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12 July 2011
SUPERSEDING
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DETAIL SPECIFICATION

SURFACE TREATMENTS AND INORGANIC COATINGS FOR METAL SURFACES OF WEAPONS SYSTEMS

Reactivated after 12 July 2011 and may be used for new and existing designs and acquisitions.

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 cleaning, surface treatment, and application of inorganic coatings for metallic surfaces of weapons systems parts.

2. APPLICABLE DOCUMENTS

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

Comments, suggestions, or questions on this document should be addressed to: Commander, Naval Air Warfare Center Aircraft Division, Code 4L8000B120-3, Highway 547, Lakehurst, NJ 08733-5100 or emailed to michael.sikora@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.daps.dla.mil.

AMSC N/A AREA MFFP

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 cited in the solicitation or contract.

FEDERAL SPECIFICATIONS

TT-N-95	-	Naphtha, Aliphatic
TT-I-735	-	Isopropyl Alcohol
TT-C-490	-	Chemical Conversion Coatings and Pretreatments for Ferrous Surfaces (Base for Organic Coatings)

COMMERCIAL ITEM DESCRIPTION

A-A-59315	-	Powder Materials for Flame and Plasma Sprayed Coatings, General Requirements for

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-PRF-680	-	Degreasing Solvent
MIL-DTL-5541	-	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-A-8625	-	Anodic Coatings for Aluminum and Aluminum Alloys
MIL-DTL-13924	-	Coating, Oxide, Black, for Ferrous Metals
MIL-DTL-16232	-	Phosphate Coating, Heavy, Manganese or Zinc Base
MIL-C-17711	-	Coatings, Chromate, for Zinc Alloy Castings and Hot Dip Galvanized Surfaces
MIL-P-23408	-	Plating: Tin-Cadmium (Electrodeposited)
MIL-PRF-32295	-	Cleaner, Non-Aqueous, Low-VOC, HAP-Free
MIL-DTL-45204	-	Gold Plating, Electrodeposited
MIL-R-46085	-	Rhodium Plating, Electrodeposited
MIL-Z-81572	-	Zirconium Oxide, Lime-stabilized, Powder and Rod, for Flame Spraying
MIL-C-81751	-	Coating, Metallic-Ceramic
MIL-T-81772	-	Thinner, Aircraft Coating
MIL-DTL-83488	-	Coating, Aluminum, High Purity
MIL-PRF-85570	-	Cleaning Compounds, Aircraft Exterior
MIL-PRF-87937	-	Cleaning Compound, Aerospace Equipment

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-865	-	Selective Brush Plating, Electrodeposition
MIL-STD-870	-	Cadmium Plating, Low Embrittlement, Electrodeposition
MIL-STD-889	-	Dissimilar Metals
MIL-STD-1500	-	Cadmium-Titanium Plating, Low Embrittlement, Electrodeposition

MIL-STD-7179 - Finishes, Coatings, and Sealants, for the Protection of Aerospace Weapons Systems

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

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.

ASTM INTERNATIONAL

ASTM D329	-	Standard Specification for Acetone. (DoD adopted)
ASTM B545	-	Standard Specification for Electrodeposited Coatings of Tin. (DoD adopted)
ASTM B600	-	Standard Guide for Descaling and Cleaning Titanium and Titanium Alloy Surfaces. (DoD adopted)
ASTM B633	-	Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel. (DoD adopted)
ASTM B679	-	Standard Specification for Electrodeposited Coatings of Palladium for Engineering Use
ASTM B700	-	Standard Specification for Electrodeposited Coatings of Silver for Engineering Use
ASTM A967	-	Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts. (DoD adopted)
ASTM D1732	-	Standard Practices for Preparation of Magnesium Alloy Surfaces for Painting. (DoD adopted)

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

SAE INTERNATIONAL

SAE AMS2403	-	Plating, Nickel, General Purpose
SAE AMS2404	-	Plating, Electroless Nickel. (DoD adopted)
SAE AMS2416	-	Plating, Nickel-Cadmium, Diffused. (DoD adopted)
SAE AMS2418	-	Plating, Copper. (DoD adopted)
SAE AMS2423	-	Plating, Nickel, Hard Deposit
SAE AMS2424	-	Plating, Nickel, Low Stressed Deposit. (DoD adopted)
SAE AMS2427	-	Aluminum Coating, Ion Vapor Deposition (DoD adopted)
SAE AMS2430	-	Shot Peening, Automatic. (DoD adopted)
SAE AMS2432	-	Shot Peening, Computer Monitored
SAE AMS2447	-	Coating, Thermal Spray, High Velocity Oxygen/Fuel Process.

SAE AMS2460	-	Plating, Chromium
SAE AMS2700	-	Passivation of Corrosion Resistant Steels. (DoD adopted)
SAE AMS7881	-	Tungsten Carbide-Cobalt Powder, Agglomerated and Sintered
SAE AMS7882	-	Tungsten Carbide-Cobalt Chrome Powder, Agglomerated and Sintered
SAE AMS-C-8837	-	Coating, Cadmium (Vacuum Deposited). (DoD adopted)
SAE AMS-C-81562	-	Coatings, Cadmium, Tin-Cadmium and Zinc (Mechanically Deposited). (DoD adopted)
SAE AMS-M-3171	-	Magnesium Alloy, Processes for Pretreatment and Prevention of Corrosion on. (DoD adopted)
SAE AMS-P-81728	-	Plating, Tin-Lead (Electrodeposited). (DoD adopted)
SAE AMS-QQ-P-416	-	Plating, Cadmium (Electrodeposited). (DoD adopted)

(Copies of these documents are available from www.sae.org or SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001.)

2.3 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 Materials and processes. Materials and processes shall conform to applicable documents, as specified herein. Additional guidance may be found in the DoD Corrosion Prevention and Control Planning Guidebook. Materials and processes not covered by applicable specifications and any deviations from the requirements herein shall not be used unless approved by the cognizant engineering organization (see 6.5).

3.2 Finishing requirements. Unless otherwise specified, all fabrication operations, including thermal treatments and cleaning, shall have been completed prior to application of any surface treatment, metallic coating, and/or non-metallic coating.

3.3 Surfaces. Parts, with the exception of those processed in accordance with MIL-DTL-16232, shall conform to specified dimensions and surface roughness conditions after final cleaning, surface treatment or coating. In the case of metals which may respond in a non-uniform manner when metal removal is done with mechanical, chemical, electrochemical, or electromechanical methods, inspection procedures shall be established and used to ensure each part has a uniform surface, including freedom from pits and intergranular attack. Where etching results, the degree found shall be demonstrated not to affect the serviceability of the parts.

3.4 Cleaning. Cleaning, prior to application of surface treatments and coatings, shall be as specified herein. These methods shall be utilized in a manner which does not result in damage to the metal, including freedom from pits, intergranular attack, and hydrogen embrittlement. When specified in the contract or order, an appropriate hydrogen embrittlement relief test shall be conducted. After cleaning, all parts shall be completely free of corrosion products, scale, paint,

grease, oil, flux (see 3.4.3), and other foreign materials including other metals. After cleaning, the parts shall be coated as soon as practicable. Particular care shall be exercised in the handling of parts to ensure that foreign metals are not inadvertently transferred, as may occur when steel is allowed to come into contact with zinc surfaces. In addition, assemblies containing parts under sustained tensile stresses, or containing crevices which may retain cleaning solutions, shall not be cleaned as assemblies.

3.4.1 Organic contamination removal. The materials and processes used shall be completely characterized and controlled to ensure that there will be no subsequent corrosion effects.

3.4.1.1 Organic soils. Organic soils shall be removed by emulsion cleaning, semi-aqueous immersion cleaning, alkaline or electrolytic alkaline cleaning (anodic only), solvent immersion, solvent spraying, solvent hand cleaning, vapor degreasing, or combinations thereof, whichever is more applicable to the nature of the part and soil to be removed. Parts displaying corrosion effects shall be subject to rejection.

3.4.1.2 Hand cleaning. Hand cleaning shall be performed using degreasing solvents (MIL-PRF-680 or MIL-PRF-32295), aliphatic hydrocarbons (such as aliphatic naphtha, TT-N-95, or paint thinner, MIL-T-81772 Type I), isopropyl alcohol (TT-I-735), or acetone (ASTM D329). Solvent hand cleaning shall be performed using a clean, lint free cloth. Residues from the cleaning agents shall be thoroughly rinsed off. Wiping/drying after cleaning shall be performed using a clean dry cloth to ensure that surface contaminants are removed.

3.4.2 Inorganic contamination (scale) removal. Inorganic contamination removal (descaling) shall be performed as specified herein. If specified by the cognizant engineering organization, parts shall be stress relieved prior to chemical or electrochemical methods of descaling to remove residual tensile stresses.

3.4.2.1 Aluminum and its alloys. Aluminum and its alloys shall be either chemically or mechanically cleaned except as specified herein. Cleaners conforming to MIL-PRF-85570 or MIL-PRF-87937 are recommended for chemical cleaning. Mechanical cleaning using abrasives containing iron and its oxides, steel wool and wire, and copper alloy based materials shall not be used.

3.4.2.2 High strength steels. Steels, including corrosion and heat resistant steels, hardened by thermal treatment or by cold working to full or surface hardness level of Rockwell C40 (180 ksi) and greater, shall be cleaned using either mechanical means, alkaline or electrolytic alkaline descaling (anodic only), molten salt bath methods or, when necessary, acid pickling. Acid pickling shall be followed by a two hour bake at a temperature of 375 ±25° F (190 ±15° C) prior to the coating operation. Baking for hydrogen embrittlement relief shall begin within four hours of completion of acid pickling. No machining or mechanical deformation shall be performed prior to baking. For several steel types, a thin oxide layer may be formed after the two hour bake which may result in poor coating adhesion.

3.4.2.3 Low-strength steels. Steels of Rockwell hardness less than C40 (180 ksi) shall be cleaned using either mechanical means, alkaline or electrolytic alkaline descaling, molten salt bath methods, acid pickling, or combinations thereof. Immersion times in the pickling bath shall be kept at a minimum to prevent hydrogen absorption.

3.4.2.4 Corrosion and heat resistant steels. Corrosion and heat resistant steels having a Rockwell hardness less than C40 (180 ksi) shall be cleaned by chemical or mechanical processes, or combinations thereof as specified in 3.4.2.3. High strength corrosion and heat resisting steels, Rockwell C40 (180 ksi) or greater, shall be cleaned as specified in 3.4.2.2. For metals and alloys that are sensitive to contamination by gaseous constituents, such as hydrogen, oxygen, and nitrogen, and are exposed to atmospheres containing such materials during processing (e.g. heat treatment), sufficient metal shall be removed during manufacture to eliminate the contaminated material. Verification of the complete elimination of contaminated material shall be documented. If chemical cleaning methods are used to remove the impurities, the cleaning shall not result in any attack of the surface, either pitting or intergranular. After chemical cleaning, the surface shall be examined using a microscopic method at a magnification that clearly establishes the absence of attack. Parts with pitted surfaces or showing signs of intergranular attack shall be subject to rejection.

3.4.2.5 Magnesium and its alloys. Magnesium and its alloys shall be cleaned in accordance with SAE AMS-M-3171, or by other processes approved by the cognizant engineering organization.

3.4.2.6 Titanium and its alloys. For removal of contamination other than organic soil (see 3.4.1), titanium and its alloys shall be cleaned in accordance with ASTM B600.

3.4.3 Flux removal. Soldering, welding, and brazing fluxes shall be removed by the use of hot water, soap and water, alcohol (TT-I-735), degreasing solvent (MIL-PRF-680), or other methods that do not result in attack of the metal. Methyl alcohol shall not be used on magnesium or titanium and their alloys. Acid or alkaline materials shall not be used, unless approved by the cognizant engineering organization. The completeness of flux removal shall be determined in accordance with the applicable welding, soldering, or brazing specification.

3.4.4. Use of abrasives. Abrasives used on any metal or alloy shall not have been used on other metals or alloys unless they were used for a similar base metal (for example, aluminum abrasives on aluminum alloys).

3.4.5 Rinsing. When either acid (pH<5) or alkaline (pH>8) materials are employed, the cleaned parts shall be given a thorough rinse with water of a purity that removes all acid or alkali prior to the coating operations, such that no residual contamination remains.

3.5. Methods of application. Metallic coatings shall be applied by electrodeposition, vacuum deposition, mechanical deposition, metallic compound deposition, thermal spraying methods, hot dip methods, or ion vapor deposition, in conformance to applicable specifications. Metallic coatings may be applied by sputtering as specified and approved by the cognizant engineering organization.

3.5.1 Electrodeposition restrictions. Unless otherwise specified in the applicable plating specification, electrodeposited coatings shall not be used on steel parts having a surface hardness of Rockwell C49 (240 ksi) or greater unless approval is obtained from the cognizant engineering organization.

3.5.2 Thermal spraying. Assemblies that will trap plating solutions and assemblies or parts that are of extreme size and weight for conventionally available plating or coating equipment shall be thermal sprayed. The material for coating shall be applied directly to the surface of the part after surface preparation. Unless otherwise specified in the contract or order, the coating thickness shall be not less than 0.004 inch and shall not be greater than 0.006 inch. Powders used for plasma spray coatings shall conform to A-A-59315.

3.5.2.1 For corrosion control (see 3.9). When metallic materials such as zinc or aluminum are thermal sprayed for corrosion control of parts, no undercoating of another metal such as molybdenum shall be permitted on the substrate.

3.5.2.2 For functional purposes (see 3.10). When non-metallic coatings, such as zirconia, alumina, metallic-ceramics, carbides, silicides, titanates, and cermets, are thermal sprayed for functional use on parts, an undercoat of another material or mixtures of materials in various proportions to produce coatings shall be allowed as a substrate where required to control the matching of the coefficients of thermal expansion between the base metal and the coating.

3.5.2.3 Thermal spraying restrictions. When coatings are applied thermally, in no case shall the part be raised to a temperature that would adversely affect its mechanical, corrosion or stress corrosion resistant properties. If a part is shot-peened prior to the coating application, all thermal treatments performed after shot peening shall conform to the requirements of SAE AMS2430.

3.5.3. Hot-dip coating restrictions. When approved by the cognizant engineering organization, coatings may be applied by the hot-dip method.

3.5.4 Brush plating restrictions. Brush plating shall be used only for touch-up. Brush plated chrome coatings have substantially lower hardness values than conventionally plated chrome coatings, resulting in a lower abrasion resistance. Brush plating may be approved by the cognizant engineering organization when conventional plating methods are inappropriate. When approved by the cognizant engineering organization, brush plating shall be in accordance with MIL-STD-865.

3.6 Metallic coatings.

3.6.1 Cadmium coatings. Electrodeposited cadmium shall be in accordance with SAE AMS-QQ-P-416 or MIL-STD-870. Other cadmium coatings shall be in accordance with SAE AMS-C-8837 or SAE AMS-C-81562. Cadmium coatings may be applied by thermal spray using materials in A-A-59315. Unless otherwise specified in the contract or order, cadmium coatings shall be Class 1 thickness (0.0005 inch). Parts with threads shall be plated to Class 2

thickness (0.0003 inch). Unless otherwise specified in the contract or order, cadmium coatings shall be post-treated with the conversion coating required by the cadmium coating specification.

3.6.1.1 Cadmium coatings shall not be used for the following applications:

a. Parts that may be in contact with hydraulic fluids, fuels, lubricating oil, and other petroleum based fluids.

b. Parts in frictional contact where gouging or binding may be a detrimental factor.

c. In confined spaces, in the presence of organic materials that give off corrosive or damaging vapors.

d. On titanium parts or fasteners. In addition, cadmium plated parts, including interference-fit fasteners and press-fit bushings, shall not be used in contact with titanium. Under certain conditions, titanium can be embrittled by contacting cadmium components. Embrittlement has been determined to occur in cadmium plated titanium parts at temperatures as low as 150° F.

e. Parts that will be subsequently soldered.

f. Components that will come into contact with graphite composites.

g. Parts that will be exposed to temperatures above 450° F (232° C).

3.6.1.2 Parts containing recesses or entrapments. Parts containing recesses or entrapments that may retain cleaning and plating fluids shall be vacuum cadmium plated in accordance with SAE AMS-C-8837. Additional protection, such as an organic coating system, may be required for recesses that cannot be coated by these methods.

3.6.2 Cadmium-titanium plating. Cadmium-titanium plating shall be in accordance with MIL-STD-1500.

3.6.3 Nickel-cadmium plating. Nickel-cadmium plating shall be in accordance with SAE AMS2416.

3.6.4 Tin-cadmium coatings. Electrodeposited tin-cadmium shall be in accordance with MIL-P-23408. Other tin-cadmium coatings shall be in accordance with SAE AMS-C-81562.

3.6.5 Tin and tin-lead plating. A plating of tin or tin-lead may be used on parts that are subsequently soldered. Tin plating shall be applied in accordance with ASTM B545 and tin-lead plating shall be in accordance with SAE AMS-P-81728.

3.6.6 Aluminum coating. Aluminum and aluminum alloy coatings shall be used where the properties of these materials present distinct protective advantages in comparison with other coatings and platings at temperatures greater than 450° F. Aluminum and aluminum alloy

coatings are also used for corrosion resistance and galvanic compatibility (see 3.9). Aluminum and aluminum alloy coatings shall be in accordance with MIL-DTL-83488. IVD aluminum coating shall be in accordance with SAE AMS2427. Unless otherwise specified, aluminum coatings shall be post-treated with an authorized conversion coating as specified in 3.8.2.

3.6.7 Zinc plating and coating. Zinc plating shall be in accordance with ASTM B633 and zinc coating shall be as specified in SAE AMS-C-81562. Unless otherwise specified, zinc plating or coating shall have a minimum thickness of 0.001 inch and shall be post-treated with an authorized conversion coating as specified by MIL-C-17711. Zinc plating and coating shall not be used for the following applications:

a. Parts for aerospace and missile systems, unless specifically approved by the cognizant engineering organization.

b. Parts in contact where corrosion products might interfere with normal functioning.

c. Grounding contacts where the increased electrical resistance of zinc-plated surfaces would be detrimental.

3.6.8 Chromium plating. Chromium plating shall be used for all surfaces subject to wear or abrasion, except where other surface hardening processes, such as nitriding or carburizing are used, or where other wear and abrasion resistant coatings are specified. Chromium plating shall be in accordance with SAE AMS2460, Class 2 (engineering). Unless otherwise specified in the contract or order, chromium plating thickness shall be not less than 0.002 inch. If a Class 1 (corrosion) coating is specified, and the part will not be subjected to lubricants during use, a nickel undercoat shall be applied in accordance with SAE AMS2403 having a minimum thickness of 0.0015 inch and a maximum thickness of 0.015 inch. Chromium plating shall be used on only one of the two contacting surfaces.

3.6.9 Tungsten-carbide-cobalt coating. When authorized by the cognizant engineering organization, tungsten-carbide-cobalt coating in accordance with SAE AMS7881 or SAE AMS7882 may be applied as an alternate to chromium plating. Tungsten-carbide-cobalt coating shall be applied using the high velocity oxygen/fuel process (SAE AMS2447).

3.6.10 Nickel plating. Unless otherwise specified in the contract, or when used as an undercoating, the electrodeposited nickel thickness shall be not less than 0.002 inch. Plating shall be in accordance with SAE AMS2403 when corrosion or oxidation resistance, or buildup of surfaces is required. Plating shall be in accordance with SAE AMS2423 when wear resistance is required. Where applications require low residual stress in the plated nickel, plating shall be in accordance with SAE AMS2424. Nickel plating shall be used for the following applications only:

a. Where temperatures do not exceed 1000° F (538° C) and other coatings would not be adequate.

b. To minimize the effects of crevice corrosion with unplated corrosion-resistant steel or stainless steel in contact with other stainless steel.

c. As an undercoat for the other functional coatings (see 3.10).

d. To restore dimensions by rebuilding worn surfaces.

e. For resistance to sand erosion.

f. When not in contact with aluminum or aluminum alloy coating, except when approved by the cognizant engineering organization.

3.6.11 Electroless nickel coating. Electroless nickel coatings shall be in accordance with SAE AMS2404. Unless otherwise specified by the cognizant engineering organization, when electroless nickel is used for corrosion protection or wear resistance, the thickness shall be not less than 0.0015 inch and shall be not greater than 0.003 inch.

3.6.12 Silver plating. Silver plating shall be in accordance with ASTM B700. When electrodeposited silver is used on steel, an underplate of either copper or nickel, or a combination of both, shall be applied. Unless otherwise specified by the cognizant engineering organization, the underplate and the silver plate thickness shall be not less than 0.0005 inch, yielding a 0.001 inch minimum total thickness. Silver plating shall not be used in the following applications:

a. On titanium or in contact with titanium for parts that are used at temperatures above 350° F (177° C) in service. Under certain conditions, titanium can be embrittled by contacting silver components. Embrittlement has been determined to occur in silver brazed titanium parts at temperatures above 350° F (177° C).

b. With nickel base alloys for parts that are used above 1000° F (538° C) in service.

c. On aluminum or aluminum alloys, or in contact with aluminum parts, unless approved by the cognizant engineering organization

3.6.13 Gold plating. Gold plating shall be in accordance with MIL-DTL-45204.

3.6.14 Palladium plating. Palladium plating shall be in accordance with ASTM B679.

3.6.15 Rhodium plating. Rhodium plating shall be in accordance with MIL-R-46085.

3.6.16 Copper plating. Copper plating shall be in accordance with SAE AMS2418.

3.6.17 Zirconium oxide coating. Zirconium oxide coating shall be processed from materials in accordance with MIL-Z-81572.

3.7 Metallic-ceramic coatings.

3.7.1 Methods of application. Metallic-ceramic coatings shall be applied by spraying, dipping, electrophoretic deposition, or thermal spraying methods in conformance with applicable specifications, followed by a fusion or mechanical treatment, if applicable. Where thermal application processes are used, in no case shall the part be subjected to a temperature that would adversely affect its mechanical, corrosion, or stress corrosion properties. If the part is shot-peened prior to coating, the thermal application shall not impair the effectiveness of the shot-peening operation.

3.7.2 Metallic-ceramic coating. Metallic-ceramic coatings shall be used for surfaces subject to oxidation, corrosion, galvanic corrosion, and for protection from corrosion due to other environments (see 3.9). Metallic-ceramic coatings shall be in accordance with MIL-C-81751.

3.8 Surface treatments and oxide coatings.

3.8.1 Secondary passivation. Also designated as post-treatment, sealing, conversion coating, or rinsing. Most sacrificial metallic coatings, anodizes, and phosphates require a post-treatment passivation for optimum corrosion and adhesion performance. Secondary passivation of these processes shall be required unless deviation is authorized by the cognizant engineering organization.

3.8.2 Coatings for aluminum and aluminum alloys. Unless otherwise specified, all aluminum and aluminum alloys, including clad aluminum alloy surfaces, shall be either anodized to produce coatings conforming to MIL-A-8625 or shall receive a chemical conversion treatment to produce coatings conforming to MIL-DTL-5541. Parts subject to wear, abrasion, erosion, and severe corrosion conditions shall be anodized.

3.8.2.1 Anodic coatings. Anodic coatings are preferred for aluminum parts subject to wear, abrasion, erosion, or severe corrosion conditions.

3.8.2.1.1 Anodic coatings for corrosion resistance. Parts anodized in accordance with MIL-A-8625 Type I or II shall be sealed or post-treated with a corrosion-resistant finish approved by the cognizant engineering organization. Hot water seal shall not be used unless authorized by the cognizant engineering organization. Sealing processes can have a significant effect on the adhesion of primers and polymer coatings. Parts that require painting or bonding after anodization shall follow the sealing process specified in the contract or order.

3.8.2.1.2 Anodizing for wear resistance. Hard anodic coatings shall conform to MIL-A-8625 Type III. Hard anodic coatings shall be used on parts where the functional purpose is to provide a wear or abrasion resistant surface. It should be noted that hard anodic coatings may have a detrimental effect on the fatigue life of aluminum alloys. Sealing of hard anodize coatings for increased corrosion resistance may be authorized by the cognizant engineering organization if there is no detrimental effect on hardness or wear.

3.8.2.2 Conversion coatings.

3.8.2.2.1 Aircraft applications. All non-clad aluminum and aluminum alloys used in locations classified as exterior aircraft surfaces by MIL-STD-7179 shall be conversion coated to produce coatings conforming to MIL-DTL-5541 Class 1A.

3.8.2.2.2 Electrical applications. Chemical films conforming to MIL-DTL-5541 Class 3 shall be used on electrical parts where low electrical contact resistance is required. Other surface treatments for low electrical resistance and corrosion protection may be used when approved by the cognizant engineering organization.

3.8.3 Coatings for magnesium and magnesium alloys.

3.8.3.1 Anodic coatings. All magnesium alloys shall be anodized in accordance with ASTM D1732 Type I, Class A or Class C, or Type II, Class A or Class D. Parts, subsequent to anodizing, shall be sealed in accordance with SAE AMS-M-3171 Type VII. Anodized magnesium surfaces may be stripped and re-anodized when approved by the cognizant engineering organization.

3.8.3.2 Conversion coating. SAE AMS-M-3171 treatments shall only be used for temporary protection or touch-up of damaged anodic coatings. All surfaces that have the anodic or chemical film removed or damaged shall be touched up using the SAE AMS-M-3171 Type I or Type VI process.

3.8.4 Coatings for ferrous metals

3.8.4.1 Phosphate coatings. When approved by the cognizant engineering organization, phosphate treatments may be used on surfaces where it is impractical to apply an adequate corrosion control coating or where a corrosion control coating will interfere with the part's function. When approved for use on steel parts, phosphate treatments shall be in accordance with MIL-DTL-16232 or TT-C-490 Type I or II. Unless otherwise specified by the cognizant engineering organization, all phosphate coatings shall be post-treated with a rinse, such as chromate.

3.8.4.2 Black oxide. When approved by the cognizant engineering organization, black oxide coatings may be applied to ferrous metals. Black oxide coatings shall be applied in accordance with MIL-DTL-13924.

3.8.5 Surface treatments for corrosion and heat-resistant steel alloys. Unplated corrosion-resistant and heat-resistant steel alloys shall be finished as specified by the cognizant engineering organization.

3.8.6 Passivation treatment for Ferrous Alloys. Stainless steels (200, 300, 400 series) and precipitation-hardened corrosion resistant steels shall undergo passivation in accordance with ASTM A967 (stainless steels) or SAE AMS2700 (corrosion resistant steels), or by other methods approved by the cognizant engineering organization. Passivation shall be followed by a

thorough rinsing and drying. Carburized or nitrided surfaces shall not be subjected to passivation. Passivation is not required for corrosion resistant steels that are to be inorganically coated.

3.8.7 Shot-peening and other residual compressive stress-inducing treatments. Shot-peening, in accordance with SAE AMS2430 or SAE AMS2432, and other compressive stress-inducing treatments may be used to obtain required fatigue behavior. Shot peening in accordance with SAE AMS2430 and other stress-reducing treatments may be used to enhance stress corrosion cracking resistance. The maximum temperatures for use on any part shall be not greater than 50° F less than the recovery temperature of the stressed surface of the material involved. Procedure details shall be prepared and listed on the applicable drawings or applicable reference documents for parts. Specific attention shall be paid to use of recognized procedures, equipment, materials, and control methods.

3.9 Coatings for corrosion control.

3.9.1 Steel and copper based parts. Unless otherwise specified in the contract or order, steel and copper based parts shall be cadmium, nickel-cadmium, tin-cadmium, tin-lead, tin, aluminum (steel parts only), zinc, nickel, or metallic-ceramic coated (see 3.6.1, 3.6.3 through 3.6.7, 3.6.10, and 3.7).

3.9.2 Corrosion resistant materials. When approved by the cognizant engineering organization, coatings may be omitted from corrosion and stress corrosion resistant materials, except for the following conditions:

a. Where the intended use is such that added protection is warranted.

b. Where parts of these materials are in contact with dissimilar metals as specified in MIL-STD-889.

c. Where unsealed crevices exist either within the part or the assembly of which it is a component.

3.9.3 Sintered bearings. Sintered bearings of the oil-impregnated type shall not be plated. Crevices between the bearing and the housing shall be sealed.

3.9.4 Non-corrosion resistant metal parts. All non-corrosion resistant metal parts used for components of lubricating and hydraulic systems and components exposed to lubricants or hydraulic fluids, except for tubing, shall be tin-cadmium plated in accordance with MIL-P-23408. When approved by the cognizant engineering organization, alternative protective systems may be used.

3.10 Coatings for functional purposes. Coatings for functional purposes shall be as specified in 3.6.8, 3.6.11 through 3.6.17, and 3.7. Unless otherwise specified in the contract or order, where the selected coating does not provide corrosion protection for the base metal and the coated surface or portion thereof is exposed to corrosive environment, an undercoat of 0.0010 to

0.0016 inch of nickel on steel or zinc parts or an undercoat of 0.0008 to 0.0010 inch of nickel on copper alloy parts in accordance with 3.6.11 shall be used. Coatings proposed for applications where temperatures exceed 1000° F (538° C) in service shall be subject to approval by the cognizant engineering organization.

3.11 Temperature limitations. Unless otherwise specified, the service temperature of the coating, items in direct contact with the coating, or, when erosive conditions exist, surrounding parts which may be contacted by eroded coating particles, shall not exceed the limits in table I.

TABLE I. Maximum service temperatures of various coatings.

METAL	MAXIMUM TEMPERATURE °F	NOTES
Silver	1200	1/
Nickel	1000	
Metallic ceramic	950	2/
Aluminum	925	2/
Zinc	500	
Cadmium	450	3/
Tin-lead	350	4/
Tin-cadmium	345	4/
Tin	330	4/
1/ Shall not be used on titanium parts or in contact with titanium parts exposed to temperatures greater than 350° F in service (see 3.6.12).		
2/ Above 950° F there may be an unfavorable effect upon the fatigue strength of the steel base metal due to diffusion.		
3/ Shall not be used on or in contact with titanium parts or fasteners (see 3.6.1.1 (d)).		
4/ Pure tin or tin containing materials that undergo a solid-state transformation shall not be used on parts that are used at subzero temperatures.		

3.12 Workmanship. Parts and assemblies shall be the result of use of the best processes covered herein, as demonstrated by serviceability of the parts.

4. VERIFICATION

4.1 Inspection. Items subject to this specification shall meet all requirements of this specification. The methods of cleaning metal surfaces, application of surface treatments, and all materials entering into the processes shall be subject to inspection as specified in the contract or order (see 6.6).

4.2 Previous approval. Acceptance or approval of material, surface treatment, or corrosion preventive process during the course of manufacture shall not guarantee the acceptance of the finished product.

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 may be helpful, but is not mandatory.)

6.1 Intended use. The surface treatments and coatings prescribed by this specification are intended for use on metal surfaces of aerospace weapons, electrical, electronic and other systems.

6.2 Ordering data. This section is not applicable to this specification.

6.3 Definitions. The terms “coating” and “plating” as used in this document may be used interchangeably. However, the term “coating” is generally applied to materials on metal surfaces deposited by nonelectrodeposition processes, whereas “plating” refers to those materials deposited electrolytically.

6.4 Cognizant engineering organization. The cognizant engineering organization is the term applied to the engineering organization responsible for the design of the item being cleaned and coated.

6.5 Deviation from requirements. Any deviations from the requirements of this specification must be identified and supported with technical data and approved by the cognizant engineering organization.

6.6 Inspection information.

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

6.6.2 Responsibility for compliance. The inspection set forth in this specification should become a part of the contractor’s overall inspection system or quality program. The absence of any inspection requirements in the specification does not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for

acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

6.7 Subject term (key word) listing.

Anodic coatings
Ceramic coatings
Corrosion control
Metallic coatings
Plating

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

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

Review activities:
Army - AR, AV, EA, MI
Navy - OS

Preparing activity:
Navy - AS

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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.daps.dla.mil.