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MILITARY STANDARD

MATERIALS AND PROCESSES FOR CORROSION PREVENTION AND CONTROL IN AEROSPACE WEAPONS SYSTEMS

FSC MFFP

DEPARTMENT OF THE AIR FORCE

1. This Military Standard has been approved by the Department of the Air Force and is published to provide requirements for effective corrosion prevention and control programs.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to the Aeronautical Systems Division, ENESS, WPAFB, Ohio 45433 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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FOREWORD

The purpose of this standard is to establish the requirements for materials, processes and techniques, and to identify the tasks required to implement an effective corrosion prevention and control program during the conceptual, validation, development and production phases of aerospace weapons systems.

1. SCOPE

1.1 Scope. This standard establishes the requirements for materials, processes and techniques, and identifies the tasks required to implement an effective corrosion prevention and control program during the conceptual, validation, development and production phases of aerospace weapon systems. The intent is to minimize life cycle cost due to corrosion.

1.2 Intended use. This standard is to provide a mechanism for implementation of sound materials selection practices and finish treatments during the design, development, production and operational cycles of the aerospace weapon systems. This standard defines requirements to insure establishment and implementation of a corrosion prevention advisory board (where applicable), a corrosion prevention and control plan and its accompanying finish specification as directed in Section 4. The corrosion prevention and control plan will dictate the organization of the boards, their basic duties, operating procedures, and the finish philosophies used in the systems. The finish specification will therefore be required to specify the detailed finish and coating systems to be used on the respective aerospace weapons system in accordance with the finish philosophies as approved in the corrosion prevention and control plan. This standard is derived from experience gained on protection of aerospace weapons systems against corrosion by the military services and industry. It represents technical guidance and requirements for incorporation in the corrosion prevention and control plan and finish specification.

1.3 Applicability. This standard is applicable for use by all Air Force procuring activities and their respective contractors involved in the design and procurement of aerospace weapon systems. The detailed corrosion prevention and control plan and the finish specification applies to all elements of aerospace weapon systems, including spares. Numerous materials and processes used in ground support equipment, and electronic and propulsion subsystems are not specifically covered by this standard. The requirement for the establishment of a corrosion prevention advisory board shall pertain to major aerospace systems approved for Air Force use as defined by AFR 800-2, Acquisition Program Management.

2. REFERENCED 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 standard to the extent specified herein:

SPECIFICATIONS

FEDERAL

QQ-P-416	Plating, Cadmium (Electrodeposited)
TT-P-1757	Primer Coating, Zinc Chromate, Low Moisture Sensitivity

MILITARY

MIL-M-3171	Magnesium Alloy, Processes for Pretreatment and Prevention of Corrosion On
MIL-S-5002	Surface Treatments and Inorganic Coatings for Metal Surfaces of Weapons Systems
MIL-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-F-7179	Finishes and Coatings: Protection of Aerospace Weapons Systems, Structures and Parts, General Specification For
MIL-A-8625	Anodic Coatings, For Aluminum and Aluminum Alloys
MIL-S-8784	Sealing Compound Aluminum Integral Fuel Tanks and Fuel Cells, Cavities, Low Adhesion, Accelerator Required
MIL-S-8802	Sealing Compound, Temperature Resistant, Integral Fuel Tanks and Fuel Cell Cavities, High Adhesion
MIL-C-8837	Coating, Cadmium (Vacuum Deposited)
MIL-F-18264	Finishes: Organic, Aircraft: Application and Control Of
MIL-P-23377	Primer Coating: Epoxy-Polyamide, Chemical and Solvent Resistant
MIL-M-25047	Marking and Exterior Finish Colors For Airplane, Airplane Parts and Missiles (Ballistic Missiles Excluded)

MIL-P-27418	Plating, Soft Nickel (Electrodeposited Sulfamate Bath)
MIL-C-27725	Coatings, Corrosion Preventive, For Aircraft Integral Fuel Tanks
MIL-S-38249	Sealing Compound, Firewall
MIL-M-38795	Manual, Technical: System Peculiar Corrosion Control
MIL-M-45202	Magnesium Alloys, Anodic Treatment Of
MIL-M-46080	Magnesium Castings; Process for Anodic Cleaning and Surface Sealing Of
MIL-S-81733	Sealing and Coating Compound, Corrosion Inhibitive
MIL-C-83231	Coatings, Polyurethane Rain Erosion Resistant for Exterior Aircraft and Missile Plastic Parts
MIL-C-83286	Coating, Urethane, Aliphatic, Isocyanate, for Aerospace Applications
MIL-S-83430	Sealing Compound, Integral Fuel Tanks and Fuel Cell Cavities, Intermittent Use to 360°F
MIL-C-83445	Coating Systems, Polyurethane, Non-Yellowing, White, Rain Erosion Resistant, Thermally Reflective
MIL-C-83488	Aluminum Coating
MIL-P-83953	Pencil, Aircraft Marking
MIL-C-83982	Compound, Sealing, Fluid Resistant

STANDARDS

FEDERAL

FED-STD-151	Metal, Test Methods

MILITARY

MIL-STD-810	Environmental Test Methods
MIL-STD-889	Dissimilar Metals
MIL-STD-1500	Cadmium-Titanium Plating, Low Embrittlement, Electro-deposition

DEPARTMENT OF THE AIR FORCE

AFR 400-44	Corrosion Prevention and Control Program
AFR 800-2	Acquisition Program Management
T.O. 1-1-1	Cleaning of Aerospace Equipment
T.O. 1-1-2	Corrosion Prevention and Control For Aerospace Equipment
T.O. 1-1-4	Exterior Finishes, Insignia and Markings Applicable to USAF Aircraft
T.O. 1-1-8	Application of Organic Coatings, Aerospace Equipment
T.O. 1-1-689	Prevention and Control of Corrosion and Fungus in Communication, Electronic Meteorlogical, and Avionic Equipment

FORMS

DD 1423	Contract Data Requirements List

(Copies of documents required by contractors 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)

ASTM G47	Determining Susceptibility to Stress-Corrosion Cracking of High-Strength 7XXX Aluminum Alloy Products

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

3. DEFINITION (NOT APPLICABLE)

4. GENERAL REQUIREMENTS. The contractor shall prepare a Corrosion Prevention and Control Plan. The plan shall define corrosion prevention and control requirements and considerations for systems definition, design, engineering development, production and deployment phases, consistent with the design life of the system.

5. DETAIL REQUIREMENTS

5.1 Documentation. The following documents shall result from the implementation of the Corrosion Prevention and Control Program.

5.1.1 Corrosion prevention and control plan. The contractor shall prepare a Corrosion Prevention and Control Plan which describes the contractor's approach to corrosion prevention and control measures which shall be implemented for the purpose of minimizing or eliminating potential corrosion in the aerospace weapons system being procured. This includes installation of government furnished equipment and contractor designed associated ground equipment.

5.1.2 Finish specification. The contractor shall prepare a finish specification which identifies the specific finish or techniques to be used on the various substrates of all parts components and assemblies to protect them against corrosion in the environments to which they will be exposed. After the document has been approved by the responsible Air Force procuring activity, the requirements contained therein shall be included in all applicable production drawings.

5.1.3 System peculiar corrosion control technical order. The contractor shall prepare a system peculiar corrosion control technical order which details the procedures for corrosion control and maintenance to be utilized by personnel in the organizational, intermediate and depot levels. This document shall be prepared in accordance with MIL-M-38795. In addition maximum use of General Technical Orders 1-1-1, 1-1-2, 1-1-4, 1-1-689 and 1-1-8 will be made. Through Field Surveys and Air Force technical order change requests, this technical order shall be updated as required.

5.2 Schedule for submission.

5.2.1 Corrosion prevention and control plans. The initial draft of the corrosion prevention and control plan shall be submitted to the procuring activity as a part of the proposal package. The corrosion prevention plan and finish specification shall be submitted for approval sixty days subsequent to contract award or in accordance with the DD-1423. Revision of this document shall be accomplished as required to properly record a change to materials and processes being used for corrosion prevention and control. Through design studies, analysis of failure reports, and weapons systems inspections, data shall be collected which shall be analyzed for required revisions to this document.

5.2.2 System peculiar corrosion control technical order. The system peculiar corrosion control technical order shall be submitted as required by the procuring activity.

5.3 Implementation of corrosion prevention advisory board.

5.3.1 Air Force Advisory Board (AFAB).

5.3.1.1 Membership. The board shall be chaired by a representative of the procuring activity and include engineering representatives from the contractor. The board shall include members from the contractor's organization and from the Air Foce as follows:

a. Contractor members: The contract members shall be authoritative representatives of the contractor's organizations which are necessary to insure that proper materials, processes, and treatments are selected and subsequently properly applied and maintained from the initial design stage to the final deliverable hardware.

b. Air Force members: The Air Force team will be as designated by the applicable Systems Program Office in accordance with the provisions of AFR 400-44.

5.3.1.2 Duties.

a. The primary function of the AFAB shall be to interface with the contractor's corrosion team (CCT) to insure that the goals of this standard are attained. The AFAB shall monitor the contractors activity during all phases of the program and shall act on behalf of the Air Force during the contract.

b. The Air Force member(s) shall attend those contractors team meetings deemed appropriate, based on the agenda items to be discussed, and, if necessary, to present the Air Force position on controversial technical decisions made at previous meetings.

c. The chairman shall maintain authority to conduct periodic reviews, on a scheduled basis, of the contractor's design, of the contractor and subcontractor facilities where critical parts and assemblies are being fabricated, processed, assembled and readied for shipment to evaluate the adequacy of the efforts in corrosion prevention and control. Discrepancies will be documented and submitted for review and resolution by the board. The reviews shall be scheduled as frequently as deemed necessary by the chairman.

5.3.2 Contractor's Corrosion Team (CCT).

5.3.2.1 Membership.

a. The membership of the CCT shall include a representative(s) from the project design, materials and process engineering, operations (or manufacturing), quality control, material (or subcontractor procurement) and contracts. This representation is intended to be flexible and the recommended membership may be altered depending on the size of the contract and the internal structure contractor.

b. A chairman of the CCT shall be selected and will serve as the manager of the CCT and contractor focal point for the program.

5.3.2.2 Duties. The primary function of the CCT is to insure that adequate corrosion prevention and control requirements are being implemented during all phases of the aerospace weapons system being procured. Specific duties shall include:

a. The team shall be responsible for assuring that the documents outlined under section 5.1 are prepared and submitted in accordance with the required schedule.

b. The team shall obtain the necessary design reviews, clarification, resolutions of any differences in technical position and final approval of the documentation on a timely basis.

c. The chairman shall establish periodic meetings as required to resolve problems as they occur. Other meetings shall be convened should a critical or major problem arise which requires action by the team.

d. The chairman will notify all Air Force and contractor members of each meeting date, the topics to be discussed, and any decisions resulting from the previous meeting.

e. The chairman or his designees shall sign off on all production drawings after review of materials selection, treatments and finishes.

f. The chairman will maintain a running log of all action items and their resolutions.

g. The chairman shall establish the principal tasks to be accomplished to implement corrosion prevention and control procedures in the contractor and subcontractor manufacturing facilities.

5.4 Materials and process considerations in design.

5.4.1 Selection considerations. The primary consideration in the design and construction of aerospace weapons systems is the ability of the design to comply with structural and operational requirements. In addition, the aerospace weapons are expected to perform reliably and require minimum maintenance over a specified lifetime, which includes minimizing the rate of deterioration. Therefore, in the selection of suitable materials and appropriate processing methods to satisfy structural requirements, consideration must also be given to those materials, processing methods and protective treatments which reduce service failures due to deterioration of parts and assemblies in service. Deterioration modes which contribute to service failures include but are not limited to pitting corrosion, galvanic corrosion, exfoliation corrosion, stress corrosion, corrosion fatigue, thermal embrittlement, fretting fatigue, oxidation, hydrogen embrittlement, weathering and fungus growth. In the entire design phase attention shall be given to precautionary measurements to minimize deterioration of individual parts and assemblies as well as the entire system. Precautionary measures include proper selection of materials, limitations of design operating stresses, relief of residual stress levels, shot peening, heat treatments which reduce corrosion susceptibility and protective coatings and finishes.

5.4.2 General design guidelines for corrosion prevention.

5.4.2.1 Exclusion of rain and airborne spray. The design of the system shall be such as to prevent water leaking into, or being driven into, any part of the system interior either on the ground or in flight. All windows, doors, panels, canopies, etc, shall be provided with sealing arrangements such that the entry of water is minimized when these items are correctly closed. Particular care shall be taken to prevent wetting of equipment, and heat and sound proofing materials. Sharp corners and recesses should be avoided so that moisture and solid matter cannot accumulate to initiate localized attack. Sealed floors with suitable drainage shall be provided for galleys, toilets, and cockpits.

5.4.2.2 Ventilation. Ventilation shall be sufficient to prevent moisture retention and buildup.

5.4.2.3 Drainage. Drain holes shall be provided to prevent collection or entrapment of water or other unwanted fluid in areas where exclusion is impractical. All designs shall include considerations for the prevention of water or fluid entrapment and insure that drain holes are located to effect maximum drainage of accumulated fluids. Actual aircraft configuration and attitude shall be considered in addition to component design.

5.4.2.4 Dissimilar metals. Use of dissimilar metals as defined by MIL-STD-889, in contact shall be limited to applications where similar metals cannot be used due to peculiar design requirements. When it is necessary to use dissimilar metals in contact, the metals shall be protected against galvanic corrosion. Galvanic corrosion can be minimized by interposition of a material which will reduce the overall electrochemical potential of the joint or by interposition of an insulating or corrosion inhibiting material.

5.4.3 Metallic materials.

5.4.3.1 Aluminum.

5.4.3.1.1 Alloy selection. The selection of aluminum alloys for structural application requires consideration of their resistance to stress-corrosion cracking (SCC). Maximum use shall be made of alloys and heat treatments which minimize susceptibility to SCC. Relative SCC ratings for high strength aluminum alloy products based on ASTM standard tests and service experience are given below. Although the ratings are based primarily on the results of standard corrosion tests, an experience factor can be substituted for those materials which have established service records. The ratings are given for the short transverse test direction as this is the most critical SCC condition in structural applications.

Alloy and Temper	Rolled Plate	Rod and Bar	Extruded Shapes	Forgings
2014-T6	Poor	Poor	Poor	Poor
2024-T3, T4	Poor	Poor	Poor	
2024-T6		Good		Poor
2024-T8	Good	Excellent	Good	Intermediate
2124-T851	Good			
2219-T3, T37	Poor		Poor	
2219-T6, T8	Excellent	Excellent	Excellent	Excellent
6061-T6	Excellent	Excellent	Excellent	Excellent
7049-T73	Excellent		Good	Good
7149-T73			Good	Good
7049-T76			Intermediate	
7X75-T736				Good
7050-T736	Good		Good	Good
7050-T76	Intermediate		Intermediate	
7X75-T6	Poor	Poor	Poor	Poor
7X75-T73	Excellent	Excellent	Excellent	Excellent
7X75-T76	Intermediate		Intermediate	

All aluminum sheets used in external environments and interior corrosive environments shall be clad on both sides except where the design requires surface metal removal by machining or chemical milling or where the design requires adhesive bonding or where the design uses alloys of the 5000 or 6000 series type.

5.4.3.1.2 Aluminum alloy selection limitations. Mill product forms of aluminum alloys 2020, 7079, and 7178 in all temper conditions shall not be used for structural applications. The use of 7XXX-T6 aluminum alloys shall be limited to thickness not to exceed 0.188 inch (4.78 mm).

5.4.3.1.3 Maximum metal removal. Maximum metal removal from surfaces of non-stress relieved structural parts after final heat treatment shall not exceed 0.150 inch (3.81 mm) per side unless the final temper of condition has been demonstrated to have a stress-corrosion resistance of 25 ksi (173 Megapascals (MPa)) or higher in the short transverse grain direction as determined by a 20 day alternate immersion test given in ASTM G47, Method 76. This requirement is applicable to 2000 and 7000 series alloys, but 30 days shall be used on 2000 series alloys. Stretch stress-relieved or compression stress-relieved aluminum products shall be used wherever possible. Maximum metal removal requirements are not intended to apply to machanically stress-relieved products because of the low level of internal stresses resulting from mechanical stress-relieving.

5.4.3.1.4 Shot peening for stress corrosion resistance. All critical surfaces of all structural forgings, machined plate and extrusions; where accessible after final machining and heat treatment, must be completely shot peened using a minimum of two coverage passes or placed in compression by other suitable means, except for alloys having a demonstrated stress corrosion resistance of 25 ksi or higher in the short transverse direction and web areas under 0.080 inch (2.03 mm) thick where no short-transverse grain is exposed by machining. Those areas of forgings requiring lapped, honed, or polished surface finishes for functional engineering requirements shall be shot peened prior to such subsequent surface finish operations. Aluminum forgings with a stress corrosion threshold less than 25 ksi (173 MPa) shall, after shot peening, have essentially no residual surface tensile stresses in the final heat treated and machined condition. Finish clean-up of shot peened surfaces as required for fit up will not exceed (0.003 inch (0.07 mm) of surface removal for aluminum alloys.

5.4.3.1.5 Stress corrosion factor. High strength aluminum alloy parts shall be designed, manufactured, assembled, and installed so that sustained residual tensile stresses are minimized to prevent premature failures due to stress corrosion cracking.

5.4.3.2 Low alloy, high strength steels. All low alloy, high strength steel parts, 180 ksi (1230 MPa) Ultimate Tensile Strength (UTS) and above, including fasteners require corrosion preventative metallic coatings by a process proven to be nonembrittling to the alloy/heat treatment combination. Applicable metallic coatings and finishes are described in subsequent sections of this document.

5.4.3.2.1 Limitation on use of protective metallic coatings. Soft surface coatings such as cadmium, nickel-cadmium, and aluminum shall not be used for sliding or wear applications. Cadmium plated surfaces shall not be used in applications where surface temperature exceeds 450°F (232°C). Cadmium shall not be used on functional fuel system components that can come into contact with fuel during operation of the aircraft. Cadmium plated fasteners, used in areas where contact with fuel can occur, shall be overcoated with an approved fuel tank coating or sealant. The use of chromium plating for corrosion protection of alloy steel wear surfaces in interior environments is acceptable. For applications involving exposure to the exterior environment, chromium plating shall be considered an acceptable corrosion protection of alloy steel wear surfaces only when the chrome plating is periodically lubricated (fluid or grease types only) or a 0.0015 inch (0.03 mm) minimum layer of nickel plating is applied under the chrome. All chrome plated steel parts used in fatigue applications shall be shot peened prior to plating. Chrome plated surfaces shall not be used in applications where service temperatures exceed 700°F (370°C).

5.4.3.2.2 Stress corrosion factors. Alloy steel parts heat treated to 180 KSI UTS (1230 MPa) and above shall be designed, manufactured, assembled and installed such that sustained residual surface tensile stresses shall be minimized to prevent premature failures due to stress corrosion cracking. Whenever practicable, the use of press or shrink fits, tape pins, clevis joints in which tightening of the bolt imposes a bending load on the female lugs, and straightening or assembly operations that result in sustained residual surface tensile stresses in these materials shall be avoided. In cases where such practices cannot be avoided, apply protective treatment such as stress relief heat treatments, optimum grain-flow orientation, wet installed (with a protective material) inserts and pins, and shot peening or similar surface working to minimize the hazard of stress-corrosion cracking or hydrogen embrittlement damage.

5.4.3.3 Corrosion resistant steels. All corrosion resistant steels shall be passivated. In addition 400 series martensitic steel require coatings for protection against corrosion. Table I should be used as a guide in the selection of corrosion resistant steels for structural applications.

5.4.3.3.1 Corrosion resistant steels limitations. No corrosion resistant precipitation hardening steels shall be used in the H900 condition. Corrosion resistant maraging, Almar series, Custom series, etc., steels shall not be used in sustained load applications. Corrosion resistant 19-9DL and 431 steels shall not be used for any applications. Series 400 martensitic grade corrosion resistant steels shall not be used in the 150,000 to 180,000 psi (1035 to 1230 MPa) strength range. Unstabilized austenitic steels may be used up to 700°F (370°C). Welded assemblies thereof shall not be used unless they have been given a solution heat treatment after welding (except for the stabilized grades 321 and 347, ELC 304 and ELC 316).

TABLE I. Corrosion characteristics of corrosion resistant steels.

Class	Alloy	General Corrosion Resistance	Stress Corrosion Resistance
Austenitic	301	Excellent	Excellent
	316	Excellent	Moderate
	347	High	Excellent
	A286	High	Excellent
	321	High	Excellent
	304 (ELC)	High	Excellent
	302	High	Excellent
	304	High	Excellent
	310	Excellent	Excellent
Martensitic	440C	Low to Moderate	Susceptibility varies significantly with composition, heat treatment, and product form.
	420	Low to Moderate - Will develop superficial rust film with atmospheric exposure	
	410		
	416		
	21-6-9	Moderate	Susceptibility varies significantly with composition, heat treatment, and product form.
	PH13-8MO	Moderate	
	PH15-7MO	Moderate	
	PH14-8MO	Moderate	
	17-4PH	Moderate	
	15-5PH	Moderate	
	AM355	Moderate	
	AM350	Moderate	

5.4.3.4 Titanium

5.4.3.4.1 Surface considerations. The surfaces of titanium mill products (sheet, plate, bar, forging, and extrusion) shall be 100 percent machined, chemically milled, or pickled to remove all contaminated zones and layers formed while the material was at elevated temperature. This includes contamination as a result of mill processing, heat treating and elevated temperature forming operations.

5.4.3.4.2 Fretting. Titanium alloys are highly susceptible to the reduction of fatigue life by fretting at interfaces between titanium alloys or titanium and other metals. In any design where fretting is suspected, tests shall be made to determine whether such a condition will exist. Design considerations shall be applied to minimize fretting in structural applications.

5.4.3.4.3 Special precautions. Titanium parts shall not be cadmium plated. Silver brazing of titanium parts shall be avoided for elevated temperature applications. Cadmium plated clamps, fixtures, and jigs shall not be used for fabrication or assembly of titanium components or structure.

5.4.3.5 Magnesium. Magnesium alloys shall be used only with specific approval of the procuring activity. Use of magnesium shall be restricted to non-corrosion prone areas where adequate protection systems can be maintained with ease and high reliability. Magnesium alloys shall not be used in primary flight control system; for landing gear wheels, for primary structure; or other areas subject to abuse, foreign object damage, or to abrasion; or to any location where fluid or moisture entrapment is possible.

5.4.3.6 Beryllium. In applications where beryllium is an approved material, consideration shall be given to suitable protective coatings to protect parts against corrosion. Tests shall be conducted to determine suitability of the protective coating under conditions simulating the expected corrosive environment.

5.4.3.7 Mercury. Mercury and many compounds containing mercury can cause accelerated stress cracking of aluminum and titanium alloys. Devices containing mercury shall not be used on installed equipment or during production where apillage can contact these materials.

5.4.3.8 Depleted uranium. The general finish for depleted uranium shall be nickel plate to the requirements of MIL-P-27418, plus one coat of MIL-P-23377 Type I primer, thickness 0.0006 to 0.0009 inch (0.015 to 0.023 mm).

5.4.4 Insulating blankets. Where thermal-accoustical insulating blankets are required, they shall be either procured with a permanent baked on water repellant binder system or suitably protected with sealant to prevent any moisture absorbed by the blanket from contacting the metal structure. The blankets shall be attached to the aircraft frame members and contact with aircraft skins shall be avoided.

5.5 Corrosion prevention during manufacturing operations. Adequate precaution shall be taken during manufacturing operations to maintain the integrity of corrosion prevention requirements and to prevent the introduction of corrosion or corrosive elements.

5.5.1 Cleaning. Cleaning of the various types of metallic surfaces, prior to application of the surface treatments and coatings, shall be as specified in MIL-S-5002, using materials and processes which have no damaging effect on the metal, including freedom from pits, intergranular attack and significant etching. 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 specific 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.

5.5.1.1 Titanium contamination. Care shall be taken to ensure that cleaning fluids and other chemicals are not used on titanium assemblies where entrapment can occur. Substances which are known to be contaminants and can produce stress corrosion cracking at various temperatures include:

a. Hydrochloric acid
b. Trichlorethylene
c. Carbon tetracholoride
d. All chlorides
e. Chlorinated cutting oils
f. Freons
g. Methyl alcohol

5.5.2 Surface damage. Damage to any previously applied surface treatment or protective finish shall be repaired. Damage to surfaces which will become inaccessible because of mating with other parts shall be touched up prior to mating. Organic coatings used for repair shall be the same as those on the undamaged areas.

5.5.3 Marking pencils. Ordinary lead pencils containing graphite shall not be used to mark metal parts. Nongraphitic marking pencils covered by MIL-P-83953 shall be used.

5.5.4 Cleaning after assembly. All closed compartments shall be cleaned after assembly to remove debris such as metal chips, broken fasteners, and dust. Particular attention shall be given to insure that drain holes are not blocked.

5.5.5 Protection of parts during storage and shipment. All parts and assemblies shall be given adequate protection to prevent corrosion and physical damage during temporary or long term storage and shipment.

5.6 Inorganic finishes.

5.6.1 Detail requirements. Cleaning, surface treatments and inorganic finishes for metallic surfaces of aerospace weapons systems parts shall be in accordance with MIL-S-5002. Those parts or surfaces of parts located in corrosion susceptible areas or which form exterior surfaces of the system shall require chemical finishing to provide maximum corrosion resistance.

5.6.1.1 Aluminum. All nonclad parts made from 7000 series aluminum alloys shall be sulfuric acid anodized in accordance with MIL-A-8625, Type II. They may be chromic acid anodized, MIL-A-8625, Type I, provided the anodized 7000 series test specimens meet the weight and corrosion resistance requirements of MIL-A-8625, Type II. All nonclad parts made from 2000 series aluminum alloys shall be anodized in accordance with MIL-A-8625, Type I or II. Clad 2000 and 7000 series aluminum alloys may be anodized in accordance with MIL-A-8625, Type I or II, but shall have a chemical film in accordance with MIL-C-5541 as a minimum corrosion preventative coating.

5.6.1.2 Cadmium coatings. Cadmium coatings for all steel parts including fasteners shall have a minimum thickness of 0.0003 inch (0.008 mm) and shall be subsequently treated with a chromate conversion coating. High strength steels having an ultimate tensile strength of 180,000 psi (1230 MPa) and above shall be coated with the titanium-cadmium process in accordance with MIL-STD-1500, the vacuum deposition process in accordance with MIL-C-8837, or a similar non-embrittling process.

5.6.1.3 Aluminum coatings. Aluminum coating per MIL-C-83488 or equivalent shall be considered acceptable alternative coatings to cadmium. Decreased toxicity and decreased environmental contamination are obtained by using aluminum coatings.

5.6.1.4 Magnesium. Magnesium alloys shall be treated in accordance with MIL-M-45202 or MIL-M-46080 prior to painting. Hole drilled after finishes have been applied shall be treated in accordance with MIL-M-3171, Type VI.

5.7 Organic finishes

5.7.1 Detail requirements. All finishes and coatings shall be consistent with the requirements of MIL-F-7179.

5.7.1.1 Organic finishes. The organic finishes or finish systems used shall provide the necessary protection against corrosion for all materials used in areas subjected to corrosive environments. All exterior paints and colors shall be consistent with thermal design requirements. Marking and color schemes shall be in accordance with MIL-M-25047 and T.O. 1-1-4, or as otherwise specified by the procuring activity. The exterior organic finish system shall be MIL-C-83286 aliphatic polyurethane over MIL-P-23377 epoxy polyamide primer. This organic finish system is suitable for temperature requirements to 350°F (176°C). Interior primer shall conform to MIL-P-23377 except in high temperature areas such as engine bays. Where primers are required in high temperature areas, the selected material shall be approved by the procuring activity. Integral fuel tank coatings shall meet the requirements of MIL-C-27725. All exterior plastic parts which are subject to rain or solid particle erosion shall be protected by coatings conforming to specifications MIL-C-83231 or MIL-C-83445. Justification data, including both laboratory and service experience, shall be submitted for approval by the procuring activity whenever materials other than those given above are proposed.

5.7.1.2 Organic finish application. The MIL-C-83286 aliphatic polyurethane coating shall be applied in two coats to a thickness of 0.0018 to 0.0023 inch (0.045 to 0.058 mm), for an overall average total topcoat thickness of 0.0020 inch (0.051 mm). The MIL-P-23377 primer shall be applied to a thickness of 0.0006 to 0.0009 inch (0.015 to 0.022 mm), for an overall average primer thickness of 0.0008 inch (0.020 mm). Organic finishes shall be applied in accordance with MIL-F-18264.

5.7.1.3 Magnesium surfaces. Magnesium surfaces shall receive pretreatment, two coats of primer and two top coats prior to assembly. All faying surfaces shall be sealed with and all fasteners must be installed wet with a corrosion inhibiting sealant conforming to MIL-S-81733.

5.8 Environmental sealing

5.8.1 General requirements. Environmental sealing is utilized to provide protection from corrosion by excluding moisture and other corrodants from joints. It is important that the areas to be coated with sealant be adequately cleaned before sealant is applied.

5.8.2 Detail requirements. All joints and seams located in exterior or internal corrosive environments, including those in landing gear wells, control surface wells, attachment wells and structure under fairings shall be faying surface sealed with sealant conforming to MIL-S-81733, MIL-C-83982, MIL-S-8802 or MIL-S-83430. The MIL-S-81733 specification covers a sealant which contains a soluble chromate content of 3 to 6 percent for corrosion inhibition. For sealing high temperature areas, MIL-S-38249, firewall sealant, shall be used. The use of sealants not covered by a Military Specification must be approved by the procuring activity. Removable panels and access doors shall be sealed, either by mechanical seals or separable fay surface sealant MIL-S-8784. High adhesion sealant such as MIL-S-8802 may also be used for access door sealing providing a suitable parting agent is used on one surface.

5.9 Fastener installation

5.9.1 Detail requirements. All permanently installed fasteners except as noted in 5.9.3 (all fasteners not normally removed for regular access or servicing) used in areas up to 225°F (107°C) shall be wet installed with either a corrosion inhibiting sealant conforming to MIL-S-81733 or an epoxy primer conforming to MIL-P-23377. In high temperature areas, exceeding 225°F (107°C), MIL-P-23377 epoxy primer, or a sealant which is suitable for the thermal environment shall be used. Fasteners in integral fuel tanks shall be installed with wet sealant as specified in MIL-S-8802 or MIL-S-83430. The use of sealants not covered by a military specification must be approved by the procuring activity.

5.9.2 Removable fasteners. Quick release fasteners and removable fasteners penetrating exterior surfaces shall be designed and installed so as to provide a seal to prevent moisture or fluids from entering. Holes for these fasteners shall be primed with MIL-P-23377 epoxy primer and allowed to dry prior to installing the fastener.

5.9.3 Fasteners in titanium. Titanium, monel, and stainless steel fasteners installed in titanium structures may be installed dry, unless sealing is required for liquid tightness or pressurization.

5.9.4 Monel and stainless steel fasteners. Monel fasteners or stainless steel fasteners shall be coated with cadmium or aluminum when used in contact with aluminum components.

5.10 <u>Special consideration</u>. Cadmium plated parts such as interference fit fasteners or press fit bushings shall not be used in contact with titanium components. Other cadmium and silver plated parts and fasteners shall not be used in contact with titanium components at temperatures in excess of 450°F (232°C). Titanium fasteners or components shall not be cadmium plated. Cadmium plated fasteners and aluminum fasteners shall not be used in contact with graphite composites.

Custodians:
Air Force - 11

Preparing Activity:
Air Force - 11

Project Number: MFFP-F192

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