INCH-POUND

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1 April 1999
SUPERSEDING
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1 May 1985

DETAIL SPECIFICATION

COATING, ALUMINUM, HIGH PURITY

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

1. SCOPE

1.1 Scope. This specification establishes the requirements for coating low alloy steel, stainless steel, aluminum alloy, copper alloy, and titanium alloy parts with high purity aluminum (99 percent plus) (see 6.1).

1.2 Classification. High Purity aluminum coatings should be of the following classes and types (see 6.1.1, 6.1.2).

1.2.1 Classes.

Class 1 - 0.0010 inch thick (0.026 mm) (min)

Class 2 - 0.0005 inch thick (0.013 mm) (min)

Class 3 - 0.0003 inch thick (0.008 mm) (min)

1.2.2 Types.

Type I - as coated

Type II - with supplementary chromate treatment (see 3.4)

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: ASC/ENSI, 2530 Loop Rd West, Wright-Patterson AFB OH 45433-7101, by using the self-addressed Standardization Document Improvement Proposal (DoD Form 1426) appearing at the end of this document or by letter.

AMSC N/A AREA MFFP

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 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 requirement documents cited in sections 3 and 4 of this specification whether or not they are listed.

2.2 Government documents

2.2.1 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 issue of the *Department of Defense Index of Specifications and Standards (DoDISS)* and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

DEPARTMENT OF DEFENSE

MIL-S-5002	Surface Treatments and Inorganic Coatings for Metal Surfaces of Weapon Systems
MIL-C-5541	Chemical Conversion Coating on Aluminum and Aluminum Alloys
MIL-T-9046	Titanium and Titanium Alloy, Steel, Strip and Plate

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Defense Printing Service Detachment Office, 700 Robbins Avenue, Building 4D, and 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 the documents that are DoD adopted are those listed in the issue of *DoDISS* cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the *DoDISS* are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS STANDARDS

ASTM E18	Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM B117	Operating Salt Spray (Fog) Apparatus (DoD Adopted)
ASTM B487	Measurement of Metal and Oxide Coating, Thickness by Microscopic Examination of a Cross Section, Method of (DoD Adopted)
ASTM B499	Measurement of Coating Thickness by the Magnetic Method Nonmagnetic Coatings on Magnetic Base Metals (DoD Adopted)
ASTM B567	Measurement of Coating Thickness by the Beta Backscatter Method (DoD Adopted)
ASTM E1004	Test Method for Electromagnetic (Eddy-Current) Measurements Of Electrical Conductivity

(Application for copies should be addressed to the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken PA 19428-2959, (610-832-9500))

SOCIETY OF AUTOMOTIVE ENGINEERS

AMS-QQ-A-250/4	Aluminum Alloy 2024, Plate and Sheet
AMS-QQ-A-250/12	Aluminum Alloy 7075, Plate and Sheet
AMS- 6350	Steel Sheet, Strip, and Plate 0.95Cr – 0.20Mo – (0.28 – 0.33C) (SAE 4130)

(Application for copies should be addressed to the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096)

2.4 Order of precedence. 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 material shall be capable of conforming to the requirements of this specification and in accordance with 3.1.1.

3.1.1 Composition. The composition of the aluminum coating shall not be less than 99.0 percent aluminum.

3.2 Equipment and processes. As specified in 3.9.2, the equipment and processes employed to produce high purity aluminum coatings shall be capable of providing a uniform coating.

3.2.1 Processes. The process used to deposit the coating shall not cause a temperature rise in the parts that could cause adverse reaction between the coating and the substrate or adversely affect the substrate.

3.2.1.1 Cleaning. All base metals shall be cleaned in accordance with MIL-S-5002 or equivalent cleaning method, prior to coating with high purity aluminum.

3.3 Areas of deposit. Except as specified in 3.5.4, the coating shall completely cover all visible surfaces, including roots of threads, and sharp corners. The coating shall be deposited directly on the base metal without a preliminary coating of other metal.

3.4 Supplementary chromate treatment (Type II). Unless otherwise specified, the high purity coating shall be Type II, which is a Type I coating with a supplementary chromate treatment in accordance with MIL-C-5541, Class 1A. Chromate treated parts, other than fasteners, should receive additional protective coatings. Application requiring electrical conductivity (see 6.1) shall be chromate treated with a MIL-C-5541 solution which meets both Class 1A (corrosion resistance) and Class 3 (low electrical resistance) requirements.

3.5 Thickness of coating. Except as specified in 3.5.4, the thickness of high purity aluminum shall be as specified in 1.2.1 on all visible surfaces.

3.5.1 Class 1 thickness. Class 1 thickness shall be used where tolerance will permit.

3.5.2 Class 2 thickness. Class 2 thickness shall be used where Class 1 thickness is unacceptable for dimensional thickness reasons.

3.5.3 Class 3 thickness. Class 3 thickness shall be used for close tolerance applications such as finely threaded parts.

3.5.4 Exceptions to Class 1, 2, and Class 3 thickness. Fixture contact points, holes, recesses, internal threads, and other areas where a controlled deposit cannot be obtained shall not be subject to a thickness requirement. However, there shall be visual evidence of coating in holes and recesses down to a depth of at least the diameter of the hole or recess. Fastener areas that cannot be touched with a 0.020-inch diameter ball shall not be subject to thickness requirement. Threads that gage undersize solely as a result of coating thickness shall be considered acceptable.

3.6 Stripping of aluminum coatings. Steel parts to be recoated shall be stripped by mechanical means or in a suitable caustic solution. If stripped with caustic solution, steel parts having hardness Rockwell C-40 or greater shall be baked after stripping at an appropriate time

and temperature to relieve any hydrogen embrittlement in the base metal. Nonsteel parts shall be stripped by mechanical means or in a suitable chemical solution that does not result in degradation of the base metal.

3.7 Adhesion. When tested in accordance with 4.4.2, the adhesion of the coating shall not show separation from the base metal at the interface when examined at a minimum magnification of approximately four-diameters. The interface between the aluminum and the base metal is the surface of the base metal before coating. The formation of cracks in the deposit caused by rupture of the base metal but does not result in flaking, peeling or blistering of the deposit shall not be cause for rejection.

3.8 Corrosion resistance. When tested in accordance with 4.4.3, test samples shall show no evidence of corrosion of the base metal after testing as specified in table 1. The appearance of white corrosion products on the aluminum coating during the test period shall not be cause for rejection.

Table 1. Salt Spray Test

Class	Test Period (hours)	
	Type I	Type II
1	504	672
2	336	504
3	168	336

3.9 Workmanship

3.9.1 Base metal. The base metal shall be free from defects that will be detrimental to the appearance or the protective value of the coating.

3.9.2 Coating. The high purity aluminum coating shall be smooth, fine grained, adherent, uniform in appearance, free from staining, pitting, and other defects. The coating shall show no indication of contamination or improper operation of equipment used to produce the deposit, such as excessively powdered or darkened coatings. Type II parts processed in accordance with MIL-C-5541 requirements shall have a continuous, distinctly colored protective film ranging in color from yellow and iridescent bronze through olive drab and brown.

3.10 Base metal integrity. When tested in accordance with 4.4.4, aluminum base metal parts, after coating, shall have a Rockwell B hardness change of no more than 3 points. The hardness after coating shall meet the minimum acceptable value for that alloy and temper.

4. VERIFICATION

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

a. Conformance inspection (see 4.2).

4.2 Conformance inspections. Conformance inspections shall include the examination of 4.2.1 and the tests of 4.3.1 through 4.4.4.

4.2.1 Inspection lot. A lot shall consist of coated samples of approximately the same size, shape, material type, and class of coating, coated in the same production run. In the case of short production runs, a lot for inspection purposes may be made up of a group of small lots covering orders of parts similar in size and shape and coated under similar conditions. Lot size shall not exceed normal production run capability.

4.2.1.1 Sample for thickness and adhesion. A random sample of two specimens shall be taken from each inspection lot or a minimum of two test specimens shall be prepared in accordance with 4.3 to represent the inspection lot.

4.2.1.2 Sample for corrosion resistance. A random sample of two specimens shall be taken from the designated inspection lot at a minimum of once per month or two test specimens shall be prepared in accordance with 4.3 to represent the inspection lot. Failure of any sample shall require random sampling for five consecutive inspection lots (see 4.2.1) without failure.

4.2.1.3 Sample for base metal integrity. When the base metal is aluminum, two random samples shall be taken from each inspection lot.

4.3 Test specimens. When the coated parts are of such form or material as to not readily adaptable to a test specified herein, or for destructive tests, or for sampling of small lot sizes, test specimens shall be tested instead. Test specimens shall be introduced into a lot at regular intervals at the cleaning operation preliminary to the coating and shall not be separated from the lot until after completion of the processing. Conditions affecting the coating of the specimens, including the spacing and positioning with respect to coating source and to other objects being coated, shall correspond as nearly as possible to those affecting the significant surfaces of the specimens represented.

4.3.1 Adhesion test samples

4.3.1.1 Steel parts. In accordance with AMS 6350 or equivalent, use metal strips approximately 1 inch by 4 inches by 0.040 inch made of 4130 steel for steel parts.

4.3.1.2 Titanium parts. In accordance with MIL-T-9046 or equivalent, use metal strips approximately 1 inch by 4 inches by 0.040 inch made of Ti-6Al-4V for titanium parts.

4.3.1.3 Aluminum or copper parts. In accordance with AMS-QQ-A-250/4 or equivalent, for 2000 series aluminum or copper parts, or 7075-T6 in accordance with AMS-QQ-A-250/12 or equivalent, for 7000-series aluminum parts, use metal strips approximately 1 inch by 4 inches by 0.040 inch made of 2024-T81.

4.3.2 Thickness test sample. In accordance with AMS 6350 or equivalent, use metal strips approximately 1 inch by 4 inches by 0.040 inch made of 4130 steel. Test samples shall be used only when the base metal is other than a ferrous alloy.

4.3.3 Corrosion test samples. In accordance with AMS 6350 or equivalent, use panels at least 3 inches wide by 6 inches long by 0.040 inch made of 4130 steel for corrosion tests.

4.4 Methods of inspection

4.4.1 Thickness. In accordance with 4.2.1.1, test samples shall have the thickness determined by eddy current test, beta backscatter test, micrometer measurements, microscopic test, or magnetic tests. The magnetic test is applicable only to ferrous alloy substrates. The beta backscatter test shall be made in accordance with ASTM B567. The microscopic test shall be made in accordance with ASTM B487. The magnetic test shall be made in accordance with ASTM B499. For verification of other test methods, the microscopic test shall be used. If the thickness of the coating on a nonferrous alloy part cannot suitably be measured with any of these test devices, test specimens in accordance with 4.3.2 may be used. Due to coating wraparound the coating thickness on the test specimens (4.3.2) is thicker than on the production parts. To compensate for the wraparound effect the thickness on the production parts is determined by dividing the thickness measured on the test specimens by 1.6.

4.4.2 Adhesion. In accordance with 4.2.1.1, test samples shall have adhesion determined by methods 4.4.2.1 or 4.4.2.2. Test samples for individual production parts shall be in accordance the 4.4.2.3. The eddy current test for conductivity measures shall be made in accordance with ASTM E1004.

4.4.2.1 Nonadhesion. Scrape the surface of the coated article (4.3.1) to expose the base metal and examine at a minimum of four-diameter magnification for evidence of nonadhesion. Any evidence of nonadhesion from the base metal shall be cause for rejection.

4.4.2.2 Strip rupture. Clamp the coated test strip (4.3.1) in a vise and bend back and forth until strip rupture occurs. If the edge of the ruptured coating can be peeled back or if separation between the coating and the base metal can be seen at the point of rupture when examined at four-diameter magnification adhesion it shall be cause for rejection.

4.4.2.3 As-applied coating. For individual production parts only, burnish the as-applied coating with glass bead until a shiny, uniform appearance is obtained. The peening nozzle shall be held at 6 to 8 inches above the part and the nozzle shall slowly be passed completely over the part. Peening residue shall be removed with dry nitrogen gas or oil-free filtered air. Removal of the coating from the base metal shall be cause for rejection.

4.4.3 Corrosion resistance. In accordance with 4.2.1.2, test samples shall be corrosion resistance tested as specified in ASTM B117 to determine conformance with 3.8 herein.

4.4.4 Base metal integrity. In accordance with 4.2.1.3, test samples shall have the Rockwell B hardness measured in accordance with ASTM E18.

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of material is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department or Defense Agency, or within the Military Department's System Command. Packaging data retrieval is available from the managing Military Department 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. The high purity aluminum coatings covered by this specification are intended for use as corrosion protective coatings on ferrous and aluminum alloy parts. The requirements for coating low alloy steel, stainless steel, aluminum alloy, copper alloy, and titanium alloy parts with high purity aluminum (99 percent plus) are military unique. Control of the application process is absolutely critical because of the potential change in mechanical fatigue life or strength on aluminum substrates to which the coating is being applied. Coating may be applied by any process which produces a high purity (99 percent plus) aluminum coating. Ion vapor deposited aluminum, sputtered aluminum, and aluminum electrodeposited using an organic electrolyte are processes that meet this criteria. It can be used on high strength steel without causing hydrogen embrittlement, for high temperature applications up to 925°F (496°C), and in lieu of anodize on fatigue-critical aluminum structures. It can also be applied to copper, titanium, and stainless steel alloys to provide corrosion compatibility with aluminum structure. Type II (Chromate, see 3.4) high purity aluminum coating can also be used for applications which require an electrically conductive surface such as electrical bonding and ground, and Electromagnetic (EMI) Interference compatibility.

6.1.1 Class 1 and Class 2 coatings. Class 1 and Class 2 coatings are intended as general purpose coatings where corrosion protection and/or dissimilar metal compatibility is required for structural and functional ferrous and non-ferrous alloy parts.

6.1.2 Class 3 coatings. Class 3 coatings are intended as special purpose coatings where corrosion protection and/or dissimilar metal compatibility is required for close tolerance or threaded parts (such as bushings, pins, fastener, etc.).

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number and date of this specification.

b. Class and type of coating required (see 1.2).

6.2.1 Options. Any desired options offered herein may be utilized in procurement document.

6.3 Reagent for microscopic determination. The following typical reagent may be used for etching aluminum coatings on steel for microscopic determination of coating thickness:

10 percent weight NaOH

6.4 Dimensional tolerance. The dimensional tolerance of most threaded specimens, such as nuts, bolts, and similar fasteners with complementary threads do not permit the application of a coating thickness much greater than Class 3. If heavier coatings are required for corrosion resistance, allowance must be made in the manufacture of the threaded fasteners for tolerance necessary for coating build-up.

6.5 Samples. If samples with bids are required, they should be specifically asked for in the invitation for bids, and the particular purpose to be served by the bid sample should be definitely stated. This specification will apply in all other respects.

6.6 Subject term (key word) listing

Aluminum coating
Chromate treatment
Corrosion resistance
Ion vapor deposition
Multi-coat coating
Sprayable
Strippable
Water emulsion

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

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

Preparing activity:
Air Force - 11

(Proj. No. MFFP-0630)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity may complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
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I RECOMMEND A CHANGE:	DOCUMENT NUMBER MIL-DTL-83488D	2. DOCUMENT DATE (YYMMDD) 990401

DOCUMENT TITLE
COATING, ALUMINUM, HIGH PURITY

4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (include Zip Code)	d. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON *(If applicable)*	e. DATE SUBMITTED *(YYMMDD)*

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE (Include Area Code	
ASC/ENSI (AF-11)	(1) Commercial (937)255-6281	(2) AUTOVON 785-6281
c. ADDRESS *(Include Zip Code)* BLDG 560 2530 LOOP ROAD W WRIGHT-PATTERSON AFB OH 45433-7101	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340	