

MIL-C-81740(AS)

15 August 1969

MILITARY SPECIFICATION

COATINGS, ALUMINUM AND ALUMINUM ALLOYS
(METALLIC COMPOUND DECOMPOSITION)

This specification has been approved by the Naval
Air Systems Command, Department of the Navy.

1. SCOPE

1.1 Scope - This specifications covers the requirements for aluminum and aluminum alloy coatings deposited by decomposition of metallic compounds on ferrous and non-ferrous metals.

1.2 Classification -

1.2.1 Classes - Deposited aluminum and aluminum alloy coatings shall be of the following classes as specified (see 6.2):

Class 1 - 0.0005 inch thick

Class 2 - 0.0003 inch thick

Class 3 - 0.0002 inch thick

Class 4 - 0.0001 inch thick

1.2.2 Types - Deposited aluminum and aluminum alloy coatings shall be of the following types as specified (see 6.2):

Type I - As coated

Type II - Supplementary conversion treatment (see 3.3.7)

Type III - Supplementary anodizing treatment (see 3.3.8)

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Military

MIL-S-5002

Surface Treatments and Metallic Coatings for Metal
Surfaces of Weapons Systems

FSC MFFP

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SPECIFICATIONS

Military (Continued)

MIL-C-5541 Chemical Films and Chemical Film Materials for
Aluminum and Aluminum Alloys

MIL-A-8625 Anodic Coatings for Aluminum and Aluminum Alloys

STANDARDS

Federal

Fed. Test Method Metals; Test Methods
Std. No. 151

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

3. REQUIREMENTS

3.1 Materials - The materials used, complex aluminum-organic compounds or aluminum in conjunction with or without added elements, shall be such as to produce aluminum and aluminum alloy coatings which meet the requirements of this specification.

3.1.1 Composition - Unless otherwise specified, the aluminum coating composition shall be as specified in Table I. The coating composition for aluminum alloys shall be in accordance with the applicable contract, order or drawing (see 6.1.1).

TABLE I

COATING COMPOSITION

ELEMENTS		PERCENT BY WEIGHT
Aluminum	(Al)	99.5 min.
Iron	(Fe)	0.40 max.
Silicon	(Si)	0.25 max.
Copper	(Cu)	0.05 max.

TABLE I (Continued)

ELEMENT	PERCENT BY WEIGHT
Manganese (Mn)	0.05 max.
Magnesium (Mg)	0.05 max.
Zinc (Zn)	0.05 max.
Titanium (Ti)	0.03 max.
Others, each	0.03 max.

3.2 Equipment and processes - The equipment and processes employed to accomplish the coating by metallic compound decomposition shall be approved by the contracting agency.

3.3 General requirements -

3.3.1 Coating application - Unless otherwise specified, the coating shall be applied after all basis metal heat treatments and mechanical operations such as machining, brazing, welding, forming and perforating of the article have been completed.

3.3.2 Stress relief treatment - Unless the coating process requires the parts to be at temperatures in excess of 400° F (205° C), all steel parts shall be given a stress relief heat treatment at a minimum of 375 ±25° F (191 ±14° C) for 3 hours or more prior to cleaning and coating if they contain or are suspected of having damaging residual tensile stresses caused by machining, grinding or cold forming operations. Parts which are cold straightened are considered to contain damaging residual tensile stress (see 6.5). The temperature and time at temperature shall be such that maximum stress relief is obtained without reduction in hardness to less than the specified minimum.

3.3.3 Cleaning - All steel parts having a hardness of Rockwell C33 and higher shall be cleaned using materials which will have no damaging effects on the metal, including freedom from pits, intergranular attack, significant etching and hydrogen embrittlement. Steel parts having a hardness of less than Rockwell C33 which have been exposed to hydrogen contamination processes, such as cathodic cleaning, pickling and etching shall be heat treated at a minimum of 375 ±25° F (191 ±14° C) for three hours or more prior to coating. Other basis metals shall be cleaned in accordance with MIL-S-5002.

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all coatings shall be capable of passing the salt-spray test
5 (see 3.4.4).

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3.3.4 Unless otherwise specified in the contract, all surfaces shall be as specified in Table II on all visible surfaces. Where Class 1 is specified, the thickness shall be Class 2 minimum thickness. If the thickness is specified on the applicable drawings, the thickness shall be as specified.

3.3.5 Unless otherwise specified, all other visible surfaces shall be Class 3 minimum thickness. Where Class 4 is specified, all other visible surfaces shall be Class 2 minimum thickness.

3.3.6 Unless otherwise specified in the contract or order or controlled drawings, all surfaces shall be Class 1 thickness (see 6.6):

3.3.7 Unless otherwise specified, all washers and articles with portions externally exposed shall have a minimum of Class 2 thickness. All surfaces shall be treated with MIL-C-5541, Type II coatings which are capable of passing MIL-C-5541 (see 6.2).

3.3.8 The conversion treatment of Class II surfaces shall be in accordance with the process used for anodized coatings.

3.4

3.4.1 Unless otherwise specified, immediately prior to coating, surfaces to be coated shall be blasted and cleaned with oil-free dry air. The surface roughness finish specified in the contract, all other surfaces shall be Class 3 maximum thickness. The maximum thickness shall not exceed 0.0008 inch. Unless otherwise specified, aluminum and aluminum surfaces shall be prepared by decomposition of a suitable metallic compound or by a preliminary coating of other metal.

3.4.1.1 The coating shall completely cover all surfaces, including recesses and sharp corners.

Conversion Treatment (Type II) - The conversion treatment of all Class II surfaces shall be a chemical treatment in accordance with MIL-C-5541, as specified (see 6.2). The articles shall be dried in accordance with the process used. The appearance to coatings on separate specimens shall be tested by salt-spray test for unpainted chemical films of

Anodizing Treatment (Type III) - The anodizing treatment for aluminum coatings to Type III shall be an electrochemical process in accordance with MIL-A-8625, Types I or 2, as specified

- (b) Holes and other openings, and internal threads from which the external environment is completely excluded shall not be subjected to a thickness requirement but shall show evidence of coating. There shall be no bare areas.

TABLE II
THICKNESS

CLASS	THICKNESS	
	INCH, MINIMUM	EQUIVALENT THICKNESS, MICROMETERS (APPROX) <u>1/</u>
1	0.0005	13
2	0.0003	8
3	0.0002	5
4	0.0001	3

1/ 0.001 inch = 1 mil = 25.4 micrometers (microns)

3.4.1.2 Thickness - If the process used develops diffusion and alloy layers, the thickness shall be considered to be all of the discrete phases produced during the process plus the diffusion layer at 25 percent enrichment.

3.4.2 Types - Unless otherwise specified in the contract or order, the coating shall be Type II. Where specified for use on Class 1 or Class 2 coating, the coating shall be Type III (see 6.1.3).

3.4.3 Adhesion - The adhesion of the coating shall be such that when examined at a magnification of approximately 4 diameters, the coating does not separate from the basis metal at the interface when subject to the tests described in 4.5.3. The interface between the coating and the basis metal is the surface of the basis metal before coating. The formation of cracks in the coating caused by rupture of the basis metal which do not result in flaking, peeling, or blistering of the coating shall not be considered as nonconformance to this requirement.

3.4.4 Corrosion resistance - Coated specimens or parts treated with materials for either Type II (see 3.3.7) or Type III (see 3.3.8) shall be capable of protecting the substrate aluminum or aluminum alloy deposit when subjected to the 5 percent salt spray corrosion test as specified in 4.5.4 and in accordance with the schedule shown in Table III.

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3.4.4.1 Type II treatment - The specimens or articles supplementarily treated with the chemical conversion coating materials (Type II) shall show no visual evidence of corrosion attack after 96 hours exposure, when compared with unexposed specimens, except in those areas of identification markings and as are used for support during processing. If there is any evidence of corrosion attack which can be established by microscopic examination to be the result of coating defects due to treatment, the specimens or articles are acceptable. When specified in the contract, order or applicable drawing, the corrosion resistance of Type II treatment shall be determined (see 6.2).

3.4.4.2 Type III treatment - The specimens or articles supplementarily treated by anodizing (Type III), after 168 hours exposure, shall show no more than a total of 15 isolated spots or pits in a total of 150 square inches of total area of 5 or more test pieces; nor more than 5 isolated spots or pits on the significant surface totaling 30 square inches of one or more test pieces, except in those areas of identification markings and electrode contact marks. Such corrosion spots or pits shall not be larger than 1/32 inch in diameter. When specified in the contract, order or applicable drawing, the corrosion resistance of Type III treatment shall be determined (see 6.2).

TABLE III

SCHEDULE FOR CORROSION RESISTANCE
PROPERTIES OF TREATED COATINGS

TREATMENT TYPE	COATING TREATED WITH MATERIALS CONFORMING TO	EXPOSURE TO 5% SALT SPRAY - HOURS
II	MIL-C-5541, Classes 1, 2, and 3	96
III	MIL-A-8625, Types I and II	168

3.5 Workmanship -

3.5.1 Basis metal - The basis metal shall be free from visible defects that will be detrimental to the appearance or protective value of the coating. The basis metal shall be capable of withstanding processing temperatures without effect on mechanical properties, and shall be subjected to such precleaning and mechanical cleaning procedures as necessary to yield coatings as herein specified.

3.5.2 Coating - The coating shall have a metallic luster; and shall be non-powdery, smooth, fine-grained, adherent, uniform in appearance, free from blisters, pits, nodules, burning and other defects. The coating shall show no indication of contamination or improper operation of equipment used to produce the

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coating. Superficial staining which has been demonstrated as resulting from any drying or baking operation shall not be cause for rejection. All details of workmanship shall conform to the best practice for high quality coating.

4. QUALITY ASSURANCE PROVISIONS

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

4.2 Lot - A lot shall consist of coated articles of the same material, class and type coated and treated under the same conditions, and approximately the same size and shape submitted for inspection at one time. In no case shall the lot size exceed production for one week.

4.3 Quality conformance sampling -

4.3.1 For visual examination and nondestructive tests - A sample of coated article shall be drawn by taking at random from each lot the number of articles indicated in Table IV. The lot shall be accepted or rejected according to the procedures in 4.3.1.1 for visual examination and 4.3.1.2 for coating thickness (nondestructive tests).

TABLE IV
SAMPLING FOR VISUAL EXAMINATION AND
NONDESTRUCTIVE TESTS

NUMBER OF ITEMS IN LOT INSPECTIONS	NUMBER OF ITEMS IN SAMPLES (RANDOMLY SELECTED)	ACCEPTANCE NUMBER (MAXIMUM NUMBER OF SAMPLE ITEMS NONCON- FORMING TO ANY TEST)
15 or less	7 ^{1/}	0
16 to 40	10	0
41 to 110	15	0
111 to 300	25	1
301 to 500	35	1
501 and over	50	2

^{1/} If the number of items in the inspection lot is less than 7, the number of items in the sample shall equal the number of items in the inspection lot.

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4.3.1.1 Visual examination - Samples selected in accordance with 4.3.1 shall be examined for compliance with the requirements of 3.5.1 before coating and 3.5.2 after coating. If the number of nonconforming articles exceeds the acceptance number for that sample, as stated in Table IV, the lot represented by the sample shall be rejected.

4.3.1.2 Thickness of coating (nondestructive tests) - Samples selected in accordance with 4.3.1 shall be inspected and the coating thickness measured by the applicable tests detailed in 4.5.2 at locations on each article as defined in 3.4.1 for compliance with the requirements. The articles shall be considered nonconforming if one or more measurements fail to meet the specified minimum thickness. If the number of defective items in any sample exceeds the acceptance number for the specified sample, as stated in Table IV, the lot represented by the sample shall be rejected. Separate specimens (see 4.4) shall not be used for thickness measurements unless a need has been demonstrated.

4.3.2 For destructive tests - A random sample of five coated parts or articles shall be taken from each lot or five separately coated specimens shall be prepared in accordance with 4.4 to represent each lot. If the number of articles in the lot is five or less, the number of articles in the sample shall be specified by the contracting agency.

4.3.2.1 Composition (destructive tests) - Samples selected in accordance with 4.3.2 shall be tested for coating composition as specified in 3.1.1.

4.3.2.2 Thickness of coating (destructive tests) - If sampling and testing for thickness of coating by nondestructive testing is not applicable, samples selected in accordance with 4.3.2 shall be measured for coating thickness by the applicable tests detailed in 4.5.2 at several locations on each article as defined in 3.4.1 for compliance with the specified requirements. Measurements on threaded articles such as screws, nuts, bolts and other fasteners shall be made on the shank, or other smooth surfaces as close to the threads as possible. If the coating thickness at any place on any article or specimen is less than the specified minimum thickness, the lot shall be rejected. Separate specimens (see 4.4) shall not be used for thickness measurements unless a need has been demonstrated.

4.3.2.3 Adhesion (destructive tests) - The articles or specimens used for the destructive thickness test (see 4.3.2.2), if of suitable size and form, may be used as the specimens for the adhesion test to determine compliance with the requirements of 3.4.3. Failure of one or more of the test specimens shall constitute failure of the lot.

4.3.2.4 Corrosion resistance (destructive tests) - When specified in the contract or order, compliance with the requirements for corrosion resistance shall be determined (see 3.4.4). A set of five separate test specimens prepared in accordance with 4.4 shall be tested. Failure of one or more of the test specimens shall reject the lot.

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4.4 Quality conformance specimen preparation - When the coated articles are of such form, shape, size and value as to prohibit use thereof, or are not readily adaptable to a test specified herein, or when destructive tests of small lot sizes are required, the test shall be made by the use of separate specimens coated concurrently with the articles represented. The separate specimens shall be of a basis metal equivalent to that of the articles represented. "Equivalent" basis metal includes chemical composition, grade, heat treat condition and finish of surface prior to coating. For example, a cold-rolled steel surface should not be used to represent a hot-rolled steel surface. Due to the impracticality of forging or casting separate test specimens, hot-rolled specimens may be used to represent forged and cast articles. The separate specimens may also be cut from scrap castings when alloy castings are being coated. These separate specimens shall be introduced into a lot at regular intervals prior to the cleaning operations preliminary to coating and shall not be separated therefrom until after completion of coating. Conditions affecting the coating of specimens including the spacing, coating media, residual air pressure, temperature, etc., in respect to other objects being coated shall correspond as nearly as possible to those affecting the significant surfaces of the articles represented. Separate specimens shall not be used for thickness measurements, however, unless the necessity for their use has been demonstrated.

4.4.1 Specimens for composition, thickness and adhesion tests - If separate specimens for composition, thickness and adhesion tests are required, they shall be strips approximately 1 inch wide, 4 inches long and 0.04 inch thick.

4.4.2 Specimens for corrosion resistance test - If separate specimens for corrosion resistance test are required, they shall be panels not less than 6 inches in length, 4 inches in width and approximately 0.04 inch thick.

4.5 Quality conformance tests -

4.5.1 Composition - When specified in the contract or order, the composition shall be determined by using x-ray fluorescence techniques, chemical or spectrochemical procedures.

4.5.2 Thickness - The magnetic test, Method 522 of Fed. Test Method Std. No. 151a (dated May 6, 1959) may be used for nondestructive measuring of coating thickness provided a calibration is established for those coatings resulting in diffusion and alloy layers. The microscopic test, Method 521 of Fed. Test Method Std. No. 151a (dated May 6, 1959) may be used for destructive measuring of aluminum and aluminum alloy coating thickness. At the option of the supplier, instruments which use the principle of beta-radiation back scatter may also be used for thickness measurements. However, for referee test, the microscopic test shall be used.

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4.5.3 Adhesion - Adhesion may be determined by scraping the surface or shearing with a sharp edge, knife, or razor through the coating down to the basis metal and examining at four diameters magnification for evidence of nonadhesion. Alternately the article may be clamped in a vise and the projecting portion bent back and forth until rupture occurs. If the edge of the ruptured coating can be peeled back or if separation between the coating and the basis metal can be seen at the point of rupture when examined at four diameters magnification, adhesion is not satisfactory.

4.5.4 Corrosion resistance - Specimens shall be washed in distilled or deionized water, dried with a soft cloth and then subjected to a 5 percent salt spray test in accordance with Method 811 of Fed. Test Method Std. No. 151a (dated May 6, 1959), except that the significant surfaces shall be inclined approximately 6 degrees from the vertical. Specimens with Types II and III supplementary coatings shall be exposed for the hours stated in Table III. After exposure, specimens shall be cleaned in running water, not warmer than 100° F (38° C), blown with clean, dry air and compared with unexposed specimens for the effects of corrosion. To secure uniformity of results, Type II supplementary coatings shall be aged at room temperature for 24 hours before subjection to the salt spray test.

5. PREPARATION FOR DELIVERY

5.1 Packaging and packing - Preservation, packaging and packing methods for metallic compound decomposition aluminum coated parts or articles employed by a supplier shall be such as to preclude damaging during shipment and handling.

6. NOTES

6.1 Intended use - Aluminum and aluminum alloy coatings covered by this specification are intended for use as a protective coating for steel used at temperatures in excess of 450° F. The degree of corrosion resistance will vary with the class of coating. That is, Class 1 should be used where severe chemical corrosion can occur, Class 2 for medium chemical corrosion, Class 3 for light chemical corrosion, and Class 4 for general usage.

6.1.1 Aluminum alloy coatings - Aluminum alloy coatings should be used in peculiar environments where the strengthening effect of alloying constituents provide enhanced resistance to erosion and abrasion. In such cases, the specific composition and other peculiar requirements should be specified.

6.1.2 Type II treatment - The purpose of the Type II finish is to provide a corrosion-preventative film when left unpainted as well as to improve adhesion of paint finish systems to the coating.

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6.1.3 Type III treatment - The purpose of the Type III finish is to improve surface corrosion protection of the coating under severe service conditions or as a base for paint finish systems. The surface of the coating is affected by the anodizing treatment, thereby diminishing the amount of metallic coating present to form the oxide layer. With coatings of 0.0003 inch (0.3 mil) or greater, the reduction may be insignificant, but can be with coatings of 0.0002 inch (0.2 mil) or less. It is therefore recommended that the supplementary Type III treatment not be applied to coatings of 0.0002 inch or less.

6.2 Ordering data - Purchasers should exercise any desired options offered herein, and procurement documents should specify the following:

- (a) Title, number, and date of this specification
- (b) Class and type required (see 1.2.1, 1.2.2, and 3.4.2.)
- (c) Coating composition, if other than specified (see 3.1.1)
- (d) When coating is to be applied, if other than specified (see 3.3.1)
- (e) Undercoating required (see 3.3.5)
- (f) Class of Type II supplementary finish to be used, if applicable (see 3.3.7)
- (g) Type of Type III supplementary finish to be used, if applicable (see 3.3.8)
- (h) Thickness of coating if other than specified (see 3.4.1, 3.4.1.1 and 3.4.1.2)
- (i) Whether corrosion resistance test is required (see 3.4.4.1, 3.4.4.2 and 4.3.2.4)
- (j) Whether test for composition is required (see 4.5.1)

6.3 Type II temperature limitations - Conversion treatments (not to be painted) should not be used on coated parts which are continuously exposed to temperatures in excess of 150° F (66° C) or intermittently exposed for short periods to temperatures of approximately 300° F (131° C) or more. However, these treatments may be used to prevent finger marking and corrosion which may occur at room temperature during assembly and storage.

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6.4 Type II handling precautions - Conversion treatments (Type II), which involve only dipping in chemical solutions, normally require a sufficient period of drying, approximately 24 hours at 70 to 90° F (21 to 32° C) to render the parts suitable for handling without damage to the coating while in gelatinous forms; and it is important with such coatings that the workmanship be such that the coating is not excessively damaged while wet.

6.5 Stress relief - There is a hazard that cold-worked or cold-staughtened steel parts of hardness Rockwell C40 and below may crack during cleaning. Such parts should have a suitable heat treatment for stress relief prior to cleaning (see 3.3.2).

6.6 Threaded articles - As heavier coatings than Class 3 are required for satisfactory corrosion resistance, allowance should be made in the manufacture of most threaded articles such as nuts, bolts and similar fasteners with complimentary threads for coating build-up. Certain recessed areas, such as root diameters of threads, have a tendency to exhibit lack of build-up with the diffusion formed coating.

6.7 Limitations - Aluminum and aluminum alloy coatings should not be used on parts which in service reach a temperature of 925° F (496° C) or higher or come in contact with other parts which reach these temperatures. MIL-S-5002 contains additional information where aluminum and aluminum alloy coatings and the supplementary treatments may be used for weapons systems applications.

Preparing activity:

Navy - AS

(Project No. MFFP-N025)

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