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MIL-S-5002D
30 November 1989
SUPERSEDING
MIL-S-5002C
26 July 1971

MILITARY SPECIFICATION

SURFACE TREATMENTS AND INORGANIC COATINGS FOR METAL SURFACES OF WEAPONS SYSTEMS

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 treatments and inorganic coatings for metallic surfaces of weapons systems parts.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

FEDERAL

O-A-51	-	Acetone, Technical.
O-T-236	-	Tetrachloroethylene (Perchloroethylene), Technical Grade.
O-T-620	-	Trichloroethane-1,1,1, Technical, Inhibited (Methyl Chloroform)
P-D-680		Dry Cleaning Solvent
QQ-C-320	-	Chromium Plating (Electrodeposited).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Systems Engineering and Standardization Department (Code 53), Naval Air Engineering Center, Lakehurst, NJ 08733-5100, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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QQ-N-290	-	Nickel Plating (Electrodeposited).
QQ-P-35	-	Passivation Treatments for Corrosion Resisting Steel.
QQ-P-416	-	Plating, Cadmium (Electrodeposited).
QQ-S-365	-	Silver Plating, Electrodeposited, General Requirements for.
TT-N-95	-	Naphtha, Aliphatic.

MILITARY

MIL-M-3171	-	Magnesium Alloy, Processes for Pretreatment and Prevention of Corrosion on.
MIL-C-5541	-	Chemical Conversion Coatings on Aluminum Alloys.
MIL-M-6874	-	Metal Spraying, Process for.
MIL-F-7179	-	Finishes, Coatings, and Sealants for the Protection of Aerospace Weapons Systems.
MIL-A-8625	-	Anodic Coatings, for Aluminum and Aluminum Alloys.
MIL-C-8837	-	Coating, Cadmium (Vacuum Deposited).
MIL-T-10727	-	Tin Plating, Electrodeposited or Hot-dipped, for Ferrous and Nonferrous Metals.
MIL-S-13165	-	Shot-Peening of Metal Parts.
MIL-C-14550	-	Copper Plating (Electrodeposited).
DOD-P-16232	-	Phosphate Coating, Heavy, Manganese or Zinc Base (for Ferrous Metals).
MIL-C-17711	-	Coatings, Chromate, for Zinc Alloy Castings and Hot Dip Galvanized Surfaces.
MIL-P-18317	-	Plating, Black Nickel (Electrodeposited) on Brass, Bronze, or Steel.
MIL-C-23217	-	Coating, Aluminum, Vacuum Deposited.
MIL-P-23408	-	Plating, Tin-Cadmium (Electrodeposited).
MIL-C-26074	-	Coating, Electroless Nickel, Requirements for
MIL-M-45202	-	Magnesium Alloy, Anodic Treatment of.
MIL-G-45204	-	Gold Plating, Electrodeposited.
MIL-P-45209	-	Palladium Plating (Electrodeposited).
MIL-R-46085	-	Rhodium Plating, Electrodeposited.
MIL-T-81533	-	1,1,1 Trichloroethane (Methyl Chloroform), Inhibited, Vapor Degreasing.
MIL-C-81562	-	Coating, Cadmium, Tin-Cadmium and Zinc (Mechanically Deposited).
MIL-Z-81572	-	Zirconium Oxide, Line-stabilized, Powder and Rod, for Flame Spraying.
MIL-P-81728	-	Plating, Tin-Lead (Electrodeposited).
MIL-C-81740	-	Coating, Aluminum and Aluminum Alloys (Metallic Compound Decomposition).
MIL-C-81751	-	Coating, Metallic-Ceramic.
MIL-C-81797	-	Coating, Inorganically Bonded Aluminum (Electrophoretically Deposited).
MIL-P-83348	-	Powder, Plasma Spray.
MIL-C-83488	-	Coating, Aluminum, Ion Vapor Deposited.
MIL-C-85455	-	Chromium-Molybdenum Plating (Electrodeposited).

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STANDARDS

MILITARY

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

(Copies of specifications and standards can be obtained from the Naval Publications and Forms Center, (Attn:NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS shall be the issue of the nongovernment documents which is current on the date of the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
ASTM B 600 - Recomended Practices For Descaling And Cleaning Titanium And Titanium Alloy Surfaces.
ASTM B 633 - Electrodeposited Coatings of Zinc on Iron and Steel.
ASTM D 2942 - Total Acid Acceptance of Halogenated Organic Solvents (Nonreflux Methods)
ASTM D 3443 - Chloride In Trichlorotrifluoroethane.

(Applications for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)
AMS 2416 - Plating - Nickel-Cadmium, Diffused.
AMS 2424 - Plating - Nickel, Low Stressed Deposit

(Applications for copies should be addressed to the Society Of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede 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. Materials and processes not covered by applicable specifications shall not be used unless approved by the cognizant engineering organization.

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.

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3.3 Surfaces. Parts, with the exception of those processed in accordance with DOD-P-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, appropriate 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, 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 assure 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 either parts under sustained tensile stresses or crevices which may retain cleaning solutions shall not be cleaned as assemblies.

3.4.1 Organic contamination removal. Organic soils shall be removed by emulsion cleaning, alkaline or electrolytic alkaline cleaning (anodic only), solvent immersion, solvent spraying, vapor degreasing (see 3.4.1.2), solvent hand cleaning, or combinations thereof, whichever is more applicable to the nature of the part and soil to be removed. The materials and processes used shall be completely characterized and controlled to ensure no corrosion effects. Vapor degreasing shall be performed using either perchloroethylene conforming to O-T-236, or 1,1,1 trichloroethane conforming to MIL-T-81533 or O-T-620. When vapor degreasing is utilized, the condensate of each vapor degreasing unit shall be tested for acidity at least once each month, as dictated by history and usage, to determine conformance with 3.4.1.1. If an acid condition exists, the use of the vapor degreasing unit shall be discontinued until the acid condition is corrected and available treated parts shall be 100 percent inspected for corrosion effects. Parts displaying corrosion effects shall be subject to rejection. Hand cleaning shall be performed using the solvents mentioned above or aliphatic petroleums such as naphtha conforming to TT-N-95, or acetone conforming to O-A-51. Solvent hand cleaning shall be performed using a lint free cloth. Residues from the cleaning agents shall be thoroughly rinsed off.

3.4.1.1 Acid acceptance. When tested in accordance with 4.3.1, The total acid acceptance as equivalent NaOH in weight percent shall be .01 percent or above for perchloroethylene and .03 percent or above for 1,1,1-trichloroethane.

3.4.1.2 Titanium and Titanium alloys. Organic contamination removal from titanium and titanium alloys shall be as specified in 3.4.1 but subject to the following limitations. Assembled titanium parts shall not be vapor degreased. Unassembled titanium parts may be vapor degreased if followed by an acid or alkaline dip. The time of vapor degreasing shall be the minimum to effect removal without causing damage.

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3.4.2 Inorganic contamination (scale) removal. Inorganic contaminination 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, (see 6.4), or mechanically cleaned except as specified herein. Mechanical cleaning using abrasives containing iron and its oxides, steel wool and wire, and copper alloy based materials, which may become embedded and accelerate corrosion of aluminum alloys, 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 higher, 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 2 hour bake at a temperature of 375 ± 25°F (190 ± 15°C) prior to the coating operation, see 6.5.

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 such that hydrogen absorption is prevented.

3.4.2.4 Corrosion and heat resisting steels. Corrosion and heat resisting steels having a Rockwell Hardness less than C40(180 KSI) shall be cleaned by suitable chemical or mechanical processes, or combinations thereof as specified in 3.4.2.3. However, high strength corrosion and heat resisting steels, C40(180 KSI) and above, shall be cleaned as specified in 3.4.2.2. For metals and alloys which are sensitive to contamination by gaseous constituents, such as hydrogen, oxygen, and nitrogen, and are exposed to atmospheres containing such materials during heat treatment, etc., sufficient metal shall be removed during manufacture to eliminate the contaminated material (see 3.2). Verification that the procedures used to provide complete elimination of contaminated material shall be documented. Where chemical cleaning methods are used to remove the impurities, the materials shall not result in any attack of the surface, either pitting or intergranular. Weekly determination for this behavior shall be made using a microscopic method and examined at a magnification which will clearly establish the condition. Parts with pitted surfaces or showing intergranular attack shall be subject to rejection.

3.4.2.4.1 Passivation treatment. 200, 300, 400 series and precipitation-hardened corrosion resistant steels shall undergo passivation in accordance with QQ-P-35, or by other methods approved by the cognizant engineering organization, see 3.1 and 6.7. 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 which are to be inorganically coated, or abrasively cleaned for the purpose of painting.

3.4.2.5 Magnesium and its alloys. Magnesium and its alloys shall be cleaned in accordance with MIL-M-3171.

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3.4.2.6 Titanium and its alloys. For removal of contamination other than organic soil, (see 3.4.1.2), titanium and its alloys shall be cleaned in accordance with ASTM B 600.

3.4.3 Flux removal. Soldering, welding, and brazing fluxes shall be removed by the use of hot water, soap and water, alcohol, dry cleaning solvents conforming to P-D-680 (Type II), or other appropriate 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. Flux removal effectiveness shall be such that no more than 13 ppm of chloride ion is present when tested in accordance with 4.3.2. If non-chloride containing fluxes are used, an appropriate test method shall be developed and used subject to approval of the cognizant engineering organization, see 3.1.

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 alloys), or it can be demonstrated that the suppliers' recycling process eliminates damaging contaminants.

3.4.5 Rinsing. When either acid or alkaline materials are employed, the cleaned parts shall be given a thorough rinse with water of adequate purity to remove all acid or alkali prior to the coating operation, such that no residual contamination remains.

3.5 Coatings.

3.5.1 Metallic coatings.

3.5.1.1 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. If specifically approved by the cognizant engineering organization, brush plating in accordance with MIL-STD-865 may be used where conventional plating methods are inappropriate, see 6.8. 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 above unless approval is obtained from the cognizant engineering organization. Where coatings are applied thermally, in no case shall the part be raised to a temperature which 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 MIL-S-13165.

3.5.1.2 Cadmium coatings. Electrodeposited cadmium shall be in accordance with QQ-P-416 or MIL-STD-870, see 3.5.4. Other cadmium coatings shall be in accordance with MIL-C-8837, MIL-C-81562, or thermal spray coated in accordance with MIL-M-6874. Unless otherwise specified, cadmium coatings shall be Class 1 thickness (0.0005 inch). Parts with threads shall be plated to Class 2 thickness (0.0003 inch). Cadmium coatings shall not be used for the following applications:

a. Parts which 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.

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

d. On titanium parts or fasteners. In addition, cadmium plated parts such as interference-fit fasteners or press-fit bushings shall not be used in contact with titanium, see 6.9.

e. Parts which will be subsequently soldered.

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

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

3.5.1.2.1 Parts containing recesses or entrapments. Parts containing recesses or entrapments which may retain cleaning and plating fluids shall be vacuum coated in accordance with MIL-C-8837, or thermal spray coated in accordance with MIL-M-6874. Additional protection, such as an organic coating system, may be required for recesses that cannot be coated by these methods.

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

3.5.1.4 Nickel-cadmium plating. Nickel-cadmium plating shall be in accordance with AMS 2416, (see 3.5.4).

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

3.5.1.6 Tin and tin-lead plating. A plating of tin or tin-lead may be used on parts which are subsequently soldered. Tin plating shall be applied in accordance with MIL-T-10727 and tin-lead plating shall be in accordance with MIL-P-81728, (see 3.5.4).

3.5.1.7 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 in excess of 450°F. Aluminum and aluminum alloy coatings are also used for corrosion resistance and galvanic compatibility, see 3.5.4. Aluminum and aluminum alloy coatings shall be in accordance with MIL-C-81740, MIL-C-23217, or MIL-C-83488. Unless otherwise specified, surface treatment of aluminum and aluminum alloy coatings, when required, shall be as specified in 3.5.3.1.

3.5.1.8 Zinc plating and coating. Zinc plating shall be in accordance with ASTM B 633 and zinc coating shall be as specified in MIL-C-81562 (see 3.5.4). Unless otherwise specified, zinc plating or coating shall have a minimum thickness of 0.001 inch. Zinc plating and coating shall not be used for the following applications:

a. Parts for aerospace and missile systems.

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 objectionable.

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3.5.1.8.1 Chromate treatment. Zinc plated or coated parts, specified for a Type II finish, shall be given a supplementary chromate conversion coating in accordance with MIL-C-17711.

3.5.1.9 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 QQ-C-320, Class 2 (engineering), with a minimum thickness of 0.002 inch, unless otherwise specified. 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 QQ-N-290 having a minimum thickness of 0.0015 inch. When chromium plating is specified, it shall be used on only one of two contacting surfaces.

3.5.1.10 Nickel plating. Except when used as an undercoating, see 3.5.5, electrodeposited nickel shall be in accordance with QQ-N-290, Class 2 (engineering) with a minimum thickness of 0.002 inch, unless otherwise specified. Nickel plating shall be used for the following applications only:

a. Where temperatures do not exceed 1,000°F (538°C) and other coatings would not be suitable.

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

c. As an undercoat for other functional coatings (see 3.5.5).

d. To restore dimensions by rebuilding worn surfaces.

e. For resistance to sand erosion.

3.5.1.10.1 Low residual stress. Where applications require low residual stress in the plated nickel, plating shall be in accordance with AMS 2424 .

3.5.1.11 Silver plating. Silver plating shall be in accordance with QQ-S-365. Silver plating shall not be used on titanium or in contact with titanium, see 3.5.6, for parts which are used at temperatures above 550°F (289°C) in service, see 6.10. Silver shall not be used with nickel base alloys above 1000°F (538°C). When electrodeposited silver is used on steel, an underplate of either copper or nickel, or combinations of both shall be applied. Unless otherwise specified by the cognizant engineering organization, the underplate and the silver plate shall each have a minimum thickness 0.0005 inch, yielding a 0.001 inch minimum total thickness.

3.5.1.12 Gold plating. Gold plating shall be in accordance with MIL-G-45204.

3.5.1.13 Palladium plating. Palladium plating shall be in accordance with MIL-P-45209.

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

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3.5.1.15 Black nickel plating. Black nickel plating shall be in accordance with MIL-P-18317.

3.5.1.16 Copper plating. Copper plating shall be in accordance with MIL-C-14550.

3.5.1.17 Hot-dip coatings. Hot-dip coatings may be used within the limitations prescribed herein for the same coating materials applied by other methods where specifically approved by the cognizant engineering organization. Hot dip tin coatings shall be in accordance with MIL-T-10727.

3.5.1.18 Electroless nickel coating. Electroless nickel coatings shall be in accordance with MIL-C-26074. When electroless nickel is used for corrosion protection or wear resistance, the minimum thickness shall be 0.0015 inch and the maximum thickness shall not exceed 0.003 inch, unless otherwise specified by the cognizant engineering organization.

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

3.5.1.20 Chromium-molybdenum plating. Chromium-molybdenum plating shall be in accordance with MIL-C-85455.

3.5.1.21 Thermal spraying. Assemblies which will trap plating solutions and assemblies or parts which 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 suitable surface preparation. Unless otherwise specified, the coating thickness shall be 0.004 to 0.006 inch. Powders which are to be used for plasma spray coatings shall conform to MIL-P-83348.

3.5.1.21.1 For corrosion control (see 3.5.4). 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 as the substrate.

3.5.1.21.2 For functional purposes (see 3.5.5). When non-metallic coatings, such as zirconia, alumina, metallic-ceramics (MIL-C-81751), carbides, silicides, titanates, cermets, etc., 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 of the base metal and the coating.

3.5.2 Ceramic-metallic and ceramic coatings.

3.5.2.1 Methods of application. Metallic-ceramic and 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.

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3.5.2.2 Metallic-ceramic coating. Metallic-ceramic coatings are to be used for surfaces subject to oxidation, corrosion, galvanic corrosion, and for protection from corrosion due to other environments, (see 3.5.4). Metallic-ceramic coatings shall be in accordance with MIL-C-81751 or MIL-C-81797.

3.5.3 Surface treatments and oxide coatings.

3.5.3.1 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-C-5541. Parts subject to wear, abrasion, erosion, and severe corrosion condition shall be anodized.

3.5.3.1.1 Aircraft applications. All non-clad aluminum and aluminum alloys used in exterior locations of aircraft which are classified as exterior surfaces by MIL-F-7179 shall be anodized to produce coatings complying with the requirements of MIL-A-8625.

3.5.3.1.2 Electrical parts. Chemical films conforming to Class 3 treatment of MIL-C-5541 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.

3.5.3.1.3 Hard anodic coatings for aluminum and its alloys. Hard anodic coatings shall conform to Type III of MIL-A-8625. They shall be used on parts where the functional purpose is to provide a wear resistant surface. It should be noted that hard anodic coatings have a detrimental effect on the fatigue life of aluminum alloys.

3.5.3.2 Magnesium and magnesium alloys.

3.5.3.2.1 Method. All magnesium alloys shall be anodized in accordance with MIL-M-45202, Type I, Class A or Class C, or Type II, Class A or Class D. MIL-M-3171 treatments shall only be used for temporary protection or touch-up of damaged anodic coatings, see 3.5.3.2.2.

3.5.3.2.2 Touch-up. All surfaces which have the anodic or chemical film removed or damaged shall be touched up, using either the Type I or Type VI process of MIL-M-3171. Magnesium surfaces, anodic coated in accordance with MIL-M-45202, may be stripped and re-anodized when approved by the cognizant engineering organization.

3.5.3.3 Phosphate coatings. Phosphate treatments, when approved by the cognizant engineering organization, 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 parts function. When approved for use on steel parts, phosphate treatments shall be in accordance with DOD-P-16232.

3.5.3.4 Surface treatments for corrosion and heat-resisting steel alloys. Unplated corrosion-resisting and heat-resisting steel alloys shall be finished as specified.

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3.5.4 Coatings for corrosion control of steels and copper based parts. Unless otherwise specified, steels and copper base parts shall be cadmium, nickel-cadmium, tin-cadmium, tin-lead, tin, aluminum (steel parts only), zinc, nickel, or metallic-ceramic coated, (see 3.5.1.2 thru 3.5.1.8, 3.5.1.10, and 3.5.2.2).

3.5.4.1 Exceptions. Unless otherwise specified, the following exceptions apply:

3.5.4.1.1 Corrosion resistant materials. 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 defined in MIL-STD-889.

c. Where unsealed crevices exist either within the part or the assembly of which it may be a component, or in contact with wood.

3.5.4.1.2 Sintered bearings. Sintered bearings of the oil-impregnated type shall not be plated. Crevices between the bearing and the housing shall be sealed if the two constitute a dissimilar metal as defined in MIL-STD-889.

3.5.4.1.3 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. Alternative protective systems may be used subject to the approval of the cognizant engineering organization.

3.5.5 Coatings for functional purposes. Coatings for functional purposes shall be as specified in 3.5.1.9, 3.5.1.11 through 3.5.1.16, and 3.5.1.18 through 3.5.1.20. Unless otherwise specified, 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 QQ-N-290 or AMS 2424 shall be used. Coatings proposed for applications where temperatures exceed 1,000°F (538°C) in service shall be subject to approval by the cognizant engineering organization.

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3.5.6 Temperature limitations. Unless otherwise specified, the temperature of the coated parts, items in direct contact with the coated parts, or, when erosive conditions exist, surrounding parts which may be contacted by eroded coating particles shall not exceed the following:.

Silver	1,200°F	1/
Nickel	1,000°F	
Metallic ceramic	950°F	2/
Aluminum	925°F	2/
Zinc	500°F	
Cadmium	450°F	3/
Tin-lead	350°F	4/
Tin-cadmium	345°F	4/
Tin	330°F	4/

1/ Shall not be used on titanium parts or in contact with titanium parts exposed to temperatures over 550 deg.F in service (see 3.5.1.11).

2/ Above 950°F there may be an unfavorable effect upon the fatigue strength of the steel base metal due to diffusion.

3/ See 3.5.1.2 (d).

4/ Pure tin or tin containing materials which undergo a solid-state transformation, shall not be used for parts which are for use at subzero temperatures.

3.6 Shot-peening and other residual compressive stress-inducing treatments. Shot-peening, in accordance with MIL-S-13165, and other compressive stress-inducing treatments shall be used to obtain improved fatigue behavior and stress corrosion cracking resistance, using controlled procedures. The maximum temperatures for use on any part shall not exceed 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.

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

4. QUALITY ASSURANCE PROVISIONS

4.1 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.

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4.1.1 Responsibility for compliance. All items must meet all requirements of section 3. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall 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.

4.2 Inspection. The methods of cleaning metal surfaces, application of surface treatments, and all materials entering into the processes shall be subject to inspection. When inspection is conducted at the contractor's plant, all required tests shall be done by the contractor.

4.2.1 Previous approval. Acceptance or approval of material or of any surface treatment or corrosion preventive process during the course of manufacture shall, in no case, be construed as a guarantee of the acceptance of the finished product.

4.3 Test methods.

4.3.1 Acid acceptance test. Determination of acid acceptance as equivalent NaOH weight percent shall be conducted in accordance with ASTM D 2942.

4.3.2 Flux removal. Welded, soldered, or brazed areas shall be tested for completeness of flux removal by leaching the area with a small quantity of distilled water. To the leachate, add a few drops of nitric acid and a few drops of 5 percent silver nitrite solution. If a white percipitate is formed in an amount greater than that formed in an equal volume of standard sodium chloride solution (equivalent to 13 ppm as chloride) treated in the same manner, flux removal is not complete.

5. PACKAGING

This section is not applicable to this specification.

6. NOTES

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 "platings" are those materials deposited electrolytically.

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6.4 Aluminum Cleaners. Cleaners conforming to MIL-M-7752, MIL-C-43616, or MIL-C-87936 are recommended for cleaning aluminum parts, (see 3.4.2.1).

6.5 Effects of the embrittlement bake. For several steel types, a thin oxide layer may be formed after the two hour bake which may result in poor coating adhesion.

6.6 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.

6.7 Passivation. A passive film can be obtained by embedding steel grit into the surface of a part and then applying a phosphate coating in accordance with DOD-P-16232. Note that this procedure becomes less effective for parts having high rockwell harness values due to the difficulty of embedding the steel grit. This method may be useful on 400 series and cast CRES alloys which are inherently difficult to passsivate.

6.8 Brush plated chrome. Brush plated chrome coatings have substantially lower hardness values than conventionally plated chrome coatings. This will result in a lower abrasion resistance.

6.9 Liquid metal embrittlement. Under certain conditions, titanium can be embrittled by contacting cadmium or silver components. Embrittlement has been determined to occur in cadmium plated titanium parts at temperatures as low as 150°F, and in silver brazed titanium parts at temperatures above 600°F.

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

6.11 Key word listing. The following subject terms (key words) are listed to allow identification of this document during retrieval searches:

Coatings
Inorganic Coatings
Surface Treatments
Weapons Systems

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

Review activities:
Army - AR, AV, EA, MI
Navy - OS
Air Force - 99

User activities:
DLA-ES

Preparing activity:
Navy - AS

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1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-S-5002D	SURFACE TREATMENTS AND INORGANIC COATINGS FOR METAL SURFACES OF WEAPONS SYSTEMS

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
b. ADDRESS *(Street, City, State, ZIP Code)*	☐ VENDOR ☐ USER ☐ MANUFACTURER ☐ OTHER *(Specify)*:

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

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7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
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