NOT MEASUREMENT
SENSITIVE

MIL-PRF-8625F
w/AMENDMENT 2
23 November 2020
SUPERSEDING
MIL-A-8625F
w/AMENDMENT 1
15 September 2003

PERFORMANCE SPECIFICATION

ANODIC COATINGS FOR ALUMINUM AND ALUMINUM ALLOY

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 six types and two classes of electrolytically formed anodic coatings on aluminum and aluminum alloys for non-architectural applications (see 6.1).

1.2 Classification. The anodic coating types and classes covered by this specification are as specified herein (see 6.2 and 6.21).

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 22 ±2V, (see 3.4.1)
Type IC – Non-chromic acid anodizing, for use as a non-chromate alternative for Type I and IB coatings (see 3.4.1 and 6.1.2)
Type II – Sulfuric acid anodizing, conventional coatings produced from sulfuric acid bath (see 3.4.2)
Type IIB – Thin sulfuric acid anodizing, for use as a non-chromate alternative for Type I and IB coatings (see 3.4.2 and 6.1.2)
Type III – Hard anodic coatings (see 3.4.3)

Comments, suggestions, or questions on this document should be addressed to Commanding Officer, Naval Air Warfare Center Aircraft Division Lakehurst, Systems Standardization and PHS&T Branch, Code BL32600, Mail Stop 120-3, Route 547, Joint Base MDL, NJ 08733-5100 or emailed to frank.magnifico@navy.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST online database at https://assist.dla.mil.

AMSC N/A AREA MFFP

1.2.2 Classes.

Class 1	Non-dyed (see 3.5)
Class 2	Dyed (see 3.6)

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This document does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.1.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the solicitation or contract.

FEDERAL STANDARD

FED-STD-141 – Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-PRF-23377 – Primer Coatings: Epoxy - High Solids
MIL-DTL-81706 – Chemical Conversion Materials for Coating Aluminum And Aluminum Alloys
MIL-PRF-85582 – Primer Coatings: Epoxy, Waterborne

DEPARTMENT OF DEFENSE STANDARD

MIL-STD-1916 – DoD Preferred Methods for Acceptance of Product

(Copies of these documents are available online at https://quicksearch.dla.mil.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) INTERNATIONAL

ASTM B117 – Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B137 – Standard Test Method for Measurement of Coating Mass Per Unit Area on Anodically Coated Aluminum
ASTM B244 – Standard Test Method for Measurement of Thickness of

		Anodic Coatings on Aluminum and of Other Nonconductive Coatings on Nonmagnetic Basis Metals with Eddy Current Instruments
ASTM D822/D822M	–	Standard Practice for Filtered Open-Flame Carbon-Arc Exposures of Paint and Related Coatings
ASTM D2244	–	Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
ASTM D4060	–	Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
ASTM E376	–	Standard Practice for Measuring Coating Thickness by Magnetic-Field or Eddy Current (Electromagnetic) Testing Methods
ASTM G152	–	Standard Practice for Operating Open Flame Carbon Light Apparatus for Exposure of Nonmetallic Materials
ASTM G155	–	Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Nonmetallic Materials

(Copies of these documents are available online at www.astm.org.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE) INTERNATIONAL

SAE AMS4037	–	Aluminum Alloy 2024, Plate and Sheet

(Copies of these documents are available online at http://www.sae.org.)

2.3 Order or precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes 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 that meet the requirements of this specification.

3.1.1 Base metal. The base metal shall be free from surface defects, caused by machining, cutting, scratching, polishing, buffing, roughening, bending, stretching, deforming, rolling, sandblasting, vapor blasting, etching, heat treatment condition, alloy chemistry imbalance and inclusions, that will cause coated test panels or parts to fail any of the requirements of this specification. The base metal shall be subjected to 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, purchase order or applicable drawing (see 6.2), process operating conditions shall be at the option of the supplier.

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), 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, purchase order or applicable drawing (see 6.2), anodic coatings shall not be applied to assemblies that will entrap the electrolyte in joints or recesses (components shall be anodized separately prior to assembly). When anodizing of assemblies is authorized by the contract, purchase order or applicable drawing, the processing method used shall not result in subsequent damage to the assembly from electrolyte entrapment (type I or IB coatings shall be used unless another coating type is specified). Assemblies that 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 anodic coatings meeting the requirements of this specification.

3.3.1.3 Anodizing of complex shapes. When anodizing complex shapes which will entrap the electrolyte in recesses, the processing method used shall not result in subsequent damage to the part from electrolyte entrapment (type I or IB coatings shall be used unless another coating type is specified).

3.3.2 Handling and cleaning. Parts shall be so handled during all pretreatments, anodizing and post treatments so 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 purchase order (see 6.2).

3.3.3 Reflective surfaces. When specified in the contract or purchase order (see 6.2), parts fabricated to produce a highly reflective surface shall be chemically or electrochemically brightened, prior to anodic coating (see 6.9).

3.3.4 Touch up (mechanical damage and contact marks). Unless otherwise specified (see 6.2), mechanically damaged areas from which the anodic coating has been removed without damage to the part may be touched up using chemical conversion materials in accordance with MIL-DTL-81706 for class 1A coatings and the applicable method of application. Touch up shall apply only to inadvertent mechanical damage such as scratch marks. For type III coatings, touch up shall only be allowed in areas that will not be subjected to abrasion (see 6.1.1). The mechanically damaged area(s) shall not exceed 5 percent of the total anodized area of the item or touch up shall not be permitted. When specified in the contract or purchase order (see 6.2), contact marks shall be touched up using the method herein required for mechanical damage.

3.4 Coatings. Conventional anodic coatings as specified in the contract, purchase order or applicable drawings (see 6.2), shall be prepared by any process or operation to produce the specified coating on aluminum and aluminum alloys.

3.4.1 Type I, IB, and IC 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. Type IC coatings shall be the result of treating aluminum and aluminum alloys electrolytically in a bath containing mineral or mixed mineral/organic acids (non-chromic acid) to produce a uniform anodic coating on the metal surface. Unless otherwise specified in the contract, purchase 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, IB, or IC coating shall be in the required temper obtained by heat treatment, such as –T4, –T6, or – T73, prior to anodizing.

3.4.1.1 Type IC coatings. Type IC coatings provide a non-chromate alternative to type I and IB coatings. Unless approved by the procuring activity, substitution of a type IC coating where Type I or IB is specified shall be prohibited.

3.4.2 Type II and IIB coatings. Type II and IIB 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 the required temper obtained by heat treatment such as –T4, –T6, or –T73, prior to anodizing.

3.4.2.1 Type IIB coatings. Type IIB coatings provide a non-chromate alternative to type I and IB coatings. Unless approved by the procuring activity, substitution of a type IIB coating where type I or IB is specified shall be prohibited.

3.4.2.2 Photosensitized (identification) nameplates. When type II anodic coatings are specified for use in photosensitized nameplates, oxalic acid anodizing may be used in lieu of sulfuric acid anodizing. If oxalic acid anodizing is used, the resultant coating shall meet the requirements of this specification for type II anodic coatings. If copy and background color are added to photosensitive nameplates, silver compounds or dyes shall be used. Unprocessed photosensitive aluminum shall be classified as class 1. Nameplates made from photosensitive aluminum shall be classified as class 2.

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 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, purchase order or applicable drawing, type III coatings 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 nominal silicon content higher than 8.0 percent may be anodized subject to approval of the procuring activity. Heat treatable alloys shall be in a temper obtained by heat treatment, such as –T4, –T6, or –T73, prior to anodizing.

3.5 Class 1. When class 1 is specified in the contract, applicable drawing, or purchase order (see 6.2), 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 sealing process shall also be considered as non-dyed.

3.6 Class 2. When class 2 is specified in the contract, applicable drawing, or purchase order (see 6.2), 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 (or color uniformity) associated with the inherent porosity of the casting. The 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 and color uniformity requirements shall be as specified on the contract, purchase order or applicable drawing (see 6.2).

3.6.1.1 Casting alloys. Dyed casting alloys may show a slight lack of color uniformity. The degree of non-uniformity that is acceptable shall be established by the procuring activity (see 6.2).

3.7 Detail requirements.

3.7.1 Types I, IB, IC, II, and IIB coatings.

3.7.1.1 Weight of coating. Prior to dyeing or sealing, Type I, IB, IC, II, and IIB coatings shall meet the coating weight requirements of table I when tested in accordance with 4.5.2 (see 6.10.6).

TABLE I. Types I, IB, IC, II, and IIB unsealed anodic coating weights.

Coating Type	**Coating Weight (mg/ft^2)**
I and IB	200 minimum
IC 1/	200 minimum – 700 maximum
II	1000 minimum
IIB	200 minimum – 1000 maximum

1/ Coating weights over 700 mg/ft^2 may be used if specified in the contract or order (see 6.1.2 and 6.2).

3.7.1.2 Corrosion resistance. After exposure to the salt spray test specified in 4.5.3, specimens shall be visually examined to determine that all of the following conditions are met:

a. Test specimens shall show no more than a total of 15 isolated pits (see 6.19), none larger than 0.031 inch in diameter, in a total of 150 square inches of test area grouped from five or more test pieces. Areas within 0.062 inch from identification markings, edges and electrode contact marks remaining after processing shall be excluded.
b. Test specimens shall show no more than 5 isolated pits, none larger than 0.031 inch in diameter in a total of 30 square inches from one or more test pieces. Areas within 0.062 inch from identification markings, edges and electrode contact marks remaining after processing shall be excluded.
c. In addition to the requirements in (a) and (b) above, types I and IB test specimens that exhibit large areas of gross discoloration (dark grey areas) shall meet the following additional requirement. The total number and per panel number of pits used to verify that the requirements of (a) and (b) above are met shall be determined by adding the number of pits found with the unaided eye to the number of pits found in the areas of gross discoloration determined when examined at a magnification of 10X. This requirement does not apply to areas of slight discoloration or fading such as those areas that may result from chromate leaching during salt spray exposure.

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), unless otherwise specified in the contract or purchase order (see 6.2). Light fastness resistance shall be determined only when specified in the contract, purchase order or applicable drawing (see 6.2).

3.7.1.4 Paint adhesion. When tested in accordance with 4.5.6, no intercoat separation shall occur between the paint system and the anodic coating or between the anodic coating and the base metal. Paint adhesion shall be determined only when specified in the contract, purchase order or applicable drawing (see 6.2).

3.7.2 Type III coatings.

3.7.2.1 Thickness of coating. Unless otherwise specified in the contract, purchase order or applicable drawing (see 6.2), the nominal thickness of the coating shall be 0.002 inch (2 mils) (see 6.16, 6.17 and 6.10 through 6.10.5). Unless otherwise specified, the thickness of the coating shall not vary by more than ±20 percent for coatings up to 0.002 inch thick (2 mils) when tested in accordance with 4.5.1. Coatings over 0.002 inch (2 mils) shall not vary by more than ±0.0004 inch (0.4 mils) in thickness. 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).

3.7.2.2 Abrasion resistance. When tested in accordance with 4.5.5, unsealed type III coatings shall provide a hard abrasion resistant finish as specified herein (see 6.17). The anodic coating shall have a maximum wear index of 3.5 mg/1000 cycles on aluminum alloys having a copper content of 2 percent or higher (see 6.13). The wear index for all other alloys shall not exceed 1.5 mg/1000 cycles.

3.8 Sealing.

3.8.1 Types I, IB, IC, II, and IIB. All types I, IB, IC, II, and IIB anodic coatings shall be completely sealed, unless otherwise specified in the contract, purchase order, or applicable drawing (see 6.2). They shall be sealed in accordance with 3.8.1.1 or 3.8.1.2, as applicable. If wetting agents are used, they shall 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 or potassium 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, cobalt or nickel acetate, or other suitable chemical solutions (see 6.15).

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). When type III coatings are provided unsealed, parts shall be thoroughly rinsed in cold, clean water and dried after anodizing.

3.9 Dimensions of coated articles. DELETED.

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. 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/coating. Painting/coating operations shall be performed as soon as practical after the anodizing process on clean coatings. If parts require storage prior to painting/coating, they shall be stored in a manner that will avoid contamination. If the parts become contaminated, they shall be cleaned in a manner that is not detrimental to the anodic coating or the base 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. Except for touch up areas in accordance with 3.3.4, and as noted below, the applied anodic coating shall be continuous, smooth, adherent, uniform in appearance, free from powdery areas, loose films, breaks, scratches and other defects which will reduce the serviceability of anodized parts or assemblies. Differences in anodic coating appearance resulting from inherent base metal differences in a component such as the presence of welds, components containing cast and machined surfaces, and differences in grain size within a forging shall not be cause to reject the anodic coating unless otherwise specified in the contract or purchase order (see 6.2). Slight discoloration from dripping or rundown of the sealing solution from designed crevices in a component shall be allowed.

3.13.1 Contact marks. The size and number of contact marks shall be at a minimum consistent with good practice (see 6.14). If a specific location for contact marks is desired, the location shall be as specified on the applicable drawing, contract or purchase order (see 6.2).

4. VERIFICATION

4.1 Responsibility for inspection. DELETED.

4.1.1 Responsibility for compliance. DELETED.

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

a. Process control inspection (see 4.3).
b. Conformance inspection (see 4.4).

4.3 Process control inspection.

4.3.1 Process control document (PCD). The anodizer shall develop, maintain, and adhere to a PCD describing the anodizing process and procedures used to meet the requirements of this specification. As a minimum, the PCD shall describe the following:

- All steps in the processing sequence.
- Ranges for immersion time and temperature for each step in the process.
- Chemical constituents used and allowable solution control ranges to be used for solution analysis (see 4.3.2) for each step in the process.
- Ranges for temperature, current density and anodizing time (or voltage ramps and hold times) as applied to individual alloys or alloy series.

4.3.2 Solution analysis. Solution analysis shall be performed on all the processing solutions in the anodizing line to determine if the solution controls are within the acceptable ranges as established in the PCD (see 4.3.1). Solution analysis shall be performed at least once every two weeks, unless otherwise specified by the procuring activity. 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. 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 the completion of the contract or purchase order.

4.3.3 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.

4.3.3.1 Frequency of the process control tests. Process control tests shall be conducted at least once a 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.

Test	Applicable type	Number of specimens to be tested	Paragraph		
			Specimen preparation	Requirement	Test method
Coating weight	I, IB, IC, II, IIB III 1/	3	4.3.3.2.1	3.7.1.1 3.7.2.1.1	4.5.2
Coating Thickness	III 1/	3	4.3.3.2.2	3.7.2.1	4.5.1
Corrosion resistance	I, IB, IC, II, IIB III 2/	5 (minimum)	4.3.3.2.3	3.7.1.2	4.5.3
Light fastness	I, IB, IC, II, IIB class 2 only	3	4.3.3.2.3	3.7.1.3	4.5.4
Abrasion resistance	III	2	4.3.3.2.4	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).
2/ Type III coatings shall be tested for corrosion resistance only when it is specified that the coating is sealed at the option of the procuring activity.

4.3.3.2 Process control test specimens. Production parts shall be used for process control inspection provided they can be adapted to the applicable test. If the production parts cannot be adapted to a particular test, test panels shall be used. At the option of the supplier, test panels shall be composed of either 2024-T3 in accordance with SAE AMS4037 or the alloy representing the largest percent of work anodized during the monthly process control period. Whenever possible, the specimen panels shall be anodized with an actual production run. Additional details for the specimen panels shall be as specified in 4.3.3.2.1 through 4.3.3.2.4.

4.3.3.2.1 Test specimens for coating weight. Coating weight shall be determined on undyed and unsealed production parts or specimen panels (see 4.3.3.2). When specimen panels are used, they shall have a minimum width of 3 inches, a minimum length of 3 inches, and a minimum nominal thickness of 0.032 inch.

4.3.3.2.2 Test specimens for coating thickness. Coating thickness shall be determined on type III production parts or specimen panels (see 4.3.3.2). When specimen panels are used, they shall have a minimum width of 3 inches, a minimum length of 3 inches, and a minimum nominal thickness of 0.032 inch.

4.3.3.2.3 Test specimens for corrosion and light fastness resistance. Corrosion resistance shall be determined on undyed and sealed production parts or specimen panels (see 4.3.3.2). When light fastness testing is specified (see 6.2), it shall be performed on dyed and sealed (class 2) production parts or specimen panels (see 4.3.3.2). When specimen panels are used, they shall have a width of not less than 3 inches, a length of not less than 10 inches, and a nominal thickness of not less than 0.032 inch.

4.3.3.2.4 Test specimens for abrasion resistance. Abrasion resistance shall be determined on type III production parts or specimen panels (see 4.3.3.2). When specimen panels are used, they shall have a width of 4 inches, a length of 4 inches, and a minimum nominal thickness of 0.063 inch.

4.3.4 Failure. Failure to conform to any of the process control requirements specified in table II shall result in immediate halt of production. The reason for failure shall be determined and corrected before production resumes. All traceable work from the time the failed process control specimens were anodized to the time when production was halted shall be rejected unless otherwise specified by the contracting officer. Traceable work shall be defined as all work in which the location is known. Process control testing shall be performed at the start of production.

4.4 Conformance (i.e., lot acceptance) inspection. Conformance inspection shall consist of visual examination (see 3.13), color examination for class 2 coatings (see 3.6.1), and coating thickness examination for type III coatings (see 3.7.2.1). When specified in the contract or order (see 6.2), conformance inspection shall also include paint adhesion testing in accordance with 4.5.6.

4.4.1 Lot. A lot shall consist of all items of the same part number anodized in the same tank using the same process and of the same coating type and class offered for acceptance at one time. In addition, the lot size shall not exceed the number of items processed in one shift.

4.4.2 Sampling for visual, color (class 2) and thickness (type III) examinations. Samples for visual examination, color (class 2), and coating thickness (type III) shall be selected from each lot of anodized parts, after anodizing, sealing and dyeing (if applicable), in accordance with the provisions of MIL-STD-1916, Verification Level II. The acceptance criteria shall be as specified in the contact or order (see 6.2).

4.4.2.1 Visual examination. DELETED.

4.4.2.2 Dimensional examination. DELETED.

4.4.3 Sampling for paint adhesion testing. When the paint adhesion test is specified (see 4.4), two test panels shall be tested in accordance with 4.5.6 to determine conformance to 3.7.1.4. The test panels shall be 3 inches in width by 10 inches in length with a minimum nominal thickness of 0.032 inch. Unless otherwise specified, the test panels shall be composed of either 2024-T3 in accordance with SAE AMS4037 or the predominant alloy in the lot from which the paint adhesion test is required to be performed. Unless another paint system is specified in the contract or order (see 6.2), the paint system in 4.4.3.1 shall be applied to the anodized panels.

4.4.3.1 Preparation of paint adhesion specimens. Specimen panels (see 4.4.3) shall be finished with one coat of an epoxy-polyamide primer conforming to either MIL-PRF-23377 (Class 1 or 2) or MIL-PRF-85582. In either case, the primer shall be applied to a dry film thickness of 0.0006 to 0.0009 inch (0.6 to 0.9 mil) and dried in accordance with the applicable primer specification before testing in accordance with 4.5.6.

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

4.5 Test methods.

4.5.1 Anodic coating thickness. Test specimens prepared in accordance with 4.3.3.2.2, shall be tested for anodic coating thickness in accordance with ASTM B244, or ASTM E376 to determine conformance to the requirements of 3.7.2.1. If either ASTM B244, or ASTM E376 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 4.3.3.2.1 shall be tested for anodic coating weight either in accordance with ASTM B137, or the method specified in 4.5.2.1. Type I, IB, IC, II, and IIB 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 immediately after anodizing, prior to dyeing or sealing. An analytical balance or other instrument sensitive to at least 10 percent of the net anodic coating weight on test specimen shall be used. Specimens shall be cleaned and dried for a minimum of 30 minutes at 93º ±6 ºC (200º ±10 ºF) and allowed to cool to room temperature before weighing.

b. Immediately after 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

c. 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 specimen's weight remaining constant. The stripping solution shall be discarded after one liter of the solution has dissolved 5 grams of the anodic coating.

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

e. 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. Test specimens, prepared in accordance with 4.3.3.2.3, 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 B117, except that the significant surface shall be inclined 6 degrees from the vertical. Specimens shall be exposed for 336 hours. After exposure, specimens shall be examined to determine compliance with 3.7.1.2.

4.5.4 Light fastness resistance (class 2 only). Test specimens, prepared in accordance with 4.3.3.2.3, shall be tested for light fastness resistance by exposure to ultraviolet radiation in accordance with either ASTM D822/822M, ASTM G152, or ASTM G155 for a period of 200 hours, except that the specimens shall 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 D2244. 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 4.3.3.2.4, shall be tested in accordance with ASTM D4060 using CS-17 wheels with a 1,000 gram load. The wheels shall revolve on the anodic coating at a speed of 70 revolutions per minute (RPM) for 10,000 cycles. The abrasion wheels shall be refaced at least once every 10,000 cycles. The wear index shall be determined after the 10,000 cycle period by dividing the weight loss by 10. The wear index shall meet the requirements of 3.7.2.2.

4.5.6 Paint adhesion test. When specified (see 4.4), specimen panels prepared in accordance with 4.4.3 shall be tested for wet tape adhesion. The test shall be conducted as described in FED-STD-141, Method 6301.3 to determine conformance with 3.7.1.4.

5. PACKAGING (This section is not applicable to this specification.)

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful but is not mandatory)

6.1 Intended use. The coatings covered in this specification are intended to provide corrosion resistance, improved paint adhesion and abrasion resistance as specified in 6.1.1 through 6.1.3. This document is not intended to sufficiently cover anodic coatings for use in structural adhesive bonding.

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 chemical conversion systems conforming to MIL-DTL-81706. Repair of mechanically damaged areas by the use of materials conforming to MIL-DTL-81706 (see 3.3.4) will not restore abrasion resistance but will provide an effective means of reestablishing corrosion resistance. Where anodic coatings are required on fatigue critical components, type I or IB coatings (see 6.1.2) are used due to the thinness of the coating (see 6.10.7).

6.1.2 Type IC and IIB. Type IC and IIB coatings provide non-chromate alternatives to type I and IB coatings where corrosion resistance, paint adhesion, and fatigue resistance is required. Note that type IC and IIB may not serve as suitable replacements when the effects of electrolyte entrapment is the primary concern (see 3.3.1.2 and 3.3.1.3). Maximum type IC and type IIB coating weights of 700 mg/ft^2 and 1000 mg/ft^2, respectively, are specified in table I for fatigue purposes (see 6.10.7). If higher type IC coating weights are permissible for the intended use, it should be specified in the contract or order (see 6.2). If higher type IIB coating weights are permissible for the intended use, type II should be specified.

6.1.3 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 dyed color and/or corrosion resistance is also a factor. Wear resistance is reduced by sealing or exposure to heated aqueous solutions. 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.

6.1.3.1 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 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 3.3.1.1 and 3.3.2).
f. If coating weight for type IC can exceed the maximum specified in table I.
g. Color and uniformity of Class 2 coatings, if applicable (see 3.6.1 and 3.12).
h. Degree of non-uniformity of dyed casting alloys (see 3.6.1.1).
i. Light fastness resistance, if applicable, and a Delta E value if different than 3 (see 3.7.1.3).
j. Type III coating thickness, if applicable (see 3.7.2.1).
k. Coating weight for thickness, type III, if substituted (see 3.7.2.1.1).
l. Special sealing requirements (see 3.8).
m. When applicable, the allowable difference in anodic coating appearance resulting from inherent base metal differences (see 3.13).
n. Provide the specific location of contact marks if important to the function of the part (see 3.13.1 and 6.14).
o. Acceptance criteria for conformance inspections (see 4.4.2).
p. If paint adhesion testing is required for conformance testing (see 4.4) and the required paint system (if different than that in 4.4.3.1).

6.2.1 Consideration of data requirements. DELETED.

6.2.2 Exception to drawings for types I, IB, IC, II, and IIB coatings. When the anodic coating type is not specified on the drawing, type I, IB, IC, II, or IIB 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 may be supplied within the limits of this specification, at the option of the contractor.

6.3 Painting/coating. When anodic coatings are required to be painted/coated, 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 or coating anodized parts, wiping, buffing or mechanical operations should be kept to a minimum. This may damage the less dense outside layer of the anodic coating making it susceptible to subsequent adhesion failures. Sealing processes can have a significant effect on adhesion of primers and other polymeric materials to the anodized surface as well as the cohesive strength of the anodized layer. If these factors are important to the application, such as subsequent painting operations, specific details for (or the omission of) the sealing process should be specified in the contract or order.

6.4 Electrolytic action. Severe attack by the electrolyte on castings or welds may be caused 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. SAE AMS-STD-595 may be used as a guide for specifying color of anodic coatings. The color standards in SAE AMS-STD-595 are intended for paint finishes and should be used for approximate comparison only with the anodic coatings (see 6.2).

6.7 Lapping. The type III anodic coatings generally have increased surface roughness as well as having the property of being less dense 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). The percentage of reflectivity obtained from a part which has been electrolytically brightened and subsequently anodized will depend on the alloy and the coating thickness. Certain alloys are more capable of obtaining a highly brightened surface and thicker anodic coatings will reduce reflectivity.

6.10 Design information. (Non-mandatory information referenced in this section is helpful to manufacturers/design authorities only and does not constitute a requirement for processors.)
.

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 ¼ 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 6.7). 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 ½ 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 or 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 (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 for type III. Thickness of the heavy type III coating can be controlled to extremely close tolerances. Anodized coatings 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 typical 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, IC, IIB, and some type II coatings are too thin and too brittle to withstand abrasive damage during such assembly. With type III coatings assembly may be accomplished by grinding, lapping or otherwise removing the surplus coating. All anodic coatings are brittle and may crack and spall due to force fittings.

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

Coating type	Thickness range (inch)
I, IB, IC, and IIB	0.00002 to 0.0007
II	0.00007 to 0.0010
III	0.0005 to 0.0045

6.10.6 Typical Coating thickness types I, IB, IC and II. 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, IB, IC and II, class I.

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

Alloy designation	Thickness of coating (inch)	
	Type I, IB, and IC	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 reduction in fatigue will be.

6.11 Duplex sealing. The corrosion resistance of dyed parts, especially those anodized in a sulfuric acid bath, type IC, II and IIB, 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, IB, IC, and IIB coatings. Type I and IB coatings have a different pore structure and along with type IC and IIB coatings are thinner than type II coatings which make them more difficult to dye. As a result, type I, IB, IC, and IIB black anodized may not be readily obtainable.

6.13 Alloys having 2 percent or more copper content. Aluminum alloys having a nominal copper content of 2 percent or higher include all 2xxx series alloys, 7050 and 7178 (see 3.7.2.2).

6.14 Size of contact marks. In order to obtain the desired current density without burning the parts, the size or number of contact marks will be greater on parts having higher surface areas. Because current density is a measure of the required current per square foot of aluminum being anodized, a part having twice as much surface area relative to another will require twice as much current. Trying to force the higher currents required for larger parts through smaller contact areas sufficient for parts with lower surface areas may result in burning.

6.15 Sealing. The hot deionized water seal is advantageous from an environmental viewpoint. In addition, the use of a hot deionized water seal on type I and IB coatings yields good corrosion resistance and may eliminate the appearance of patchy dark gray areas after salt spray exposure (see 6.18 and 3.7.1.2).

6.16 Effects on coating thickness. A hard coat of 2 mils or more is extremely difficult to obtain on high silicon die castings such as 360, 380, and 383. It is recommended that this be considered when specifying a coating thickness for high silicon castings.

6.17 Effects of type III coating thickness on abrasion resistance. The abrasion resistance of type III coatings will decrease as the coating thickness approaches 3 mils. In general, the abrasion resistance does not increase with increasing coating thickness.

6.18 Corrosion resistance of type I and IB coatings. Although pitting may not be visually evident with the unaided eye, the appearance of dark gray areas on the surface after salt spray exposure is an indication of coating degradation.

6.19 Definition of a pit. A pit is defined as an area of localized corrosion having a depth greater than its width. As a general rule, a pit usually displays a characteristic tail or line (see 3.7.1.2).

6.20 Acceptance criteria. DELETED.

6.21 Supersession 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.

6.22 Subject term (key word) listing.

Anodizing
Chromate
Chromic acid
Cobalt
Nickel
Phosphoric acid
Potassium dichromate
Sodium dichromate
Sulfuric acid

6.23 Amendment notations. The margins of this specification are marked with vertical lines to indicate modifications generated by this amendment. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations.

Custodians:
Army – MR
Navy – AS
Air Force – 20

Preparing activity:
Navy – AS
Project MFFP-2020-009

Review activities:
Army – AR, AV, AT, CR, CR4, MI
Navy – OS, SH
Air Force – 70, 71, 170
DLA – CC

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above by using the ASSIST Online database at https://assist.dla.mil.