for anodic coating thickness in accordance with ASTM B 244, Measuring Thickness of Anodic Coatings on Aluminum with Eddy Current Instrument, Method 520 or Method 520.1 of FED-STD-151, at the option of the contractor, to determine conformance to the requirement of 3.10.2.1. 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. If one or more of the items or panels fails to meet the specified thickness range for the Type III 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.

4.5.2 Anodic coating weight. If the surface area is measurable, random items or separate specimen panels, prepared in accordance with 4.3.3.2.1, shall be selected. The selected items or prepared specimen panels shall be tested for anodic coating weight either in accordance with ANSI/ASTM B 137, Weight of Coating on Anodically Coated Aluminum, or the method specified in 4.5.2.1, at the option of the supplier, to determine conformance to the requirements of 3.10.1.1, for the specified minimum weight of the Type I or Type II coatings. The item or separate specimen panel shall be considered defective if the coating weight fails to meet the specified minimum weight and no further work shall be processed until adjustments have been made to bring the coating weight up to the required minimum.

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

a. The test panel or specimen of material to be tested 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 30 minutes at 93°C (200°F) and allowed to cool to room temperature before weighing.

b. Immediately following weighing, the test panel or specimen of material shall be stripped by immersion in a phosphoric-chromic acid solution for 5 minutes at 100°C (212°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 panel or specimen 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 panel or specimen from its weight in milligrams prior to stripping and dividing by the surface area expressed in square feet.

4.5.3 Corrosion resistance. When processed parts are such that they may be conveniently adapted for the corrosion resistant test, the actual parts may be selected for test in lieu of separate test panels prepared in accordance with 4.3.3.2.2. The selected items or specimen test panels shall be tested for corrosion resistance in accordance with the method specified in 4.5.3.1.

4.5.3.1 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 811.1 of FED-STD-151 or ASTM B 117, Method of Salt Spray (Fog) Testing, except that the significant surface shall be inclined approximately 6 degrees from the vertical. Specimens with Types I 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 3.10.1.2.

4.5.4 Light fastness resistance. (Class 2 only). When processed parts are such that they may be conveniently adapted for the radiation test, the actual part may be selected for test in lieu of separate test panels prepared in accordance with 4.3.3.2.2. The selected items or prepared specimen test panels shall be tested for light fastness resistance by exposure to ultra-violet radiation in accordance with either ASTM G 23 or ASTM D 822, for a period of 200 hours, except that the specimens will be exposed continuously to light without water spray. After exposure, the tested specimens shall be compared with duplicate specimens not exposed to a light source for the same period of time to determine compliance with 3.10.1.3. If there is any visual indication of appreciable fading or discoloration of the semimetallic luster or when determined by ASTM D 2244, Method for Instrumental Evaluation of Color Differences of Opaque Materials, as compared with the unexposed specimens, the dyed anodic films shall be considered unsatisfactory and the lot represented by the specimens shall be rejected (see 6.7.)

4.5.5 Abrasion resistance. When processed parts are such that they may be conveniently adapted for the abrasion test, the actual part may be selected for test in lieu of separate test panels prepared in accordance with 4.3.3.2.3. The selected items or specimen test panels 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. After abrading, the specimens shall be weighed to the nearest milligram and the weight loss obtained to determine compliance with the requirements of 3.10.2.2. If the amount of the coating abraded is more than specified, the coating shall be considered unsatisfactory.

5. PACKAGING (Not applicable to this specification)

6. NOTES

6.1 Intended use.

6.1.1 Types I and II. The conventional Types I 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 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-5541 (see 3.3.5) will not restore abrasion resistance but 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, 3.5, 3.4.2, and 3.4.3).

c. Class of anodic coating (see 1.2.2, 3.7., and 3.8.1).

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

e. Special cleaning and fabrication requirements (see 3.3.1, 3.3.2, 3.3.3 and 3.3.4).

f. Type III coating thickness, if applicable (see 3.5).

g. Color of Class 2 coating, if applicable (see 3.8.1 and 3.13).

h. Color requirement for small parts identification, if applicable (see 3.10.1.1).

i. Light fastness resistance, if applicable (see 3.10.1.3).

j. Coating weight for thickness, Type III, if substituted (see 3.10.2.1.1).

k. Special sealing requirements (see 3.11).

l. Special sampling plans (see 4.4.4).

m. Corrosion resistance (see 3.10.1.2).

n. Degree of non-uniformity of dyed casting alloys (see 3.8.2).

6.2.2 Exceptions to drawings. When either Type or Class of anodic coating or both, are not specified on drawings, except for hard coatings, then either Type I or Type II, Class 1 or Class 2, anodic coating may be furnished at the option of the contractor within the limits of this specification.

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 and make the coat 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, 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 Light-fastness. The black dye has been found satisfactory by the Department of the Army in post-anodic processing of Type II coating to meet the requirements of light-fastness (see 3.10.1.3) when tested in accordance with 4.5.4.

6.8 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 down 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.

6.9 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.

6.10 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).

6.11 Design information.

6.11.1 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.

6.11.1.1 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 shall 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, must be subsequently treated in accordance with MIL-C-5541 to provide surface protection. Discoloration on the surface that has been sized is acceptable (see 6.8). 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.

6.11.2 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 6.11.1). 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 6.11.1) divided by the sine of 1/2 the included angle.

6.11.3 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.

6.11.4 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.

6.11.5 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 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.

6.11.6 Coating weight - thickness relationship.

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

6.11.6.2 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 38% milligrams per square foot) should be required. For ordinary applications for interior service, coatings 0.0004 inch thick are ample. Where abrasive 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.

6.11.7 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.

6.12 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.

6.13 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

Preparing activity:
Navy - AS
(Project no. MFFP-0265)

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

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

TABLE I. Types I and II anodic coating weights.

Type	Milligrams per square foot (minimum)	
	Class 1	Class 2
I	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 the minimum coating weights shall be 1400 milligrams per square foot.

TABLE II. Process control tests and specimens.

Test	Applicable type	Specimen size	Paragraph	
			Requirement	Preparation
Coating Weight	I, II	1/	3.10.1.1	4.3.3.2.1
Corrosion resistance	I, II	1/	3.10.1.2	4.3.3.2.2
Light fastness 2/	I, II	1/	3.10.1.3	4.3.3.2.2
Abrasion resistance	III	1/	3.10.2.2	4.3.3.2.3

1/ Production part or specimen of same alloy.

2/ Light fastness test is required only when specified in the contract, order or applicable drawing. If more than one alloy is being processed in production, test specimens shall be used for the alloy with the largest quantity.

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

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

Coating type	Thickness range, inch
I	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	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

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-A-8625D	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)*

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