INCH-POUND

MIL-DTL-32459
26 JUNE 2013

DETAIL SPECIFICATION

COATINGS, ANODIC FOR MAGNESIUM AND MAGNESIUM 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 general requirements for the application and inspection of applying an anodic, hexavalent chromium-free and HAP (Hazardous Air Pollutants) free coating to magnesium alloys parts, newly developed and/or used parts that have been stripped and cleaned down to the base metal (magnesium alloy). These coatings will provide corrosion protection and abrasive resistance properties to magnesium base metals, including magnesium alloys and to produce a surface suitable for the subsequent application of a protective organic finish (see 6.1), as applicable.

1.2 Classification. The types and classes of anodic coatings and of anodizing solutions that are covered by this specification are as follows (see 6.2).

1.2.1 Types. Anodic finishes are classified by coating thicknesses (see Table I for a summary).

Type I. Type I finishes are considered thin and have a coating thickness in the range of 0.0002 to 0.0004 inch (5 to 10 µm) when applied by immersion.

Type II. Type II finishes are considered heavy or intermediate and have a coating thickness in the range of 0.0005 to 0.0007 inch (13 to 18 µm) when applied by immersion.

Type III. Type III finishes are considered thick and have a coating thickness in the range of 0.0008 to 0.0010 inch (20 to 25 µm) when applied by immersion.

Comments, suggestions, or questions on this document should be addressed to: Director, U.S. Army Research Laboratory, Weapons and Materials Research Directorate, Specifications and Standards Office, Attn: RDRL-WMM-D, Aberdeen Proving Ground, MD 21005-5069 or emailed to richard.j.squillacioti.civ@mail.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

Type IV. Type IV finishes have a coating thickness in the range of 0.0001 to 0.0003 inch (2.5 to 7.5 µm) when applied by brushing with a high voltage.

Type V. Type V finishes have a coating thickness that is less than 0.0002 inch (5 µm) when applied by brushing with a low voltage.

TABLE I. Characteristics of the various types of anodic coatings.

COATING TYPE	DESCRIPTION	THICKNESS RANGE	APPLICATION
Type I	Immersion Thin	0.0002 to 0.0004 inch	Immersion
Type II	Immersion Heavy or Intermediate	0.0005 to 0.0007 inch	Immersion
Type III	Immersion Thick	0.0008 to 0.0010 inch	Immersion
Type IV	Thick Touchup	0.0001 to 0.0003 inch	High voltage Brushing
Type V	Thin Touchup	less than 0.0002 inch	Low voltage Brushing

1.2.2 Classes. Anodizing classifications (see Table II for a summary).

Class A. Use Class A anodizing solution for parts made from magnesium alloys not listed in Class B or Class C.

Class B. Use Class B anodizing solution for parts made of EV31 and WE43 magnesium alloys.

Class C. Use Class C anodizing solution for parts made of QE22 magnesium alloys.

Class D. Use Class D anodizing solution for Type V finishes.

TABLE II. Characteristics of the various anodizing classes.

CLASS	ANODIZING SOLUTION TO BE USED ON PARTS MADE FROM
Class A	Magnesium alloys not listed in Class B or Class C
Class B	EV31 and WE43 magnesium alloys
Class C	QE22 magnesium alloys
Class D	Type V finishes

1.2.3 Engineering drawing default. When the anodic coating type is not specified on the engineering drawing or in another specification, Type I should be used. The anodizing solution class should be as specified in 1.2.2. There is no requirement to specify the solution class on the engineering drawing.

1.3 Safety-Hazardous Materials. Hazardous materials should be handled in accordance with all Federal, State, and local regulations.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this specification. This section 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, 4, or 5 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks 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.

FEDERAL SPECIFICATIONS

A-A-58054	-	Abrasive Mats, Non-Woven, Non-Metallic

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-PRF-23377	-	Primer Coatings: Epoxy, High-Solids
MIL-PRF-85582	-	Primer Coatings: Epoxy, Waterborne

(Copies of these documents are available online at http://quicksearch.dla.mil or https://assist.dla.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.3 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.

ASTM INTERNATIONAL

ASTM B117	-	Standard Practice for Operating Salt Spray (Fog) Apparatus
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 D610	-	Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces
ASTM D1193	-	Standard Specification for Reagent Water
ASTM D1654	-	Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D3359	-	Standard Test Methods for Measuring Adhesion by Tape Test
ASTM D4060	-	Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
ASTM E466	-	Standard Practice for Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials

(Copies of these documents are available online from www.astm.org or ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959.)

2.4 Order of 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 First article. When specified (see 6.2), a sample shall be subjected to first article inspection in accordance with 4.4.

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

3.2.1 Abrasive mats. Abrasive mats shall be non-woven, non-metallic mats made of nylon fiber conforming to A-A-58054 Type I, Grade A (Type I, Aluminum oxide (minimum of 94 % AL/ 0/3 and a hardness of 9.4 Moh's); Grade A, Grit size 280 to 400 or finer (ScotchBrite™ or equivalent)).

3.2.2 Alkaline etch cleaner. The alkaline cleaner to be used shall contain 50 – 70 g/L of borate and 30 – 50 g/L of pyrophosphate.

3.2.3 Pretreatment solution. The pretreatment solution shall be as specified in the contract or purchase order (see 6.2). It shall contain 40 – 70 g/L of fluorides. The pretreatment solution is also knows as Fluoride Activator solution.

3.2.4 Anodizing solutions. Class A, B and C anodizing solutions shall be alkaline, chromate-free, and contain silicates. Class B anodizing solutions shall also contain vanadate. Class A, B and C anodizing solutions shall contain 1 – 12 g/L of silicate and Class B anodizing solutions shall contain 0.3 – 1.2 g/L of vanadate. Class D anodizing solutions shall contain 2.5 – 16.5 g/L of silicate. Solutions used for anodizing shall be capable of producing coatings that conform to all requirements specified herein. All anodizing solutions shall not contain any HAP's or carcinogens and have no adverse effects on human health when used as intended.

3.2.5 Reverse osmosis (RO) water. RO water must be Type III or better as defined in the conductivity specification in ASTM D1193.

3.2.6 Masking. All liners, bushings, inserts, dissimilar metal and other hardware shall be removed from parts or shall be masked prior to anodizing to prevent solution contact during processing.

3.2.6.1 Masking materials. Masking materials shall be either organic or inorganic materials that are suitable to seal off dissimilar metals and other hardware on the magnesium component. Masking materials must be chemical compatible with pretreatment and anodizing processes.

3.2.7 Panels. Panels utilized herein shall be made from the following magnesium alloys: AZ91, EV31, QE22, WE43, ZE41 and other magnesium alloys that have been approved by the contract or purchase order (See 6.2). The specific alloy specification shall be specified in the contract or purchase order (see 6.2).

3.2.8 Post treatment solution. Unless otherwise specified in the contract or purchase order (see 6.2), the post treatment solution shall contain 128 – 166 g/L of sodium di-hydrogen phosphate (NaH2PO4). If post treatment is not specified only water rinses will be done.

3.2.9 Primer, epoxy. The epoxy primer shall be made in accordance with Type I, Class N of MIL-PRF-23377, or Type I, Class N of MIL-PRF-85582.

3.3 Parts.

3.3.1 Used parts. All parts that have been in service or previously coated or anodized shall be stripped and/or clean down to the base magnesium alloy and shall now be considered equivalent to new parts and all of its requirements shall be met (see 6.6).

3.3.2 New parts. All new parts shall have clean surfaces, free from water break, prior to immersion in the anodizing solution and be free from broken edges before anodizing and unless otherwise specified in the contract or purchase order (see 6.2), shall have all machining, drilling or other metal removal done prior to anodizing. All parts shall be subjected to cleaning, etching, anodizing and sealing procedures as necessary to yield coatings meeting all the requirements of this specification.

3.4 Equipment and processes. The following equipment is required to perform the procedures and operations described in this specification. Unless otherwise specified in the contract or purchase order (see 6.2), process operating conditions shall be at the option of the supplier.

3.4.1 Anodizing unit - Brush. The brush anodizing unit shall consist of rectifiers, cables, clamps, collection trays, carts, and fixtures of such type as to produce Type IV and Type V coatings which conform to the requirements specified herein (see 1.2.1.4 and 1.2.1.5).

3.4.2. Continuity tester or resistance tester, low-voltage. An ohmmeter or multimeter with a 9 V battery source capable of measuring 1MΩ or greater shall be utilized.

3.4.3 Electrical items. Electrical items shall consist of rectifiers, bus bars, cathodes, recorders, and controls suitable to meet requirements specified in Table III. Meters on electrical items shall be accurate to ±1 percent of range.

TABLE III. Coating requirements.

Coating Type	Coating Thickness	Approximate Dimensional Buildup (No Etch)	Approximate Dimensional Buildup (with 3 minute etch time)	Approximate Dimensional Buildup (with 5 - 10 minute etch time)
Type I	0.0002 to 0.0004 inch	0.0001 to 0.0002 inch	0.0000 to 0.0001 inch	-0.0001 to 0.0001 inch
Type II	0.0005 to 0.0007 inch	0.00025 to 0.00035 inch	0.00015 to 0.00025 inch	-0.0001 to 0.00015 inch
Type III	0.0008 to 0.0010 inch	0.0004 to 0.0005 inch	0.0003 to 0.0004 inch	0.0002 to 0.0003 inch
Type IV	0.0001 to 0.0003 inch	0.00005 to 0.00015 inch	N/A	N/A
Type V	Less than 0.0002 inch	N/A	N/A	N/A

3.4.4 Fixtures. Fixtures shall consist of a set of suitable hardware that can be used to suspend parts in the anodizing solution in the immersion tanks, shall be of materials that are fully compatible with the anodizing process.

3.4.5 Safety equipment. Safety equipment includes plastic or rubber aprons, boots, chemical goggles, face masks and gloves.

3.4.6 Tanks. Tanks used for immersion baths shall be fabricated from or coated with compatible materials.

3.4.6.1 Controls. Tanks shall be equipped with environment controls allowing agitation of immersion bath solution and controlling temperature variations within the specified limits.

3.4.6.2 Ventilation. The ventilation of immersion tanks shall be provided as required by Federal, State, local or company regulations.

3.5 Environmental, health and safety. Equipment, materials, solutions, and emissions (if applicable) shall be controlled, handled, used, and disposed of in accordance with all local Federal and State regulations.

3.6 Procedures and operations.

3.6.1 Preparation.

3.6.1.1 Fabrication. All operations that are part of a component's fabrication shall be completed before the component is anodized. All detachable hardware shall be removed or un-detachable dissimilar metals shall be masked from the component before anodization (Type I, II, or III). The masked components shall be touchup anodized (Type IV or V) after the immersion.

3.6.1.2 Electrical contacts. Electrical contacts between the component being anodized and the power source shall be firmly connected to avoid uninterrupted current flow and thereby eliminating local overheating of the component. Electrical contact location shall be applied in an area where the anodization is not required or is optional. Components shall be suspended such that gas entrapment during anodization is minimized.

3.6.1.3 Blind holes. Prior to immersion or being anodized, blind holes may be plugged with the appropriate material, such as, silicon, polypropylene, or nylon plugs. Material used shall be chemical compatible with a high pH, caustic environment. Plugged holes shall be subsequently brush anodized (Type V).

3.6.2 Procedure. All parts shall be subjected to an appropriate cleaning, pretreatment, anodizing, and post treatment cycle as specified in the contract or purchase order (see 6.2).

3.6.2.1 Cleaning. Parts shall be cleaned, free of grease, oils, or other contaminants using aqueous degreasing solutions. Surfaces requiring touchup anodizing (Type IV or V) shall be cleaned by hand. All dissimilar metal, such as ferrous alloys, liners, bushings, plugs, and other hardware shall be masked prior to immersion in an anodizing solution (Type I, II, or III), and shall be masked on parts which will be touched-up after anodizing (Type IV or V), if necessary. The masking shall sufficiently protect the ferrous alloys from corrosion in an alkaline solution.

3.6.2.1.1 Prior to immersion anodizing (Type I, Type II, and Type III). Proceed as follows: Refer to Table I and process as specified in the contract or purchase order (see 6.2).

a. Perform final cleaning using an alkaline etch cleaner containing borate and pyrophosphate (see 3.2.2). NOTE: Borate/pyrophosphate alkaline etch cleaner will remove approximately 0.0001 inch (0.1 mils) of magnesium during a 3 minute soak time. Dimensional buildup calculations need to account for this metal loss if this processing step is utilized (see Table III).

b. Rinse using deionized or reverse osmosis water (see 3.2.5).

3.6.2.1.2 Prior to touchup anodizing (Type IV and V). Proceed as follows:

a. Lightly abrade surface to be treated, as dimensions permit, using fine grade abrasive mats, 180 grit aluminum oxide sandpaper or other suitable media. Abrade to clean, bare metal.
NOTE: Light abrading may be omitted on fresh machined surfaces, provided the coating meets the requirements specified herein.

b. Rinse using fresh, running water to remove all particles. The rinse shall result in a water-break free surface.

3.6.2.2 Pretreatment.

a. Type I, II, and III: The cleaned part shall be pretreated in a fluoride-containing solution prior to anodizing. For Type IV and V, spot treatment with a fluoride-containing solution on the areas to be touchup anodized is allowed, if necessary.

b. Rinse using deionized or reverse osmosis water. The rinse shall result in a water-break free surface. Water-break free is checked visually by observing a continuous sheet of water on the part. Evidence of beading indicates a failed water-break free test. A drainage time of about 30 seconds should be allowed before observing for water-break free condition. Parts that fail the water-break free test shall be handled per written instructions as specified by the contract or purchase order (see 6.2). Upon approval, the parts will undergo repeat cleaning per 3.6.2.1, followed by pretreatment per 3.6.2.2 a. Etch (3.6.2.1.1 a) shall not be repeated for parts that fail the water-break test. Reprocessed parts shall be re-evaluated for water-break per above.

3.6.2.3 Anodizing. Anodizing shall be performed in a suitable chromate-free alkaline solution containing silicates and other additives as stated in 3.2.4. Parts made from any magnesium alloys not listed for Class B, Class C or Class D shall be anodized in Class A solution, parts made from EV31 and WE43 shall be anodized in Class B solution, and parts made from QE22 magnesium alloy shall be anodized in Class C solution. Parts shall be rotated, rocked or turned as necessary to prevent bare spots caused by gas entrapment.

3.6.2.4 Processing.

a. The Type I, II and III coatings shall be produced at the designated current densities throughout the process as specified in Table IV. There shall be no arcing or burning during the immersion. Rinse thoroughly using fresh, tab water to remove residual electrolyte.

b. The Type IV and Type V coatings shall be produced in the specified amperage and voltage ranges as specified in Table IV. There shall be no arcing or burning during the touchup process. Rinse parts thoroughly with hot (105 $^{\circ}$ to 180 $^{\circ}$ F) water.

3.6.2.5 Post-treatment. Parts with Type I, II or III coatings may be post-treated at 80 to 115° F (27 to 46° C) in a bath containing sodium di-hydrogen phosphate (NaH_2PO4) in de-ionized or reverse osmosis water maintained at a pH of 4.2 to 4.6.

3.6.2.6 Final rinsing and drying. Parts shall be rinsed thoroughly in fresh, running RO water and dried to the extent that no visual moisture is observed.

3.6.2.7 Masking material. All masking material shall be removed.

3.6.2.8 Touchup of contact marks, blind holes, and scratches. Contact marks, blind holes, and coatings that have been scratched or abraded through to bare metal and bare areas left by masking of all dissimilar metal, such as ferrous alloys, liners, bushings, plugs, and other hardware shall be touched up using Type IV or Type V touchup anodizing unless as specified in the contract or purchase order (see 6.2).

TABLE IV. Anodizing conditions.

Operating Conditions	Type I & II Coating	Type III Coating	Type IV Coating	Type V Coating
Temperature	36 to 70° F (2 to 21° C)	36 to 70° F (2 to 21° C)	50 to 100° F (10 to 38° C)	50 to 100° F (10 to 38° C)
Current Density	2 to 15 amperes per square foot (22 to 161 A/m^2)	2 to 15 amperes per square foot (22 to 161 A/m^2)	N/A	N/A
Maximum Current	N/A	N/A	0.1 to 5 amperes Total	0.1 to 5 amperes Total
Voltage	0 to 600 Volts DC	0 to 600 Volts DC	0 to 300 Volts DC	0 to 70 Volts DC
Time	10 to 30 minutes	40 to 90 minutes	Varies [1/]	Varies [1/]

[1/] dependent on area to be coated

3.6.3 Properties.

3.6.3.1 Appearance. The anodic appearance shall be visually continuous, smooth, adherent, and uniform. All visual evidence of burning, discontinuity, non-adherence of the anodized components

shall not be accepted. All anodized component's corners or edges shall not be visually darkened or discolored. Evidence of excessive buildup shall not be accepted. The size and number of electrical contact marks shall be kept to a minimum. The color of anodic coatings produced from Class A and Class B solutions shall be white to gray. The color of anodic coatings produced from Class C solution shall be tan to dark brown. The color of the anodic coatings produced from Class D solutions shall be white to gray with a metallic appearance under the coating.

3.6.3.2 Coating thickness. The coating thickness shall be 0.0002 to 0.0004 inch (0.005 to 0.010 mm) for Type I coatings, 0.0005 to 0.0007 inch (0.013 to 0.018 mm) for Type II, 0.0008 to 0.0010 inch (0.020 to 0.025 mm) for Type III coatings, 0.0001 to 0.0003 inch (0.003 to 0.008 mm) for Type IV coatings and 0.0002 inch (0.005 mm) maximum for Type V coatings. The coating thickness shall be determined as specified in 4.8.1.

3.6.3.3 Electrical continuity. Unless otherwise specified in contract or purchase order (see 6.2), the Type I, Type II, Type III and Type IV coatings shall not conduct electricity. The electrical continuity shall be determined as specified in 4.8.2. Type V is used when parts requires low electrical conductivity.

3.6.3.4 Corrosion resistance. Corrosion resistance test panels shall be constructed as specified in 4.7.1.1. Anodized test panel shall be tested in accordance with 4.8.3 for corrosion resistance. The ASTM D1654 ratings shall be 9 or greater after the coated test panel of ZE41 or QE22 magnesium alloy have been subjected to 24 hours (for Type I and II), 72 hours (for Type III), 6 hours (for Type IV) or 2 hours (for Type V) in salt spray. The ASTM D1654 ratings shall be 9 or greater after the coated test panels of AZ91, EV31, or WE43 magnesium alloy or any magnesium alloy that is not listed herein have been subjected to 168 hours (for Type I or II), 336 (for Type III), 96 hours (for Type IV), or 12 hours (for Type V) of salt spray. See Table V for a summary.

TABLE V. Salt Spray Testing Durations, Hours

ASTM D1654 ratings shall be 9 or greater when subject to the number of hours in a salt spray					
Test panels coated with MG alloy	Specification	Coating type			
		Type I and II	Type III	Type IV	Type V
ZE41	As specified in the contract or purchase order (see 6.2)	24 hours	72 hours	6 hours	2 hours
QE22		24 hours	72 hours	6 hours	2 hours
AZ91		168 hours	336 hours	96 hours	12 hours
EV31		168 hours	336 hours	96 hours	12 hours
WE43		168 hours	336 hours	96 hours	12 hours
Other magnesium alloys not listed		168 hours	336 hours	96 hours	12 hours

3.6.3.5 Wear resistance. Wear resistance test panels shall be constructed as specified in 4.7.1.2. Anodized test panel shall be tested in accordance with 4.8.4 for wear resistance.

3.6.3.5.1 Test panels made of AZ91, ZE41, or QE22 magnesium alloys. Test panels made of AZ91, ZE41, or QE22 magnesium alloys coated with a Type I or II anodic coating shall exhibit a wear resistance index value of less than 30.

3.6.3.5.2 Test panels made of EV31, WE43 magnesium alloy or any magnesium alloy that is not listed herein. Test panels made of EV31, WE43 magnesium alloy or any magnesium alloy that is not listed herein coated with a Type I or II anodic coating shall exhibit a wear resistance index of less than 35.

3.6.3.6 Primer Adhesion. Adhesion of the primers specified in 3.2.9 to Type I, II, III, IV, or V anodic coatings shall be such that when tested as specified in 4.8.5, the ASTM D3359 adhesion rating shall be 4B or higher.

3.6.3.7 Wet paint adhesion. The wet paint adhesion requirement shall be as specified in contract or purchase order (see 6.2) and shall be tested as specified in 4.8.6.

3.6.3.8 Impact resistance. The impact resistance requirement shall be as specified in the contract or purchase order (see 6.2) and shall be tested as specified in 4.8.7.

3.6.3.9 Fatigue properties. Coated panels (not all magnesium (Mg) coated parts are required for fatigue tests, e.g. Mg armor plate) that are specified in the contract or purchase order (see 6.2) shall be fatigue tested as specified in 4.8.8. Anodic coated samples shall not produce appreciable fatigue debit when compared with uncoated samples. The level of appreciable fatigue debit shall be defined in the contract or purchase order (see 6.2) for the specific application.

3.7 Personnel requirements. Personnel performing the procedures described herein shall be adequately trained to perform the procedures in accordance with the requirements of this specification.

4. VERIFICATION

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

a. First article inspection (see 4.4).
b. Conformance inspection (see 4.5).

4.2 Testing responsibility and facilities. Unless otherwise specified in the contract or purchase order (see 6.2), the contractor is responsible for the performance of all the requirements as specified herein. Unless otherwise specified in the contract or purchase order (see 6.2), the contractor may use his own or any other facilities suitable for the performance of the requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform or check any of the inspections set forth in this specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements and to determine the validity of the results.

4.2.1 Monitoring procedures for materials. Materials and solutions shall be monitored to ensure that requirements specified in 3.2 are met.

4.2.2 Monitoring procedures for equipment. Equipment used in this process shall be monitored to ensure that calibrations and requirements specified in 3.4 are met.

4.3 Lot. A lot shall consist of all the parts with the same part number from the same supplier from a specific purchase order or contract.

4.4 First article inspection. When required (see 6.2), first article inspection samples submitted in accordance with 3.1 shall be examined for all the provisions of this specification applicable to end item examination and shall utilize the same requirements and test methods as the production acceptance inspection shown in 4.5 except for sampling. Sampling for first article shall be in accordance with Table VI.

Table VI. Test panel allocation for first article tests

Test Performed	Minimum Number of Panels to be Tested	Test Method Paragraph	Acceptance Criteria Paragraph
Appearance	4	None	3.6.3.1
Thickness	4	4.8.1	3.6.3.2
Electrical Continuity	4	4.8.2	3.6.3.3
Corrosion Resistance	4	4.8.3	3.6.3.4
Wear Resistance	4	4.8.4	3.6.3.5
Primer Adhesion	4	4.8.5	3.6.3.6
Wet paint adhesion	0	4.8.6	3.6.3.7
Impact resistance	0	4.8.7	3.6.3.8
Fatigue	5	4.8.8	3.6.3.9

4.4.1 First article tests. First article tests shall consist of all the tests specified in 4.8.

4.5 Conformance inspection. The acceptance examination under 4.7 and the tests under 4.8 shall serve as a basis for the acceptance of individual production lots.

4.6 Sampling.

4.6.1 Monitoring procedure for immersion anodizing process (Type I, II and III). To assure continuous control of the immersion anodizing process chemical analysis shall be performed as specified by the contract or purchase order (see 6.2). In addition, control tests of the anodizing process shall be conducted for each solution class at least once per month. Tests may be omitted any

calendar month in which processing is not performed, provided testing is resumed immediately prior to the next production lot (see 4.3) processed to the requirements specified herein. Monitoring shall be performed as follows:

a. Table VII defines the number of test panels that shall be prepared to meet the requirements specified in 4.7.
b. Apply the same cleaning, pretreatment, anodizing, and post treatment to the test panels as is applied to production parts. Test panels shall be processed in the same tanks with the same equipment used for production parts.
c. Examine the test panels using the test methods specified in 4.8 for conformance to requirements specified in 3.6.3.1 through 3.6.3.10.

Table VII. Process control for type I, II, and III coatings: test panel allocation
(To be performed on a monthly basis as defined in 4.6.1)

Test Performed	Minimum Number of Panels to be Tested	Test Method Paragraph	Acceptance Criteria Paragraph
Appearance	2	None	3.6.3.1
Thickness	2	4.8.1	3.6.3.2
Electrical Continuity	2	4.8.2	3.6.3.3
Corrosion Resistance	1	4.8.3	3.6.3.4
Wear Resistance	1	4.8.4	3.6.3.5
Primer Adhesion	0	4.8.5	3.6.3.6
Wet paint adhesion	0	4.8.6	3.6.3.7
Impact resistance	0	4.8.7	3.6.3.8
Fatigue properties	0	4.8.8	3.6.3.9

4.6.2 Monitoring procedure for touchup anodizing process (Type IV and Type V). The touchup anodizing process and solutions shall be monitored during production as specified by the contract or purchase order (see 6.2).

4.6.2.1 Certification of touchup anodizing solution. Each batch of touchup anodizing solution shall be tested and the date and batch number shall be maintained as part of the test record. Testing shall be performed as follows:

a. Brush anodize the number of test panels specified in Table VIII using the batch of solution for which certification is requested.

b. Examine the anodized test panels for conformance to requirements specified in 3.6.3.1 through 3.6.3.9.

c. The solution batch shall be considered certified if all test panels pass the required testing.

4.7 Examination. The anodic coating on each aerospace part shall be 100-percent visually examined for conformance to the appearance requirements specified in 3.6.3.1 and shall meet the coating thickness requirements specified in 3.6.3.2. Test methods shall be as specified in 4.8.

4.7.1 Test panels. Test panel dimensions and requirements shall be as specified in 4.7.1 through 4.7.6 and test methods shall be as specified in 4.8.

4.7.1.1 Corrosion resistance test panels. Test panels shall have an approximate thickness of 0.2 inches (5 mm). The length and width should be a minimum of 3 by 4 inches (76 by 102 mm).

4.7.1.2 Wear resistance test panels. Test panels shall be 4 inches (102 mm) square with rounded corners, and with a 0.25-inch (6.4-mm) diameter hole centrally located. Panel thickness shall be approximately 0.2 inch (5 mm).

4.7.1.3 Primer adhesion test panels. Test panels shall be finished with one coat of epoxy primer conforming to MIL-PRF-23377 or MIL-PRF-85582 (see 3.2.9). The length and width of the test panels should be a minimum of 3 by 4 inches (76 by 102 mm) with a minimum nominal thickness of 0.2 inches. 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 4.8.5.

4.7.1.4 Fatigue test specimens. Test specimens shall be machined from magnesium alloys. Specimen dimensions and test parameters shall meet requirements defined in ASTM E466.

4.7.1.5 Process control test panels. Test panels shall be machined from the same magnesium alloy in the same heat-treat condition as production parts processed the previous calendar quarter. Test panels must have unique ID numbers stamped on them to allow for process tracking. Surveillance shall be exercised to ensure that test panels of all magnesium alloys processed to this specification are processed in the same manner as the parts. Test panels shall receive the Type I and Type II anodic coating.

4.7.1.6 Touchup anodizing solution certification test panels. Test panels shall be machined from ZE41, EV31 or WE43 magnesium alloy for certifying Class A and B and Class D solutions, and QE22 magnesium alloy for certifying Class C solutions.

4.7.1.7 Touchup anodizing personnel qualification test panels. Test panels shall be machined from ZE41, EV31, WE43, or QE22 magnesium alloys, as determined by the anodizing solution class.

4.7.1.8 Allocation of test panels. Test panels shall be allocated as specified in Table VII or Table VIII. All panels shall be inspected for appearance, electrical continuity, and coating thickness as required.

4.8 Test methods.

4.8.1 Anodic coating thickness measurements. Anodic coating thickness measurements (see 3.6.3.2) shall be performed in accordance with the eddy current method specified in ASTM B244. Compute the coating thickness as an average of not less than five measurements. When part configuration does not permit eddy current inspection, coating thickness measurements may be performed on a test panel of the same magnesium alloy as the parts being coated and processed with the lot (see 4.3) of parts the test panel represents. In case of dispute, determine coating thickness by metallographic examination of a perpendicular cross section through the coated specimens.

Table VIII. Solution certification and personnel qualification test panels for touchup anodizing (type IV and type V)

	Minimum Number of Panels Needed			
Test Performed	**Touchup Anodizing Solution Certification**	**Touch up Anodizing Personnel Qualification**	**Test Method Paragraph**	**Acceptance Criteria Paragraph**
Appearance	4	4	None	3.6.3.1
Thickness	4	4	4.8.1	3.6.3.2
Electrical Continuity (Type IV Only)	4	4	4.8.2	3.6.3.3
Corrosion Resistance	2	2	4.8.3	3.6.3.4
Wear Resistance	0	0	4.8.4	3.6.3.5
Primer Adhesion	2	2	4.8.5	3.6.3.6
Wet paint adhesion	0	0	4.8.6	3.6.3.7
Impact resistance	0	0	4.8.7	3.6.3.8
Fatigue properties	0	0	4.8.8	3.6.3.9

4.8.2 Electrical continuity (see 3.6.3.3). Lightly touch the surface of the anodic coated part with the leads from a conventional low-voltage continuity or resistance tester. Monitor the instrument for conduction of electricity. Record and maintain results.

4.8.3 Corrosion resistance test. Test panels used for the corrosion resistance test (see 4.7) shall meet requirements specified in 3.6.3.4. Proceed as follows:

a. The test panels shall be tested for corrosion resistance in salt spray in accordance with ASTM B117.

b. After performing the salt spray test, the test panels shall be evaluated in accordance with ASTM D610. For AZ91, QE22 and ZE41, a grid with 0.05 inch (1.3 mm) squares

shall be used to measure the percent surface area corroded. If any portion of the square contains corrosion, count the entire square area as a failure. For EV31 and WE43, percent surface area corroded is measured visually.

c. Record and maintain results.

4.8.4 Wear Resistance. Test panels used for the wear resistance test (see 4.7) shall meet requirements specified in 3.6.3.5. Anodic coated test panels shall be tested for wear resistance in accordance with ASTM D4060, using the following conditions:

a. Use a 1000 gm load on taber arms

b. The CS-17 wheels shall be resurfaced before each test and after every 500 cycles by running the wheels 50 cycles against the resurfacing medium (an S-11 abrasive disk).

c. Endpoint of test shall be a visual 10 % appearance of bare metal in the taber track.

d. Record and maintain results.

4.8.5 Primer adhesion test. Test panels used for adhesion testing (see 3.6.3.6) shall meet requirements specified in 4.7. Anodic coated test panels shall be tested for primer adhesion testing in accordance with ASTM D3359. Record and maintain results.

4.8.6 Wet paint adhesion test. Testing for wet paint adhesion (see 3.6.3.7) shall be as specified by the contract or purchase order (see 6.2).

4.8.7 Impact resistance test. Testing for impact resistance (see 3.6.3.8) shall be as specified by the contract or purchase order (see 6.2).

4.8.8 Fatigue properties test. Test panels used for fatigue testing (see 4.7) shall meet requirements specified in 3.6.3.9. Anodic coated test panels shall be tested for fatigue testing in accordance with ASTM E466. Record and maintain results.

4.9 Personnel requirements. Only qualified personnel shall perform touchup anodizing in accordance with this specification. Qualification shall require proof of knowledge of the process by written examination, and a demonstration of the operator(s) ability to produce satisfactory coatings. Each operator shall brush two (2) test panels that shall meet the requirements of 4.7. Class A, Class B, Class C or Class D anodizing solution shall be used. Test panels shall be examined for conformance to 3.6.3.1 through 3.6.3.9. The operator shall be considered qualified when all test panels show no evidence of failure. As a minimum, requalification shall be required once each year.

4.10 Rejection and retest.

4.10.1 Rejection. Unless otherwise specified in the contract or order (see 6.2), failure of the first article samples to meet the requirements of this specification shall be cause for rejection of the process, and failure of the acceptance samples to meet the requirements of this specification shall be cause for rejection of the lot (see 4.10.2).

4.10.2 Re-tests. Unless specific retest procedure is specified in the contract or order (see 6.2), two retest samples shall be submitted for each failed sample (parts shall be stripped and recoated and resubmitted). Failure of either of the retest samples shall be cause for rejection of the material (lot). First article retests shall not be permitted until the supplier has made the necessary correction in the processing of the material (lot) to the satisfaction of the procuring activity.

4.11 Records. All records including but not limited to solution analyses, additions of chemicals, inspection results, and test results for all anodized components processed in accordance with the specification shall be documented and maintained on file by the anodizing facility for at least three years after completion of the contract.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

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

6.1 Intended use. This specification (Types I, II, and III) is intended to provide the requirements needed to apply immersion anodic, hexavalent chromium-free and HAP (Hazardous Air Pollutants) free coatings to magnesium alloys for the purpose of increasing their corrosion and abrasion resistance, and to produce a surface suitable for the subsequent application of a protective finish. Type IV and Type V coatings are intended for touchup and repair of existing coatings.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of the specification.
b. Type and class required (see 1.2)
c. When first article is required (see 3.1).
d. Pretreatment solution (see 3.2.3).
e. Other magnesium alloys (see 3.2.7)
f. Specific magnesium alloy specifications (see 3.2.7 and Table V)
g. Post treatment solution if different (see 3.2.8).
h. If condition of new parts is different (see 3.3.2).
i. If process operating conditions are different (see 3.4).
j. Specify procedure (see 3.6.2).
k. Specify process for anodizing prior to immersion (see 3.6.2.1.1).
l. Procedure for handling parts that fail the water-break test (see 3.6.2.2b),

m. If touchup is different (see 3.6.2.8).
n, Electrical continuity requirements (see 3.6.3.3).
o. Wet paint adhesion requirements (see 3.6.3.7).
p. Impact resistance requirements (see 3.6.3.8).
q. If part requires fatigue testing (see 3.6.3.9).
r. Level of appreciable fatigue debit (see 3.6.3.9)
s. If someone other than the contractor is responsible for the performance of all the requirements of the specification (see 4.2).
t. If the contractor can't use his own facility or any other facility for testing (see 4.2).
u. Chemical analysis for controlling immersion anodizing process (see 4.6.1).
v. Procedure for monitoring touch-up anodizing process and solutions during production (see 4.6.2).
w. A wet paint adhesion test (see 4.8.6).
x. An impact resistance test (see 4.8.7).
y. If rejection requirements differ (see 4.10.1).
z. If retest requirements differ (see 4.10.2).
aa. Packaging requirements (see 5.1 and 6.4).

6.3 Definitions.

6.3.1 Touchup Anodizing. Type IV and Type V coatings are produced by touchup anodizing. Anodization similar to the Brush Tagnite™ or shallow-pan anodizing is acceptable methods of touchup anodizing. Brush Tagnite™ is an anodizing method that utilizes an electrolyte placed on an absorbing medium, pad, or brush acting as the cathode. The cathode is moved back and forth over the area to be anodized. Shallow-pan is an anodizing method that utilizes an electrolyte contained in a shallow pan. The area of the component to be anodized is placed in the electrolyte solution. The component is acting as the anode side of the electrical circuit and anodization occurs wherever the electrolyte contacts the component.

6.4 Recommended packaging, handling, storage and shipment. Anodized parts should be handled in a manner that will not allow any fingerprints, dirt, oil, or other foreign substances to contaminate the part surfaces. Anodized parts should be stored in a clean, oil free, dry environment at room temperature. Anodized parts that are to be shipped or held more than 30 days between fabrication steps should be sealed in dry polyethylene bags with desiccant. Maximum storage time in a dry, heated, indoors area should be one year without further protection. Packages of coated parts should be prepared for shipment in accordance with commercial practice and in compliance with the applicable rules and regulations pertaining to the handling, packaging, and transportation of the parts to ensure carrier acceptance and safe delivery (see 5.1 and 6.2).

6.5 Recommended specifications for magnesium alloys. The following is a list of specific magnesium alloys and their related specifications. This list is not all inclusive.

QE22A-T6	-	AMS 4418
WE43B-T6	-	AMS 4427
EV31A-T6	-	AMS 4429
ZE41A-T5	-	AMS 4439
AZ91E-T6	-	AMS 4446

6.6 Procedure to clean/strip used parts. Used parts can be stripped of old paints and coatings by any approved aerospace procedure including mechanical means such as media blast or chemical means such as chromic acid strip. Used parts must have bright, shiny magnesium metal with no residual coatings left on surface. Media blast material may not be present on the part especially at the magnesium/ferrous material interface (see 3.3.1).

6.7 Subject term (key word) listing.

Abrasion resistance
Brushing
Corrosion resistance
Finishes
Immersion

CONCLUDING MATERIAL

Custodians:
Army - MR
Navy - AS
Air Force - 11

Review activities:
Army - AR, AV, PT
Navy – MC, SH
Air Force –13, 19, 99
DLA – DC5, DH, GS4

Civil agency:
GSA – FAS

Preparing activity:
Army - MR

Project No. MFFP-2012-004

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 using the ASSIST Online database at https://assist.dla.mil/