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MILITARY STANDARD

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

AMSC N/A

FSC MFFP

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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 ASD/ENES, WPAFB, OH 45433-6533 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.

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CONTENTS

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CONTENTS - Continued

TABLES

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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 and to obtain improved reliability.

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. Materials and Processes required for corrosion prevention and control in support equipment are covered in MIL-STD-808. Materials and Process Requirements for Air Force Weapon Systems are covered in MIL-STD-1587. This standard when used in conjunction with MIL-STD-808 and MIL-STD-1587 will result in reliable aerospace systems having a good balance between acquisition costs and life cycle cost. 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. APPLICABLE DOCUMENTS

2.1 Government documents

2.1.1 Specifications and standards. The following specifications and standards 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.

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STANDARDS

FEDERAL

QQ-P-35	Passivation Treatments for Corrosion-Resisting Steel
QQ-N-290	Nickel Plating (Electrodeposited)

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, Coatings and Sealants for the Protection of Aerospace Weapons Systems
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-S-13165	Shot Peening of Metal Parts
MIL-F-18264	Finishes: Organic, Aircraft: Application and Control of
MIL-P-23377	Primer Coating: Epoxy-Polyamide, Chemical and Solvent Resistant
MIL-C-27725	Coatings, Corrosion Preventive, for Aircraft Integral Fuel Tanks
MIL-P-28809	Printed Wiring Assemblies
MIL-M-38510	Microcircuit, General Specification for
MIL-M-38795	Manual, Technical: System Peculiar Corrosion Control
MIL-C-38999	Connector, Electrical, Circular, Miniature, High Density Quick Disconnect, Environment Resistant, Removable Crimp and Hermetic Solder Contacts, General Specification for
MIL-M-45202	Magnesium Alloys, Anodic Treatment of
MIL-I-46058	Insulating Compound, Electrical (for Coating Printed Wiring Boards)
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	Coating, Aluminum, Ion Vapor Deposited
MIL-P-83953	Pencil, Aircraft Marking
MIL-C-83982	Compound, Sealing, Fluid Resistant
MIL-P-85582	Primer Coatings: Epoxy, VOC Compliant, Chemical and Solvent Resistant

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STANDARDS

MILITARY

MIL-STD-454	Standard General Specification for Electronic Equipment
MIL-STD-808	Finishes, Materials and Processes for Corrosion Prevention Control in Support Equipment
MIL-STD-889	Dissimilar Metals
MIL-STD-1500	Cadmium-Titanium Plating, Low Embrittlement, Electro-deposition
MIL-STD-1530	Aircraft Structural Integrity Program, Airplane Requirements
MIL-STD-1587	Materials and Process Requirements for Air Force Weapon Systems
MIL-STD-2073	DOD Material Procedures for the Development and Application of Packaging Requirements

2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those in effect on the date of the solicitation. (See 2.4.2.)

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. 1-1-6	Application of Organic Coatings, Aerospace Equipment
T.O. 1-1-689	Prevention and Control of Corrosion and Fungus in Communication, Electronic Meteorological, and Avionic Equipment

FORM

DD 1423	Contract Data Requirements List

(Copies of documents required by contractor in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issue of the non-Government documents which are current on the date of the solicitation. (See 2.4.3.)

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AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM G47	Determining Susceptibility to Stress-Corrosion Cracking of High-Strength 7XXX Aluminum Alloy Products
ASTM G64	Resistance of Stress Corrosion Cracking of High Strength Aluminum Alloys, Classification of
ASTM A380	Cleaning and Descaling Stainless Steel Parts, Equipment and Systems

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

AEROSPACE MATERIALS SPECIFICATIONS (AMS)

AMS 3267	Sealing Compound, Low Adhesion, Corrosion Inhibiting, for Removable Panels and Fuel Tank Inspection Plates.
AMS 3374	Aircraft Firewall, Sealing Compound, One-part Silicone

(Application for copies should be addressed to the SAE 700 Commonwealth Dr, Warrendale, PA 15096.

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.4 Source of documents

2.4.1 Government specifications, standards, and handbooks. Copies of the referenced federal and military specifications, standards, and handbooks are available from the Department of Defense Single Stock Point, Commanding Officer Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099. For specific acquisition functions, these documents should be obtained from the contracting activity or as directed by the contracting activity.

3. DEFINITIONS. Not applicable.

4. GENERAL REQUIREMENTS

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

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5. DETAIL REQUIREMENTS

5.1 Documentation. The following documents shall result from the implementation of the Corrosion Prevention and Control Program (DI-S-3598).

5.1.1 Corrosion prevention and control plan. The contractor shall prepare a corrosion prevention and control plan which describes the contractor's specific corrosion prevention and control measures to be implemented for the purpose of controlling corrosion. This corrosion prevention and control plan shall address only those materials and processes intended to be used in this specific aerospace weapon system being procured. This includes installation of government furnished equipment.

5.1.2 Finish specification. The prime contractor shall prepare a finish specification which identifies the specific organic and inorganic surface pretreatments and coatings intended to be used for protection against corrosion of the materials selected for the aerospace weapons system as previously identified in the corrosion prevention control plan. 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 prime 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, 1-1-6 and 1-1-669 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 prior to preliminary design review or in accordance with 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.

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5.3 Implementation of corrosion prevention advisory board

5.3.1 Corrosion prevention advisory board (CPAB)

5.3.1.1 Establishment. The Program Manager will establish the CPAB in accordance with AFR 400-44 during the conceptual design phase of the program prior to Full Scale Development (FSD). The CPAB will be actively involved in reviewing all design considerations and documentation relating to corrosion prevention and control throughout the life of the program.

5.3.1.2 Membership. The board shall be co-chaired by representatives of the procuring activity and the prime contractor. The board shall include members from the contractor's organization and from the Air Force as follows:

a. Prime contractor members. The contractor members shall be authoritative representatives of the contractor's organizations 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 and AFLC/AFSC Supplement 1 and supplements thereto.

5.3.1.3 CPAB Duties

a. The primary function of the Air Force members shall be to interface with the contractor's corrosion team (CCT) to insure the goals of this standard are attained. The CPAB shall monitor the contractor's activity during all phases of the program.

b. The Air Force member(s) shall attend those contractor's 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 procuring activity 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 resolved by the board. The reviews shall be scheduled as frequently as deemed necessary by the co-chairpersons.

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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.

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

f. The chairperson will maintain a continuing record of all action items and their resolutions.

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

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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 system requirements, consideration must also be given to those materials, processing methods and protective treatments which reduce failures due to deterioration. Deterioration modes which contribute to 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 measures to minimize deterioration of individual parts and assemblies as well as the entire system. Required precautionary measures are included in the following paragraphs.

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, thermal insulation and sound proofing materials. Recesses should be avoided so that moisture and solid matter cannot accumulate to initiate localized attack. Sealed floors shall be provided for galleys, toilets, and cockpits. Suitable drainage shall be provided for 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. Minimum diameter for all drains shall be 9.525mm (.375 inches) unless otherwise approved by the procuring activity. All designs shall include considerations for the prevention of water or fluid entrapment and insure that drain holes are located to permit maximum drainage of accumulated fluids. Actual aircraft configuration and attitude shall be considered in addition to component design.

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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 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. Composite materials containing graphite fibers shall be treated as graphite in MIL-STD-889.

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 G64 and service experience are given in table I. 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 Grain Direction (STGD) as this is the most critical SCC condition in structural applications.

5.4.3.1.2 Aluminum alloy selection limitations. Mill product forms of aluminum alloys 2020, 7079, and 7176 in all temper conditions shall not be used for structural applications. The use of 7XXX-T6 aluminum alloys shall be limited to thicknesses not to exceed 6.35 mm (.250 inch).

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 3.81 mm (0.150 inch) per side unless the final temper of condition has been demonstrated to have a stress-corrosion resistance of 173 MPa (25 ksi) or higher in the short transverse grain direction as determined by a 20 day alternate immersion test given in ASTM G47. 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 mechanically stress-relieved products because of the low level of internal stresses resulting from mechanical stress-relieving.

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TABLE 1. Rating for resistance to SCC aluminum alloys in the short transverse grain direction (STGD).

Alloy and Temper	Rolled Plate	Rod and Bar	Extruded Shapes	Forgings
2014-T6	Low	Low	Low	Low
2024-T3, T4	Low	Low	Low	Low
2024-T6		High		Low
2024-T8	High	Very High	High	Intermediate
2124-T851	High			
2219-T351X, T37	Very High		Very High	Very High
2219-T6,	Very High	Very High	Very High	Very High
6061-T6	Very High	Very High	Very High	Very High
7005-T53, T63			Low	Low
7039-T64	Low		Low	
7049-T74	Very high		High	High
7049-T76			Intermediate	
7149-T74			High	High
7050-T74	High		High	High
7050-T76	Intermediate	High	Intermediate	
7075-T6	Low	Low	Low	Low
7075-T736				High
7075-T74	Very High	Very High	Very High	Very High
7075-T76	Intermediate		Intermediate	
7175-T736			High	
7475-T6	Low			
7475-T73	Very High			
7475-T76	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, chemical milling, adhesive bonding or where alloys of the 1000, 3000, 5000 or 6000 series type are used.

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5.4.3.1.4 Shot peening for stress corrosion resistance and fatigue life improvement. All critical surfaces of all structural forgings, machined plate and extrusions; where accessible after final machining and heat treatment, must be completely shot peened in accordance with MIL-S-13165, ensuring 1.00% coverage as a minimum or placed in compression by other suitable means, except for alloys having a demonstrated stress corrosion resistance of 173 MPa (25 ksi) or higher in the short transverse direction and web areas under 2.03 mm (0.080 inch) 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. All aluminum products with an ASTM G47stress corrosion threshold less than 173 MPa (25 ksi) shall, after shot peening, have essentially no residual surface tensile stresses in the final heat treated and machined condition. Attachment points for primary structure shall be shot peened for fatigue life improvement. Finish clean-up of shot peened surfaces as required for fit up will not exceed 0.076 mm (0.003 inch) 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, 1241 MPa (180 ksi) 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 232°C (450°F). Cadmium shall not be used on functional fuel systems 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 sealant and coating over the sealant. Chromium plating shall be considered an acceptable corrosion prevention for alloy steel wear surfaces only when the chrome plating is periodically lubricated (fluid or grease types only) or a 0.038 mm(0.0015 inch) minimum layer of nickel plating is applied under the chromium. All chromium plated steel parts used in fatigue application shall be shot peened prior to plating. Chromium plated surfaces shall not be used in applications where service temperatures exceed 371°C (700°F).

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5.4.3.2.2 Stress corrosion factors. Alloy steel parts heat treated to 1241 MPa (180 ksi) uts 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, taper 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 accordance with QQ-P-35 or ASTM A380. In addition, 400 series martensitic steel require coatings for protection against corrosion. Table II 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. Precipitation hardening steels shall be aged at temperatures not less than 1000°F (538°C). Exception is made for castings which may be aged at 935°F ±15°F (501.5 ±9.4°C), for fasteners which may be used in the it 950 condition, and for springs which have optimum properties at the CH 900 condition. Corrosion resistant maraging 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 700°F to 1100°F tempered condition. Unstabilized austenitic steels may be used up to 370°C (700°F). Only stabilized austenitic steels (321 and 347) shall be used above 370°C (698°F). All welded or brazed austenitic steel shall be solution heat treated after welding; however, welded 321 and 347, 304L and 316L may be used without heat treatment.

5.4.3.4 Titanium

5.4.3.4.1 Surface considerations. The surfaces of titanium mill products (sheet, plate, bar, forging, casting 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 or silver plated. Cadmium plated clamps, tools, fixtures, and jigs shall not be used for fabrication or assembly of titanium components or structures.

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TABLE II. Corrosion characteristics of corrosion resistant steels.

Class	Alloy	General Corrosion Resistance	Stress Corrosion Resistance
Austenitic	301	High	Very High
	302	High	Very High
	304	High	Very High
	310	High	Very High
	316	Very High	Very High
	321	High	Very High
	347	High	Very High
Martensitic	440C 420 410 416	Low to Moderate - Will develop superficial rust film with atmospheric exposure	Susceptibility varies significantly with composition, heat treatment, and product form
Precipitation Hardening	21-6-9	Moderate	Susceptibility varies significantly with composition, heat treatment, and product form
	13-8Mo	Moderate	
	15-7Mo	Moderate	
	14-6Mo	Moderate	
	17-4PH	Moderate	
	15-5PH	Moderate	
	AM355	Moderate	
	AM350	Moderate	
	9Ni 4Co-0.20C	Moderate	Very High
	9Ni 4Co-0.30C	Moderate	Very High
	9Ni 4Co-0.45C	Moderate	Low
Other	A286	High	Very High

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5.4.3.5 Magnesium. Magnesium alloys shall be used only with specific approval of the procuring activity.

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. All beryllium shall be used in a passivated condition by a process approved by the procuring activity.

5.4.3.7 Mercury. Mercury and many compounds containing mercury can cause accelerated stress cracking of brass, aluminum and titanium alloys. Mercury shall not be used where spillage can contact these materials.

5.4.3.8 Depleted uranium. The general finish for depleted uranium shall be nickel plate to the requirements of QQ-N-290 or aluminum coated to the requirements of MIL-C-83488, plus one coat of MIL-P-23377 Type I primer, thickness 0.015 to 0.023 mm (0.0006 to 0.0009 inch).

5.4.4 Insulating blankets. Where thermal/acoustical insulating blankets are required, they shall be either procured with a permanent baked on water repellent 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. Blankets shall be easily removable to facilitate maintenance and inspection.

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 include:

a. Hydrochloric acid

b. Trichloroethylene/Trichloroethane

c. Carbon tetrachloride

d. All chlorides

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e. Chlorinated cutting oil

f. Halogenated hydrocarbons

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 conforming to 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. Packaging practices shall conform to MIL-STD-2073.

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 or chromic acid anodized, MIL-A-8625, Type IB. 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, or shall have a chemical film in accordance with MIL-C-5541 as a minimum corrosion preventative coating. All 5000 and 6000 series aluminum alloys shall have a chemical filming 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 0.008 mm (0.0003 inch) and shall be subsequently treated with a chromate conversion coating. High strength steels having an ultimate tensile strength of 1241 MPa (180 Ksi) and above, shall be plated with MIL-STD-1500, the vacuum deposition process in accordance with MIL-C-8837, or QQ-P-416, Type II, Class 2.

5.6.1.3 Aluminum coatings. Aluminum coating per MIL-C-83488 or equivalent, may be considered an acceptable alternative coatings to cadmium.

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5.6.1.4 Magnesium. Magnesium alloys shall be treated in accordance with MIL-M-45202 prior to painting. Hole(s) drilled after finishes have been applied, shall be treated in accordance with MIL-M-3171 Type VI. Parts, subsequent to anodizing may be given a surface sealing treatment per MIL-M-3171, Type VII.

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. The exterior paints and colors finish system shall be MIL-C-83286 aliphatic polyurethane over MIL-P-23377, Type 1, Class 1 or 2 or MIL-P-85582, Type 1, Class 2 primer. This organic finish system is suitable for temperature requirements to 177°C (350°F). All interior surfaces exposed to an exterior environment shall be considered as exterior surfaces and shall be primed and painted. Interior primer shall conform to MIL-P-23377, Type 1, Class 1 or 2 or MIL-P-85582, Type 1, Class 2 except 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 0.045 to 0.058 mm (0.0017 to 0.0023 inch), for an overall average total topcoat thickness of 0.51 mm (0.0020 inch). The MIL-P-23377, Type 1, Classes 1 or 2 of MIL-P-85582, Type 1, Class 2 primer shall be applied to a thickness of 0.015 to 0.023 mm (0.0006 to 0.0009 inch), for an overall average primer thickness of 0.020 mm (0.0008 inch). Organic finishes shall be applied in accordance with MIL-F-16264.

5.7.1.3 Magnesium surfaces. Magnesium surfaces shall receive two coats of primer and two coats of topcoat prior to assembly. All faying surfaces shall be sealed with a corrosion inhibiting sealant conforming to MIL-S-81733 and all fasteners shall be wet installed with MIL-S-81733 sealant or MIL-P-23377 primer.

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5.8 Environmental sealing

5.8.1 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 containing a chromate corrosion inhibitor conforming to MIL-S-81733 except when operational temperature exceed 107°C (225°F). Those areas that operate at temperatures from 107°C (225°F) to 135°C (275°F), use sealant conforming to MIL-S-83430. For sealing areas that operate at 135 to 260°C (275 to 500°F) sealant conforming to AMS 3374 shall be used. Sealants used in integral fuel tanks shall conform to MIL-S-8802 or MIL-S-83430. Removable panels and access doors shall be sealed, either by mechanical seals or separable faying surface sealants conforming to MIL-S-8784 or AMS 3267. High adhesion sealant such as MIL-S-8802 or MIL-S-83430 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 107°C (225°F) shall be wet installed with either a corrosion inhibiting sealant conforming to MIL-S-81733 or an epoxy primer conforming to MIL-P-23377, Type I, Class 1 or 2, or a MIL-P-85582, Type I, Class 2 material which does not contain water. In high temperature areas, exceeding 107°C (225°F), MIL-P-23377, Type 1, Class 1 or 2 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 conforming to MIL-S-8802 or MIL-S-83430. The use of sealant or corrosion inhibiting coatings not addressed by this paragraph 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, Type I, Class 1 or 2, or MIL-P-85582, Type I, Class 2, epoxy primer and allowed to completely 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 fastener. Monel fasteners or stainless steel fasteners shall be coated with cadmium or aluminum when used in contact with aluminum components.

5.9.5 Fasteners in graphite composites. Fastener materials for use in graphite composite structures shall be titanium or A286. Cadmium plated fasteners and aluminum fasteners shall not be used. Fasteners shall be wet when installed using sealants as specified in 5.9.1.

5.9.6 Interference fit fasteners. Cadmium plated interference fit fasteners shall not be used in contact with titanium. Fastener holes for interference fit fasteners shall be primed with MIL-P-23377, Type I, Class 1 or 2 or MIL-P-85582, Type I, Class 2 and be completely dry prior to assembly.

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5.10 Special consideration

5.10.1 Cadmium plated parts. Cadmium plated parts such as press fit bushings shall not be used in contact with titanium components. Cadmium and silver plated parts and fasteners may be used in contact with titanium components at temperatures up to 232°C (450°F). Cadmium and silver plated parts and fasteners shall not be used in contact with titanium in applications where temperatures exceed 232°C (450°F). Titanium fasteners or components shall not be cadmium plated.

5.10.2 Engine corrosion susceptibility testing. Selected materials and coatings shall be corrosion tested under simulated engine environmental conditions appropriate to their final usage during operation, handling, and storage of the engine. A new or newly overhauled engine should be selected for the corrosion susceptibility test. Prior to starting the test, the engine should be disassembled sufficiently and an inspection conducted to determine the condition of all parts normally exposed to atmospheric conditions. Detailed photographic coverage of these parts should be provided for comparison with post test conditions. The engine should then be reassembled, pretest performance calibrated, and subjected to 25 AMT cycles while being injected with a two percent of airflow weight spray solution, consisting of the following materials dissolved with sufficient distilled water to make one liter of salt spray solution:

Chemical Designation	Quantity per Liter of Spray Solution
NaCl (c.p.)	23 grams
$Na_2SO_4 10H_2O$	8 grams
Stock Solution	20 milliliters

The stock solution shall be composed of the following materials dissolved with sufficient distilled water to make one liter of stock solution:

Chemical Designation	Quantity per Liter of Stock Solution
KCl (c.p.)	10 grams
KBr	45 grams
$MgCl_2 \cdot 6H_2O$ (c.p.)	550 grams
$CaCL_2 \cdot 6H_2O$ (c.p.)	110 grams

At specified intervals during the test, the engine should be subjected to internal inspections to detect any evidence of corrosion or progression of corrosion of internal parts. Upon completion of the test, a performance check should be conducted and the engine disassembled and inspected for evidence of corrosion. Detailed photographs should be taken of all parts which show evidence of corrosion. The contractor should present test specimen evidence of metallurgical analyses that completely characterize the types of corrosion found. The test results should be considered satisfactory when the extent of corrosion is not of such a magnitude as to impair structural integrity or component operation, or be a cause of significantly reducing performance, engine durability, or parts.

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5.10.3 Electronic or avionics systems

5.10.3.1 Cleaning of printed wiring boards (PWBs). All electronic systems shall be thoroughly cleaned to remove all contamination and solder flux prior to the application of conformal coatings and prior to packaging. The cleanliness test specified in MIL-P-28809 shall be performed to verify the effectiveness of cleaning procedures.

5.10.3.2 Conformal coatings. All PWBs shall be conformally coated with a material specified in MIL-I-46058 and coated in accordance with MIL-P-28809.

5.10.3.3 PWB orientation. PWBs shall be mounted in a vertical position with the connectors on a vertical edge where design permits.

5.10.3.4 Hermetic sealing. Electronic devices not specifically covered by MIL-M-38510 shall be hermetically sealed. Maintaining a maximum internal water vapor content of 500 ppm at 100 C when tested in accordance with MIL-STD-883, Method 1018.

5.10.3.5 Electrical connectors. All connectors meeting MIL-C-38999 shall be Class W.

5.10.3.6 General requirement. The technical baseline for design and construction of electronic equipment shall be in accordance to MIL-STD-454.

6. INFORMATION FOR GUIDANCE ONLY

This section contains information of a general or explanatory nature which is helpful, but is not mandatory.

6.1 Intended use. This standard is intended to provide Air Force Systems Program Offices with a procurement document that provides timely and comprehensive consideration during systems design of corrosion prevention and control processes and of the lessons learned over the years from operational systems worldwide. System reliability and maintainability will be significantly improved by the use of this standard. It should be used in conjunction with MIL-STD-1587 in selection of materials and processes which will meet the requirements of the systems being designed in accordance with MIL-STD-1530. System reliability and maintainability will be significantly improved by the use of this standard. It should be used in conjunction with MIL-STD-1587 in selection of materials and processes which will meet the requirements of the systems being designed in accordance with MIL-STD-1530.

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6.2 Data requirements. The following Data Item Description DID) must be listed, as applicable, on the Contract Data Requirement List (DD 1423) when this standard is applied on a contract, in order to obtain the data, except where DoD FAR Supplement 27.410-6 exempts the requirement for a DD 1423.

Paragraph #	DID #	DID Title	Suggested Tailoring
5.1	DID-S-3598	Corrosion Prevention and Control Requirements	- - -

(Copies of DID's required by contractors in connection with specific acquisition functions should be obtained from Naval Publications and Forms Center or as directed by the contracting officer).

6.3 Key words

Materials and processes
Corrosion prevention/control
Stress corrosion
Cadmium plated
Sealants
Corrosion prevention advisory boards
Organic coatings
Metal finishes

6.4 Changes from previous issue. Vertical lines or asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodian:
Air Force - 11

Reviewer:
Air Force - 14

Preparing activity:
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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions - Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-STD-1568B(USAF)	Materials and Processes For Corrosion Prevention and Control

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

5. PROBLEM AREAS

a. Paragraph Number and Wording

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER (Last, First, MI) - Optional	b. WORK TELEPHONE NUMBER (Include Area Code) - Optional
c. MAILING ADDRESS (Street, City, State, ZIP Code) - Optional	8. DATE OF SUBMISSION (YYMMDD)

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