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MIL-S-5002C
AMENDMENT 1
28 August 1978

MILITARY SPECIFICATION

SURFACES TREATMENTS AND INORGANIC COATINGS
FOR METAL SURFACES OF WEAPONS SYSTEMS

This amendment forms a part of Military Specification MIL-S-5002C, dated 26 July 1971, and is approved for use by all Departments and Agencies of the Department of Defense.

Page 4

2.1, Under Specifications, Military: Add "MIL-C-83488 Coating, Aluminum, Ion Vapor Deposited."

Page 10

3.7.3.1.4, line 2: Delete "240,000" and substitute "200,000".

3.7.3.1.5, line 1: Delete "240,000" and substitute "200,000".
line 16: Add "(g) With ion vapor deposited aluminum in accordance with MIL-C-83488".
line 17: Delete "240,000" and substitute "200,000".

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3.7.3.1.6, line 2: Delete "240,000" and substitute "200,000".
line 12: Delete "240,000" and substitute "200,000".

3.7.3.2, lines 6 and 7: Delete "Parts of hydraulic equipment which may be in contact with hydraulic fluids and fuels." and substitute "Parts which may be in contact with hydraulic fluids, fuels, lubricating oil and other petroleum based fluids."

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

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

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DLA - ES

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MIL-S-5002C
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SUPERSEDING
MIL-S-5002B
30 November 1968

MILITARY SPECIFICATION

* SURFACES TREATMENTS AND INORGANIC COATINGS
FOR METAL SURFACES OF WEAPONS SYSTEMS

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

1. SCOPE

* 1.1 This specification covers the requirements for cleaning, surface treatments and inorganic coatings for metallic surfaces of weapons systems parts.

2. APPLICABLE DOCUMENTS

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

SPECIFICATIONS

Federal

O-A-51	Acetone, Technical
O-T-236	Tetrachloroethylene (Perchloroethylene); Technical Grade
O-T-634	Trichloroethylene, Technical
P-D-680	Dry Cleaning Solvent
QQ-C-320	Chromium Plating (Electrodeposited)
QQ-N-290	Nickel Plating (Electrodeposited)

FSC MFFP

SPECIFICATIONS

Federal (Continued)

QQ-P-35	Passivation Treatments for Austenitic, Ferritic, and Martensitic Corrosion-Resisting Steels (Fastening Devices)
QQ-P-416	Plating, Cadmium (Electrodeposited)
QQ-S-365	Silver Plating, Electrodeposited; General Requirements for
QQ-Z-325	Zinc Coating, Electrodeposited, Requirements for
TT-C-490	Cleaning Methods and Pretreatment of Ferrous Surfaces for Organic Coatings
TT-M-261	Methyl-Ethyl-Ketone (For Use in Organic Coatings)
TT-N-95	Naphtha, Aliphatic
TT-X-916	Xylene (For Use in Organic Coatings)

Military

MIL-M-3171	Magnesium Alloy, Processes for Pretreatment and Prevention of Corrosion on
MIL-C-5410	Cleaning Compound, Aluminum Surface, Non-Flame-Sustaining
MIL-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-W-6712	Wire, Metallizing
MIL-M-6874	Metal Spraying, Process for
MIL-M-7752	Metal Cleaner, Silicate Soap
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 Ferrous Metal Parts

SPECIFICATIONS

Military (Continued)

MIL-C-14550	Copper Plating (Electrodeposited)
MIL-P-16232	Phosphate Coatings, 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-25769	Cleaning Compound, Aircraft Surface, Alkaline Waterbase
MIL-C-26074	Coating, Nickel-Phosphorus, Electroless Nickel, Requirements for
MIL-P-27418	Plating, Soft Nickel (Electrodeposited, Sulfamate Bath)
MIL-A-40147	Aluminum Coating (Hot-dip) for Ferrous Parts
MIL-C-43616	Cleaning Compound, Aircraft Surface
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-C-81302	Cleaning Compound, Solvent, Trichlorotrifluro-ethane
MIL-T-81533	1,1,1 Trichloroethane (Methyl Chloroform) Stabilized
MIL-C-81562	Coating, Cadmium and Zinc (Mechanically Deposited)

SPECIFICATIONS

Military (Continued)

MIL-Z-81572	Zirconium Oxide, Line-Stabilized, Powder and Rod, for Flame Spraying
MIL-C-81706	Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys
MIL-P-81728	Plating, Tin-Lead (Electrodeposited)
MIL-C-81740	Coatings, Aluminum and Aluminum Alloys (Metallic Compound Decomposition)
MIL-C-81751	Coating, Metallic-Ceramic
MIL-C-81797	Coating, Inorganically Bonded Aluminum (Electrophoretically Deposited)

STANDARDS

Military

MIL-STD-753	Corrosion-Resistant Steel Parts: Sampling, Inspection and Testing for Surface Passivation
MIL-STD-889	Dissimilar Metals

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

2.2 Other publications - The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

American Society for Testing and Materials

ASTM E8	Tension Testing of Metallic Materials

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

3. REQUIREMENTS

* 3.1 Materials and processes - Materials and processes shall conform to applicable specifications, as specified herein. Materials and processes not covered by applicable specifications shall not be used unless approved by the procuring activity. Necessary process and quality control requirements shall be established, technical data developed which shall be submitted to the procuring activity substantiating advantages of the proposed coatings or process compared to the coating or process they are intended to replace with respect to corrosion resistance, dis-similar metal behavior, wear and other functional characteristics and effect on static and dynamic properties of the metals and alloys to which they are applied. Where a coating or process is selected for the part and the part is required to be overhauled, the coating or the coating process shall be available to the designated overhaul activity.

* 3.2 Finishing requirements - Unless otherwise specified, all fabrication operations including thermal treatments and cleaning shall have been completed prior to application of all surface treatments, metallic coatings and non-metallic coatings required for finishing of metals and alloys to which they are applied. All requirements covered herein are to be accomplished on individual parts unless it can be demonstrated to the procuring activity that processing materials and residues are not retained.

* 3.3 Surfaces - Unless otherwise specified, parts shall conform to specified dimensions, surface roughness and conditions, prior to and after final cleaning, surface treatment or coating. In the case of metals which may respond in a nonuniform manner when metal removal is done with mechanical, chemical, electrochemical or electromechanical methods, appropriate inspection procedures shall be established and used to insure each part has a uniform surface, including freedom from pits, intergranular attack and significant etching. 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 the surface treatments and coatings, shall be as specified hereinafter, using materials and processes which have no damaging effect on the metal, including freedom from pits, intergranular attack and significant etching. Appropriate inspection procedures shall be established and used therefor. After cleaning, all parts shall be completely free of corrosion products, scale, paint, grease, oil, flux, and other foreign materials including other metals, and shall be given the specified treatment as soon as practicable after cleaning. 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. Abrasives used on any metal or alloy shall not have been used on other metals or alloys unless used for a similar base metal (for example, aluminum alloys) and unless it can be demonstrated that the suppliers' recycling process eliminates damaging contaminates. Parts having high

residual tensile stresses, and which are to be cleaned by chemical or electrochemical methods, shall be stress relieved prior to cleaning. Assemblies which contain parts which may have high sustained tensile stresses as the result of assembly or crevices which can retain cleaning solutions shall not be cleaned as assemblies.

* 3.4.1 Organic contamination removal - Organic soils shall be removed by emulsion cleaning, alkaline cleaning, vapor degreasing or solvent cleaning, whichever is more applicable to the nature of the soil to be removed. The materials and processes used shall be completely characterized and controlled to insure no corrosion effects. Vapor degreasing shall be done with trichloroethylene conforming to O-T-634, with perchloroethylene conforming to O-T-236 or with 1,1,1 trichloroethane conforming to MIL-T-81533. The condensate of each vapor degreasing unit shall be sampled weekly using the test method specified in 4.3.1. If an acid reaction is found, the use of the installation shall be discontinued until the acid condition is corrected and also available treated parts examined for corrosion effects. If corrosion effects are noted, all parts processed during interval of cleaning shall be 100 percent inspected. Materials used for hand cleaning shall leave no contaminating residues or react with cleaning solvents. Solvents for hand cleaning shall be 1,1,1 trichloroethane conforming to MIL-T-81533, trichlorotrifluorethane conforming to MIL-C-81302, aliphatic petroleums such as naphtha conforming to TT-N-95, acetone conforming to O-A-51, methyl-ethyl-ketone conforming to TT-M-261, xylene conforming to TT-X-916, etc. Solvents shall be wiped from the part and shall not be allowed to dry on the part.

* 3.4.1.1 Titanium and its alloys - Titanium and titanium alloy assemblies shall not be vapor degreased. Titanium parts may be vapor degreased followed immediately by an alkaline dip. The time of vapor degreasing shall be the minimum to effect removal without causing damage. In lieu of degreasing, a mild alkaline cleaner conforming to MIL-M-7752, MIL-C-25769 or MIL-C-43616 shall be used for soil removal from titanium and its alloys.

* 3.4.2 Inorganic contamination removal -

* 3.4.2.1 Aluminum and its alloys - Aluminum and its alloys shall be either chemically or mechanically cleaned. The use of uninhibited alkaline materials such as sodium hydroxide solutions, and of abrasives containing iron and its oxides, steel wool and wire, and copper alloy based wire, which may become embedded and accelerate corrosion of aluminum alloys shall not be used for cleaning. Materials conforming to MIL-C-5410, MIL-C-43616, or MIL-C-25769 shall be used for chemical cleaning. Other materials or methods may be approved for use by the procuring activity (see 3.1).

* 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 and higher, shall be mechanically blasted for rust or scale removal.

* 3.4.2.3 Low-strength steels - Steels of Rockwell hardness less than C40 shall be cleaned in accordance with TT-C-490 or by other processes as approved by the procuring activity (see 3.1).

* 3.4.2.4 Corrosion and heat resisting steels - Except as indicated in 3.4.2.2, corrosion and heat resisting metals and alloys shall be cleaned by suitable chemical or mechanical processes, or combinations thereof. However, materials which are susceptible to damage by hydrogen shall be mechanically cleaned. 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 of elimination shall be done. Procedures for and verification of complete removal of contaminated material shall be accomplished. Where chemical cleaning methods are used, the materials shall not result in any attack of the surface, either pitting or intergranular. Daily determination for this behavior shall be made using a microscopic method and examined at a magnification which will clearly establish the condition. However, when intermittent cleaning operations exist, the frequency of examination shall be reduced accordingly but shall not be less than weekly intervals. Parts with pitted surfaces or showing intergranular attack shall be rejected.

* 3.4.2.4.1 The final operation for 200, 300, 400 series and precipitation-hardened corrosion resistant steels shall be a passivation treatment in accordance with QQ-P-35 or by methods approved by the procuring activity (see 3.1), followed by a thorough rinsing and drying. Solutions for passivation shall not etch the steels. Carburized or nitrided surfaces shall not be passivated. The verification of the surface passivation shall be in accordance with MIL-STD-753 for all parts.

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

* 3.4.2.6 Titanium and its alloys - For removal of contamination other than organic soil, titanium and its alloys shall be mechanically cleaned. Other cleaning methods shall not be used, unless approved by the procuring activity (see 3.1).

* 3.4.2.7 Flux removal - Soldering, welding, and brazing fluxes shall be completely removed. Hot water, alcohol, or dry cleaning solvent conforming to P-D-680, Type II, shall be used, as may be appropriate for the flux or by a method which will not attack all metals it contacts. Methyl or wood alcohol (methanol) shall not be used for magnesium and its

alloys. Acid or alkaline materials shall not be used unless approved by the procuring activity. Completeness of removal of fluxes containing chlorides shall be verified by the test specified in 4.3.2. If non-chloride containing fluxes are used, an appropriate test method shall be developed and used subject to approval of the procuring activity (see 3.1).

* 3.4.2.8 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 further treatment and not leave any residual contamination.

* 3.5 Surface treatments of aluminum and aluminum alloys - Unless otherwise specified, all aluminum and aluminum alloys including clad aluminum alloy surfaces shall either be 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. Chemical conversion coated parts where subsequent organic finishing is not specified shall not be used at temperatures in excess of 150°F.

* 3.5.1 Aircraft applications - All aluminum and aluminum alloy parts installed in exterior locations of aircraft which are subjected to erosion, abrasion, wear and severe corrosion conditions and all aluminum alloy parts forming the exterior of seaplanes, amphibious aircraft, anti-submarine warfare aircraft and aircraft operating off ships, other than carriers, shall be anodized by processes to produce coatings complying with the requirements of MIL-A-8625, either Type I or Type II.

* 3.5.2 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.

* 3.5.3 Touch-up - Unless otherwise specified, all surfaces which have the anodic or chemical conversion coatings, removed or damaged shall be touched up only where required with MIL-C-81706 materials approved for Class 1A treatment by Method B application (brush or swab).

3.6 Surface treatments of magnesium alloys -

* 3.6.1 Method - All magnesium alloys shall be surface treated or receive an anodic coating in accordance with MIL-M-3171 or MIL-M-45202. Anodic coating applied in accordance with MIL-M-45202 shall be used for parts subject to abrasion, erosion, or wear. For the Air Force, only anodic coatings in accordance with MIL-M-45202, Type I, Class C or Type II, Class D shall be applied; MIL-M-3171 treatments shall only be used for temporary protection or touch-up of damaged anodic coatings.

3.6.2 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-A-45202, may be stripped and reanodized when approved by the procuring activity.

3.7 Coatings -

* 3.7.1 Metallic coatings - Metallic coatings shall be applied by electrodeposition, vacuum deposition, mechanical deposition, metallic compound deposition, and thermal spraying methods in conformance to applicable specifications. Where thermal application processes are used, in no case shall the temperature of the part be raised to adversely affect the mechanical, or corrosion and stress corrosion properties of the part and if the part is shot-peened prior to coating, shall not impair the effectiveness of the shot-peening operation (see 3.1).

* 3.7.2 Metallic-ceramic and ceramic coatings - Metallic-ceramic and ceramic coatings shall be applied by spraying, dipping, electrophoretic deposition and thermal spraying methods in conformance to applicable specifications, followed by a fusion or mechanical treatment if applicable. Where thermal applications processes are used, in no case shall the temperature of the part be raised to adversely affect the mechanical or corrosion and stress corrosion properties of the part, and if the part is shot-peened prior to coating, shall not impair the effectiveness of the shot-peening operation (see 3.1).

* 3.7.3 Coating for corrosion control - Unless otherwise specified, non-corrosion resistant steels and copper base parts shall be cadmium, tin cadmium, tin-lead, tin, zinc, or metallic-ceramic coated (see 3.1).

3.7.3.1 Exemptions - Unless otherwise specified, the following exemptions apply.

* 3.7.3.1.1 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 not 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.

* 3.7.3.1.2 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.

* 3.7.3.1.3 Surfaces of components which are assembled without fasteners, contain nonsealed crevices and do not contain lubrication provisions shall have a suitable corrosion control coating which shall be within the temperature limitations specified in 3.7.5. If a chromium surface is specified (see 3.7.4.1), a nickel undercoat shall be used (see 3.7.4 and 3.7.4.2).

* 3.7.3.1.4 All non-corrosion resistant metal parts, including steel parts having a tensile strength up to and including 240,000 pounds per square inch (psi) used for components of lubricating and hydraulic systems and components exposed to lubricants and hydraulic fluids, except for tubing, shall be tin-cadmium plated in accordance with MIL-P-23408.

* 3.7.3.1.5 Steel parts having a tensile strength of 240,000 pounds per square inch (psi) or over shall be coated as follows:

(a) With cadmium by vacuum deposition in accordance with MIL-C-8837.

(b) With aluminum by vacuum deposition in accordance with MIL-C-23217.

(c) With cadmium or zinc by mechanical deposition in accordance with MIL-C-81562.

(d) With aluminum and aluminum alloys by metallic compound decomposition in accordance with MIL-C-81740.

(e) With zinc, aluminum, or other metals by thermal spraying (preferably flame spraying) in accordance with MIL-M-6874.

(f) With aluminum (metallic-ceramic) in accordance with MIL-C-81751 or MIL-C-81797.

Upon specific approval of the procuring activity, steel heat treated to a tensile strength level of 240,000 psi or above may be coated by electroplating provided the process can be demonstrated to be free from hydrogen embrittlement damage as indicated by satisfactory behavior of specimens prepared and tested in accordance with 4.3.3. Unless otherwise specified, to assure continuous control of the process to prevent detrimental hydrogen embrittlement during production, the satisfactory behavior of specimens, prepared and tested in accordance with 4.3.4, shall be made for each production lot of coated steel parts.

* 3.7.3.1.6 Steel parts having a tensile strength of or heat treated to less than 240,000 pounds per square inch (psi) may be either coated by electroplating or as detailed in 3.7.3.1.5. Upon specific approval of the procuring activity, such steel parts may be coated by electroplating provided the process can be demonstrated to be free from hydrogen embrittlement damage as indicated by satisfactory behavior of specimens prepared and tested in accordance with 4.3.3. Unless otherwise specified, to assure continuous control of the process to prevent detrimental hydrogen embrittlement during production, the satisfactory behavior of specimens, prepared and tested in accordance with 4.3.4 shall be made once each month or more frequently if required by the procuring activity. If evidence of hydrogen embrittlement of specimens or parts (less than 240,000 pounds per square inch) is shown, the use of the process shall be discontinued until the process conditions are corrected.

* 3.7.3.2 Cadmium plating and coating - Cadmium plating shall be in accordance with QQ-P-416 (see 3.7.3 and 3.7.5). Cadmium coatings shall be in accordance with MIL-C-8837 or MIL-C-81562. Unless otherwise specified, cadmium coating or plating shall be Class 1 thickness (0.0005 inch). Cadmium plating and coating shall not be used in the following application.

(a) Parts of hydraulic equipment which may be in contact with hydraulic fluids and fuels.

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

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

(d) On titanium or in contact with titanium or on high tensile strength steels (above 240,000 psi) where high levels of sustained stress are imposed such as exist with taper joints (see 3.7.5).

(e) Parts which will be subsequently soldered.

* 3.7.3.2.1 Parts which cannot be processed to completely remove pre-plate and plating fluids shall be vacuum coated in accordance with MIL-C-8837 or mechanically coated in accordance with MIL-C-81562.

* 3.7.3.2.2 Cadmium plated or coated parts, specified for a Type II finish, shall be supplementary chromate treated in accordance with MIL-C-17711.

* 3.7.3.3 Zinc plating and coating - Zinc plating shall be in accordance with QQ-Z-325 and zinc coating shall be in accordance with MIL-C-81562 (see 3.7.3). Unless otherwise specified, zinc plating or

coating shall be Class 1 thickness (0.001 inch). Zinc plating and coating shall not be used in the following applications:

(a) Parts for aerospace and missile systems.

(b) Parts in contact with structural fabric surfaces.

(c) Parts in contact where corrosion products might interfere with normal functioning.

(d) Grounding contacts where the increased electrical resistance of zinc-plated surfaces would be objectionable.

* 3.7.3.3.1 Zinc plated or coated parts, specified for a Type II finish, shall be supplementary chromate treated in accordance with MIL-C-17711.

* 3.7.4 Coatings for functional purposes - Coatings for functional purposes shall be as specified in 3.7.4.1 through 3.7.4.15. Unless otherwise specified, where the selected coating does not provide corrosion protection for the basis metal and the coated surface or portion thereof is exposed to corrosive environment, an undercoat of 0.0010 to 0.0016 inch of nickel or steel and zinc parts or an undercoat of 0.0008 to 0.0010 inch nickel on copper alloy parts in accordance with QQ-N-290 shall be used. The same restrictions that are applicable to steel parts, coated by chemical or electrochemical deposition and having a tensile strength of 240,000 pounds per square inch (psi) and over, as stated in 3.7.3.1.5, shall be applicable to coatings for functional use except for chromium (see 3.7.4.1). Coatings proposed for applications where temperatures exceed 1000°F in service shall be subject to approval by the procuring activity.

* 3.7.4.1 Chromium plating - Chromium plating shall be used for all surfaces subject to wear or abrasion, except where other surface hardening processes are used such as nitriding, carburizing 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 of 0.002 inch. When chromium plating is specified, it shall be used on only one of two contacting surfaces.

* 3.7.4.2 Nickel plating - Nickel plating shall be used for the following applications only:

(a) Where temperatures do not exceed 1,000°F 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 3.7.4).

(d) To restore dimensions by building up worn surfaces.

(e) For resistance to sand erosion.

Where nickel plating of parts or surfaces is specified, it shall be such as to produce coatings in accordance with QQ-N-290. Nickel plating, except where used as an underplating, (see 3.7.4) shall be Class 2 (engineering) with a minimum thickness of 0.003 inch.

* 3.7.4.2.1 Where applications require low residual tensile stress in the plated nickel, plating shall be in accordance with MIL-P-27418.

* 3.7.4.3 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.

* 3.7.4.4 Tin-cadmium plating - Tin-cadmium plating shall be in accordance with MIL-P-23408.

* 3.7.4.5 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 3.7.5).

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

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

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

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

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

* 3.7.4.11 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 procuring activity. Coatings shall be in accordance with MIL-T-10727 for tin and with MIL-A-40147 for aluminum.

3.7.4.12 Electroless nickel coating - Where specified, electroless nickel coating shall be in accordance with MIL-C-26074.

* 3.7.4.13 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. Surface treatment of aluminum and aluminum alloy coatings, when required, shall be as specified herein (see 3.5). Aluminum and aluminum alloy coatings shall be in accordance with MIL-C-81740 or MIL-C-23217.

* 3.7.4.14 Metallic-ceramic coating - Aluminum metallic-ceramic coating are to be used for surfaces subject to oxidation, corrosion, galvanic corrosion and for protection from corrosion due to other corrosive environments. Metallic-ceramic coatings shall be in accordance with MIL-C-81751 or MIL-C-81797.

3.7.4.15 Zirconium oxide coating - Zirconium oxide coating shall be processed from materials in accordance with MIL-L-81572.

3.7.5 Temperature limitations - Unless otherwise specified, the temperature of coated parts or of the surfaces with which they are in contact shall not exceed the following:

Silver	1200°F	1/
Metallic ceramic	950°F	2/
Aluminum	925°F	
Zinc	500°F	
Cadmium	450°F	3/
Tin-Lead	350°F	
Tin-Cadmium	345°F	
Tin	330°F	

1/ Shall not be used on titanium alloys or in contact with titanium (see 3.7.4.5).
2/ Above 950°F there may be an unfavorable effect upon the fatigue strength of the steel basis metal due to diffusion.
3/ Shall not be used on titanium alloys or in contact with titanium or on high tensile strength steels (above 240,000 psi) when high levels of sustained tensile stress are imposed such as exist with taper joints (see 3.7.3.2).

These temperature limitations also apply to parts which may be contacted by coating particles or coating corrosion products which may be eroded under service conditions and contact these parts. This is not applicable to aluminum coated parts. 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. Where electroplating or other protective methods as specified in this specification are not applied, other methods of protection shall be used and shall be approved by the procuring activity.

* 3.7.6 Thermal spraying - Assemblies which will trap plating solutions and assemblies or parts which are of extreme size and weight for conventially 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. Where aluminum or zinc coatings are specified or required to be thermal sprayed (see 3.7.3.1.5), the wire used for flame spraying shall conform to MIL-W-6712. Unless otherwise specified, the coating thickness shall be 0.004 to 0.006 inch. When specified in the contract, order or applicable drawing, other materials conforming to MIL-W-6712 shall be thermal sprayed for metallic coatings.

* 3.7.6.1 For corrosion control - 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.

* 3.7.6.2 For functional purposes - When non-metallic coatings such as zirconia, alumina, metallic-ceramics (MIL-C-81751, Type III), 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 co-efficients of thermal expansion of the base metal and the coating.

3.8 Nonmetallic coatings -

* 3.8.1 Phosphate treatments - Phosphate treatments, when approved by the procuring activity, may be used on surfaces where it is impractical to apply an adequate corrosion control coating or where a corrosion control coating will interfer with function. Phosphate treatments, when approved by the procuring activity, that conform to MIL-P-16232 may be used on steel parts.

* 3.8.2 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. Hard anodic coatings shall not be used on parts where subject to rework and to overhauling.

* 3.8.3 Surface treatments for corrosion-and heat-resisting steel and alloys - Unplated corrosion-resisting and heat-resisting alloys shall be furnished as specified. Such alloys need not be plated unless a coating is necessary to prevent dissimilar metal contacts and crevice corrosion (see 3.7.4.2). When plating is required, it shall be in accordance with 3.7.3).

3.9 Processing - Unless otherwise specified by the procuring activity, steel parts plated with hard coatings, such as nickel and chromium and combinations thereof, shall be processed as follows.

3.9.1 Plated parts below Rockwell C40 hardness and subject to static loads or designed for limited life under dynamic loads, or combinations thereof, need not be shot peened prior to plating or baked after plating.

3.9.2 Plated parts below Rockwell C40 hardness which are designed for unlimited life under dynamic loads shall be shot peened in accordance with MIL-S-13165 prior to plating. Unless otherwise specified, the shot peening shall be accomplished on all surfaces for which the coating is required and on all immediately adjacent surfaces when they contain notches, fillets, or other abrupt changes of section size where stresses will be concentrated.

3.9.3 Plated parts which have a hardness of Rockwell C40, or above, and are subject to static loads or designed for limited life under dynamic loads, or combinations thereof, shall be baked at 375 ±25°F for not less than 3 hours, within 4 hours or as soon as practicable after plating.

3.9.4 Plated parts which have a hardness of Rockwell C40, or above, and are designed for unlimited life under dynamic loads, shall be shot peened in accordance with MIL-S-13165 prior to plating. Unless otherwise specified, the shot peening shall be accomplished on all surfaces for which the coating is required and on all immediately adjacent surfaces when they contain notches, fillets, or other abrupt changes of section size where stresses will be concentrated. The plated parts shall be baked at 375 ±25°F for a minimum of 3 hours within 4 hours or as soon as practicable after plating.

* 3.10 Shot peening and other residual compressive stress-inducing treatments - Shot peening, in accordance with MIL-S-13165, and other compressive stress-inducing treatments may be used to obtain improved fatigue behavior and stress corrosion cracking resistance, using controlled procedures. The maximum temperatures for use of 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.

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

4. QUALITY ASSURANCE PROVISIONS

* 4.1 Responsibility for inspection - Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own

or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

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

* 4.3.1 Acid condition of vapor degreaser - Fifty milliliters of condensate from the machine under test shall be shaken with 50 milliliters of boiled distilled water to which has been added a few drops of chlorophenol red indicator solution. A yellow or orange color indicates an acid condition. At the option of the processor, the acid condition may be determined by using a pH meter employing a glass and a calomel electrode. Fifty milliliters of the condensate shall be shaken with 50 milliliters of boiled distilled water and this solution placed on the pH meter, standardized with a buffer solution of approximately 7.0. The pH of the water layer shall be 7.0 $\pm$ 0.3.

* 4.3.2 Test for chloride - containiing flux residues - Welded, soldered or brazed areas may be tested for completeness of flux removal by leaching the area with a small quantity of distilled water and adding a few drops of nitric acid and a few drops of 5-percent silver nitrate solution to the leach. If a white precipitate 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 a like manner the flux removal is not complete.

* 4.3.2.1 Standard sodium chloride solution - Weigh 0.0214 $\pm$0.0007 grams of sodium chloride after drying for 2 hours at 225°F and dissolve in distilled water. Dilute to 1 liter at 70°F in a volumetric flask.

* 4.3.3 Preproduction process qualification test for embrittlement - Four round notched steel specimen, with the axis of the specimen (load direction) perpendicular to the short transverse grain flow direction shall be selected from four individual heats (total of sixteen specimens). These specimens shall be prepared using the specific steel alloy for which preproduction qualification of the process is to be demonstrated. They shall be heat treated to the maximum tensile strength range representing production usage. The configuration shall be in accordance with Figure 8 of

ASTM E8 for rounded specimens. Specimens shall have a 60-degree V-notch located approximately at the center of the gage length. The cross section area at the root of the Vee shall be approximately equal to half the area of the full cross section area of the specimen's reduced section. The Vee shall have a 0.010 inch ±0.0005 inch radius of curvature at the base of the notch. The specimens shall be given the same pretreatments, electroplating and post-plating treatments proposed for production. The specimens shall be subjected to a sustained tensile load equal to 75 percent of the ultimate notch tensile strength of the unplated material for a minimum of 200 hours. The process shall be considered satisfactory if all specimens show no indication of cracks or failure. The test results and process control information shall be submitted to the procuring activity for approval. Until approval has been received, parts shall not be plated (see 3.7.3.1.5 and 3.7.3.1.6).

* 4.3.4 Production process control test for embrittlement - Where not called out in the applicable plating documents for quality conformance inspection and to assure adequacy of the procedures and operations employed for continuous production of high quality plating, four round notched steel specimens shall be prepared and tested as detailed in 4.3.3. Specimens may be from one or more heats. In lieu of the notched steel specimens, plated articles may be selected as detailed in the applicable plating document for test. The results of tests made to determine conformance to definite contracts or purchase orders are acceptable as evidence of the properties being obtained during production (see 3.7.3.1.5 and 3.7.3.1.6).

5. PREPARATION FOR DELIVERY

5.1 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 Definitions - The terms "coating" and "plating" as used in this document may be used interchangeable. However, the term "coating" is generally applied to materials on metal surfaces deposited by nonelectrodeposition processes, whereas "plating" are those materials deposited electrolytically.

6.3 Changes from previous issue - The outside margins of this document have been marked "*" to indicate where changes (deletions, additions, etc.) from the previous issue have been made. This has been done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content as written irrespective of the marginal notations and relationship to the last previous issue.

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