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DEPARTMENT OF DEFENSE

DESIGN CRITERIA STANDARD

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

AMSC 9572

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FOREWORD

1. This standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Comments, suggestions, or questions on this document should be addressed to: Commander, Naval Air Warfare Center, Aircraft Division, Route 547, Mail Stop 120-3, Code 4.1.2, Joint Base MDL, NJ 08733-5100, or emailed to michael.sikora@navy.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil.

3. For guidance on the technical content of this document, contact Commander, Naval Air Warfare Center, Aircraft Division, (Code 4.3), 48066 Shaw Road, 2188 Patuxent River, MD 20670.

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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 throughout the conceptual, validation, development, production, and sustainment phases of the aerospace weapons systems life cycle. Applicable systems include fixed wing aircraft, unmanned aerial vehicles, space vehicles, rotorcraft, missile systems, air delivered guided munitions, and all related ground support equipment. Meeting or exceeding the requirements of this standard, as well as applicable program-specific technical documentation, will facilitate an optimum balance between acquisition and sustainment costs for DoD aerospace weapons systems, and ultimately enhance system reliability, supportability, and safety. Authority to exceed or amend the requirements in this standard requires permission from the Cognizant Engineering Authority (CEA).

1.2 Purpose. The purpose of this standard is to provide a mechanism for implementation of sound materials selection practices and finish treatments during the design, development, production and operational (sustainment) cycles of aerospace weapons systems. This standard defines technical requirements to ensure establishment and implementation of a corrosion prevention and control plan and its accompanying finish specification. The corrosion prevention and control plan will set up operating procedures and the finish philosophies used in the systems. The finish specification details the 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.

1.3 Applicability. This standard is applicable for the Department of Defense procuring activities and their respective contractors involved in the design and procurement of aerospace weapons systems, including spares, upgrades, and major repairs.

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2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4 or 5 of this standard. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this standard, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

FEDERAL SPECIFICATIONS

TT-C-490	-	Chemical Conversion Coatings and Pretreatments for Metallic Substrates (Base for Organic Coatings)
TT-P-2760	-	Primer Coating Polyurethane, Elastomeric, High-Solids

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-DTL-5002	-	Surface Treatments and Inorganic Coatings for Metal Surfaces of Weapons Systems
MIL-PRF-8516	-	Sealing Compound, Synthetic Rubber, Electric Connectors, And Electric Systems, Chemically Cured
MIL-DTL-18264	-	Finishes, Organic, Weapons Systems, Application and Control of
MIL-PRF-23377	-	Primer Coatings: Epoxy, High-Solids
MIL-PRF-23586	-	Sealing Compound (With Accelerator), Silicone Rubber, Electrical
MIL-M-24041	-	Molding and Potting Compound, Chemically Cured, Polyurethane
MIL-PRF-27617	-	Grease, Aircraft and Instrument, Fuel and Oxidizer Resistant
MIL-PRF-32014	-	Grease, Aircraft and Instrument
MIL-PRF-32239	-	Coating System, Advanced Performance, for Aerospace Applications
MIL-M-38510	-	Microcircuits, General Specification for
MIL-A-46146	-	Adhesives-Sealants, Silicone, RTV, Noncorrosive (for use with Sensitive Metals and Equipment)
MIL-PRF-46170	-	Hydraulic Fluid, Rust Inhibited, Fire Resistant, Synthetic Hydrocarbon Base, NATO Code No. H-544
MIL-PRF-81733	-	Sealing and Coating Compound, Corrosion Inhibitive
MIL-PRF-81322	-	Grease, Aircraft, General Purpose, Wide Temperature Range, NATO Code G-395

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MIL-PRF-83282	-	Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Metric, NATO Code Number H-537
MIL-DTL-83488	-	Coating, Aluminum, High Purity
MIL-PRF-85285	-	Coating: Polyurethane, Aircraft and Support Equipment
MIL-PRF-85582	-	Primer Coatings: Epoxy, Waterborne
MIL-PRF-87252	-	Coolant Fluid, Hydrolytically Stable, Dielectric
MIL-PRF-87257	-	Hydraulic Fluid, Fire Resistant; Low Temperature, Synthetic Hydrocarbon Base, Aircraft and Missile

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-186	-	Protective Finishing For Army Missile Weapon Systems
MIL-STD-866	-	Grinding of Chrome Plated Steel and Steel Parts Heat Treated to 180,000 PSI or Over
MIL-STD-889	-	Dissimilar Metals
MIL-STD-1500	-	Cadmium-Titanium Plating, Low Embrittlement, Electrodeposition
MIL-STD-2073-1	-	Standard Practice for Military Packaging
MIL-STD-3021	-	Materials Deposition, Cold Spray
MIL-STD-7179	-	Finishes, Coatings and Sealants for the Protection of Aerospace Weapons Systems

DEPARTMENT OF DEFENSE HANDBOOKS

MIL-HDBK-275	-	Guide for Selection of Lubricants, Fluids, and Compounds for Use in Flight Vehicles and Components
MIL-HDBK-808	-	Finish, Protective and Codes for Finishing Schemes for Ground and Ground Support Equipment
MIL-HDBK-838	-	Lubrication of Military Equipment
MIL-HDBK-1250	-	Corrosion Prevention and Deterioration Control In Electronic Components and Assemblies
MIL-HDBK-6870	-	Nondestructive Inspection Program Requirements for Aircraft and Missile Materials and Parts

(Copies of these documents are available online at https://assist.dla.mil.)

2.2.2 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 of these documents are those cited in the solicitation or contract.

DEFENSE DIRECTIVE

DoDD 5000.01	-	The Defense Acquisition System

(Copies of this document are available online at http://www.dtic.mil.)

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GUIDEBOOK

Corrosion Prevention and Control Planning Guidebook for Military Systems and Equipment

(Copies of this document are available online at https://www.corrdefense.org/External/ReferenceLibrary.aspx.)

DEFENSE FEDERAL ACQUISITION REGULATION SUPPLEMENT (DFARS)

Subpart 207.105	-	Acquisition Planning: Contents of Written Acquisition Plans

(Copies of these documents are available at http://www.dcaa.mil/dfars.html.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

ASTM INTERNATIONAL

ASTM A380/A380M	-	Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM B30	-	Standard Specification for Copper Alloys in Ingot Form
ASTM B66	-	Standard Specification for Bronze Castings for Steam Locomotive Wearing Parts
ASTM B117	-	Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B148	-	Standard Specification for Aluminum-Bronze Sand Castings
ASTM B150/B150M	-	Standard Specification for Aluminum Bronze Rod, Bar, and Shapes
ASTM B169/B169M	-	Standard Specification for Aluminum Bronze Sheet, Strip, and Rolled Bar
ASTM B194	-	Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar
ASTM B196/B196M	-	Standard Specification for Copper-Beryllium Alloy Rod and Bar
ASTM B197/B197M	-	Standard Specification for Copper-Beryllium Alloy Wire
ASTM B271/B271M	-	Standard Specification for Copper-Base Alloy Centrifugal Castings
ASTM B505/B505M	-	Standard Specification for Copper Alloy Continuous Castings
ASTM B600	-	Standard Guide for Descaling and Cleaning Titanium and Titanium Alloy Surfaces
ASTM B763/B763M	-	Standard Specification for Copper Alloy Sand Castings for Valve Applications
ASTM B806	-	Standard Specification for Copper Alloy Permanent Mold Castings for General Applications

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ASTM D2247	-	Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity
ASTM D2803	-	Standard Guide for Testing Filiform Corrosion Resistance of Organic Coatings on Metal
ASTM F519	-	Standard Test Method for Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments
ASTM G47	-	Standard Test Method for Determining Susceptibility to Stress Corrosion Cracking of 2XXX and 7XXX Aluminum Alloy Products
ASTM G58	-	Standard Practice for Preparation of Stress-Corrosion Test Specimens for Weldments
ASTM G64	-	Standard Classification of Resistance to Stress Corrosion Cracking of Heat-Treatable Aluminum Alloys
ASTM G85	-	Standard Practice for Modified Salt Spray (Fog) Testing

(Copies of these documents are available online at http://www.astm.org.)

IPC Association Connecting Electronics Industries

J-STD-001	-	Requirements For Soldered Electrical And Electronic Assemblies (DoD adopted)

(Copies of this document are available online at http://www.ipc.org.)

SAE INTERNATIONAL

SAE AMS-QQ-N-290	-	Nickel Plating (Electrodeposited)
SAE AMS-QQ-P-416	-	Plating, Cadmium (Electrodeposited)
SAE AMS2175	-	Casting, Classification and Inspection of
SAE AMS2423	-	Plating, Nickel, Hard Deposit
SAE AMS2424	-	Plating, Nickel Low-stressed Deposit
SAE AMS2430	-	Shot Peening, Automatic
SAE AMS2700	-	Steels, Passivation of Corrosion Resistant
SAE AMS3265	-	Sealing Compound, Polysulfide (T) Rubber, Fuel Resistant, Nonchromated Corrosion Inhibiting for Intermittent Use to 360 °F (182 °C)
SAE AMS3269	-	Sealing Compound, Polysulfide (T) Synthetic Rubber for Integral Fuel Tank and Fuel Cell Cavities High Strength, for Intermittent Use to 360 °F (182 °C) (Stabilized Type)
SAE AMS3276	-	Sealing Compound, Integral Fuel Tanks and General Purpose, Intermittent Use To 360 °F (182 °C)
SAE AMS3277	-	Sealing Compound, Polythioether Rubber, Fast Curing for Integral Fuel Tanks and General Purpose, Intermittent Use to 360 °F (182 °C)

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SAE AMS3278	-	Sealing and Coating Compound: Polyurethane (PUR) Fuel Resistant High Tensile Strength/Elongation For Integral Fuel Tanks/Fuel Cavities/General Purpose
SAE AMS3279	-	Sealing Compound, Sprayable For Integral Fuel Tanks and Fuel Cell Cavities, For Intermittent Use to 350 °F (177 °C) (Stabilized Type)
SAE AMS3281	-	Sealing Compound, Polysulfide (T) Synthetic Rubber for Integral Fuel Tank and Fuel Cell Cavities Low Density for Intermittent Use to 360 °F (182 °C)
SAE AMS3284	-	Sealing Compound, Low Adhesion, for Removable Panels and Fuel Tank Inspection Plates
SAE AMS3374	-	Sealing Compound, Aircraft Firewall, Silicone
SAE AMS4890	-	Copper-Beryllium Alloy Castings 97Cu - 2.1Be - 0.52Co - 0.28Si Solution Heat Treated (TB00)
SAE AMS6532	-	Steel, Bars and Forgings 3.1Cr - 11.5Ni - 13.5Co - 1.2Mo (0.21 - 0.25C) Vacuum Melted, Normalized and Overaged Precipitation Hardenable
SAE AMS7259	-	Rubber: Fluorocarbon (FKM), High Temperature/Fluid Resistant, Low Compression Set/ 85 to 95 Hardness, For Seals In Fuel Systems and Specific Engine Oil Systems
SAE AMS7276	-	Rubber: Fluorocarbon (FKM) High-Temperature-Fluid Resistant Low Compression Set For Seals In Fuel Systems and Specific Engine Oil Systems
SAE AMS7287	-	Fluorocarbon Elastomer (FKM) High Temperature/HTS Oil Resistant / Fuel Resistant Low Compression Set/70 to 80 Hardness, Low Temperature Tg -22 °F (-30 °C) For Seals in Oil/Fuel/Specific Hydraulic Systems
SAE AMS7379	-	Rubber: Fluorocarbon Elastomer (FKM) 70 to 80 Hardness, Low Temperature Sealing Tg -40 °F (-40 °C) For Elastomeric Seals in Aircraft Engine Oil, Fuel and Hydraulics Systems
SAE AMS-C-8837	-	Coating, Cadmium (Vacuum Deposited)
SAE AMS-C-83231	-	Coatings, Polyurethane, Rain Erosion Resistant for Exterior Aircraft and Missile Plastic Parts
SAE AMS-S-8802	-	Sealing Compound, Temperature Resistant, Integral Fuel Tanks and Fuel Cell Cavities, High Adhesion
SAE ARP4118	-	Isolation and Corrosion Protection of Dissimilar Materials
SAE AS50881	-	Wiring, Aerospace Vehicle
SAE AS81550	-	Insulating Compound, Electrical, Embedding, Reversion Resistant Silicone
SAE J2277	-	Surface Vehicle Recommended Practice for Shot Peening Coverage Determination

(Copies of these documents are available online at http://www.sae.org.)

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AMERICAN WELDING SOCIETY (AWS)

AWS D17.1/D17.1M - Fusion Welding for Aerospace Applications

(Copies of this document are available online at http://aws.org.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Aerospace weapons systems. Applicable systems include fixed wing aircraft, unmanned aerial vehicles, space vehicles, rotorcraft, missile systems, air delivered guided munitions, and all related ground support equipment.

3.2 Aircraft structure. The structure of an aircraft includes the fuselage, wing, empennage, landing gear, rotorcraft rotor and drive systems, propellers, control systems and surfaces, airframe-engine interface components (including engine mounts, nacelles, air induction components), weapon mounts, structural operating mechanisms, components that perform a structural function, and other components as described in the contract specification.

3.3 Alternate manufacturing processes. Alternate manufacturing processes include, but are not limited to, laser additive manufacturing, electron beam additive manufacturing, weldments and cold spray processes to produce built-up structures.

3.4 Cognizant Engineering Authority (CEA). For the purpose of this standard, Cognizant Engineering Authority is that entity from the procuring activity that reviews and approves any deviations from the technical requirements contained within this standard.

3.5 Corrosion. The deterioration of a material or its properties due to a reaction of that material with its chemical environment. Traditionally, corrosion was thought of only as deterioration of metal (e.g., rusting of steel), but now corrosion includes degradation of non-metallic materials. Some non-traditional examples include rotting of wood, degradation of concrete (carbonation, alkali-silica reaction phenomena), and degradation of composite materials due to reaction with the environment.

3.6 Corrosion Prevention and Control (CPC). The rigorous application of engineering, design and analysis, quality assurance, nondestructive inspection, manufacturing, operations, and support technologies to:

a. prevent the start of corrosion
b. minimize functional impairment from corrosion, and
c. define processes for the tracking and repair of corrosion problems.

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3.7 Corrosion Prevention and Control Plan (CPCP). This plan describes the specific corrosion prevention and control measures to be implemented for the purpose of minimizing corrosion throughout the acquisition lifecycle, as well as a plan for establishing a CPCP timeline (see Appendix A) and a Corrosion Prevention Team (see Appendix B).

3.8 Corrosion prevention and control planning. Consists of planning and establishing:

a. a management structure for CPC, and

b. the technical considerations and requirements in order to implement an effective CPC regime throughout the life cycle of a program. CPC planning must include program management, engineering (including systems engineering), life cycle logistics, test and evaluation, budget/funding and contracting. A CPC Plan (CPCP) formally documents the CPC planning and execution, and is updated, refined and matured as the program proceeds through the life cycle phases.

3.9 Corrosion Prevention Team (CPT). A team that consists of Government and contractor personnel within each aerospace weapons system management function with the purpose of focusing on and emphasizing Corrosion Prevention and Control (CPC) planning and execution throughout the life of the program. Examples include a Corrosion Prevention Advisory Board (CPAB), Corrosion Action Teams (CAT), etc.

3.10 Critical surface/part. A surface/part on an aerospace weapons system that has been identified through analysis, test, or service history as being especially sensitive to the presence of damage.

3.11 Damage. The presence of any crack, flaw, corrosion, disbond, delamination, and/or other feature that degrades, or has the potential to degrade, the performance of the affected component.

3.12 Durability. The ability of the structure and/or components to resist cracking, corrosion, thermal degradation, delamination, wear and the effects of foreign object damage for a prescribed period of time.

3.13 Erosion. The progressive loss of material from a surface due to impinging fluid or solid particles.

3.14 Exterior surfaces. All surfaces normally exposed to an external environment are considered exterior surfaces. All interior surfaces that may also become wetted with water or corrosive fluid are considered exterior surfaces. These surfaces include, but are not limited to, wheels and landing gear, wheel wells, and their fairings, control surfaces, wing-fold areas, battery compartments, and bilge areas on aircraft with latrines.

3.15 Microbially Influenced Corrosion (MIC). Corrosion that is caused or promoted by microorganisms such as bacteria or fungus. It can apply to both metals and non-metals.

3.16 Nondestructive Inspection (NDI). The inspection of a structure or component in any manner that will not impair its future usefulness. The purpose of NDI may be to detect flaws at or beneath the external surface of a part, measure geometric characteristics, determine material

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structure or composition, or it may characterize physical, electrical, or thermal properties without causing changes in the part.

3.17 Stress Corrosion Cracking (SCC). Cracking induced from the combined influences of sustained tensile stress and a corrosive environment.

3.18 Structural integrity. The condition that exists when a structure is sound and unimpaired in providing the desired level of structural safety, performance, durability, and supportability.

3.19 Supportability. Acceptable quality and cost-effective preventive methods and/or in-service repair methods are either available or can be developed in a timely manner to mitigate the deterioration of materials and structures fabricated using the selected manufacturing processes and joining methods.

3.20 Sustainment. Sustainment involves the supportability of fielded systems and their subsequent life cycle product support – from initial procurement to supply management (including maintenance) to reutilization and disposal. It can include functions such as initial provisioning, cataloging, inventory management and warehousing, and depot and field level maintenance.

3.21 Wear. Damage at an interface, generally with progressive loss of material from one or both surfaces, due to relative motion between the surfaces. Wear mechanism includes adhesive, abrasive, and fretting wear, as well as corrosive and thermal wear.

4. GENERAL REQUIREMENTS

4.1 Corrosion Prevention and Control Plan (CPCP). The CPCP addresses the design, materials, and processes intended to be used on the specific system being procured including system interfaces, installation of government furnished equipment, and commercial items procured off-the-shelf. The CPCP shall contain the following (see 6.2b):

a. System design, engineering and manufacturing requirements, operations, logistics, and sustainment phases that mitigate corrosion and are consistent throughout system life.
b. An integrated management structure that ensures ongoing, effective CPC communication and coordination among team members by defining roles and responsibilities for quality assurance, process control, materials/process engineering, manufacturing, low observables, technical writing, and Environment, Safety, and Occupational Health (ESOH) compliance.
c. Materials, processing methods, manufacturing techniques, fabricating processes and protective treatments identified in the finish specification.
d. Methods for CPC sustainability, logistics support, maintenance planning (such as methods/equipment for corrosion monitoring and non-destructive inspection), ground support and test equipment, handling, transportation, and storage of parts/assemblies, personnel training and the generation/validation/verification of technical information.
e. Performance verification methods for full stack-ups of the overall protective schemes,

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including low observable materials.

f. Methods to achieve compromises between conflicting requirements of corrosion mitigation, low observables, electrical grounding, environmental compliance, safety and occupational health. Life Cycle Costs shall be a factor in achieving said compromises.

g. An interface with suppliers, subcontractors, sub-systems manufacturers and the procurement of commercial-off-the-shelf items that validates, verifies, and ensures compliance to the plan and finish specification.

h. References to applicable specifications and standards.

4.2 Finish specification. The finish specification shall be in accordance with MIL-STD-7179 and identifies the specific materials, processing methods, manufacturing techniques, protective pretreatments and treatments, organic and inorganic coatings, seals and sealants to be used for protection against corrosion of the assemblies, sub-systems and components selected for the specific system being procured and which have been identified in the corrosion prevention and control plan. All finishing materials and processes shall conform to applicable Federal and State regulations. All signature control and miscellaneous functional coating/finishing materials shall be included in and comply with the finish specification (see 6.2c).

4.3 Sustainment. Since corrosion prevention, control, and mitigation contribute significantly to the total cost of aerospace weapons systems ownership, the requirements of this standard shall be met during upgrades, procurement of spare parts, major repairs, modifications and similar support phases of existing systems. Department of Defense Directive (DoDD) 5000.01 recognizes that corrosion prevention and control is an issue over the life of an aerospace weapons system and emphasizes (1) the best time to off-set the effects of corrosion is early in system development, and (2) the requirements for the best design and materials/processes/finish selections need to prevail during the operational and support phases of fielded aerospace weapons systems. Any procurement of spare parts, upgrades, repairs and other sustainment initiatives exceeding five million dollars shall require a corrosion control plan and an accompanying process/finish specification, according to the Defense Federal Acquisition Regulation Supplement (DFARS) Part 207.105. The intent is to ensure coordination and implementation of the original corrosion prevention and control plan and process/finish specification that were approved during acquisition be continued throughout system life. Elements of a sustainment corrosion program can be found in the "Corrosion Prevention and Control Planning Guidebook for Military Systems and Equipment."

4.4 Materials and process considerations in design.

4.4.1 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 systems 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 materials and processing methods to satisfy system requirements, consideration shall also be given to those materials, processing methods and protective treatments which reduce failures due to deterioration. Modeling and validation testing shall be performed to identify corrosion-prone locations. Testing shall include selected materials,

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assembly techniques, and corrosion protection schemes in relevant environments and in-service loadings.

4.4.2 Guided missiles and rocket systems. Since guided missiles, rockets, and their components have low maintenance and high reliability performance requirements, MIL-STD-186 in conjunction with MIL-STD-1568 shall be used to establish materials and process requirements to protect these weapons systems from deterioration ensuring they meet their intended useful life.

4.4.3 Alternate manufacturing processes. Components produced using alternate manufacturing processes shall meet or exceed the CPC design capabilities of traditionally manufactured components.

4.5 General design requirements for corrosion prevention.

4.5.1 Exclusion of rain and airborne spray. The design of the system shall prevent water intrusion into, or being driven into, any part of the system interior or sealed components. All windows, doors, panels, canopies, etc. shall be provided with sealing arrangements that prevent entry of water when these items are correctly closed. Wetting of equipment, thermal insulation, and sound proofing materials shall be prevented. Recesses shall be avoided so that moisture and solid matter cannot accumulate to initiate localized attack. Sealed floors shall be provided for galleys, toilets, and crew compartments.

4.5.2 Ventilation. Ventilation to minimize moisture retention and buildup shall be included in the system design considerations and validated during system design testing.

4.5.3 Drainage. Drain holes shall be provided to prevent collection or entrapment of water or other unwanted fluid in areas where exclusion is impractical. Unless otherwise approved by the procuring activity, the minimum diameter for all drains shall be 0.375 inch (9.525 mm). All designs shall include considerations for the prevention of water or fluid entrapment and ensure that drain holes are located to permit maximum drainage of accumulated fluids. Actual system configuration and attitude, in flight and on the ground, shall be considered in addition to component design. Drainage shall be provided for crew compartments, avionics bays and boxes, engine bays/nacelles in such a manner that nearby structure shall not be compromised.

4.5.4 Galvanically dissimilar materials. Use of dissimilar metals in contact, as specified in MIL-STD-889, 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. Composite materials containing graphite fibers shall be treated as graphite in MIL-STD-889 and treated in accordance with the methods and guidelines of SAE ARP4118, where applicable.

4.5.5 Insulation/acoustic blankets. When required, insulation/acoustic blankets shall be procured with a permanent, baked-on water repellent binder system or protected with sealant to prevent any moisture from being absorbed by the blanket. Blankets shall be attached to the system frame members in a stand-off fashion to avoid contact with vehicle skins. This distance

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shall be sufficient to prevent moisture entrapment against the skins and to allow for drainage of fluids. Such attachment shall permit the blankets to be easily removed and re-attached to facilitate maintenance and inspection. Specific requirements shall be provided by the Cognizant Engineering Authority.

4.5.6 Nondestructive inspection (NDI) for corrosion. For corrosion prone areas requiring inspection, access for inspection throughout the system lifecycle shall be evaluated during system design in order to identify inspectable and non-inspectable areas. Areas deemed non-inspectable may require additional corrosion control and prevention measures in order to mitigate the risk of not being able to inspect periodically. The selection of coating and corrosion removal processes requires consideration of their effects on NDI methods. When industry standard NDI methods cannot be utilized, alternate NDI methods may be utilized with the permission of the Cognizant Engineering Authority.

4.5.6.1 NDI methodologies and techniques. NDI methodologies and techniques shall be considered during the design and procurement of aerospace weapons systems. NDI methodologies and techniques shall be required for aerospace weapons systems when the design activity or system specifications require NDI (see 6.2d) for product acceptance and recurring inspection for long-term sustainment. NDI requirements shall be established and adhered to during system development, test, production, and sustainment through the life cycle of the weapons system. MIL-HDBK-6870 can be used to determine key elements of NDI, which include the following:

a. Parts classification.
b. Coordination of design requirements and production NDI procedures.
c. Preparation and approval of production NDI procedures.
d. Development of NDI methods and procedures to support test articles.
e. Coordination, documentation of inspection requirements and procedures to support long-term sustainment including structural repairs.
f. Validation and verification of inspection procedures to support long-term sustainment.
g. Assessment and documentation of sustainment NDI capability.
h. Qualification of new technologies for use during production or component/aircraft testing or during the service life of the system.
i. Qualification of NDI methods adapted for the purpose of in-situ structural damage sensing.
j. Consideration for surface finish and preparation, prior to fluorescent penetrant inspection.

4.6 Metallic materials.

4.6.1 Aluminum.

4.6.1.1 Alloy selection. The selection of aluminum alloys for structural applications requires consideration of their resistance to stress-corrosion cracking (SCC). Maximum use shall be made of alloys and heat treatments that minimize susceptibility to SCC. Relative SCC ratings for high-strength aluminum alloy products based on ASTM G64 and service experience are

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provided in Table I. Although the ratings are based primarily on the results of standard corrosion tests, such as ASTM G64, an experience factor may be substituted for those materials that have established service records. The ratings are given for tests conducted in the Short Transverse Grain Direction (STGD) on plate greater than 0.080 inch (2.032 mm) in thickness as this is the most critical SCC condition. For welded assemblies, castings and parts made via metal additive processes (powder, wire or foil), testing for SCC shall be performed in the final heat treat condition. If no post production thermal treatment is applied, a sufficient amount of time (not less than 2 weeks) shall be allowed for the material to stabilize. Thermally accelerated stabilization treatments are allowed with the permission of the CEA. For alloys not included in Table I, consult the CEA.

TABLE I. 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			

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4.6.1.2 Aluminum alloy selection limitations. Wrought product forms of aluminum alloys 2020, 7079, and 7178 in all temper conditions and 7075-T6 shall not be used for structural applications. Use of 2000-series aluminum alloys in the -T3 and -T4 tempers and 7000-series aluminum in the -T6 tempers in thicknesses greater than 0.080 inch (2.032 mm) shall not be used. Suitably clad aluminum alloys or inherently corrosion-resistant alloys shall be used in exterior skin that is 0.125 inch (3.175 mm) or less in thickness, forms a leading-edge, exhaust trail area of any source or wheel well area, is spot- or seam-welded, or is the face sheet in bonded sandwich construction. Non-clad materials may be used for the aileron skins, the flap shroud skins and the flap shroud closure pocket. To preclude partial aging in heat-treatable alloys, the bonded sheet shall be in the artificially aged condition prior to bonding. The references to exterior surfaces and skin herein mean the external surface only and do not preclude use of material clad only on one side or the removal of cladding from internal surfaces.

4.6.1.3 Maximum metal removal. Metal removed from non-stress relieved structural parts after final heat treatment shall not exceed 0.150 inch (3.81 mm) per side, unless the following conditions are met. Final temper of condition has been demonstrated to have a stress-corrosion resistance of 25 ksi (173 MPa) or higher in the short transverse grain direction as determined by a 20-day alternate immersion test provided in ASTM G47 or equivalent as approved by the CEA.

4.6.1.4 Clad aluminum sheet. 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, and adhesive bonding or where alloys of the 1000, 3000, 5000, or 6000 series type are used. Clad high strength aluminum alloys shall not be fusion welded.

4.6.1.5 Compressive residual surface stress for corrosion resistance and fatigue life improvement. Compressive residual stress is applied via shot peening in accordance with SAE AMS2430 or other methods approved by the CEA. Critical surfaces of all structural forgings, machined plate and extrusions, where accessible after final machining and heat treatment, shall be shot peened in accordance with SAE AMS2430 and SAE J2277 or other methods approved by the CEA. Exceptions are alloys having a demonstrated stress corrosion resistance of 25 ksi (173 MPa) or higher in the short transverse direction, and web areas under 0.080 inch (2.032 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 these surface finish operations. All aluminum products with an ASTM G47 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. Attachment points for primary structure shall be shot peened for improved fatigue resistance. Finish clean-up of shot peened surfaces as required for fit up shall not exceed 0.003 inch (0.076 mm) of surface removal for aluminum alloys. Holes in primary structure shall be cold worked using processes approved by the CEA. Mechanical removal of material or exposure to temperatures exceeding 180 °F (82 °C) requires reapplication of the compressive surface layer processes.

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4.6.1.6 Stress corrosion factor. Practices, such as 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, which result in sustained or residual surface tensile stress shall be avoided. In cases where such practices cannot be avoided, corrective practices, such as stress relief heat treatment and optimum grain flow orientation shall be used to minimize the hazard of stress corrosion cracking. Materials selection shall consider the increased residual tensile stress (increased potential for SCC) due to out of tolerance conditions of non-conforming parts.

4.6.1.7 Aluminum lithium (Al-Li) alloys (special considerations). Al-Li alloys shall only be used with permission from the CEA.

4.6.2 Steels.

4.6.2.1 Low alloy, high strength steels. All low alloy, high strength steel parts, 180 ksi (1241 MPa) ultimate tensile strength (UTS) and above, including fasteners, require corrosion preventative coatings by a process proven to be non-embrittling, to the requirements of ASTM F519 for the alloy/heat treatment combination. Any corrosion resistant plating used on steels above 180 ksi (1241 MPa) UTS shall exhibit a re-embrittlement resistance of more than 200 hours in the standard ASTM F519 testing using the 1A specimen. Selection of steels shall be as follows:

a. Aircraft-quality, vacuum-melted steel shall be used for parts which are heat treated to an ultimate tensile strength of 220 ksi (1516 MPa) and above.

b. The maximum ultimate tensile strength in production parts shall not be greater than 20 ksi (137 MPa) above the established allowable minimum requirement.

c. Compositions shall be selected such that heat treatment to the required strength and service temperatures shall preclude temper embrittlement, blue brittleness, or brittle temper.

d. Steels shall be selected to have ductile-brittle fracture transition temperatures as determined by impact test, below the minimum operating temperature.

e. Steels whose mechanical properties are developed by cold deformation shall have the recovery temperature of at least 50 ºF (10 ºC) above the expected operating temperature range.

f. Critical parts shall be designed and processed so as to result in no decarburization in excess of 0.003 inch (0.076mm) of highly stressed areas. Elsewhere, decarburization shall be avoided and, where unavoidable, shall be compensated by appropriate reduction in design fatigue strength. Unless otherwise specified, designs shall preclude use of as-forged surfaces. Carburization and partial decarburization of fully hardened steel parts shall be restricted such that the difference in hardness from the surface to the nominal subsurface hardness shall not exceed two hardness units Rockwell C (HRC).

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g. The mechanical drilling of holes in martensitic steels after hardening to strength levels of 180 ksi (1241 MPa) and above shall be avoided. When such drilling is unavoidable, processes shall be in accordance with the procuring activity approved material and process specifications.

h. Grinding of martensitic steels and chromium plated martensitic steels hardened to 200 ksi (1378 MPa) and above shall be in accordance with MIL-STD-866.

i. Aeromet 100 shall be procured in accordance with SAE AMS6532.

j. H-11, D6-AC, 4340M and 300M steels shall not be used.

4.6.2.2 Stress corrosion factors. 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 shall be avoided for alloy steel parts heat treated to 180 ksi (1241 MPa) UTS and above. In cases where such practices cannot be avoided, protective treatments, 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 SCC or hydrogen embrittlement damage, shall be applied. Only the following corrosion resistant and high strength steel shall be used for critical parts: HP 9-4-30, PH 13-8, AF-1410, Modified AF-1410, and AERMET 100. For steel weldments the SCC resistance shall be prepared and inspected in accordance with ASTM G58.

4.6.2.3 Corrosion resistant steels (CRES). CRES shall be considered for all applications to reduce/eliminate the use of environmentally unfriendly/hazardous surface treatments. All CRES shall be passivated in accordance with SAE AMS2700 or ASTM A380/A380M or equivalent as approved by the CEA. While both SAE AMS 2700 and ASTM A380/A380M permit the use of citric acid for passivation, use of this process shall be approved by the CEA. In addition, martensitic steels require coatings for protection against corrosion. Table II provides corrosion information for CRES.

4.6.2.3.1 Corrosion resistant steel limitations. Precipitation hardened steels shall be aged at temperatures not less than 1000 ºF (538 ºC). Exceptions are those alloys that exhibit acceptable SCC resistance when tested in accordance with ASTM G58; castings that are aged at 935 ±15 ºF (501.5 ±9.4 ºC); fasteners in the H950 condition, and springs that have optimum properties at the CH 900 condition. Corrosion resistant maraging steels shall not be used in sustained load applications and if used (e.g., ALMAR 362, CUSTOM 455, CUSTOM 450) shall be aged at temperature not less than 1000 ºF (538 ºC). 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 ºF to 1100 ºF (371 ºC to 593 ºC) tempered condition 150 to 180 ksi (1034 to 1241 MPa strength ranges). Unstabilized austenitic steels shall not be fusion welded. Precipitation hardening semi-austenitic grades shall not be used in applications that require extended exposure to temperatures in the 750 ºF through 900 ºF (398 ºC through 482 ºC) range. Only stabilized austenitic steels (321 and 347) are to be used above 698 ºF (370 ºC). Free machining stainless steels shall be avoided for all applications. 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 post weld solution heat treatment.

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4.6.2.4 Titanium.

4.6.2.4.1 Surface considerations. The surfaces of titanium products (sheet, plate, bar, forging, casting, metal additive, 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 and welding. Chemical cleaning shall be performed in accordance with ASTM B600 or equivalent as approved by the CEA. Adequate removal of detrimental layers shall be confirmed through the use of inspection techniques approved by the CEA.

4.6.2.4.2 Fretting. Titanium alloys are highly susceptible to reduction in component life by fretting at interfaces between titanium alloys or titanium and other metals. In any design where fretting is suspected, tests shall be conducted to determine whether such a condition will exist and ensure that component life requirements are met. Design considerations shall be applied to minimize fretting in structural applications including provision made for anti-fretting coatings or inserts. The effect of anti-galling/anti-fretting compounds on the corrosion performance of the joint shall be determined.

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	Low to moderate - will develop superficial rust film with atmospheric exposure	Susceptibility varies significantly with composition, heat treatment and product form
	420		
	410		
	416		
Precipitation Hardening	21-6-9	Moderate	Susceptibility varies significantly with composition, heat treatment, and product form.
	13-8Mo	Moderate	
	15-7Mo	Moderate	
	14-8Mo	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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4.6.2.4.3 Special precautions. Titanium parts and fasteners shall not be plated with cadmium, zinc, or silver. Cadmium, zinc, or silver plated hardware clamps, tools, fixtures, and jibs shall not be used for fabrication or assembly of titanium components or structures. Cadmium, zinc or silver plated parts, such as press fit bushings and fasteners, shall not be used in contact with titanium components.

4.6.2.4.4 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 that are known to be contaminants and produce SCC include, but are not limited to, hydrochloric acid, trichloroethylene/trichloroethane, carbon tetrachloride, all chlorides, chlorinated cutting oil, halogenated hydrocarbons, and methyl alcohol.

4.6.2.5 Magnesium. Magnesium alloys shall not be used.

4.6.2.6 Beryllium and aluminum-beryllium alloys. All beryllium and beryllium containing alloys shall be used in a passivated condition by a process approved by the CEA. High content beryllium alloys (>2 percent Be) shall not be used. Alloy UNS C17200 or UNS C17300 or equivalent is required. Wrought beryllium copper shall be acquired in accordance with ASTM B196/B196M, ASTM B197/B197M, or ASTM B194. Beryllium copper castings shall be acquired in accordance with SAE AMS4890 and classified (class and grade) in accordance with SAE AMS2175.

4.6.2.7 Mercury. Mercury shall not be used where spillage can contact brass, aluminum and titanium alloys.

4.6.2.8 Depleted uranium. Depleted uranium shall not be used without the specific approval of the CEA. If approved for use, the general finish for depleted uranium shall be nickel plated in accordance with SAE AMS-QQ-N-290 or aluminum coated in accordance with MIL-DTL-83488, plus one coat of MIL-PRF-23377, Type I primer, thickness 0.0006 to 0.0009 inch (0.015 to 0.023 mm).

4.6.2.9 Tin and tin alloys. If tin or tin alloys are used where the possibility of tin pest occurrence is expected, mitigation strategies shall be addressed in the CPCP.

4.6.2.10 Bronze bearing alloys. The use of bronze alloys is prohibited, except for wrought UNS C63000 aluminum-nickel bronze in accordance with ASTM B150/B150M, ASTM B169/B169M used in moderate and light duty bearing load applications, and aluminum bronze (alloys UNS C95200-C95800) casting classified (class and grade) in accordance with SAE AMS2175, and acquired in accordance with ASTM B30, ASTM B66, ASTM B148, ASTM B271/B271M, ASTM B505/B505M, ASTM B763/B763M, and ASTM B806.

4.6.3 Organic materials. The following restriction shall apply to the selection of elastomers, plastics, and other organic materials used in the fabrication of aerospace structures and components:

a. All organic materials shall have resistance to degradation and aging (including resistance to hydrolysis, ozonolysis and other chemical processes exacerbated by

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atmospheric or operational exposure), and minimum flammability consistent with performance requirements for the intended use.

b. Hazardous decomposition and other out gassing products that are volatile and leachable, released by organic materials under operating conditions shall not come in contact with materials components or personnel.
c. Cellular plastics, foams and wood shall not be used for skin stabilization in structural components, other than in all-plastic sandwich components. Use of foam as sandwich core material shall not be used.
d. Natural leather degrades quickly and shall not be used.
e. Elastomeric encapsulating compounds used shall conform to MIL-PRF-8516, MIL-PRF-23586, MIL-M-24041, MIL-A-46146, or SAE AS81550. Use of hydrolytically unstable encapsulation materials is prohibited.

4.6.4 Composites. Imide-based/graphite composites shall not be used in structures not accessible for non-destructive inspection, non-inspectable structure, or non-removable by organizational level maintenance. Imide-based or graphite composites shall not be in contact with or adjacent to parts/materials that are susceptible to corrosion (aluminum, steel, tin) including, brackets, clips, gang channels, tubing, fasteners, etc.

4.6.5 Corrosion prevention during manufacturing operations and storage. Precautions shall be taken during manufacturing operations and long-term storage of materials and commodities to prevent the introduction of corrosion or corrosive elements. (See 4.6.9.)

4.6.6 Cleaning. Cleaning of various types of metallic surfaces, prior to application of the surface treatments and coatings, shall be as specified in MIL-DTL-5002 and in accordance with TT-C-490, using materials and processes that 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 necessary treatment immediately after cleaning. Particular care shall be exercised in the handling of parts to ensure that foreign metals are not inadvertently transferred, as may occur when steel is allowed to come into contact with zinc surfaces and cadmium in contact with titanium. All closed compartments shall be cleaned prior to closeout assembly to remove debris such as metal chips, broken fasteners, dust, and other foreign material. Particular attention shall be given to ensure that drain holes are not blocked.

4.6.7 Surface damage. Damage to surface treatments or protective finishes shall be repaired prior to component assembly, including faying surfaces. Inorganic and organic coatings used for repair shall be the same as those on the undamaged areas. Application of coatings shall be in accordance with MIL-DTL-18264 using approved material specifications and qualified materials.

4.6.8 Marking pencils**.** Graphite containing marking devices (e.g. lead pencils, etc.) shall not be used to mark metal parts.

4.6.9 Protection of parts during storage and shipment**.** All parts and assemblies shall be given adequate protection to prevent corrosion and physical damage during storage and shipment. Packaging practices shall conform to MIL-STD-2073-1.

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4.6.9.1 Storage and shipping preservatives. MIL-PRF-46170 shall not be used as a rust inhibiting storage fluid. While MIL-PRF-46170 may prevent rust, it will deposit a barium containing compound onto metallic surfaces leading to potential component (e.g., valves) failures. Operational fluids, such as MIL-PRF-83282 and MIL-PRF-87257, shall be used to fill components instead of using MIL-PRF-46170. MIL-PRF-81322 shall not be used as a shipping preservative. MIL-PRF-32014 should be used in place of MIL-PRF-81322 as a shipping preservative with few exceptions (see 4.6.14.2).

4.6.10 Inorganic finishes. Cleaning, surface treatments, and inorganic finishes for metallic surfaces of aerospace weapons systems shall be in accordance with MIL-DTL-5002. Those surfaces or parts located in corrosion susceptible areas that form exterior surfaces of the system, shall require chemical finishing to provide maximum corrosion resistance in accordance with life cycle cost considerations. Emerging environmentally compliant inorganic finishes shall be approved by the CEA. Approval for new finishes shall be based upon detailed test plans that are formulated and executed to subsequently demonstrate equivalency (or better) to the inorganic finish being replaced.

4.6.10.1 Cadmium coatings. High strength steels having an ultimate tensile strength of 180 ksi (1241 MPa) and above, shall be plated in accordance with MIL-STD-1500, with the vacuum deposition process in accordance with SAE AMS-C-8837, or electrodeposited in accordance with SAE AMS-QQ-P-416, Type II, Class 2. Cadmium-plated fasteners used in areas where contact with fuel can occur, shall be over coated with an approved fuel tank sealant in accordance with 4.6.12.

4.6.10.2 Aluminum coatings. Aluminum coatings in accordance with MIL-DTL-83488 or equivalent are an acceptable alternative to cadmium with the approval of the CEA. Ion Vapor Deposited (IVD) aluminum coatings shall be peened to eliminate porosity where galvanic dissimilarities are adverse to the material being coated. IVD aluminum coatings shall not be used where dissimilarity with the base material results in corrosion pitting if there is damage or porosity. Cold spray aluminum may be used in accordance with MIL-STD-3021 for non-structural and non-outer-mold line applications with permission of the CEA as an acceptable alternative to cadmium.

4.6.10.3 Nickel plating. Aluminum structures, avionics boxes, components or connectors shall not be nickel plated.

4.6.10.3.1 Undercoating. Where the selected coating does not provide corrosion protection for the base metal and the coated surface or portion thereof is exposed to corrosive environment, an undercoat of 0.0010 to 0.0016 inch (0.0254 mm to 0.040 mm) of nickel on steel or zinc parts or an undercoat of 0.0008 to 0.0010 inch (0.020 mm to 0.0254 mm) of nickel on copper alloy parts in accordance with SAE AMS2423 or SAE AMS2424 shall be used. Coatings proposed for applications where temperatures exceed 1000 ^{o}F (538 ^{o}C) in service shall be subject to approval of the CEA.

4.6.10.4 Zinc plating. Zinc or zinc-containing platings and coatings shall not be used on alloy steel parts heat treated to 160 ksi (1103 MPa) UTS without CEA approval.

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4.6.10.5 Chromium plating. Chromium plating shall be considered acceptable corrosion prevention for alloy steel wear surfaces only when the chrome plating is periodically lubricated (fluid or grease types only) or a pure copper flash followed by a 0.0015 inch (0.038 mm) minimum layer of nickel plating is applied under the chromium. All chromium plated steel parts shall be shot peened prior to plating. Chromium plated surfaces shall not be used in applications where service temperatures exceed 700 ºF (371 ºC).

4.6.11 Organic finishes. All organic finishes and coatings shall be in accordance with MIL-STD-7179.

4.6.11.1 Organic finishes and systems (for Air Force systems). For Air Force systems, all exterior paints and colors shall be consistent with thermal design requirements and shall conform to MIL-PRF-85285, Type IV aliphatic polyurethane topcoat over MIL-PRF-23377, Type I or II, Class C1 or C2 or MIL-PRF-85582, Type I or II, Class C1 or C2 primer. Class N of these two primers may be used on the outer-mold-line only, with the approval of the CEA. As an alternative to the aforementioned finish systems, i.e. MIL-PRF-23377, MIL-PRF-85582, and MIL-PRF-85285, materials qualified to MIL-PRF-32239 are acceptable. Exterior surfaces subjected during service to high stress, structural flexing, or susceptible to extreme corrosive attack shall be primed with MIL-PRF-81733, Type III, or TT-P-2760 followed by MIL-PRF-85285, Type IV topcoat. In high temperature areas, the selected material shall be approved by the CEA. Those nonmetallic components coated for erosion resistance with SAE AMS-C-83231, Class A or B and which may be chemically stripped during sustainment shall have a wash primer base coat, applied prior to application of the Class A or B polyurethane coats.

4.6.11.2 Fire insulating paint. Within power-plant compartments of aircraft and other compartments normally operating at temperatures below 300 °F (149 °C), where fires are likely to occur as a result of flammable fluid leakage, and in areas adjacent to bleed air ducts and valves that contain air at temperatures above 300 °F (149 °C), all fluid containers (air bottles, oxygen containers, hydraulic reservoirs, accumulators, and cylinders) that could escalate the intensity of a fire by explosion due to excessive heat, shall be protected by a finish system. The finish system shall consist of a primer qualified and applied in accordance with MIL-PRF-23377 or MIL-PRF-85582 and a thermally insulating fire barrier topcoat and sealants (such as SAE AMS3374), as determined by the CEA.

4.6.12 Environmental sealing. All permanent joints and seams located in exterior or internal corrosive environments, including those in landing gear wells, control surface vents, attachment wells and structure under fairings shall be faying surface sealed with sealants conforming to MIL-PRF-81733, SAE AMS3265, SAE AMS-S-8802, SAE AMS3281, SAE AMS3276, and SAE AMS3277. When operational temperatures are anticipated to exceed 225 ºF (107 ºC), sealant conforming to SAE AMS3276 or SAE AMS3277 shall be used. For scaling areas that operate at 275 ºF to 500 ºF (135 ºC to 260 ºC), sealant conforming to SAE AMS3374 shall be used. Sealants used in integral fuel tanks shall conform to MIL-STD-7179 or SAE AMS3278, SAE AMS3269, or SAE AMS3279. Removable panels and access doors shall be sealed, either by rubber gaskets, molded seals, mechanical seals, or separable low-adhesion faying surface sealants conforming to SAE AMS3284. High adhesion sealants such as those conforming to

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SAE AMS-S-8802, SAE AMS3277, SAE AMS3281, or SAE AMS3276 may be used for access door sealing provided the proper parting agent is used on one surface. Alternative faying surface products, such as non-curing sealants and gel tapes, shall be approved by the CEA.

4.6.13 Fastener installation. Fasteners shall be installed in accordance with MIL-STD-7179. Waterborne primers, such as those in accordance with MIL-PRF-85582, shall not be used for permanent fastener wet installation. Sealant or corrosion inhibiting coatings other than those specified in MIL-STD-7179 shall not be used unless approval has been obtained from the CEA. 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 in accordance with MIL-STD-7179 or MIL-PRF-85582, Type I, Class C1 or C2 epoxy primer and allowed to completely cure prior to installing the fastener. These fasteners shall be installed with corrosion preventive compound. Maintenance instructions shall require periodic reapplication of this material in-service.

4.6.13.1 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. Titanium fasteners in contact aluminum shall be wet installed.

4.6.13.2 Fasteners in graphite composites. Fastener materials for use in carbon fiber reinforced composite structures shall be titanium, A286, or Inconel 718. Cadmium plated fasteners and aluminum fasteners shall not be used.

4.6.13.3 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.

4.6.13.4 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-PRF-23377, Type I, Class 1 or 2 or MIL-PRF-85582, Type I, Class 2 and shall be completely dry prior to assembly. Wet installation may be waived when using pre-coated fasteners if approved by the CEA.

4.6.14 Special considerations.

4.6.14.1 Signature control. Materials, processes, primary and secondary structures used to achieve signature control shall be evaluated in accordance with SAE ARP4118 and MIL-STD-889 for corrosion resistance in full stack-up representative assemblies.

4.6.14.2 Fluids, lubricants and their containment. Only qualified military specification materials shall be used for hydraulic fluids, coolants, greases, gas turbine oils, and other functional fluids. Phosphate ester based hydraulic fluids (such as Skydrol®) are not active for new design.

4.6.14.3 Greases. MIL-PRF-32014, a corrosion-resistant lithium soap grease, shall be used in lieu of MIL-PRF-81322 and other clay thickened or non-corrosion inhibited greases in applications where the operating temperature is less than 350 °F (176 °C). For gaseous oxygen compatibility requirements or high temperature applications, perfluorinated greases in

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accordance with MIL-PRF-27617 shall be used. Greases in accordance with MIL-PRF-32014 can be used above 350 °F (176 °C) if the performance is evaluated with component level testing.

4.6.14.4 Coolant. For radar cooling systems, polyalphaolephin (PAO) based coolant in accordance with MIL-PRF-87252 shall be used.

4.6.14.5 Fluorocarbon seals. Fluorocarbon seals in accordance with SAE AMS7276, SAE AMS7259, SAE AMS7287, or SAE AMS7379 shall be used.

4.6.15 Electronic or avionics systems. All electronic assemblies and avionics shall be in accordance with J-STD-001, MIL-M-38510, and MIL-HDBK-1250. Electrical wiring interconnect systems (EWIS) shall be in accordance with SAE AS50881 and MIL-HDBK-1250.

4.6.16 Firefighting agents. Fire extinguishing agents such as Fire Fighting Foam (FFF), bromochloromethane dibromochloromethane or dry powder agents such as potassium bicarbonate or sodium bicarbonate after exposure to heat are corrosive. Decontamination procedures require flushing with generous quantities of water in conjunction with washing/rinsing of all surfaces and components exposed to fire suppressant materials. To the extent possible, designs shall minimize areas of potential exposure to these materials and facilitate the flushing and cleaning of those areas exposed.

4.6.17 Wear and erosion. The design and manufacture of aircraft shall include practices to minimize damage by wear and erosion. Coatings for the prevention of wear and erosion shall be in accordance with MIL-STD-7179.

4.6.18 Lubrication. Provisions shall be made for lubrication of all parts subject to wear using lubricants from MIL-HDBK-275 as specified in MIL-HDBK-838. The fire resistant synthetic hydrocarbon hydraulic fluid in accordance with MIL-PRF-83282 shall be used as the aircraft hydraulic fluid in operating temperatures down to -40 °F (-40 °C). For operating temperatures down to -65 °F (-54 °C), MIL-PRF-87257 shall be used. Multipurpose lubricants such as the wide temperature general purpose grease described in 4.6.14.3 shall be used whenever possible, without compromising performance and reliability. Components that are highly loaded/dynamic and in potentially corrosive environments (e.g., landing gear, arresting gear) shall make maximum use of lubrication fittings, versus other forms of lubricants.

4.6.19 Support equipment. All unique support equipment procured as a part of the aerospace weapons system acquisition shall be designed using the guidance provided in MIL-HDBK-808.

4.6.20 Welded components. Welding of aerospace components shall be performed in accordance with AWS D17.1/D17.1M or an equivalent specification approved by the CEA.

4.7 Verification of corrosion design. Aerospace weapon systems are usually designed for specified lifetimes with maintenance according to defined maintenance concepts and plans. Where possible, include formal specific corrosion criteria in the environmental test plans to include evaluation for moisture collection, sealing, etc. Specific corrosion testing shall be conducted on components and subsystems in accordance with ASTM B117 (and ASTM G85.A4

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for Naval systems only). The systems shall have negligible corrosion, as determined by the CEA, while maintaining functionality after 500 hours of ASTM B117 testing of the assembled production configuration. Additionally for naval systems, these assemblies shall be tested to 500 hours of ASTM G85.A4. Finish and corrosion protection verification shall be in accordance with Table III.

TABLE III. Corrosion protective coatings verification.

Test	Criteria
ASTM D2247 30 day humidity test	No blistering, softening, loss of adhesion or other film defect
ASTM B117 2000 hours salt spray test with scribed panels	No blistering, lifting of coating nor substrate corrosion.
ASTM G85.A4 500 hours SO_2 salt spray test with scribed panels (Navy Only)	No pitting greater than 1 millimeter in depth.
ASTM D2803 1000 hours filiform corrosion test with scribed panels.	No filiform corrosion extending beyond ¼ inch from the scribe.

4.7.1 Engine corrosion testing. Engine materials and coatings shall be corrosion tested under simulated engine environmental conditions commensurate to their final usage during operation, handling, and storage of the engine. For this testing, a new or newly overhauled engine shall be used. Prior to starting the test, the engine shall be disassembled and an inspection shall be conducted to determine the condition of all parts exposed to atmospheric conditions. Detailed photographic coverage of these parts shall be used for comparison with post-test conditions. The engine shall then be reassembled, pretest performance shall be calibrated, and subject to 25 accelerated mission test (AMT) cycles while being injected with a two percent of airflow weight spray solution, consisting of the following materials dissolved with distilled water to make one liter of salt spray solution.

Chemical designation	Quantity per liter of spray solution
NaC1 (c.p.)	23 grams
$Na_2SO_4 \cdot 10H_2O$	8 grams
Stock solution (See recipe below)	20 milliliters

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

Chemical designation	Quantity per liter of stock solution
KC1 (c.p.)	10 grams
KBr	45 grams

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$MgC1_2 \cdot 6H_2O$ (c.p.)	550 grams
$CaCl_2 \cdot 6H_2O$ (c.p.)	110 grams

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

5. DETAIL REQUIREMENTS (Not applicable.)

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This standard is intended to provide Department of Defense Program Offices with a 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-HDBK-1587 in selection of materials and processes that will meet the requirements of the systems being designed in accordance with MIL-STD-1530.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this standard.

b. Corrosion Prevention and Control Plan (CPCP) (see 4.1).

c. Finish specification (see 4.2).

d. If Nondestructive Inspection (NDI) is required (see 4.5.6.1).

e. Timelines and milestones for the CPCP and finish specification (see Appendix A).

f. The establishment of Corrosion Prevention Teams (CPTs) (see Appendix B).

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6.3 Associated Data Item Descriptions (DIDs). This standard has been assigned an Acquisition Management Systems Control (AMSC) number authorizing it as the source document for the following DIDs. When it is necessary to obtain the data, the applicable DIDs must be listed on the Contract Data Requirements List (DD Form 1423).

DID Number	DID Title
DI-MFFP-81402	Finish Specification
DI-MFFP-81403	Corrosion Prevention and Control Plan

The above DIDs were current as of the date of this standard. The ASSIST database should be researched at http://quicksearch.dla.mil to ensure that only current and approved DIDs are cited on the DD Form 1423.

6.4 Subject term (key word) listing.

Cadmium plated
Metal finishes
Organic coatings
Sealants
Stress corrosion

6.5 Alternate materials and processes. Justification data, including both laboratory and service experience, will be required for CEA approval of any alternate materials and processes.

6.6 Document websites and historical information websites. Relevant documents and historical information can be found by accessing the links below:

http://www.corrdefense.org
http://www.dscc.dla.mil/Programs/MilSpec/DocSearch.aspx
http://quicksearch.dla.mil
www.grantadesign.com (Cambridge Material Selector)

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

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CORROSION PREVENTION AND CONTROL PLAN (CPCP) AND FINISH SPECIFICATION

A.1 SCOPE

A.1.1 Scope. This appendix details the timeline and milestones for the submission of a corrosion prevention and control plan (CPCP) and finish specification (see 6.2e). This appendix is not a mandatory part of the standard. The information contained herein is intended for guidance only.

A.1.2 CPCP submission timeline. The initial draft of the corrosion prevention and control plan must be submitted to the procuring activity as part of the proposal package 60 days prior to the System Requirements Review (SRR), Milestone A. The submittal of the corrosion prevention and control plan and the finish specification must occur 60 days prior to System Design Review (SDR), Milestone B. Follow-on revision and submittal of these documents must be accomplished 60 days prior to Preliminary Design Review (PDR), Critical Design Review (CDR) and as required to properly record a change to materials and processes being selected for corrosion prevention and control. Through design studies, analysis of failure reports and on-site inspections, data must be collected and analyzed for revisions to these documents. For sustainment initiatives, the CPCP and the finish specification must be adjusted accordingly and submitted 45 days after the procurement vehicle is signed.

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CORROSION PREVENTION TEAMS (CPTs)

B.1 SCOPE

B.1.1 Scope. This appendix details the procedure for establishing a corrosion prevention team (CPT) (see 6.2f). This appendix is not a mandatory part of the standard. The information contained herein is intended for guidance only.

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B.2 PROCEDURE

B.2.1 Corrosion Prevention Team (CPT). A Government-only CPT must be established during the conceptual design phase of the program prior to Milestone A outlined in Appendix A. This government-only team, designated by the program manager, provides technical support during proposal evaluation. After contract, a contractor-only CPT (also referred to as the Contractor Corrosion Team [CCT]) must be established to ensure that adequate CPC requirements are being implemented during all phases of the aerospace weapons systems/equipment lifecycle.

B.2.2 Government/contractor membership. Each team must consist of, as a minimum, a Team Lead, and members from Program/Project Management, Systems Engineering, Life Cycle Logistics, Test and Evaluation, Facilities, Materials and Processes, Design, Quality Assurance, Manufacturing, Contracts, etc. Membership suggestions are in the "Corrosion Prevention and Control Planning Guidebook for Military Systems and Equipment." Each CPT is unique and is tailored several times during the life cycle of the system to satisfy the changing requirements of the program.

B.3 DUTIES

B.3.1 Duties of the Corrosion Prevention Team (CPT). The team must:

- Define operating procedures, and prescribe appropriate specifications and standards to be used in the system/equipment

- Outline or document the RFP and contract requirements necessary to execute the CPCP

- Address system/equipment definition, design, engineering development, production, and sustainment phases, ensuring they are consistent with the design life and affordability of the system/equipment

- Develop options for finish and coating systems to be used on the procured system/equipment

- Review all design considerations, material selections, costs, and documentation, including Statements of Work (SOWs) that may affect CPC throughout the life of the system/equipment.

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- Advise the PM on corrosion-related issues, confirm the adequacy of the corrosion maintenance documentation and guidance as they are developed, and elevate unresolved issues.

B.3.2 Duties of the Contractor Corrosion Team (CCT). The CCT must:

- Ensure that adequate CPC requirements are being implemented during all phases of the aerospace weapons system being procured.

- Ensure appropriate documents outlined under the CPCP are prepared and submitted in accordance with the required schedule

- Obtain the necessary design reviews, clarification, resolution of any differences in technical position and final approval of the documentation on a timely basis.

The chairperson's duties include:

a. Serving on the Corrosion Prevention Team (CPT) (for Air Force, this is also referred to as the Corrosion Prevention Advisory Board [CPAB]) as required.
b. Establishing periodic meetings as required to resolve problems as they occur. Other meetings should be convened, as required, or when a critical or major problem arises that requires action by the team.
c. Signing off (or designee) on all production drawings after review of materials selection, treatments and finishes.
d. Maintaining a continuing record of all action items and their resolutions.
e. Establishing the principal tasks to be accomplished to implement CPC procedures in the contractor and subcontractor manufacturing facilities.

B.4 Implementation of a Corrosion Prevention Advisory Board (CPAB). When required by the service program, the Government program manager must establish a CPAB at the start of the Engineering Manufacturing Development Stage (Milestone B as specified in Appendix A). This joint Government and contractor board, co-chaired by both a Government and prime contractor representative, must be established to advise the program manager on corrosion related issues, such as, design considerations, selection of materials and processes, program management, documentation, supportability, reliability, maintainability, sustainability and structural integrity. The CPAB should meet on a regular basis in accordance with the established board charter throughout the life of the aerospace weapons system to ensure program continuity and should also be utilized during sustainment initiatives.

B.4.1 CPAB membership. CPAB membership must include authoritative representatives from appropriate Government and contractor organizations necessary to ensure that proper materials, processes, and treatments are selected and subsequently properly applied, and maintained from the initial phase through the life cycle of the system. Suggestions on membership are in the "Corrosion Prevention and Control Planning Guidebook for Military Systems and Equipment."

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B.4.2 CPAB charter. A charter must be established at the start of Milestone B after the CPAB is organized. A charter consists of an introduction, purpose, membership (Government and contractor), responsibilities (Government and contractor), procedures and an appendix addressing the membership and contact information.

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MISCELLANEOUS FACTORS AFFECTING CORROSION

C.1 SCOPE

C.1.1 Scope. This appendix details miscellaneous factors that affect corrosion. This appendix is not a mandatory part of the standard. The information contained herein is intended for guidance only.

C.2 APPLICABLE DOCUMENTS

Engineering Circular EC-434-000-003	Material Selection Restrictions List for Navy and Marine Corps Aviation Weapons Systems
Engineering Circular EC-434-000-004	Risk Mitigation for Non-chromate Coating Systems
Engineering Circular EC-434-000-005	Corrosion Prevention and Control for Navy and Marine Corps Aviation Systems

(Copies of these documents are available from the following address: Commander, NAVAIRSYSCOMHQ, Head, Materials Engineering Division, Code 4.3.4, Building 2188, 47123 Buse Rd., Unit IPT, Patuxent River, MD 20670.)

DEFENSE FEDERAL ACQUISITION REGULATION SUPPLEMENT (DFARS)

Subpart 223	Environment, Energy And Water Efficiency, Renewable Energy Technologies, Occupational Safety, And Drug-Free Workplace
Subpart 252	Solicitation Provisions and Contract Clauses

(Copies of these documents are available at http://www.dcaa.mil/dfars.html.)

C.3 MISCELLANEOUS INFORMATION

C.3.1 Microbially Influenced Corrosion (MIC). MIC can occur in a variety of locations such as fuel systems (i.e., tanks, pipelines) or areas that experience high humidity, standing water, entrainment of water, or pooled or leaked operational fluids. MIC may be indicated by the presence of “slime,” sludge or fungus. Water or fuel that has a foul or acidic (e.g., vinegar) odor or a cloudy, flocculent appearance can also indicate the presence of microbes. MIC should be investigated in corrosion associated with water or fuel with these characteristics. If MIC is suspected, it should be reported to the fuel quality control agency for each branch of service (e.g., Air Force Petroleum Agency). Microbiologists should be consulted to help identify if MIC is present and what options can be used to mitigate the MIC.

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C.3.2 Material restrictions for Navy and Marine Corps Aircraft. Engineering circular EC-434-000-003 provides information on the hazards or restrictions for the use of materials and processes, not only for environmental, safety, and health concerns, but also for minimizing adverse effects on systems due to poor design.

C.3.3 Hexavalent chromium regulations. Hexavalent chromium (Cr^{6+}) is a chemical that has been used for decades in numerous DoD weapons systems and platforms due to its corrosion protection properties. However, Cr^{6+} is a known carcinogen. Defense Federal Acquisition Regulation Supplement (DFARS) Subparts 223 and 252 mandate programs to minimize the use of materials containing Cr^{6+} in items acquired by DoD. It codifies a DoD policy for addressing the serious human health and environmental risks related to the use of Cr^{6+}. The rule prohibits the delivery of items containing more than 0.1 percent by weight Cr^{6+} in any homogeneous material under DoD contracts unless there is no acceptable alternative to the use of Cr^{6+}. The mandatory prohibition does not apply to legacy weapons systems (developed before 2012), unless they are undergoing a major modification. Even for new and modified systems, it is not intended to preclude the use of Cr^{6+} for critical defense applications for which there are no alternatives that can meet performance requirements. If the program manager determines that Cr^{6+} is necessary for the weapons system until viable alternatives are proven, the program may seek an Authorization Request for the contract. The authorization request is developed by the program's Environment, Safety and Occupational Health (ESOH) Coordinator and the Corrosion Subject Matter Expert (SME). The authorization must be approved by the Senior Approving Official in conjunction with the Military Department's Corrosion Control and Prevention Executive. Further guidance for Naval Programs is available in Appendix 1 of Engineering Circular EC-434-000-005 and Engineering Circular EC-434-000-004.

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CONCLUDING MATERIAL

Custodians:
Army - MI
Navy - AS
Air Force - 20

Preparing activity:
Navy - AS
(Project MFFP-2015-003)

Review activities:
Army - AV
Navy - CH, EC, MC, OS, SA, SH, YD
Air Force - 11

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil.