METRIC

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MILITARY STANDARD

GENERAL REQUIREMENTS FOR ELECTRONIC EQUIPMENT SPECIFICATIONS

AMSC N/A AREA GDRQ

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FOREWORD

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

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, Code SEA 03Q42, Washington, D.C. 20362-5101 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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1. SCOPE.

1.1 Scope. This standard covers the policy guidance, and general and detailed requirements, for the preparation of specifications for electronic equipment used in shipboard (including submarines) and space applications. This document provides guidance for the use of commercial-off-the-shelf (COTS), ruggedized, and militarized equipment. Requirements shall be based on the installation and intended use of the equipment.

1.1.1 Usage. The requirements of this standard shall be tailored for all applications (see 4.1.4). This does not allow the specifier to disregard a requirement. All requirements specified herein shall be considered and evaluated by the specifier. Tailoring shall not to be based solely on the capabilities of the equipment being procured and the subjective opinion of the specifier. Tailoring decisions shall take into account the mission of the equipment, and the projected operating environment of the equipment based on analytical and/or measured field data. Tailoring decisions shall also reflect unique platform requirements, such as noise and hazardous material requirements for submarines.

1.2 Use. **This standard shall not be invoked on a blanket basis in end-item specifications.** Each requirement contained herein shall be tailored to the application of the equipment (see 1.1.1 and 4.1.4).

1.3 Classification. Electronic equipment acquisition options available to the program manager include COTS, ruggedized, and militarized. The selection of the appropriate acquisition option is the responsibility of the program manager, and shall be dependent upon the expectations for the equipment, availability of NDI equipment, functional and service requirements for the equipment, and cost-benefit tradeoffs. The acceptable ranges for each option are shown on FIGURE 1. The shape of the COTS and ruggedized areas shown on FIGURE 1 is intended to illustrate that more equipment is available that conform to the minimal acceptable criteria than conform to the fully hardened criteria. Similarly, the shape of the militarized figure is intended to show that most militarized equipment is designed to the fully hardened criteria. Selected equipment may shutdown or go into a standby mode when specified operating limits are exceeded. However, as long as the support services and other interfaces remain within their specified limits, the equipment shall not be damaged by such excursions. The procuring activity shall coordinate requirements with platform integration activities to ensure that specification requirements meet platform unique constraints. **The specific requirements for each acquisition are the responsibility of the program manager and shall be tailored within the range of acceptable limits provided herein (see 4.1.4).**

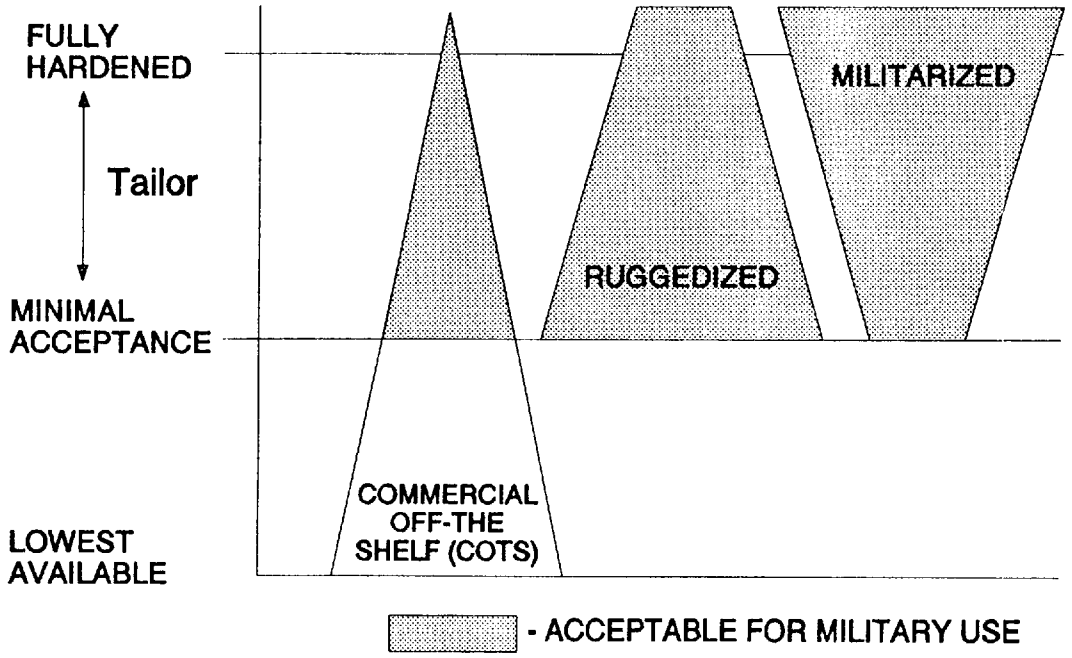

FIGURE 1. Acquisition options.

1.3.1 Specification type. The end item specification may be a design specification, a performance specification, or a hybrid of performance and design specifications. If the acquisition option is to be COTS, the specification type shall be performance. If the acquisition option is to be ruggedized, then the specification type may be either performance or a hybrid of performance and design. If the acquisition option is to be militarized, then the specification type may be performance, design, or a hybrid of performance and design. **The decision regarding the specification type is the responsibility of the program manager acquiring the equipment and is not to be left to the discretion of a contractor.**

1.3.1.1 Performance specification. A performance specification is a specification in which the equipment is treated as a black box, and the interfaces to the equipment are specified, as shown on FIGURE 2. FIGURE 2 is an example, and does not include all interfaces to the equipment. The interfaces shown in FIGURE 2 are service requirements, and include environmental conditions, support services, human factors, safety, operational constraints, and suitability requirements such as reliability, maintainability, test interfaces, supportability, operability, or producibility. These interfaces are separate from those required for functional requirements, such as I/O and target tracking. The performance specification permits the manufacturer to

perform the hardware and software design, and places the responsibility upon the specifier to ensure that all performance requirements are properly specified, and that the equipment is adequately tested to demonstrate that the equipment conforms to the performance requirements.

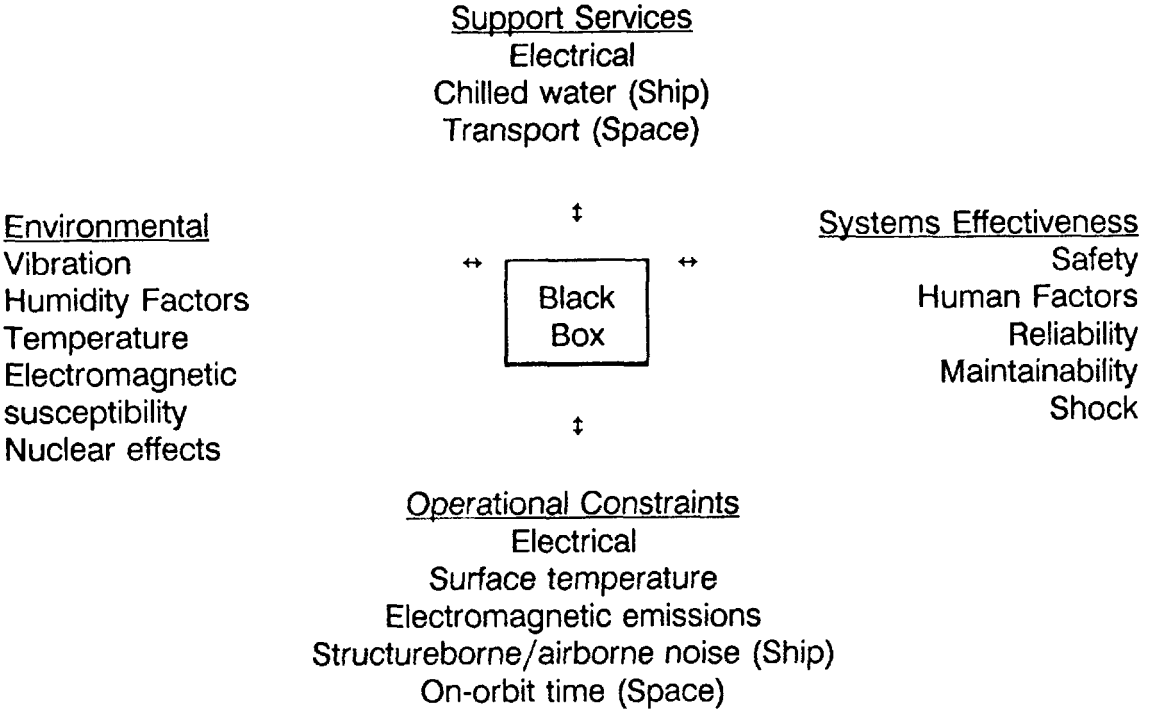

FIGURE 2. Services interfaces.

1.3.1.2 Design specification. A design specification is an end item specification in which the hardware and software are specified to the component level. The procuring activity controls the product design and production methods. It is the responsibility of the procuring activity to ensure the equipment conforms to all performance requirements.

1.4 Document organization. This document contains requirements for both ship and space applications. Applicable documents (Section 2.) and definitions (Section 3.) are applicable to both ship and space applications. Requirements have been separated into general requirements applicable to both ship and space applications (Section 4.), requirements specific to ship applications (5.1), and requirements specific to space applications (5.2). In their respective sections, requirements specific to each platform have been separated into performance and design requirements. The appendices represent a logical extension to the requirements, as invoked therein. The document organization is as shown on FIGURE 3.

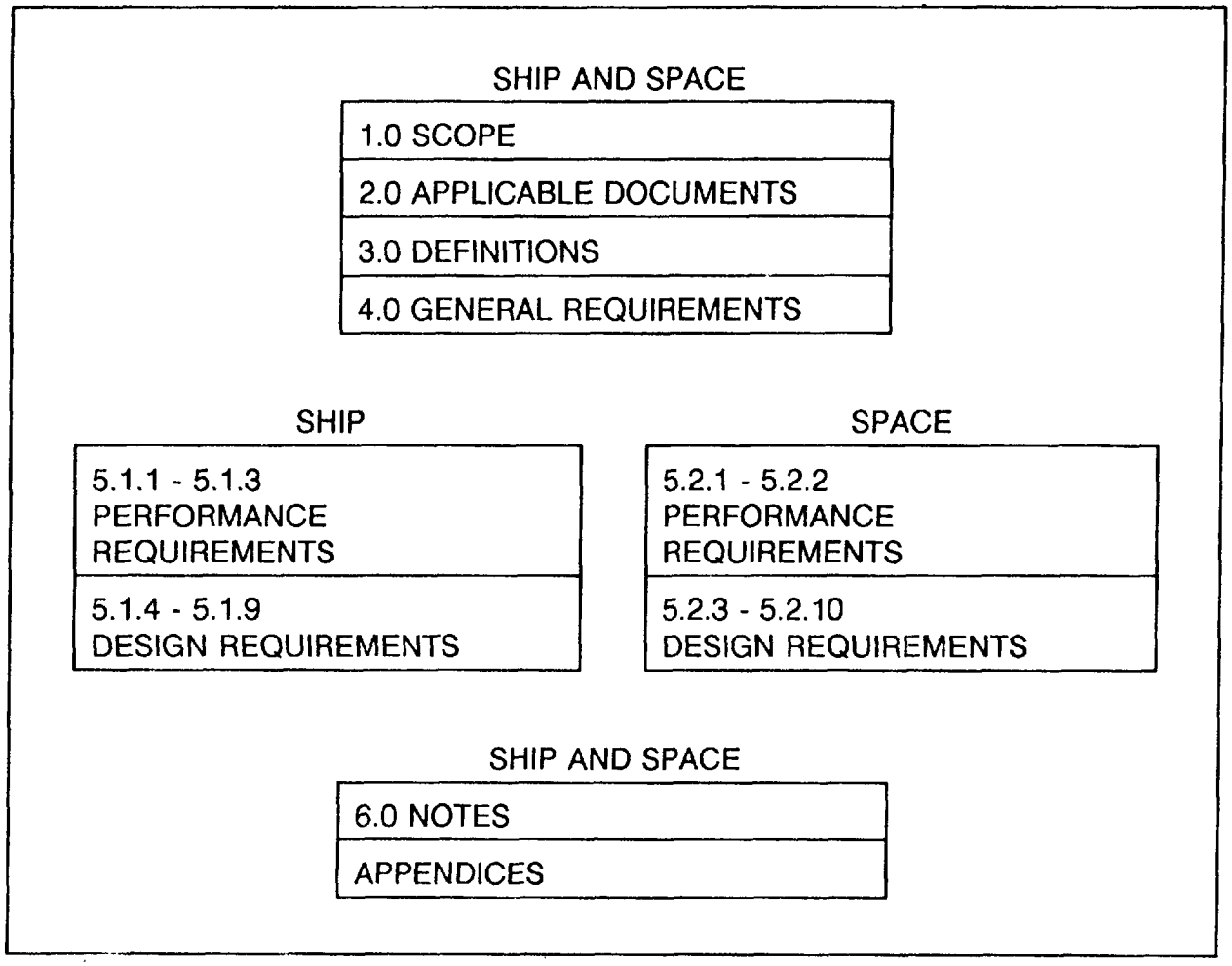

FIGURE 3. Document organization.

1.5 System classification (Ship). Equipment shall be classified as mission critical or non-mission critical, sheltered or non-sheltered, and nuclear hardened or non-nuclear hardened. Equipment noise grade shall be classified in accordance with MIL-STD-740-1 (see 5.1.3.1).

1.5.1 Tailoring of requirements. TABLE I provides guidance for tailoring requirements. Mission critical equipment shall be fully hardened (see 4.2.1) as applicable. Equipment which is exposed to weather and other external conditions shall be fully hardened for those conditions (see 3.2.50 and 3.2.57). TABLE I does not include general requirements (see Section 4.), nuclear effects (see 5.1.2.11), or conditions where fully hardened and minimal acceptance criteria are the same (see 5.1.2.1, 5.1.2.3, 5.1.2.19

and 5.1.3). TABLE I shall be tailored based on the application of the equipment. The program manger must coordinate proposed equipment specifications with platform managers to insure that requirements satisfy the platform's complete operation envelope, for example, space and weight restrictions, and so forth.

TABLE I. Shipboard tailoring matrix.

REQUIREMENT	PARAGRAPH	MINIMAL ACCEPTANCE	FULLY HARDENED
Conditions apparent throughout the ship			
Auxiliary support services	5.1.1	← TAILOR →	
Ship motion and attitude	5.1.2.13		
Shock	5.1.2.14	Non-mission	Mission
DC magnetic field	5.1.2.2	Critical	Critical
Spray tight enclosures	5.1.2.16		
Temperature	5.1.2.17		
Humidity	5.1.2.7		
External effects			
Greenwater loading	5.1.2.5	← TAILOR →	
Dust and sand	5.1.2.4		
Gun muzzle	5.1.2.6	Sheltered	Un-sheltered
Hydrostatic pressure	5.1.2.8		
Missile exhaust	5.1.2.10		
Icing	5.1.2.9		
Wind	5.1.2.20		
Salt fog	5.1.2.12		
Solar radiation	5.1.2.15		
Underwater explosion	5.1.2.18		

1.6 System classification (Space). Systems shall be classified as Class I, II, III and IV in accordance with the TABLE II.

TABLE II. System classifications.

CLASSIFICATION	PRIORITY	EXAMPLES
Class I	Very high	Shuttle; Hubble; Mission critical equipment
Class II	High	Global positioning systems; permanent C^4I systems
Class III	Medium	Temporary C^4I systems
Class IV	Low	Academic experiments

1.6.1 Tailoring of requirements. Equipment procured to a common system shall be procured to the same guidelines and classification. Probability of mission success (see 4.9), confidence level in design life validation (see APPENDIX A), and environmental design level (see 5.2.2) shall be based on the system classification in accordance with TABLE III.

TABLE III. Tailoring requirements.

SYSTEM CLASSIFICATION	PROBABILITY OF MISSION SUCCESS (PERCENT)	CONFIDENCE LEVEL IN DESIGN LIFE VALIDATION (PERCENT)	ENVIRONMENTAL CLASSIFICATION
Class I	> 99.9	99	Fully hardened
Class II	99	95	Tailored
Class III	97	93	Tailored
Class IV	95	90	Minimal acceptance

2. APPLICABLE DOCUMENTS.

2.1 Government documents.

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

SPECIFICATIONS

FEDERAL

QQ-P-35	Passivation Treatments for Corrosion-Resistant Steel
QQ-A-200	Aluminum Alloy, Bar, Rod, Shapes, Structural Shapes, Tube and Wire, Extruded; General Specification for
QQ-A-200/1	Aluminum Alloy 3003, Bar, Rod, Shapes, Tube and Wire, Extruded
QQ-A-200/4	Aluminum Alloy 5083, Bar, Rod, Shapes, Structural Shapes, Tube and Wire, Extruded
QQ-A-200/8	Aluminum Alloy 6061, Bar, Rod, Shapes, Tube and Wire, Extruded
QQ-A-225	Aluminum and Aluminum Alloy Bar, Rod, Wire, or Special Shapes; Rolled, Drawn, or Cold Finished; General Specification for
QQ-A-225/2	Aluminum Alloy Bar, Rod, and Wire; Rolled, Drawn, or Cold Finished, 3003
QQ-A-225/7	Aluminum Alloy 5052, Bar, Rod, and Wire; Rolled, Drawn, or Cold Finished
QQ-A-225/8	Aluminum Alloy 6061, Bar, Rod, Wire and Special Shapes; Rolled, Drawn or Cold Finished
QQ-A-250	Aluminum and Aluminum Alloy Plate and Sheet: General Specification for
QQ-A-250/2	Aluminum Alloy 3003, Plate and Sheet
QQ-A-250/8	Aluminum Alloy 5052, Plate and Sheet
QQ-A-250/11	Aluminum Alloy 6061, Plate and Sheet
QQ-N-281	Nickel-Copper Alloy Bar, Rod, Plate, Sheet, Strip, Wire, Forgings, and Structural and Special Shaped Sections
QQ-N-286	Nickel-Copper-Aluminum Alloy, Wrought (UNS N05500)
QQ-N-290	Nickel Plating (Electrodeposited)
QQ-Z-301	Zinc sheet and strip
QQ-C-320	Chromium Plating (Electrodeposited)
QQ-S-365	Silver Plating, Electrodeposited: General Requirements for
W-F-406	Fittings for Cable, Power, Electrical and Conduit, Metal, Flexible

TT-C-490	Cleaning Methods for Ferrous Surfaces and Pretreatments for Organic Coatings
QQ-C-502	Copper Rods and Shapes; and Flat Products With Finished Edges (Flat Wire, Strips and Bars)
QQ-A-591	Aluminum Alloy Die Castings
QQ-A-596	Aluminum Alloy Permanent and Semipermanent Mold Castings
QQ-B-639	Brass, Naval: Flat Products (Plate, Bar, Sheet, and Strip)
TT-P-645	Primer, Paint, Zinc-Molybdate, Alkyd Type
QQ-B-654	Brazing Alloys, Silver
TT-P-664	Primer Coating, Alkyd, Corrosion-Inhibiting, Lead and Chromate Free, VOC-Compliant
WW-T-700	Tube, Aluminum and Aluminum Alloy, Drawn, Seamless, General Specification for
WW-T-700/2	Tube, Aluminum, Alloy, Drawn, Seamless, 3003
WW-T-700/4	Tube, Aluminum Alloy, Drawn, Seamless, 5052
WW-T-700/6	Tube, Aluminum Alloy, Drawn, Seamless, 6061
J-W-1177	Wire, Magnet, Electrical, General Specification for

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MIL-C-17	Cables, Radio Frequency, Flexible and Semirigid, General Specification for
MIL-T-27	Transformers and Inductors (Audio, Power, and High-Power Pulse), General Specification for
MIL-S-61	Shunt, Instrument, External, 50 millivolt (Lightweight Type)
MIL-V-173	Varnish, Moisture-and-Fungus-Resistant (for Treatment of Communications, Electronic, and Associated Equipment)
MIL-T-704	Treatment and Painting of Materiel
MIL-S-901	Shock Tests, H.I. (High-Impact) Shipboard Machinery, Equipment, and Systems, Requirements for
MIL-S-1222	Studs, Bolts, Hex Cap Screws, Socket Head Cap Screws, and Nuts
MIL-I-1361	Instrument Auxiliaries, Electrical Measuring; Shunts, Resistors, and Transformers
MIL-E-2036	Enclosures for Electric and Electronic Equipment
MIL-C-2212	Contactors and Controllers, Electric Motor AC or DC, and Associated Switching Devices
MIL-R-2765	Rubber Sheet, Strip, Extruded, and Molded Shapes, Synthetic, Oil Resistant
MIL-G-3036	Grommets, Rubber, Hot-Oil and Coolant Resistant
MIL-M-3171	Magnesium Alloy, Processes for Pretreatment and Prevention of Corrosion on

MIL-D-3464	Desiccants, Activated, Bagged, Packaging Use and Static Dehumidification
MIL-G-3787	Glass, Laminated, Flat; (Except Aircraft)
MIL-L-3890	Lines, Radio Frequency Transmission (Coaxial, Air Dielectric)
MIL-S-4040	Solenoid, Electrical, General Specification for
MIL-C-5015	Connectors, Electrical, Circular Threaded, AN Type, General Specification for
MIL-B-5087	Bonding, Electrical and Lightning Protection, for Aerospace Systems
MIL-G-5514	Gland Design: Packings, Hydraulic, General Requirements for
MIL-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-W-6858	Welding, Resistance, Spot and Seam
MIL-F-7179	Finishes, Coatings, and Sealants for the Protection of Aerospace Weapons Systems
MIL-S-7742	Screw Threads, Standard, Optimum Selected Series: General Specification for
MIL-P-7788	Panels, Information, Integrally Illuminated
MIL-M-7793	Meter, Time Totalizing
MIL-B-7883	Brazing of Steels, Copper, Copper Alloys, Aluminum and Aluminum Alloys
MIL-S-8516	Sealing Compound, Polysulfide Rubber, Electric Connectors and Electric Systems, Chemically Cured
MIL-A-8625	Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-S-8660	Silicone Compound, NATO Code Number S-736
MIL-S-8879	Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification for
MIL-W-8939	Welding, Resistance, Electronic Circuit Modules
MIL-Q-9858	Quality Program Requirements
MIL-C-11693	Capacitors, Feed Through, Radio-Interference Reduction AC and DC (Hermetically Sealed in Metal Cases), Established and Non-Established Reliability, General Specification for
MIL-S-12285	Switch, Thermostatic
MIL-S-13282	Silver and Silver Alloy
MIL-F-14072	Finishes for Ground Electronic Equipment
MIL-C-14550	Copper Plating, (Electrodeposited)
MIL-P-15024	Plates, Tags and Bands for Identification of Equipment
MIL-P-15024/5	Plates, Identification
MIL-E-15090	Enamel, Equipment, Light-Gray (Formula No. 111)
MIL-R-15624	Rubber Gasket Material, 50 Durometer Hardness (Maximum)
MIL-C-15726	Copper-Nickel Alloy, Sheet, Plate, Strip, Bar, Rod and Wire
DOD-P-16232	Phosphate Coatings, Heavy, Manganese or Zinc Base (for Ferrous Metals)
MIL-F-16552	Filters, Air Environmental Control System, Cleanable, Impingement (High Velocity Type)

MIL-I-16923	Insulating Compound, Electrical, Embedding
MIL-F-17111	Fluid, Power Transmission
MIL-C-17112	Copper-Nickel-Zinc Alloy (Nickel-Silver): Castings
MIL-I-17214	Indicator, Permeability; Low-Mu (Go-No Go)
MIL-S-15743	Switches, Rotary, Enclosed
MIL-S-18396	Switches, Meter and Control, Naval Shipboard
MIL-B-17931	Bearings, Ball, Annular, for Quiet Operation
MIL-N-18307	Nomenclature and Identification for Aeronautical Systems Including Joint Electronic Type Designated Systems and Associated Support Systems
MIL-W-18326	Welding of Magnesium Alloys, Gas and Arc, Manual and Machine Processes for
MIL-H-19457	Hydraulic Fluid, Fire-Resistant, Non-Neurotoxic
MIL-S-19622	Stuffing Tubes, Nylon; and Packing Assemblies; General Specification for
MIL-C-20159	Copper-Nickel Alloy Castings (UNS C96200 and C96400)
MIL-A-21180	Aluminum-Alloy Castings, High Strength
MIL-C-22087	Copper Alloy Investment Castings
MIL-C-22520	Crimping Tools, Terminal Hand or Power Actuated, Wire Termination, and Tool Kits, General Specification for
MIL-G-22529	Grommets; Plastic
MIL-C-22931	Cable, Radio Frequency, Semirigid, Coaxial, Semi-Air Dielectric, General Specification for
MIL-B-23071	Blowers, Miniature, for Cooling Electronic Equipment, General Specification for
MIL-D-23140	Drawings, Installation Control, For Shipboard Electronic Equipment
MIL-P-23377	Primer Coatings: Epoxy, Chemical and Solvent Resistant
MIL-S-23586	Sealing Compound, Electrical, Silicone Rubber, Accelerator Required
MIL-C-23806	Cable, Radio Frequency, Coaxial, Semirigid, Foam Dielectric, General Specification for
MIL-M-24041	Molding and Potting Compound, Chemically cured, Polyurethane (Polyether Based)
MIL-C-24231	Connectors, Plugs, Receptacles, Adapters, Hull Inserts, and Hull Insert Plugs, Pressure-Proof, General Specification for
MIL-C-24308	Connector, Electric, Rectangular, Miniature Polarized Shell, Rack and Panel, General Specification for
MIL-P-24441/1	Paint, Epoxy-Polyamide, Green Primer, Formula 150, Type I
MIL-P-24441/3	Paint, Epoxy-Polyamide, Topcoat, White, Formula 152, Type I
MIL-P-24441/6	Paint, Epoxy-Polyamide, Exterior Topcoat, Dark Gray, Formula 155-Ro = 6, Type I
MIL-E-24635	Enamel, Silicone Alkyd Copolymer
MIL-C-24640	Cable, Electrical, Lightweight for Shipboard Use, General Specification for

MIL-C-24643	Cable and Cord, Electrical, Low Smoke, for Shipboard Use, General Specification for
MIL-C-24723	Castings, Nickel-Copper Alloy
MIL-C-24758	Conduit, Flexible, Weatherproof and Associated Fittings, General Specification for
MIL-E-24762	Enclosures for Electronic Equipment, Survivable, Naval Shipboard Use
MIL-P-24764	Power Supplies, Shipboard, Electronic, General Specification for
MIL-P-25732	Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Limited Service at 275°F (135°C)
MIL-C-26074	Coatings, Electroless Nickel, Requirements for
MIL-C-26482	Connector, Electrical, (Circular, Miniature, Quick Disconnect, Environment Resisting) Receptacles and Plugs, General Specification for
MIL-C-28731	Connectors, Electrical, Rectangular, Removable Contact, Formed Blade, Fork Type (for Rack and Panel and other applications), General Specification for
MIL-C-28777	Cable Assembly, Electronic Test Equipment (3 Wires, 125 and 250 Volts AC and 28 Volts DC) Grounding Plug Connector, General Specification for
MIL-M-28787	Modules, Standard Electronic, General Specification for
MIL-C-28790	Circulators, Radio Frequency, General Specification for
MIL-T-28800	Test Equipment for Use With Electrical and Electronic Equipment, General Specification for
MIL-R-28803	Readouts, Segmented, General Specification for
MIL-C-28840	Connectors, Electrical, Circular Threaded, High Density, High Shock Shipboard, Class D, General Specification for
MIL-T-31000	Technical Data Packages, General Specification for
MIL-C-38999	Connectors, Electric, Circular Miniature, High Density, Quick Disconnect, Environment Resistant, Removable Crimp Contacts, General Specification for
MIL-C-39012	Connector, Coaxial, Radio Frequency, General Specification for
MIL-M-45202	Magnesium Alloys, Anodic Treatment of
MIL-G-45204	Gold Plating, Electrodeposited
MIL-I-45208	Inspection System Requirements
MIL-I-46058	Insulating Compound, Electrical (for Coating Printed Circuit Assemblies)
MIL-M-46062	Magnesium Alloy Castings, High Strength
MIL-R-46085	Rhodium Plating, Electrodeposited
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment and Facilities
MIL-C-49055	Cables, Power, Electrical, (Flexible, Flat, Unshielded), (Round Conductor), General Specification for

MIL-C-49059	Cable, Electrical (Flexible, Flat, Unshielded), (Flat Conductor), General Specification for
MIL-P-55110	Printed Wiring Boards
MIL-C-55514	Capacitors, Fixed, Plastic (or Metalized Plastic) Dielectric, DC or DC-AC, in Nonmetal Cases, Established Reliability, General Specification for
MIL-T-55631	Transformers; Intermediate Frequency, Radio Frequency and Discriminator, General Specification for
MIL-G-81168	Gyroscope, Rate Integrating
MIL-I-81550	Insulating Compound, Electrical, Embedding, Reversion Resistant Silicone
MIL-C-81562	Coatings, Cadmium, Tin-Cadmium and Zinc (Mechanically Deposited
MIL-C-81703	Connectors, Electric, Circular, Miniature, Rack and Panel or Push-Pull Coupling, Environment Resisting
MIL-C-83286	Coating, Urethane, Aliphatic Isocyanate, for Aerospace Applications
MIL-P-83461	Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Improved Performance at 275°F (135°C)
MIL-W-83575	Wiring Harness, Space Vehicle, Design and Testing, General Specification for
MIL-A-83577	Assemblies, Moving Mechanical, for Space Vehicles, General Specification for
DOD-E-83578	Explosive Ordnance for Space Vehicles, General Specification for
MIL-T-83721	Transformers, Variable, Power, General Specification for
MIL-S-83731	Switch, Toggle, Unsealed and Sealed Toggle, General Specification for
MIL-C-83723	Connectors, Electric, Circular, (Environment Resisting), Receptacles and Plugs, General Specification for
MIL-C-83733	Connector, Plug and Receptacle, Electrical, Miniature, Rectangular Type, Rack to Panel, Environment Resisting, 200 Degrees C Total Continuous Operating Temperature, High Reliability, General Specification for
MIL-D-87157	Displays, Diode, Light Emitting, Solid State, General Specification for
MS-33540	Safety Wiring and Cotter Pinning, General Practices for

STANDARDS

FEDERAL

FED-STD-H28	Screw-Thread Standards for Federal Services
FED-STD-H28/7	Screw-Thread Standards for Federal Services Section 7 Pipe Threads, General Purpose

FED-STD-209	Clean Room and Work Station Requirements, Controlled Environment
FED-STD-313	Material Safety Data, Transportation Data and Disposal for Hazardous Materials Furnished to Government Activities
FED-STD-595	Colors Used in Government Procurement

MILITARY

MIL-STD-12	Abbreviations for Use on Drawings, and in Specifications, Standards and Technical Documents
MIL-STD-100	Engineering Drawing Practices
MIL-STD-108	Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-167-1	Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type II - Internally Excited)
MIL-STD-188-200	System Design and Engineering Standards for Tactical Communications
MIL-STD-196	Joint Electronics Type Designation System
MIL-STD-198	Capacitors, Selection and Use Of
MIL-STD-200	Electron Tubes, Selection and Use of
MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-STD-210	Climatic Information to Determine Design and Test Requirements for Military Systems and Equipment
MIL-STD-242, part 1	Electronic Equipment Parts Selected Standards, Synchros, Blowers and Acoustical Parts
MIL-STD-242, part 3	Electronic Equipment Parts Selected Standards, Resistors
MIL-STD-242, part 4	Electronic Equipment Parts Selected Standards, Capacitors
MIL-STD-242, part 6	Electronic Equipment Parts Selected Standards, Relays
MIL-STD-242, part 7	Electronic Equipment Parts Selected Standards, Switches
MIL-STD-242, part 8	Electronic Equipment Parts Selected Standards, Connectors and Sockets
MIL-STD-242, part 9	Electronic Equipment Parts Selected Standards, Fuses, Lamps and Meters
MIL-STD-242, part 10	Electronic Equipment Parts Selected Standards, Wire and Cable
MIL-STD-242, part 11	Electronic Equipment Parts Selected Standards, Radio Frequency Components
MIL-STD-242, part 12	Electronic Equipment Parts Selected Standards, Hardware and Insulators
MIL-STD-275	Printed Wiring for Electronic Equipment
MIL-STD-280	Definitions of Item Levels, Item Exchangeability, Models, and Related Terms.

MIL-STD-415	Test Provisions for Electronic Systems and Associated Equipment, Design Criteria for
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-469	Radar Engineering Design Requirements, Electromagnetic Compatibility
MIL-STD-470	Maintainability Program for Systems and Equipment
MIL-STD-471	Maintainability Verification/Demonstration/Evaluation
MIL-STD-490	Specification Practices
MIL-STD-499	Engineering Management
MIL-STD-701	List of Standard Semi-conductor Devices
MIL-STD-740-1	Airborne Sound Measurements and Acceptance Criteria of Shipboard Equipment
MIL-STD-740-2	Structureborne Vibratory Acceleration Measurements and Acceptance Criteria of Shipboard Equipment
MIL-STD-781	Reliability Testing for Engineering Development, Qualification, and Production
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production
MIL-STD-810	Environmental Test Methods and Engineering Guidelines
MIL-STD-882	System Safety Program Requirement
MIL-STD-889	Dissimilar Metals
MIL-STD-961	Military Specifications and Associated Documents, Preparation of
MIL-STD-965	Parts Control Program
MIL-STD-970	Standards and Specifications, Order of Preference for the Selection of
MIL-STD-973	Configuration Management
MIL-STD-1132	Switches and Associated Hardware, Selection and Use of
MIL-STD-1246	Product Cleanliness Levels and Contamination Control Program
MIL-STD-1250	Corrosion Prevention and Deterioration Control in Electronic Components and Assemblies
MIL-STD-1279	Meters, Electrical Indicating, Selection and Use of
MIL-STD-1286	Transformers, Inductors, and Coils, Selection and Use of
MIL-STD-1310	Shipboard Bonding, Grounding, and other Techniques for Electromagnetic Compatibility and Safety
MIL-STD-1378	Requirements for Employing Standard Electronic Modules
MIL-STD-1388-1	Logistic Support Analysis
MIL-STD-1390	Level of Repair
MIL-STD-1395	Filters and Networks, Selection and Use of
MIL-STD-1397	Input/Output Interfaces, Standard Digital Data, Navy Systems

DOD-STD-1399, Section 070, Part 1	Interface Standard for Shipboard Systems, DC Magnetic Field Environment (Metric)
DOD-STD-1399, Section 071	Interface Standard for Shipboard Systems, Mass/Size/Shape, Shipboard Units (Metric)
MIL-STD-1399, Section 072, Part 1	Interface Standard for Shipboard Systems, Blast Environment, Missile Exhaust
MIL-STD-1399, Section 072, Part 2	Interface Standard for Shipboard Systems, Blast Environment, Gun Muzzle
MIL-STD-1399, Section 102	Interface Standard for Shipboard Systems, Low Pressure Dry Air Service for Surface Ships
MIL-STD-1399, Section 105	Interface Standard for Shipboard Systems, Sea Water Service for Surface Ships
MIL-STD-1399, Section 106	Interface Standard for Shipboard Systems, Compressed Air Service for Surface Ships
MIL-STD-1399, Section 300	Interface Standard for Shipboard Systems, Electric Power Alternating Current (Metric)
MIL-STD-1399, Section 301	Interface Standard for Shipboard Systems, Ship Motion and Attitude (Metric)
MIL-STD-1399, Section 390	Interface Standard for Shipboard Systems, Electric Power, Direct Current, (Other Than Ship's Battery) for Submarines (Metric)
DOD-STD-1399, Section 406	Interface Standard for Shipboard Systems, Digital Computer Grounding (Metric)
DOD-STD-1399, Section 441	Interface Standard for Shipboard Systems, Precise Time and Time Interval (PTTI)
MIL-STD-1399, Section 502	Interface Standard for Shipboard Systems, Electronics Systems Parameters
DOD-STD-1399, Section 532	Interface Standard for Shipboard Systems, Cooling Water for Support of Electronic Equipment (Metric)
MIL-STD-1399, Section 702	Interface Standard for Shipboard Systems, Synchro Data Transmission
MIL-STD-1472	Human Engineering Design Criteria
MIL-STD-1515	Fasteners Used in the Design and Construction of Aerospace Mechanical Systems
MIL-STD-1516	Unified Code for Coatings and Finishes for DOD Materiel
MIL-STD-1539	Electrical Power, Direct Current, Space Vehicle Design Requirements
MIL-STD-1540	Test Requirements for Space Vehicles
MIL-STD-1541	Electromagnetic Compatibility Requirements for Space Systems
MIL-STD-1543	Reliability Program Requirements for Space and Missile Systems
MIL-STD-1547	Electronic Parts, Materials and Processes for Space and Launch Vehicles
MIL-STD-1629	Procedures for Performing a Failure Mode Effects and Criticality Analysis

MIL-STD-1661	Mark and Mod Nomenclature System
MIL-STD-1683	Connectors and Jacketed Cable, Electric, Selection Standard for Shipboard Use
MIL-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) (Metric)
MIL-STD-1809	Space Environment for USAF Space Vehicles
MIL-STD-1815	Ada Programming Language
MIL-STD-1838	Common Ada Programming Support Environment (APSE) Interface Set (CAIS)
MIL-STD-1839	Calibration and Measurement Requirements
MIL-STD-2000	Standard Requirements for Soldered Electrical and Electronic Assemblies
DOD-STD-2003-3	Electric Plant Installation Standard Methods for Surface Ships and Submarines (Penetrations)
MIL-STD-2038	Requirements for Employing Standard Power Supplies
DOD-STD-2143	Magnetic Silencing Requirements for the Construction of Nonmagnetic Ships and Craft (Metric)
MIL-STD-2165	Testability Program for Electronic Systems and Equipment
DOD-STD-2167	Defense System Software Development
DOD-STD-2168	Defense Standard Software Quality Evaluation
MIL-STD-2200	Requirements for Employing Standard Enclosure Systems
MIL-STD-6866	Inspection, Liquid Penetrant

HANDBOOKS

MIL-HDBK-5	Metallic Material and Elements for Aerospace Vehicle Structures
MIL-HDBK-217	Reliability Prediction of Electronic Equipment
MIL-HDBK-225	Synchros Description and Operation
MIL-HDBK-235-1	Electromagnetic (Radiated) Environment Considerations for Design and Procurement of Electrical and Electronic Equipment, Subsystems and Systems
MIL-HDBK-235-2	Electromagnetic Radiation Environment From Friendly or Own Force Emitters
MIL-HDBK-235-3	Electromagnetic Radiation Environment From Hostile Force Emitters
MIL-HDBK-235-4	Electromagnetic Radiation Environment, Army Installations
MIL-HDBK-237	Electromagnetic Compatibility Management Guide for Platforms, Systems and Equipment
MIL-HDBK-241	Design Guide for Electromagnetic Interference (EMI) Reduction in Power Supplies
MIL-HDBK-246	Program Managers Guide for the Standard Electronic Modules Program
MIL-HDBK-251	Reliability/Design Thermal Applications

MIL-HDBK-263	Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) (Metric)
MIL-HDBK-287	Tailoring Guide for DOD-STD-2167A, Defense System Software Development
MIL-HDBK-340	Application Guidelines for MIL-STD-1540; Test Requirements for Space Vehicles
MIL-HDBK-472	Maintainability Prediction
MIL-HDBK-700	Plastics
MIL-HDBK-722	Glass

(Unless otherwise indicated, copies of Federal and military specifications, standards, and handbooks are available from the DODSSP - Customer Service, Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.1.2 Other Government documents, drawings, and publications. The following other documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the DODISS, and supplement thereto, cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS shall be those in effect on the date of the solicitation.

PUBLICATIONS

ASSISTANT SECRETARY OF DEFENSE

SD-2	Nondevelopmental Item Program, Buying NDI

(Application for copies should be addressed to The Office of the Assistant Secretary of Defense for Production and Logistics, Washington, DC 20301-8000.)

ASSISTANT SECRETARY OF THE NAVY

TAAF	The Test, Analyze, and Fix (TAAF) Process; A Technical Brief for TAAF Implementation
Tri-Service Technical Brief 002-93-08	Environmental Stress Screening Guidelines

(Application for copies should be addressed to The Office of the Assistant Secretary of the Navy (Research, Development, and Acquisition), Product Integrity, Washington, DC 20360-5000.)

DEPARTMENT OF COMMERCE

NTIA Manual of Regulation — Manual of Regulations and Procedures for Federal Radio Frequency Management

(Application for copies should be addressed to United States Department of Commerce, National Telecommunications and Information Administration, Washington, DC 20230.)

DEPARTMENT OF DEFENSE (DOD)

DOD 4120.3-M — Defense Standardization and Specification Program Policies, Procedures and Instructions
DOD 4245.7-M — Transition From Development to Production
DOD DIR 3405.1 — Computer Programming Language Policy
DOD Directive 4245.4 — Acquisition of Nuclear Series Cable Systems
DOD INST 5000.2 — Defense Acquisition Management Policies/Procedures

(Application for copies should be addressed to the DODSSP - Customer Service, Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

FEDERAL REGULATIONS

29 CFR 1910 — Code of Federal Regulations, Title 29, Part 1910
47 CFR 15 — Code of Federal Regulations, Title 47, Part 15

(The Code of Federal Regulations (CFR) and the Federal Register (FR) are for sale on a subscription basis by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. When indicated, reprints of certain regulations may be obtained from the Federal agency responsible for issuance thereof.)

GENERAL SERVICES ADMINISTRATION (GSA)

FPMR 101-29 — Federal Standardization
NAVSO P-6071 — Best Practices

(Application for copies should be addressed to the Superintendent of Documents, US Government Printing Office, Washington, DC 20402.)

CHIEF OF NAVAL OPERATIONS (CNO)

SECNAVINST 5200.32 — Management of Embedded Computer Resources in Department of the Navy Systems

OPNAVINST 1500.2	Responsibilities and Procedures for Establishment and Coordination of Contractor - Developed Training For Military and Civilian Personnel
OPNAVINST 1500.8	Navy Training Planning Process
OPNAVINST 1500.44	Responsibilities for Development of Personnel Training Requirements and Related Plans
OPNAVINST 3000.12	Operational Availability of Equipment and Weapons Systems
OPNAVINST C5510.93	Navy Implementation of National Policy on Control of Compromising Emanations (limited distribution)

(Application for copies should be addressed to the DODSSP - Customer Service, Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

40M38277	Connectors, Electrical, Circular, Miniature, High Density, Environment Resisting, Specification for
40M38298	Connector, Electrical, Special Miniature Circular, Environment Resisting, 200°C, Specification for
40M39569	Connectors, Electrical, Miniature Circular, Environment Resisting, 200°C, Specification for
NASA-STD-3000	Manned System Integration Standard
NASA Reference Publication 1061	Outgassing Data for Space Vehicles
NASA Technical Paper 2361	Design Guidelines for Assessing and Controlling Charging Effects
NHB 1700.7	Safety Policy and Requirements for Payloads Using the Space Transportation System (STS)
SAMTO HB S-100 (KHB 1700.7)	Space Transportation System Payload Ground Safety Handbook.

(Unless otherwise indicated, copies of Federal and military specifications, standards, and handbooks are available from the DODSSP - Customer Service, Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

FIPS PUB 1-2	Code for Information Interchange, Its Representation, Subsets and Extensions
FIPS PUB 119	Ada
NAVMAT P-4855-1 (NAVSO P-3641)	Navy Power Supply Reliability Design and Manufacturing Guidelines (Stock No. 0518-LP-204-4800)

NAVSO P-3634 Sneak Circuit Analysis (Stock No. 0518-LP-394-8010)

NAVSO P-3651 Thick Film Ceramic Boards with Leadless Components (Stock No. 0518-LP-394-8400)

NAVSO P-3676 Navy Primary and Secondary Batteries (Stock No. 0518-LP-207-7600)

TE000-AB-GTP-010 Parts Derating Requirements and Application Manual for Navy Electronic Equipment (Stock No. 0910-LP-494-5300)

(Unless otherwise indicated, copies of documents are available to Government agencies from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099. Copies of documents are available to non-Government agencies from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22151.)

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

MIL-STD-1680 Installation Criteria for Shipboard Secure Electrical Information Processing Systems (classified)

S9510-AB-ATM-010 Nuclear Powered Submarine Atmosphere Control Manual

S9407-AB-ATM-010 Nuclear Powered Submarine Atmosphere Control Manual (Classified)

S9086-VD-STM-101/CH-631 V1 Naval Ships' Technical Manual, Chapter 631, Volume 1, Preservation of Ships in Service - General

S9086-VD-STM-101/CH-631 V2 Naval Ships' Technical Manual, Chapter 631, Volume 2, Preservation of Ships in Service - Surface Preparation and Painting

S9086-VD-STM-101/CH-631 V3 Naval Ships' Technical Manual, Chapter 631, Volume 3, Preservation of Ships in Service - Surface Ship/Submarine Applications

(Application for copies should be addressed to the Commander, Naval Sea Systems Command, Washington, DC 20362-5101.)

NAVSEA INST C3401.1 Nuclear Survivability Design Standards for Surface Ships of the U. S. Navy. (limited distribution)

(Application for copies should be addressed to the Commander, Naval Sea Systems Command (Code 09P21), Washington, DC 20362-5101.)

NAVAL SURFACE WARFARE CENTER DAHLGREN DIVISION (NSWCDD)

NSWC TR 87-192	Suggested Electronic Equipment Standards for Nuclear Weapons Environments
NSWC TR 90-22	Basic Nuclear Survivability Concepts for Navy Computational Electronics

(Application for copies should be addressed to the Commanding Officer, Naval Surface Warfare Center Dahlgren Division, Dahlgren, VA 22448-5000.)

NAVAL SURFACE WARFARE CENTER CRANE DIVISION (NSWC CRANE DIVISION)

SHARP TP-001	Standard Battery Systems - Preferred Standard Battery List

(Application for copies should be addressed to the Naval Weapons Support Center, Code 602, Building 2940, Crane, IN 47522-5060.)

TM S9310-AQ-SAF-010	Technical Manual for Batteries, Navy Lithium Safety Program Responsibilities and Procedures

(Application for copies should be addressed to the Naval Weapons Support Center, Code 3057, Building 36, Crane, IN 47522-5060.)

DRAWINGS

DEFENSE ELECTRONICS SUPPLY CENTER (DESC)

DESC 87060	Circuit Breakers, Magnetic, Panel Seal, Shock Enhanced, Trip-Free, Series Trip, Single Pole (0.2 to 30 Amperes)
DESC 87061	Circuit Breakers, Magnetic, Panel Seal, Shock Enhanced, Trip-Free, Series Trip, Two Pole (0.2 to 30 Amperes)
DESC 87062	Circuit Breakers, Magnetic, Panel Seal, Shock Balanced, Trip Free, Series Trip, Three Pole (0.2 to 30 Amperes)

(Application for copies should be addressed to the Defense Electronics Supply Center, Attn: DESC-ES, 1507 Wilmington Pike, Dayton, OH 45444.)

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 these documents shall be those listed in the issue of the DODISS, and supplement thereto, cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS shall be those in effect on the date of the solicitation.

AMERICAN CONFERENCE OF GOVERNMENT AND INDUSTRIAL HYGIENISTS (ACGIH)

ACGIH ISBN 0-936-712-39-2 Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents in the Work Environment

(Copies can be obtained through any commercial bookstore.)

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI X3.131 Small Computer System Interface (SCSI)
ANSI X3T9.5 Fiber Distribution Data Interface (FDDI) Station Management (SMT)

(Applications for copies should be addressed to the American National Standards Institute, 11 West 42 Street, New York, NY 10036.)

AMERICAN SOCIETY OF HEATING AND AIR CONDITIONING ENGINEERS (ASHRAE)

ASHRAE Handbook HVAC Systems and Applications

(Application for copies should be addressed to the American Society of Heating and Air Conditioning Engineers, 1791 Tullie Circle, NE, Atlanta, GA 30329.)

AMERICAN SOCIETY FOR QUALITY CONTROL (ASQC)

ANSI/ASQC Q90 Quality Management and Quality Assurance Standards - Guidelines for Selection and Use
ANSI/ASQC Q91 Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation and Servicing
ANSI/ASQC Q92 Quality Systems - Model for Quality Assurance in Production and Installation
ANSI/ASQC Q93 Quality Systems - Model for Quality Assurance in Final Inspection and Test
ANSI/ASQC Q94 Quality Management and Quality System Elements - Guidelines

(Applications for copies should be addressed to the American Society for Quality Control, 310 West Wisconsin Avenue, Milwaukee, WI 53203.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 153 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 494 Standard Specification for Castings, Nickel and Nickel Alloy

ASTM B 16	Rod, Bar and Shapes for Use in Screw Machines, Free Cutting Brass
ASTM B 21	Rod, Naval Brass, Bar and Shapes (METRIC)
ASTM B 26	Aluminum-alloy Sand Castings
ASTM B 36	Brass Plate and Sheet, Strip and Rolled Bar
ASTM B 80	Magnesium Alloy Sand Castings
ASTM B 121	Plate, Leaded Brass, Sheet, Strip and Rolled Bar
ASTM B 122	Plate, Sheet, Strip, and Rolled Bar, Copper Nickel Tin Alloy, Copper Nickel Zinc Alloy, (Nickel Silver) and Copper Nickel Alloy
ASTM B 124	Copper and Copper Alloy Forging Rod Bar and Shapes
ASTM B 138	Manganese Bronze Rod, Bar and Shapes
ASTM B 139	Phosphor Bronze Rod, Bar, and Shapes, General Specification for
ASTM B 151	Rod and Bar, Copper-Nickel-Zinc Alloy (Nickel Silver) Wire and Copper-Nickel Alloy Wire
ASTM B 194	Copper-Beryllium Alloy Plate, Sheet, Strip and Rolled Bar
ASTM B 196	Copper-Beryllium Alloy Rod and Bar
ASTM B 197	Copper-Beryllium Alloy Wire
ASTM B 206	Copper-Nickel-Zinc Alloy (Nickel and Silver) Wire and Copper-Nickel Alloy Wire
ASTM B 545	Standard Specification for Electrodeposited Coatings of Tin
ASTM D 568	Rate of Burning and/or Extent and Time of Burning of Flexible Plastics in a Vertical Position, Test Method for
ASTM B 633	Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
ASTM D 635	Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position, Test Method for
ASTM D 1000	Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
ASTM D 1868	Standard Method for Detection and Measurement of Partial Discharge (Corona) Pulses in Evaluation of Insulation System
ASTM D 3951	Standard Practices for Commercial Packing
ASTM D 4169	Performance Testing of Shipping Containers and Systems, Practice of
ASTM E 595	Standard Test Method for Total Mass Loss and Collected Volatile Condensable Material From Outgassing in a Vacuum Environment
ASTM F 104	Standard Classification System for Nonmetallic Gasket Materials
ASTM F 1166	Standard Practices for Human Engineering Design for Marine Systems, Equipment and Facilities

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103-1187.)

ELECTRONIC INDUSTRIES ASSOCIATION (EIA)

EIA 310	Racks, Panels, and Associated Equipment
EIA RS-232	Interface Between Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange
EIA RS-422	Electrical Characteristics of Balanced Voltage Digital Interface Circuit

(Application for copies should be addressed to the Electronic Industries Association, 2001 Pennsylvania Avenue, NW, Washington, DC 20006.)

THE INSTITUTE FOR INTERCONNECTING AND PACKAGING ELECTRONIC CIRCUITS (IPC)

IPC L 125	Specification for Plastic substrates, Clad or Unclad, for High Speed / High Frequency Interconnections
IPC RB 276	Qualification and Performance Specification for Rigid Printed Boards
IPC HF 318	Microwave End Product Board Inspection and Test
IPC D 330	CIU Documents

(Application for copies should be addressed to the Institute for Interconnecting and Packaging Electronic Circuits, 7380 N. Lincoln Avenue, Lincolnwood, IL 60646.)

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 68-2-11Ka	Basic Environmental Testing Procedures, Part 2: Tests, Test Ka: Salt Mist
IEC 68-2-13	Basic Environmental Testing Procedures, Part 2: Tests, Test M: Low Air Pressure
IEC 68-2-30Db	Basic Environmental Testing Procedures, Part 2: Tests, Test Db and Guidance: Damp Heat, Cyclic (12 + 12 hour cycle)
IEC 68-2-3Ca	Basic Environmental Testing Procedures, Part 2: Tests, Test Ca: Damp Heat, Steady State

(Applications for copies should be addressed to the American National Standards Institute, 11 West 42 Street, New York, NY 10036.)

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE)

ANSI/IEEE 100	IEEE Standard Dictionary of Electrical and Electronic Terms
ANSI/IEEE 488.1	IEEE Standard Digital Interface for Programmable Instrumentation
ANSI/IEEE 696	IEEE Standard 696 Interface Devices
ANSI/IEEE 802.3	Information Processing Systems - Local Area Networks - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specification
ANSI/IEEE 802.5	Token Ring Access Method and Physical Layer Specifications
IEEE 896.1	IEEE Standard Backplane Bus Specification for Multiprocessor Architectures: Futurebus
ANSI/IEEE 961	Standard for an 8-Bit Microcomputer Bus System: STD Bus
ANSI/IEEE 1014	Standard for a Versatile Backplane Bus: VMEbus
ANSI/IEEE 1196	Standard for a Simple 32-Bit Backplane Bus: NuBus
ANSI/IEEE 1296	Standard for a High-Performance Synchronous 32-Bit Bus: MULTIBUS II

(Applications for copies should be addressed to the Institute of Electrical and Electronics Engineers Inc., 445 Hoes Lane, Piscataway, NJ 08855-1331.)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	National Electrical Code (NEC)

(Application for copies should be addressed to the National Fire Protection Association, One Batterymarch Park, P. O. Box 9101, Quincy, MA 02269-9101.)

UNDERWRITERS LABORATORIES, INC. (UL)

UL-478	Information-Processing and Business Equipment
UL-1012	Power Supplies.

(Application for copies should be addressed to the Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062.)

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.

3. DEFINITIONS.

3.1 Definitions of acronyms. For the purpose of this specification, the acronyms provided herein shall apply.

A	-	Ampere
AC	-	Alternating current
A_o	-	Operational availability
BIT	-	Built-in-test
C	-	Celcius
C^4I	-	Command, control, communications, computer, and intelligence
CLIPS	-	Classified information processing system
COTS	-	Commercial off-the-shelf
CSCI	-	Computer software configuration item
dB	-	Decibel
DC	-	Direct current
DODISS	-	Department of Defense Index of Specifications and Standards
EISA	-	Extended industry standard architecture
EMC	-	Electromagnetic compatibility
EMCON	-	Emission control
EMI	-	Electromagnetic interference
EMP	-	Electromagnetic pulse
ESD	-	Electrostatic discharge
FCC	-	Federal Communications Commission
FDDI	-	Fiber distribution data interface
g	-	Acceleration of gravity
GFB	-	Government furnished baseline
GIDEP	-	Government/industry data exchange program
GPIB	-	General purpose interface bus
HVAC	-	Heating, ventilation, and air conditioning
HM&E	-	Hull, mechanical, and electrical
Hz	-	Hertz
IC	-	Integrated circuit
I/O	-	Input/Output
kHz	-	Kilohertz
km	-	Kilometer
kVA	-	Kilovoltampere
kW	-	Kilowatt
LAN	-	Local area network
mA	-	Milliampere
MCCR	-	Mission critical computer resource

MTBF	-	Mean-time-between-failures
MTTF	-	Mean-time-to-failure
MTTR	-	Mean-time-to-repair
MSDS	-	Material safety data sheet
NATO	-	North Atlantic Treaty Organization
NDI	-	Nondevelopmental item
NPT	-	National taper pipe (thread)
NTDS	-	Naval tactical data system
OASPL	-	Overall sound pressure level
OSA	-	Open systems architecture
PTTI	-	Precise time and time interval
RMS	-	Root-mean-square
RF	-	Radio frequency
SBS	-	Standard battery system
SCSI	-	Small computer systems interface
SEM	-	Standard electronic module
SES	-	Standard enclosure system
SHARP	-	Standard hardware acquisition reliability program
SPS	-	Standard power supply
TAAF	-	Test, analyze, and fix
TREE	-	Transient radiation effects on electronics
UPS	-	Uninterruptable power supply
V	-	Volt

3.2 Definitions of terms. For the purpose of this specification, the definitions specified in ANSI/IEEE 100 and 3.2.1 through 3.2.57 shall apply.

3.2.1 Battleshort. A function which disables equipment protection and personnel safety interlocks in order to keep the equipment on-line during high readiness states. Battleshort maintains the maximum available mission readiness and system availability by avoiding interlock caused shutdowns and prolonged start-ups following shutdown.

3.2.2 Catastrophic fault. A fault which will destroy the system or subsystem and its function almost immediately.

3.2.3 Classified information processing system (CLIPS). Any equipment, device, or system which is electrically powered and which processes, converts, reproduces, or otherwise manipulates any form of classified information.

3.2.4 Commercial off-the-shelf (COTS). Items which can be purchased through commercial retail or wholesale distributors as is, for example, equipment that is available as a catalog item. Modified COTS equipment is COTS equipment which has been customized to conform to functional requirements. All references to COTS equipment shall be construed to include modified COTS equipment.

3.2.5 Compromising emanations. Unintentional intelligence-bearing signals which, if intercepted and analyzed, disclose the national security information transmitted, received, handled, or otherwise processed by any CLIPS.

3.2.6 Computer software configuration item (CSCI). See DOD-STD-2167.

3.2.7 Continuously degrading faults. Faults which permit continued use of the equipment for a limited time. Continued operation for an extended period may cause a continuously degraded fault to become a catastrophic fault.

3.2.8 Corrosion. See MIL-STD-1250.

3.2.9 Data rights. The right to use, disclose, reproduce, prepare derivative works, distribute copies to the public, and perform publicly and display publicly, data in any manner and for any purpose, and to have or permit others to do so. Data shall mean recorded information, regardless of form or the media on which the information may be recorded, including technical data and computer software. Data does not include information incidental to contract administration, such as financial, administrative, cost or pricing or management information.

3.2.10 Electromagnetic interference (EMI). Any electromagnetic disturbance that interrupts, obstructs, or otherwise degrades or limits the effective performance of electronic or electrical equipment. EMI can be induced intentionally, as in some forms of electronic warfare, or unintentionally, as a result of spurious emissions and responses, intermodulation products, and so forth.

3.2.11 Electromagnetic pulse (EMP). An electromagnetic traveling wave resulting from a nuclear event.

3.2.12 Electrostatic discharge (ESD). A transfer of electrostatic charge between objects at different potentials caused by direct contact or induced by an electrostatic field.

3.2.13 Emission control (EMCON). A shipboard operational condition in which acoustic, electromagnetic, and optical emitters, such as radars and communications equipment, are inhibited or limited.

3.2.14 Enclaving. A synergistic zoning of the combat system, HM&E systems, and damage control systems into regions which, if necessary, can function independently to provide a subset of the ship's mission capabilities.

3.2.15 Failure (battleshort). See ANSI/IEEE 100. Several definitions exist, dependent upon the application/equipment type.

3.2.16 Faults (battleshort). See ANSI/IEEE 100. Several definitions exist, dependent upon the application/equipment type.

3.2.17 Fully hardened. The most stringent performance criteria for a requirement (see 3.2.30). Fully hardened equipment may be COTS, ruggedized, or militarized equipment. **Fully hardened is not synonymous with fully militarized.**

3.2.18 Functional requirements. Parameters related to the ability of the equipment to perform the intended mission. Examples are frequency and bandwidth. Functional requirements shall be specified in the end item specification. Specification guidance for functional requirements is not provided in this document.

3.2.19 Government/industry data exchange program (GIDEP). See MIL-STD-1556.

3.2.20 Greenwater loading. Mechanical loading due to wave slap.

3.2.21 Harmful corrosion. Corrosion which may interfere with the performance of the equipment or its associated parts.

3.2.22 Host space vehicle. The space vehicle which contains a payload, or provides auxiliary support services (in the form of electrical power, and so forth) to the payload.

3.2.23 Launch system. See MIL-STD-1540.

3.2.24 Launch vehicle, expendable. See MIL-STD-1540.

3.2.25 Launch vehicle, recoverable. See MIL-STD-1540.

3.2.26 Leakage current. All currents, including capacitively coupled currents, that conduct between exposed conductive surfaces of a unit and ground or other exposed surfaces of the unit.

3.2.27 Levels of assembly (Space). See MIL-STD-1540. Software levels of assembly shall be as defined in DOD-STD-2167.

3.2.28 Levels of assembly (Ship). See MIL-STD-280. Software levels of assembly shall be as defined in DOD-STD-2167.

3.2.29 Militarized. Items which are designed and manufactured to military specifications.

3.2.30 Minimal acceptance. The least strict performance criteria for a requirement.

3.2.31 Mission critical. Equipment that contributes significantly to the safety, maneuverability, and continued mission capability of the platform. Mission critical equipment shall be identified as such by the program manager.

3.2.32 Mission critical computer resources (MCCR). Computer resources, hardware or software, that are physically part of, dedicated to, or essential in real time to the mission performance of weapon systems; used for weapon system specialized training, simulation, diagnostic test and maintenance, or calibration; or used for research and development of weapon systems.

3.2.33 Modified COTS. See COTS (3.2.4).

3.2.34 Modularizing. The ability to remove and replace all components supporting a common function in a single operation.

3.2.35 Multipacting. See MIL-STD-1540.

3.2.36 Nondevelopmental item (NDI). An item not requiring development. NDI equipment can be COTS, ruggedized, or militarized. NDI may include any of the items in a through d:

a. Item of supply that is available in the commercial marketplace.
b. Previously developed item of supply that is in use by a department or agency of the United States, a state or local Government, or a foreign Government with which the United States has a mutual defense cooperation agreement.
c. Item described above that requires only minor modification to conform to the procuring agency's requirements.
d. Item currently being produced that does not conform to the above requirements solely because the item is not yet in use, or not yet available in the commercial marketplace (Section 907 of the Defense Acquisition Improvement Act of 1986).

3.2.37 Open systems architecture (OSA). A physical and logical organization of system functions, structures, and operations based on open system interface standards to meet requirements.

3.2.38 Operational availability (A_o). The expected percentage of time that a weapon system or individual equipment will be ready to perform satisfactorily in an operating environment when called for at any random point in time.

3.2.39 Operational constraint. Limits (parameters) which define the operational characteristics and/or environment.

3.2.40 Payload. An assembly carried into space to perform the operational mission.

3.2.41 Plain text. Intelligible text or signals which have meaning and which can be read or acted upon without the application of any decryption (see 3.2.3).

3.2.42 Power density. Power divided by unit volume, including cooling fins and EMI filters.

3.2.43 Program manager. Government program manager (Navy and Air Force) or Government combat developer (Army).

3.2.44 Protoflight test. A prototype flight test which consolidates tests to minimize costs. A protoflight test typically incorporates all acceptance test features, but adds some margin to the acceptance test levels to demonstrate qualification, but not so much as to initiate failure. When compared with qualification tests that would be required on a separate unit, protoflight tests are typically conducted for reduced time durations, at reduced test levels, or both.

3.2.45 Pyroshock. The shock environment imposed on the space vehicle components due to the structural response when the space or launch vehicle pyrotechnic device is ignited. Resultant structural response accelerations resemble the form of superimposed complex decaying sinusoidal waveforms which decay to a few percent of the maximum acceleration in 5 to 15 milliseconds.

3.2.46 Qualification tests (Space). See MIL-STD-1540.

3.2.47 Reengineering. Examination and alteration of an existing system to reconstitute the system in a new form.

3.2.48 Ruggedized. COTS equipment that has been modified for military use. The modifications may be in the form of added parts, such as shields, power conditioners, and so forth, or in the form of direct modification to COTS equipment. Ruggedized may be referred to as ruggedized COTS.

3.2.49 Service requirements. Parameters related to the ability of an equipment to perform in its application, including but not limited to environmental conditions, auxiliary support services, and equipment supportability. The principle categories of service requirements and their relationship to equipment are shown on FIGURE 2. Service requirements are discussed in 4. and 5..

3.2.50 Sheltered. Installations that are protected from the external environment. Sheltered includes both controlled and uncontrolled internal climates.

3.2.51 Space vehicle. See MIL-STD-1540.

3.2.52 Stable degraded faults. Faults which permit indefinite continued use of the equipment at a reduced capability.

3.2.53 Standard hardware acquisition reliability program (SHARP). A coordinated program that provides standard hardware for improved acquisition and reliability. SHARP includes the SES, SBS, SEM, and SPS.

3.2.54 Telemetry points. Sampling points within a spacecraft from which onboard conditions, such as voltages, temperature, and so forth, are examined and encoded for transmission to the ground.

3.2.55 TEMPEST. Investigations and studies of compromising emanations. TEMPEST is sometimes used synonymously with the term compromising emanations.

3.2.56 Transient radiation effects on electronics (TREE). Effects on electronics resulting from a nuclear event. In sensitive semiconductors, the energy absorbed in electronic parts may be sufficient to temporarily or permanently alter the operating characteristics/state of the semiconductor device.

3.2.57 Unsheltered. Installations that are not protected from the external environments.

4. GENERAL REQUIREMENTS.

4.1 Policy guidance. **The specifier shall tailor performance and design criteria to conform to the applications and operating conditions for which the equipment is intended to be used.** The requirements specified herein apply to shipboard and space applications; the requirements may be applied to other application areas as determined by the program manager. This document implements the acquisition policies of the DOD and the Department of the Navy, applicable to the procurement of electronic equipment. The program manager should consult DOD 4245.7-M and NAVSO P-6071 for guidance in transitioning from development to production and managing technical risk.

4.1.1 Applicability. Fully hardened COTS and ruggedized equipment are permitted for mission critical applications, provided the equipment conforms to service and functional requirements. The principal justification for the use of COTS and ruggedized equipment is rapid introduction of new technologies into military applications. In some instances, cost savings may be possible (see 4.1.5.1).

4.1.2 Acquisition preference. The order of preference for acquisition shall be NDI (which includes COTS, ruggedized NDI, and militarized NDI), ruggedized items requiring new development, and militarized items requiring new development.

4.1.2.1 NDI. NDI is the preferred acquisition strategy. Guidelines for NDI are provided in DOD INST 5000.2 and SD-2.

4.1.2.1.1 Standard hardware (Ship). When possible and cost effective over the equipment life cycle, militarized equipment shall use SES (see 5.1.6.3), SPS (see 5.1.4.10), SBS (see 5.1.4.11), and SEM (see 5.1.7.7.1) hardware from the SHARP.

4.1.2.2 Ruggedized equipment. When COTS equipment is not available to conform to requirements, ruggedization is the preferred strategy provided cost and logistic considerations are favorable.

4.1.3 Specification selection. When available, end item specifications shall use or cite commercial consensus standards of U.S. industry as a first preference, international consensus standards as a second preference, and Federal/military specifications and standards as a third preference in accordance with MIL-STD-970. The cited specifications shall be suitable for the specified environmental and service conditions.

4.1.3.1 Specification guidance. Specifications shall follow the general guidelines of MIL-STD-961 or MIL-STD-490 for format. Commercial item descriptions shall follow the

guidance of DOD 4120.3-M. The format and instructions for the preparation of Commercial item descriptions shall be in accordance with FPMR 101-29 and SD-2.

4.1.4 Tailoring of requirements. Applications vary in terms of severity and criticality. Two factors of significant importance in the military and space environment that are not common in the commercial environment are survivability and combat system integration. The purpose of the platform is to carry out its mission in extreme conditions, which may include exposure to such hazards as shock, fire, and thermal extremes. The specifier must understand the constraints and limitations of supporting systems which must operate under the same conditions, and accommodate the direction of future system designs, such as integrated systems. The performance requirements provided in 5.1.1, 5.1.2, 5.1.3, 5.2.1, and 5.2.2 apply to COTS, ruggedized, and militarized acquisitions. The design requirements in 5.1.4 through 5.1.9, and 5.2.3 through 5.2.11, apply to militarized requirements and may be selectively applied to COTS and ruggedized acquisitions as determined by the specifier (see APPENDIX B). The requirements in this standard are to be tailored to reflect the projected operating conditions for the equipment being specified, based on field and measured data rather than subjective opinion (see 1.1.1). Additional tailoring guidelines are provided in 1.6.1 and 1.5.1.

4.1.4.1 Unique applications. Requirements for unique applications which apply to a small fraction of units or have a small probability of occurrence shall be addressed in such a manner that the performance criteria and costs are minimized for similar systems and equipment. For unique applications, a separate, less expensive solution shall be considered such as modification of individual units and the development of field kits/add-ons.

4.1.4.2 Commonality. When similar functions are performed by different equipment, consideration shall be given to incorporating all required capabilities into one piece of hardware. The end item specification shall be non-proprietary such that any qualified manufacturer may provide the equipment.

4.1.4.3 Equipment specification. Specification requirements shall be driven by the equipment application rather than equipment capabilities.

4.1.5 General application. The specifier shall tailor the requirements of this standard based on the application of the equipment (see 4.1.4), and shall encourage contractors to submit cost effective tailoring recommendations based on life cycle analysis. Design, application, safety, and quality considerations, as well as economic factors, shall govern the selection of parts, materials, and processes used in the design, acquisition, construction, and support of material for the DOD. Whenever acquisition documents do not explicitly specify the items or standards and specifications to be used, selection of a suitable standard or specification for a specific design application shall be the responsibility of the procuring activity.

4.1.5.1 Economic considerations. When two or more items or processes will satisfy design parameters, selection shall be made in a manner that is most economical to the Government. Economic factors include, but are not limited to, consideration of life-cycle costs related to development, initial fabrication, production, reliability, operation, maintenance, supply, and replacement.

4.1.6 OSA. An OSA shall be used (see 4.2.4 and 4.12) when possible. Design tolerances shall permit parts, subassemblies, and assemblies to be used in parent assemblies without regard to the source of supply or manufacture.

4.2 Mission critical requirements (Ship). All mission critical equipment shall be in accordance with 4.2.1 through 4.2.4.5. These requirements shall be reviewed for applicability to non-mission critical equipment, and tailored into the equipment specifications as appropriate (see 4.1.4).

4.2.1 Mission critical equipment. Fully hardened requirements shall be specified for mission critical equipment to the extent applicable. C^4I equipment shall not be intrinsically treated as mission critical. Mission critical equipment shall be identified as such by the program manager.

4.2.2 Survivability. Survivability shall be a major system design criteria, and is applicable to all mission critical equipment. Survivability features shall include the ability to withstand battle damage (graceful degradation), to maintain maximum readiness during an engagement (reconfiguration), and to permit rapid repairs following any casualties (modularity).

4.2.2.1 Battleshort. Interlock bypass circuits shall be provided to override personnel safety and maintenance interlocks. Interlocks provided for protection against catastrophic faults shall not be bypassed. Interlock bypass circuits shall be provided to override equipment interlocks used to protect against continuously degrading faults and stable degraded faults. Interlock bypass circuits shall latch such that loss of power does not disable the battleshort mode. The use of battleshort accepts the potential damage to equipment as a trade-off for its operation during battle.

4.2.2.1.1 Battleshort indication. Visual indication shall be provided when the equipment is in the battleshort mode. Indicator lights shall be located in a position clearly visible to personnel, and on the equipment cabinet that is in the battleshort mode. An audible alarm shall be provided to indicate when personnel hazards exist while in the battleshort mode. A means shall be provided for manually disabling the audible alarm. The means for manually disabling the audible alarm shall be such that the audible alarm will be re-enabled when the alarm signal has been removed. A means shall be provided for remote indication of the battleshort mode at a central location.

4.2.2.1.2 Activation of battleshort. The equipment shall be provided with means for remote activation of the battleshort mode. The remote feature shall be such that spurious signals will not disable the battleshort mode. The equipment shall be provided with a maintenance switch for disabling of the battleshort feature, and a means for remote indication of the switch position. When applicable, the battleshort feature shall be disabled when equipment is in the training mode. When equipment has both manual and automatic restart modes, the equipment shall go into the automatic restart mode when battleshort has been enabled.

4.2.2.1.3 Catastrophic fault indication. Interlocks for protection against catastrophic faults shall include provisions to indicate the cause of equipment shutdown when in the battleshort mode. The indication circuitry shall be such that status indication will be maintained through power interruptions of 8 hours. The intent of this requirement is to identify cause of shutdown following or under casualty conditions, when inadvertent loss of power has occurred.

4.2.2.2 Smart loadshed. Equipment rated 5 kVA or more shall be provided with a means for being placed in a low power mode when loadshed has been activated from a remote location, which may include reduced capability, standby, or turn-off. The low power mode shall be such that the equipment will automatically resume full specified performance when loadshed has been de-activated. Equipment provided with an UPS may ride-through the loadshed period, and not require provisions for smart loadshed.

4.2.2.3 Systems monitoring and control. Systems and equipment shall be designed for supervisory monitoring and control from a central location, for implementation of a total ship mission readiness assessment and reporting system. To ensure adequate capabilities, the information specified in a through e shall be made available:

a. Equipment operational status
b. Battleshort indication
c. EMCON condition
d. Interface operations
e. Capability level.

Control capabilities include the ability to perform smart loadshed, central setting of battleshort, EMCON, and combat system reconfiguration control. For equipment that does not have a LAN interface and requires low volume communications, the monitoring and control capabilities may be incorporated using a NATO Low Level Serial interface in accordance with MIL-STD-1397. Specifications for equipment level communications devices are provided in the appendix of MIL-STD-1397. For submarine applications, specific guidance shall be provided by OPNAV-02 and NAVSEA-08.

4.2.2.4 Redundancy and enclaving. Redundancy criteria shall be determined from the operating requirements and shall include multiple independent signal paths, parallel processing, auxiliary/standby components, and backup controls to eliminate single points of failure. Modularizing and enclaving shall be utilized to improve the equipment survivability and to reduce MTTR. Modularizing may incorporate the use of SEM, SPS, SBS, and SES (see 4.1.2.1).

4.2.2.5 Special considerations. Even though the combatant's mission priority may be simultaneous engagement of multiple threats and other tactical offensive capabilities, the specifier shall consider soft kills that may be inflicted by lightly armed adversaries. The concern is secondary damage (fragmentation, water, and heat) resulting from otherwise inconsequential hostile fire. A higher level of survivability is needed for point defense and maneuverability subsystems to enable a damaged combatant to safely withdraw and effect repairs.

4.2.3 Power interface. The power interface shall be as specified in 4.2.3.1 through 4.2.3.2.

4.2.3.1 Ship electrical power. Mission critical equipment shall remain fully operational through momentary power interruptions of 100 milliseconds or less, shall operate through line voltage variations of plus 35 percent to minus 20 percent, shall limit line current harmonics to 3 percent of the fundamental, shall be suitable for continuous operation from 50 Hz to 67 Hz, and shall restart immediately (within 1 second) following short term power interruptions of less than 5 minutes duration. Computers that require longer than 1 second to re-boot shall be modified to retain volatile memory during short term power interruptions, through application of battery backup or other means. High power transmitters shall inhibit pulses, but shall otherwise remain fully operational until external power has been restored. The requirements specified herein are to provide for continued combat capability under the casualty and emergency conditions expected to be encountered aboard ship.

4.2.3.1.1 Navy Standard Electronic Power System. The Navy Standard Electronic Power System specified in APPENDIX C may be implemented to conform to 4.2.3.1. Implementation may be either completely internal to the equipment or as a stand alone unit supplying a group of low powered, functionally compatible equipment.

4.2.3.1.2 Circuit breaker protection. The circuit breaker protection for the equipment, and the interface to the electrical power system, shall be coordinated to ensure that the circuit breaker closest to the cause of an overcurrent or fault current condition will trip first (see 5.1.4.4.5). This requirement is to prevent inadvertent shutdown of adjacent equipment connected to a common source.

4.2.3.2 Advanced electrical distribution systems. New combat systems such as high energy weapons, will put a strain upon electrical power resources and impose

significant transients on the electrical system. End item specifications for new electronic equipment shall incorporate the anticipated electrical system characteristics and shall isolate the equipment as much as possible, for example, through the use of the Navy Standard Electronic Power System.

4.2.4 Computer resources. Navy Computer resources shall be in accordance with SECNAVINST 5200.32. Equipment shall have nonproprietary intracomputer and intercomputer interfaces which support an OSA (see 4.1.6). Computer programming languages shall be in accordance with DOD DIR 3405.1. Equipment shall have the capability to accept upgrades in computer technology and shall be capable of interfacing with all system architectures envisioned during service life.

4.2.4.1 Data buses. The preferred method for data transfer between system components shall be by a common data bus. The use of an industry accepted standard data bus format is encouraged. TABLE IV and TABLE V provide industry standard external interfaces and internal data busses, respectively.

TABLE IV. Industry standard external interfaces

INTERFACE	STANDARD	FORMAT
NTDS	MIL-STD-1397	Digital (Parallel/Serial)
SCSI	ANSI X3.131	Digital (Parallel)
RS-232	EIA RS-232	Digital (Serial)
RS-422	EIA RS-422	Digital (Serial)
GPIB	ANSI/IEEE 488.1	Digital (Parallel)
TOKEN RING	ANSI/IEEE 802.5	Digital (Serial)
ETHERNET	ANSI/IEEE 802.3	Digital (Serial)
FDDI	ANSI X3T9.5	Digital fiber optic (Serial)
TACTICAL	MIL-STD-188-200	Analog
SAFENET II	(Under development	Digital fiber optic (Serial)

TABLE V. Industry standard internal data busses	
INTERFACE	STANDARD
Futurebus	IEEE 896.1
Multibus II	ANSI/IEEE 1296
NuBus	ANSI/IEEE 1196
S-100	ANSI/IEEE 696
STD Bus	ANSI/IEEE 961
VMEbus	ANSI/IEEE 1014
PC Bus	(Under development)
EISA	(Under development)

4.2.4.2 Fiber optics. The preferred method for data transmission shall be fiber optics. Fiber optic systems shall be tailored from MIL-STD-454, Requirement 76.

4.2.4.3 Mass storage media. Optical media is the preferred method of mass storage. Magnetic media shall be limited to applications when optical media cannot be used due to operational or physical limitations.

4.2.4.4 Distributive processing. Reliance on central computer systems for operation and control of the combat system shall be avoided. Computing and processing functions shall be placed at the system element which these functions control and to which input is provided. Care shall be taken to ensure problems that occur within a system can be isolated to the line-replaceable-unit level.

4.2.4.5 Software and firmware. All software and firmware shall be supplied in accordance with requirements tailored from DOD-STD-2167 in accordance with MIL-HDBK-287. COTS software shall be provided with documentation in accordance with 4.7. Software upgrades shall be in accordance with 4.12 to ensure that data and databases generated under past revisions can be read or converted for use into the later revision. Programmable Read-Only Memories shall be documented for logistic purposes; the high-level source code shall be provided for all militarized firmware.

4.3 Equipment control (Space). Requirements for mass and power shall be in accordance with 4.3.1 through 4.3.2.

4.3.1 Mass. Equipment mass shall be controlled during the acquisition process for the preservation of performance margins, and as a control of other mass properties such as the equipment center of gravity.

4.3.2 Power management. Equipment power consumption shall be controlled during the acquisition process for the preservation of performance margins.

4.4 TEMPEST. CLIPS shall be in accordance with OPNAVINST C5510.93. CLIPS installed on ships shall be in accordance with MIL-STD-1680.

4.5 Engineering management. Engineering management shall be in accordance with MIL-STD-499. MIL-STD-499 specifies program requirements, and shall not be invoked in the end item specification.

4.6 Logistic considerations. Logistical support shall be considered in the analysis of life-cycle-costs in accordance with MIL-STD-1388-1. Logistical support is to be specified in the Statement of Work and shall not be invoked in the end item specification. Logistical support is a major issue in the decision to use NDI equipment. Guidance is provided in SD-2 and DOD INST 5000.2. The acquisition of NDI equipment shall consider the life cycle costs, including potential obsolescence.

4.7 Documentation. Documentation for use, training, operation, maintenance, and repair of equipment shall be provided. Documentation shall clearly indicate the conditions in which the equipment is designed to operate, and the specific requirements which must be observed during installation and use of the equipment. When adequate, the use of vendor supplied documentation shall be encouraged. The procuring activity shall ensure that vendor supplied documentation is accurate and complete.

4.7.1 Installation control drawings (Ship). Installation control drawings shall be provided for permanently mounted equipment. Installation control drawings for ruggedized and militarized equipment shall be in accordance with MIL-D-23140.

4.7.2 Hazardous materials. The procuring activity shall be provided a MSDS at time of submittal of bid for each hazardous material in accordance with FED-STD-313 (see 5.1.3.9). The MSDS shall be included with each shipment of the material covered by the end item specification. Hazardous material and hazardous material containers shall be marked in accordance with 29 CFR 1910.1200 and MIL-STD-129. Parts containing hazardous material, such as beryllium oxide insulators, shall be marked with the appropriate hazard warning.

4.7.3 Data rights. The program manager shall ensure that the Government's interests are protected with respect to vendor proprietary information concerning equipment. In the event an equipment is removed from production or deleted from the vendor's

catalog, sufficient data shall be provided to the Government to continue support of the equipment. The level of detail of the data provided shall be adequate to continue support of the equipment at the line-replaceable-unit level (see 4.10.4).

4.7.4 Drawings and nomenclature (Ship). Drawings for militarized equipment shall be in accordance with MIL-STD-100. Technical data shall be in accordance with MIL-T-31000. Drawings and technical data for commercial equipment and subassemblies shall be adequate to support the equipment at the line-replaceable-unit level (see 4.7.3).

4.8 A_o. Requirements for A_o shall be specified in the end item specification. Guidance is provided in OPNAVINST 3000.12.

4.9 Reliability. Quantitative reliability requirements in terms of MTBF shall be specified in the end item specification. Guidance on the probability of mission success for space equipment, from which system MTBF may be derived is provided in 1.6.1. The probability of mission success for space equipment shall include consideration of any potential failures in associated ground operations that might not be corrected in time to avoid an impact on the space equipment. Guidance on reliability program requirements for ship, avionics, mobile, and land applications is provided in MIL-STD-785. Guidance on reliability program requirements for space applications is provided in MIL-STD-1543. MIL-STD-785 and MIL-STD-1543 specify program requirements, and shall not be invoked in the end item specification. Reliability of militarized equipment shall be predicted in accordance with MIL-HDBK-217 and tested in accordance with MIL-STD-781. The determination of quantitative reliability requirements for COTS and ruggedized equipment shall be the responsibility of the program manager. Analysis, field experience or test (such as accelerated life tests) shall be required as evidence of achievement of reliability.

4.10 Maintainability. Quantitative maintainability requirements in terms of MTTR shall be specified in the end item specification. MIL-STD-470 specifies program requirements for maintainability, elements of which are specified in the Statement of Work, and shall not be invoked in the end item specification. Maintainability requirements shall be tailored to the acquisition such as pre-launch and post-launch activities for space equipment. Maintainability of militarized equipment shall be predicted in accordance with MIL-HDBK-472 and tested in accordance with MIL-STD-471. The determination of quantitative maintainability requirements for COTS and ruggedized equipment shall be the responsibility of the program manager.

4.10.1 Equipment maintainability (Space). Unless otherwise specified, space vehicles and payloads shall be designed in such a manner as to not require any scheduled maintenance or servicing while deployed. Provisions shall be considered for recovering deployed equipment for repairs. The design of equipment shall incorporate test and telemetry points to allow verification of functional performance. The design

shall facilitate installation and replacement of major components during factory assembly, and of explosive ordnance devices, batteries, and other site replaceable items at the launch site when mounted on the launch vehicle. Access shall be provided to test plugs, harness break-in points, external umbilical connections, safe and arm devices, explosive ordnance devices, pressurant and propellant fill and drain valves, and other devices that may be required for pre-launch maintenance, alignment, and servicing. Alignment references for critically aligned components shall be visible directly through windows or access doors.

4.10.2 Accessibility. Consideration shall be given to equipment accessibility by maintenance personnel in the equipment's installed configuration.

4.10.3 Special tools. The use of special tools shall require the approval of the procuring activity. Special tools needed for testing, operation, and maintenance shall be furnished with the equipment. Special tools for ship, mobile, and land applications shall be mounted securely in or on the equipment in a convenient and accessible place. Special tools are defined as those tools not listed in the Federal Supply Catalog (copies of this catalog may be consulted in the office of the Defense Contract Management Area Operations (DCMAO)).

4.10.4 Level of repair analysis. Guidance for level of repair analysis is provided in MIL-STD-1390.

4.10.5 Testability. Test provisions shall be provided for isolating failures to the line replaceable unit, or to a group of line replaceable units, through the use of test points, BIT capability (including software), or test equipment. MIL-STD-2165 specifies both technical and program requirements for testability. Elements of the program requirements of MIL-STD-2165 are to be addressed in the Statement of Work, and are not to be invoked in the end-item specification. To the extent that the technical requirements of MIL-STD-2165 are applicable to the end-item specification, testability technical requirements shall be tailored from MIL-STD-2165. In particular, levels of fault detection and fault isolation shall be specified for all items, including NDI. Test levels shall be in accordance with MIL-STD-415. Only Class A and Class B provisions shall be specified for COTS and ruggedized equipment.

4.10.5.1 Test equipment and BIT devices. Test equipment and BIT of militarized equipment shall be in accordance with MIL-T-28800. Test equipment calibration shall be in accordance with MIL-STD-1839.

4.10.5.2 Test cables and extender cards. Test cables and extender cards of militarized equipment shall be provided and shall be fitted with connectors to allow removable subassemblies to be electrically reconnected for maintenance.

4.10.5.3 External test points. Protection shall be provided in the test point circuitry to prevent equipment damage caused by the external grounding of test points. This requirement does not apply to internal test points provided for factory quality assurance purposes.

4.11 Training. Training requirements shall be determined for the proper and safe use, operation, maintenance, and repair of the system equipment and software. Consideration shall be given to on-line and built-in training helps, aids, tutorials, and other instructional media. The use of vendor and/or crew developed training is encouraged.

4.11.1 Vendor developed training. Vendor developed training shall be used in accordance with OPNAVINST 1500.2 when appropriate. Vendor developed training shall be integrated in Chief of Naval Education and Training (CNET) curricula in accordance with OPNAVINST 1500.8 and OPNAVINST 1500.44.

4.11.2 Unmanned vehicles (Space). Training requirements shall be determined for assembly, test, launch, and operations of the vehicle. Training materials shall cover launch, on-orbit deployment, on-orbit maintenance, and ground operations as applicable. For ground operations, consideration shall be given to on-line and built-in training helps, aids, tutorial, and other instructional media. The use of crew and vendor developed training is preferred and shall be encouraged.

4.11.3 Manned vehicles (Space). Training requirements shall be determined for proper and safe assembly, test, launch, on-orbit deployment, on-orbit assembly, on-orbit operations, on-orbit maintenance, and ground operations as required. For on-orbit and ground operations, consideration shall be given to on-line and built-in training helps, aids, tutorial, and other instructional media. The use of crew and vendor developed training is preferred and encouraged.

4.12 Interchangeability. Interchangeability shall support an OSA (see 4.1.6). Interface specifications shall be provided for interchangeable items as part of the item documentation specified in 4.7. System software shall be reusable in accordance with DOD-STD-2167. Hardware from different sources of supply may be designated as interchangeable when appropriate.

4.13 Environmental design guidance (Ship). Environmental design guidance shall be provided by the procuring activity. An environmental management plan, life cycle environmental profile, and environmental design test plan shall be provided in accordance with MIL-STD-810. Each plan shall be prepared by the procuring activity, or by the contractor as directed by the procuring activity. Limited information on environmental conditions is provided in MIL-STD-810 and MIL-STD-210. Information on electromagnetic environmental management guides is provided in MIL-HDBK-237.

4.14 Human factors engineering. A human factors engineering program shall be prepared in accordance with DOD INST 5000.2. Human factors engineering requirements shall be tailored in accordance with MIL-H-46855. Ruggedized and militarized equipment shall be in accordance with ASTM F 1166. ASTM F 1166 shall be part of the selection criteria for determining the suitability of NDI.

4.14.1 Manned vehicles (Space). Human engineering design criteria for equipment installed in manned space vehicles, or intended for on-orbit maintenance/recovery, shall be tailored from NASA-STD-3000. Particular attention shall be made to surface temperature (see 5.2.2.2.2), radiation (see 5.2.2.2.3), connectors (see 5.2.4.10), fasteners (see 5.2.4.11), controls (see 5.2.4.14), circuit breakers (see 5.2.1.3), and computer resources (see 5.2.11).

4.15 Serial numbers. Serial numbers shall be unique to each unit of equipment. Serial numbers shall be furnished by the vendor for COTS and ruggedized equipment. Serial numbers may be furnished by the Government or vendor for militarized equipment.

4.16 Marking requirements. Marking of militarized equipment and items thereof shall be as specified in 4.16.1 through 4.16.8. Identification plates shall be in accordance with MIL-P-15024 and MIL-P-15024/5.

4.16.1 Mounting and location. Identification plates and information plates shall be mounted in a conspicuous space on the front panel of the item level to which the plate applies, when possible.

4.16.2 ESD marking. Warning labels shall be affixed to the protective packaging and to the equipment. Identification markings shall be affixed on all ESD sensitive subassemblies visible to maintenance personnel prior to maintenance handling in the equipment. Enclosures, assemblies, and subassemblies containing class 1 or class 2 ESD sensitive components, as defined in MIL-STD-1686, shall be marked in accordance with MIL-STD-1686.

4.16.3 Lubrication points. Lubrication points shall be marked as LUBRICATION POINT.

4.16.4 Nomenclature. The item name and type designation for equipment shall be established in accordance with MIL-STD-196 and MIL-N-18307. When specified in the end item specification, nomenclature shall be established in accordance with MIL-STD-1661.

4.16.5 Battery circuit identification. Equipment designed to operate from batteries shall be marked as specified in a through e in a convenient form for use by operating and maintenance personnel:

a. Battery type number.
b. Battery location and position.
c. Polarity.
d. Nominal voltage.
e. Interconnection between batteries.

4.16.6 Electrical power source plates. Information plates conforming to 29 CFR 1910 and FIGURE 4 shall be provided on each unit of the equipment that is powered from multiple electrical power sources. This requirement shall not apply to non-maintainable satellites.

4.16.7 Power supplies. Power supplies shall be marked in accordance with UL-1012.

DANGER - SHOCK HAZARD THIS UNIT ENERGIZED FROM MULTIPLE SOURCES. ENSURE THE FOLLOWING SWITCHES ARE IN THE OFF POSITION AND TAGGED-OUT BEFORE ATTEMPTING MAINTENANCE.			
CIRCUIT	VOLTAGE	LOCATION	SWITCH IDENTIFICATION

FIGURE 4. Electrical power source information plate.

4.16.8 Weight markings. For equipment weighing in excess of 15 kilograms, the equipment weight shall be marked on the external surface of the equipment in a location visible to personnel during installation and removal of the equipment.

4.17 ESD. ESD control shall be in accordance with MIL-STD-1686 using the guidance of MIL-HDBK-263. When metal oxide semiconductor parts and other parts sensitive to ESD are used in equipment, protective circuits shall be incorporated in the equipment to ensure that ESD sensitive parts and subassemblies are protected in all phases of handling and testing. Spare parts, modules, printed circuit board subassemblies, and so forth, shall be protected from ESD damage. Equipment shall be tested in accordance with MIL-STD-1686.

4.18 Corrosion. Militarized equipment subject to corrosion shall be in accordance with MIL-STD-1250.

4.19 Packaging. Equipment shall be packaged in accordance with ASTM D 3951 and shall be tested in accordance with ASTM D 4169.

4.20 Quality assurance. Emphasis shall be placed upon developing manufacturing processes whose variability around target product critical attributes is minimized rather than on simply being within the product tolerance. Program requirements are to be addressed in the Statement of Work, and are not to be invoked in the end-item specification (See APPENDIX A). MIL-Q-9858, MIL-I-45208, ANSI/ASQC Q90 through Q94 (ISO 9000 through ISO 9004), and DOD-STD-2168 provide elements of an effective quality program. ANSI/ASQC Q90 through Q94 do not address Government furnished equipment or Government use of contractor facilities, and their application shall be tailored. Manufacturers certified to MIL-Q-9858 and MIL-I-45208 shall not be required to become certified to the ANSI/ASQC Q90 series of standards. ANSI/ASQC Q91 is the approximate equivalent to MIL-Q-9858, and ANSI/ASQC Q93 is the approximate equivalent to MIL-I-45208. Quality should be evaluated as part of the selection process.

4.21 Safety. Safety shall be specified for all acquisitions, including NDI and ruggedized acquisitions. MIL-STD-882 specifies program requirements for safety, elements of which are addressed in the Statement of Work, and shall not be invoked in the end-item specification. Shipboard and space equipment shall be in accordance with MIL-STD-454, Requirement 1. Shipboard equipment shall be in accordance with ASTM F 1166 and 5.1.3.10. Space equipment shall be in accordance with MIL-STD-1472.

5. DETAILED REQUIREMENTS

5.1 Ship equipment. Naval ships and the shipboard environment pose unique requirements on the design of electronic equipment. The following sections provide detailed criteria that establish the boundaries of the requirements which are applicable to shipboard platforms. Shipboard requirements applicable to COTS, ruggedized, and militarized equipment are provided in 5.1.1 through 5.1.3.11. Sections 5.1.4 through 5.1.9 are design requirements applicable to militarized equipment. These requirements may be adopted for ruggedized and COTS equipment. All equipment shall be in accordance with the minimal acceptance limits for all shipboard environmental conditions to which the equipment will be subjected; mission critical equipment shall be fully hardened such that the equipment will operate under the full range of applicable environment conditions. Environmental tests may be combined where cost effective and approved by the procuring activity. The program manager shall tailor requirements to the application in a cost effective manner (see 4.1.4); for example, greenwater loading is not to be applicable to equipment installed in a controlled environment. A table of features for militarized equipment that may be appropriate for COTS and ruggedized equipment is provided in APPENDIX B. The procuring activity shall coordinate requirements with ship managers to ensure that specification requirements satisfy the platform's complete operational envelope.

5.1.1 Auxiliary support services. The equipment shall be compatible with the services to which the equipment is connected, as specified in 5.1.1.1 through 5.1.1.6.1.

5.1.1.1 AC power. Equipment shall be suitable for operation in accordance with 440 V RMS, type I power as specified in MIL-STD-1399, Section 300. Equipment shall be tested in accordance with MIL-STD-1399, Section 300.

5.1.1.1.1 Fully hardened. Equipment shall be suitable for operation under Type I power in accordance with MIL-STD-1399, Section 300. The preferred equipment service is 440V, 60Hz, 3-phase. Equipment shall be fully operational for all voltage and frequency conditions specified for Type I power in accordance with MIL-STD-1399, Section 300, including emergency conditions. Equipment shall remain operational for momentary power interruptions of 100 milliseconds, and shall restart within 1 second following power interruptions of 5 minutes.

5.1.1.1.2 Minimal acceptance. Equipment shall suitable for operation under Type I power in accordance with MIL-STD-1399, Section 300. The preferred equipment service is 440V, 60Hz, 3-phase. Equipment shall not be damaged when subjected to all voltage and frequency conditions specified for Type I power in accordance with MIL-STD-1399, Section 300, including emergency conditions. Equipment shall be fully

operational for worst case voltage and frequency conditions in accordance with MIL-STD-1399, Section 300.

5.1.1.1.3 Ruggedization techniques. The ship's electrical power system is significantly different from commercial standards. For example, fault current of public utilities will typically be limited to 65,000 A RMS at 13,000 V RMS, when surface ship fault current is limited to 100,000 A RMS at 450 V RMS (with two of three generators paralleled). COTS equipment can be ruggedized to be powered from the ship's electrical service. The primary considerations for ruggedization are as specified in a through h:

a. MIL-STD-1399, Section 300, specifies a harmonic current limit of 3 percent of the fundamental for equipment rated 1 kVA or more. The shipboard electrical system has a lower reactance/resistance ratio than the commercial applications, and harmonic currents have a higher impact on voltage distortion.

b. The voltage variations specified in MIL-STD-1399, Section 300, are more severe than those seen in the commercial environment. The line voltage may be 155 V AC (220 V peak) for 2 minutes for 115 V AC equipment, which may be sufficient to damage COTS equipment. Voltage spikes are 1000 V for 115 V RMS equipment, when COTS equipment is typically rated for 600 V.

c. The line and return leads on the 115 V, 60 Hz service are both HOT, that is, both line and return spade connectors on convenience outlets have a potential to ground. The return lead on COTS equipment may not be fully insulated. The equipment will remain energized when the equipment is shut-off and the return lead is not disconnected, presenting a safety hazard.

d. Equipment permanently located and energized more than 50 percent of the working day, such as copiers, personal computers and peripherals, soda machines, and money machines, shall not to be connected to the ship's isolated receptacle circuits (see 5.1.3.10.7). This includes all equipment permanently installed in office or engineering spaces. Convenience outlet services are rated 15A, and present a fire hazard when overloaded, such as when several workstations are co-located. Equipment of this type are to be connected to a separate dedicated, hard-wired circuit supplied by the lighting distribution system.

e. Equipment may adopt the approach provided in APPENDIX C. A power conditioner is placed between the equipment and the electrical system. When harmonic currents are minimized, such types of power conditioners are referred to as unity power factor power supplies. SPS do not conform to the 3 percent current harmonic limits in accordance with MIL-STD-1399, Section 300, which applies for equipment rated 1kVA and more. APPENDIX C recommends a polyphase transformer. Transformer technologies are mature, and transformers

are both reliable and robust. Solid state unity power factor power supplies are being developed; however, the specifier should be aware that this technology is not mature and the risk of failing to conform to specified performance and reliability criteria is greater.

f. An alternative for 115 V AC equipment rated at less than 1 kVA is to use a double-pole switch to disconnect both power and return lines. Another alternative is to apply a grounded isolation transformer to the equipment. The equipment should be tested to verify that the equipment return is fully insulated from the equipment case. Voltage arrestors should be applied to protect against voltage spikes; voltage arrestors that conduct at less than 220 V (see b.) should be removed and replaced with voltage arrestors of a higher rating. The equipment should be tested for operation at plus 35 percent voltage, or over-voltage protection applied to remove the equipment from the line under such conditions.

g. Fixed duration restart times following momentary power interruptions and voltage variations are unacceptable during a battle engagement. To achieve an equipment restart in minimum time, a proportional timer whose restart time is a function of the power interruption time, or a functional approximation thereof, may be used in place of fixed duration time delay relays.

h. An Electrical Power Interface Compatibility mobile test facility is available for testing equipment under the electrical power conditions specified in MIL-STD-1399, Section 300. Further information on this facility may be obtained from NAVSEA 03E13 or NSWCDD, Code N85.

5.1.1.2 Submarine DC power. Equipment shall be suitable for the conditions specified for electrical power in accordance with MIL-STD-1399, Section 390.

5.1.1.2.1 Fully hardened. Equipment shall remain fully operational for the conditions specified for user voltage tolerance and transient voltage conditions in accordance with MIL-STD-1399, Section 390.

5.1.1.2.2 Minimal acceptance. Equipment shall remain fully operational for the conditions specified for user voltage tolerance conditions in accordance with MIL-STD-1399, Section 390. Equipment may shutdown or go into a standby condition, but shall not be damaged, when operating outside these limits.

5.1.1.3 Seawater. This requirement shall apply to open shipboard cooling systems which use ocean water. Equipment shall be suitable for the conditions specified in MIL-STD-1399, Section 105.

5.1.1.3.1 Fully hardened and minimal acceptance. Equipment shall be fully operational for the conditions specified in MIL-STD-1399, Section 105.

5.1.1.4 Cooling water. This requirement shall apply to closed shipboard cooling systems which use fresh water. Equipment shall be suitable for the conditions specified in DOD-STD-1399, Section 532.

5.1.1.4.1 Fully hardened and minimal acceptance. Equipment shall be fully operational for the conditions specified in DOD-STD-1399, Section 532.

5.1.1.5 Compressed air. Equipment shall be suitable for the conditions specified in MIL-STD-1399, Section 106.

5.1.1.5.1 Fully hardened and minimal acceptance. Equipment shall be fully operational for the conditions specified in MIL-STD-1399, Section 106.

5.1.1.6 Dry air. This requirement is applicable to equipment requiring high quality (non-conductive) gas under pressure, such as waveguides, and other equipment requiring compressed air of greater purity than is available from the ship service low pressure air system specified in 5.1.1.5. Equipment shall be suitable for the conditions specified in MIL-STD-1399, Section 102.

5.1.1.6.1 Fully hardened and minimal acceptance. Equipment shall be fully operational for the conditions specified in MIL-STD-1399, Section 102.

5.1.2 Environmental conditions. Environmental conditions shall be as specified in this section. Separate requirements shall be provided for shipment, installation, and operation. All equipment shall be suitable for the environmental conditions where the equipment will be installed and used. Specification requirement for environmental conditions under which the equipment is to be fully operational shall be tailored to the application and use of the equipment (see 4.1.4), and from the environmental conditions specified in this section. The equipment shall not require alignment or adjustment when fully operational. Some IEC and ASTM tests are similar to the MIL-STD-810 tests. The IEC standards noted in this section are accepted in lieu of MIL-STD-810 methods. Other industry consensus standards may be approved on a case-by-case basis for an individual acquisition. COTS and ruggedized equipment which have been design qualified against MIL-STD-810 (or equivalent) are acceptable if the design qualification conforms to or exceeds the requirements of the end item specification, as tailored from this document.

5.1.2.1 Altitude, nonoperating. Equipment with hermetic seals shall be such that the equipment will not be damaged when under transit in an unpressurized cargo bay of an aircraft at 4.6 kilometers. Although it is normally conducted for safety purposes only, the program manager shall determine if the equipment is to be fully functional

following an explosive decompression test. In general, the rate of altitude change shall not exceed 10 meters per second. Altitude tests shall be tailored in accordance with IEC 68-2-13 or MIL-STD-810, Method 500.

5.1.2.2 DC magnetic field environment. Requirements for DC magnetic fields shall be as specified in 5.1.2.2.1 through 5.1.2.2.2.

5.1.2.2.1 Fully hardened. Equipment shall operate in the magnetic field conditions specified in DOD-STD-1399, Section 070, Part 1.

5.1.2.2.2 Minimal acceptance. Requirements for equipment used on ships which contain degaussing or mine neutralization equipment shall be tailored in accordance with DOD-STD-1399, Section 070, Part 1. The primary concern of DC magnetic fields is the distortion caused on displays using cathode ray tube technology. DOD-STD-1399, Section 070, Part 1 specifies a magnetic field level of 20 Oersteds (1600 A per meter), when shipboard measurements have shown that magnetic fields may vary from 2 Oersteds (160 A per meter) to 20 Oersteds (1600 A per meter). As a tailorable requirement, it is recommended that equipment be required to operate satisfactorily in an environment of 10 Oersteds (800 A per meter), and that shielding be employed if necessary.

5.1.2.3 Electromagnetic susceptibility. Electromagnetic susceptibility requirements shall be tailored in accordance with MIL-STD-461 (see 5.1.3.5). Expected electromagnetic levels for topside equipment is provided in MIL-HDBK-235-1, MIL-HDBK-235-2, MIL-HDBK-235-3, and MIL-HDBK-235-4. Electromagnetic susceptibility tests shall be tailored in accordance with MIL-STD-462.

5.1.2.4 Dust and sand. Requirements for dust and sand shall be as specified in 5.1.2.4.1 through 5.1.2.4.2.

5.1.2.4.1 Fully hardened. Equipment shall withstand dust and sand. Dust and sand tests shall be tailored in accordance with MIL-STD-810, Method 510.

5.1.2.4.2 Minimal acceptance. Requirements for equipment operation in dust and sand conditions shall be specified only for those installations determined by the specifier to have excessive dust and sand conditions.

5.1.2.5 Greenwater loading. Requirements for greenwater loading shall be as specified in 5.1.2.5.1 through 5.1.2.5.2.

5.1.2.5.1 Fully hardened. Equipment parts exposed to greenwater loading shall show no mechanical or electrical damage when the mean greenwater load is 42 kilopascals for surface ships, and 62 kilopascals for submarines.

5.1.2.5.2 Minimal acceptance. Requirements for equipment operation under greenwater loading shall be specified only for those installations determined by the specifier to be subject to greenwater loading.

5.1.2.6 Gun muzzle. Requirements for gun muzzle effects shall be as specified in 5.1.2.6.1 through 5.1.2.6.2.

5.1.2.6.1 Fully hardened. Equipment shall be in accordance with the interface requirements in accordance with MIL-STD-1399, Section 072, Part 2.

5.1.2.6.2 Minimal acceptance. Requirements for equipment operation under gun muzzle effects shall be specified only for those installations determined by the specifier to be subject to gun muzzle effects.

5.1.2.7 Humidity. Requirements for humidity shall be as specified in 5.1.2.7.1 through 5.1.2.7.2. Equipment shall be suitable for exposure in an uncontrolled environment for 8 hours (see 5.1.2.17).

5.1.2.7.1 Fully hardened. Equipment shall maintain specified performance when subjected to 100 percent relative humidity. Humidity tests shall be tailored in accordance with IEC 68-2-30Db or MIL-STD-810, Method 507, to simulate shipping and storage conditions, and when applicable, installation in an uncontrolled environment. The temperature range in IEC 68-2-30Db shall be changed to "25°C to 55°C". Equipment not subjected to testing in accordance with IEC 68-2-30Db or MIL-STD-810 shall withstand 95 percent relative humidity, and humidity tests shall be tailored in accordance with IEC 68-2-3Ca. IEC 68-2-3Ca shall be modified to require 21 days testing.

5.1.2.7.2 Minimal acceptance. Equipment shall be capable of operation in an environment conforming to the full range of requirements for data processing spaces in accordance with the ASHRAE Handbook (HVAC Systems and Application Volume).

5.1.2.8 Hydrostatic pressure. Requirements for hydrostatic pressure shall be as specified in 5.1.2.8.1 through 5.1.2.8.2.

5.1.2.8.1 Fully hardened. Parts of the equipment that will be immersed in seawater shall withstand the hydrostatic pressure without physical or electrical damage and without leakage. Hydrostatic pressure tests shall be tailored in accordance with MIL-STD-810, Method 512, at the maximum operational depth of the equipment.

5.1.2.8.2 Minimal acceptance. Requirements for equipment operation under hydrostatic pressure shall be specified only for those installations determined by the specifier to be subjected to immersion in seawater.

5.1.2.9 Icing. Requirements for icing shall be as specified in 5.1.2.9.1 through 5.1.2.9.2.

5.1.2.9.1 Fully hardened. Exposed equipment shall withstand an icing load of 20 kilograms per square meter. Icing tests shall be tailored in accordance with MIL-STD-810, Method 521.

5.1.2.9.2 Minimal acceptance. Requirements for equipment operation under icing loads shall be specified only for those installations determined by the specifier to be subject to icing.

5.1.2.10 Missile exhaust. Requirements for missile exhaust effects shall be as specified in 5.1.2.10.1 through 5.1.2.10.2.

5.1.2.10.1 Fully hardened. The equipment shall be in accordance with the interface requirements of MIL-STD-1399, Section 072, Part 1.

5.1.2.10.2 Minimal acceptance. Requirements for equipment operation under missile exhaust effects shall be specified only for those installations determined by the specifier to be subject to missile exhaust.

5.1.2.11 Nuclear hardening. Requirements for nuclear hardening shall be as specified in 5.1.2.11.1 through 5.1.2.11.2.

5.1.2.11.1 Fully hardened. Levels of nuclear survivability shall be tailored from NAVSEA INST C3401.1. Requirements for air blast, thermal radiation, and free field EMP shall be tailored from NSWC TR 87-192 for exposed equipment and exposed cable; modified to limit conducted current levels to 10A on cables that penetrate the ship's hull. Requirements for air blast induced shock, TREE, and conducted EMP shall be tailored from NSWC TR 87-192 for all equipment. EMP tests shall be tailored in accordance with MIL-STD-461 (see 5.1.2.3).

5.1.2.11.2 Minimal acceptance. The specifier shall determine the requirement for nuclear hardening, and the degree required for nuclear hardening. DOD Directive 4245.4 provides further guidance. Installation in a sheltered, controlled environment does not protect the equipment from all effects of a nuclear event.

5.1.2.11.3 Ruggedization techniques. COTS equipment can be ruggedized to conform to the nuclear environment. The specifier may consult NSWC TR 90-22 for techniques to harden equipment to the nuclear environment. Suggested guidelines for nuclear hardening are provided in a through d.

a. Air blast and thermal radiation: Appropriate shielding and insulation may be applied to protect exposed equipment.

b. Air blast induced shock: To conform to this requirement and the underwater shock requirements of MIL-S-901, equipment may be shock mounted (see 5.1.2.14).

c. EMP: Appropriate electromagnetic shielding and grounding shall be used. Protection may be applied at I/O ports to prevent propagation of the EMP into equipment. For small signal interfaces, terminal protection devices or filter pin connectors shall be used due to the fast rise time of the EMP. For power circuit interfaces, metal oxide varistors may be applied.

d. TREE: The ship's hull is relatively transparent to the TREE conditions. Radiation detection, power interruption and dump may be applied. With this approach, a radiation detection IC provides a signal for power supplies to momentarily turn off, and high voltage circuits and capacitors to be crow-barred (discharged to ground). A radiation detection IC is under development and will be available as a SEM module. Using this approach, any momentary component latch-ups will not result in a sustained fault of components and subsequent failure. Power supplies of COTS equipment and capacitors used to store energy would be modified to interface with the radiation detection IC. Other methods employed include part selection and derating. Fiber optics may be sensitive to TREE conditions. Fiber optic cables shall be selected which are insensitive to TREE.

5.1.2.12 Salt fog. Requirements for salt fog shall be as specified in 5.1.2.12.1 through 5.1.2.12.2.

5.1.2.12.1 Fully hardened. Equipment shall withstand salt fog. Salt fog tests shall be tailored in accordance with MIL-STD-810, Method 509. As an alternative, salt fog tests shall be tailored in accordance with IEC 68-2-11Ka, except with a duration for exposure of 48 hours.

5.1.2.12.2 Minimal acceptance. Requirements for equipment operation under salt fog effects shall be specified only for those installations determined by the specifier to be subjected to salt fog effects.

5.1.2.13 Ship motion and attitude. Requirements for ship motion and attitude shall be as specified in 5.1.2.13.1 through 5.1.2.13.2.

5.1.2.13.1 Fully hardened. Equipment shall be fully operational for the ship motion and attitude conditions in accordance with DOD-STD-1399, Section 301. Inclination tests shall be in accordance with APPENDIX D.

5.1.2.13.2 Minimal acceptance. Ships motion and attitude conditions are defined in DOD-STD-1399, Section 301. Under heavy weather conditions, office equipment such

as duplicating machines may be permitted to shut down when the inclination exceeds a pre-specified limit.

5.1.2.14 Shock. Equipment used aboard ship is subjected to shock and vibration as a result of shipping and service conditions, as well as from hostile engagements (see 5.1.2.11.3). Equipment shall be designed to operate within the service environment to be encountered aboard ship. Shock tests and requirements for ship equipment are specified in a through d.

a. Functional shock and bench handling: MIL-STD-810, Method 516, procedures I and VI
b. Storage and transportation: MIL-STD-810, Method 516, procedures II, III, IV, and VIII
c. Combat condition: MIL-S-901
d. Packaging: ASTM D 4169 (see 4.19)

Ship equipment shall be tested in accordance with MIL-S-901 (item c) to simulate operational conditions during exposure to weapons effects, and ASTM D 4169 (item d) to simulate packaging handling and transportation (see 4.19).

5.1.2.14.1 Tailoring guidance. A shock spectrum and transient duration shall be defined which represent the extreme design conditions to be encountered. When published data is not available, guidance shall be sought from NAVSEA 03K21 and NAVSEA 03P3. To determine the testing requirements for combat shock, equipment shall be classified into grades in accordance with MIL-S-901. The procedures of MIL-STD-810, Method 516, shall be reviewed for applicable conditions that are not adequately specified by MIL-S-901 and ASTM D 4169.

5.1.2.14.2 Fully hardened. Equipment shall be classified as Grade A and shall be in accordance with MIL-S-901.

5.1.2.14.3 Minimal acceptance. Equipment which is normally stowed for combat shall not require testing. All other equipment shall be classified as Grade B and be tested in accordance with MIL-S-901.

5.1.2.14.4 Ruggedization techniques. To conform to the high impact shock conditions of MIL-S-901, items in a through e should be considered:

a. Enclosures and drawer mounts should be strengthened
b. Expansion cards in electronic equipment racks should be secured in place
c. Components that are vertically mounted on a printed circuit board may not tolerate shock and vibration
d. Components mounted in carriers may not remain in place

e. Attention should be given to dynamic devices, such as hard disk drives, that may have close operating tolerances

5.1.2.14.4.1 Shock mounts. During equipment design, shock is treated as a spectral function. Shock mounts may be employed to attenuate shock at equipment and component resonant frequencies. Equipment motion and sway must be considered. A shock mount applied to attenuate shock may be resonant at vibration frequencies. Vibration (see 5.1.2.19) is a steady state condition, when shipboard shock is a transient condition. The application of shock mounts should take into consideration shock testing in accordance with MIL-S-901, shock testing during ship shock trials, vibration testing in accordance with MIL-STD-167-1 (see 5.1.2.19), and environmental stress screening vibration in accordance with Tri-Service Technical Brief 002-93-08 (see 5.1.4.1).

5.1.2.14.4.2 Integrated shock attenuation. Equipment modules may be mounted in a structure specifically designed to attenuate both shock and vibration. Under these conditions, the individual modules may be tested to a lesser functional shock level, which is supported by the performance characteristics of the special mounting structure. The systems integrator shall ensure that the installed system conforms to the high impact shock requirements of MIL-S-901.

5.1.2.15 Solar radiation. Requirements for solar radiation shall be as specified in 5.1.2.15.1 through 5.1.2.15.2.

5.1.2.15.1 Fully hardened. Exposed equipment shall not be damaged and shall maintain specified performance when exposed to the sun at its service location. Solar radiation tests shall be tailored in accordance with MIL-STD-810, Method 505, procedure II.

5.1.2.15.2 Minimal acceptance. Requirements for equipment operation under solar radiation shall be specified only for those installations determined by the specifier to be subject to solar radiation.

5.1.2.16 Spray tight and drip proof enclosures. Requirements for spray tight and drip proof enclosures shall be as specified in 5.1.2.16.1 through 5.1.2.16.2.

5.1.2.16.1 Fully hardened. Requirements shall be tailored from MIL-STD-108. Typical applications include submarines and hazardous locations.

5.1.2.16.2 Minimal acceptance. General, requirements for spray tight and drip proof enclosures is not applicable to equipment installed in controlled spaces.

5.1.2.17 Temperature ranges. Requirements for temperature shall be as specified in 5.1.2.17.1 through 5.1.2.17.2. Temperature tests shall be tailored in accordance with

MIL-STD-810, Method 501, and MIL-STD-810, Method 502. Safety criteria shall be as specified in 5.1.3.10.9. The specified criteria for equipment installed in controlled spaces shall consider failure of the environmental control system for 8 hours, that is, equipment shall be suitable for exposure in an uncontrolled environment for 8 hours (see 5.1.2.7).

5.1.2.17.1 Fully hardened. Equipment temperature requirements shall be tailored from TABLE VI.

TABLE VI. Temperature fully hardened limits.

ENVIRONMENT	OPERATING	NON-OPERATING
Uncontrolled	-25°C to +65°C	-40°C to +70°C
Controlled	0°C to +50°C	-40°C to +70°C

5.1.2.17.2 Minimal acceptance. Equipment temperature requirements shall be tailored from TABLE VII. Equipment shall not be damaged when ambient conditions are outside nominal operating limits.

TABLE VII. Temperature minimal acceptable limits.

ENVIRONMENT	OPERATING	NON-OPERATING
Uncontrolled	-25°C to +50°C	-40°C to +70°C
Controlled	+10°C to +50°C	-40°C to +70°C

5.1.2.18 Underwater explosion. Requirements for underwater explosion shall be as specified in 5.1.2.18.1 through 5.1.2.18.2.

5.1.2.18.1 Fully hardened. Equipment which is submerged and exposed to external sea pressure shall withstand the underwater explosion test in accordance with MIL-S-901 for wetted-surface type mounted items.

5.1.2.18.2 Minimal acceptance. Requirements for equipment operation under underwater explosion conditions shall be specified only for those installations determined by the specifier to be subjected to underwater explosions.

5.1.2.19 Vibration. Shipboard equipment shall be in accordance with the type I vibration requirements of MIL-STD-167-1.

5.1.2.20 Wind effects. Requirements for wind effects shall be as specified in 5.1.2.20.1 through 5.1.2.20.2.

5.1.2.20.1 Fully hardened. The exposed equipment, or portions thereof, shall operate within performance limits in winds of 140 kilometers per hour with gusts of 250 kilometers per hour, and shall withstand, without damage, winds of 185 kilometers per hour with gusts of 325 kilometers per hour.

5.1.2.20.2 Minimal acceptance. Requirements for equipment operation under wind effects shall be specified only for those installations determined by the specifier to be subject to wind effects.

5.1.3 Operational constraints. Equipment shall be in accordance with the operational constraints as specified in 5.1.3.1 through 5.1.3.12. Requirements specified are applicable to fully hardened and minimal acceptance.

5.1.3.1 Airborne noise. Submarine noise requirements shall be tailored to the submarine specification generated by the ship acquisition manager. Equipment generated airborne noise shall be in accordance with MIL-STD-740-1. Equipment shall be tested in accordance with MIL-STD-740-1. The specifier shall determine the grade required in accordance with MIL-STD-740-1.

5.1.3.2 Structureborne noise. Submarine noise requirements shall be tailored to the submarine specification generated by the ship acquisition manager. Equipment generated structureborne noise shall be in accordance with type III equipment of MIL-STD-740-2. Equipment shall be tested in accordance with MIL-STD-740-2.

5.1.3.3 AC power. The equipment shall be in accordance with the operational constraints (including, but not limited to, harmonic current content, ramp loading, and so forth) for type I power in accordance with MIL-STD-1399, Section 300 (see 5.1.1.1). Equipment shall be in accordance with the switching transients requirements specified in 5.1.4.8, and the grounding requirement specified in 5.1.4.7.1.

5.1.3.4 Submarine DC power. The equipment shall be in accordance with the operational constraints in accordance with MIL-STD-1399, Section 390 (see 5.1.1.2).

5.1.3.5 Electromagnetic emissions. Electromagnetic emissions requirements shall be tailored in accordance with MIL-STD-461 (see 5.1.2.3). Electromagnetic emissions tests shall be tailored in accordance with MIL-STD-462. Radar equipment shall be in accordance with the requirements of the NTIA Manual and MIL-STD-469. COTS equipment may be procured to FCC Class A or B regulations in accordance with 47 CFR 15.101 to 15.109, and modified to conform to the requirements of the shipboard installation, through application of EMI filters and shielding. FCC regulations only

specify emission limits; COTS equipment may need to be shielded for susceptibility considerations. Further guidance on COTS equipment is provided in the Appendix of MIL-STD-461.

5.1.3.5.1 EMCON. Acoustic, electromagnetic, and optical emitters, such as radars and communication systems, shall have provisions for EMCON. When EMCON is in effect, equipment shall not emit electromagnetic energy of an electrical field strength greater than 0.0090 V per meter when measured at a separation distance of 1.0 meter from the equipment.

5.1.3.6 DC magnetic requirements for minesweeper equipment. Equipment shall be in accordance with DOD-STD-2143. Magnetic material tests shall be in accordance with MIL-I-17214.

5.1.3.7 Fungus. The equipment shall not support fungal growth. Fungus tests shall be in accordance with MIL-STD-810, Method 508.

5.1.3.8 Toxic hazards. The equipment shall not expose personnel to toxic substances in excess of the threshold limit values in accordance with ACGIH ISBN 0-936-712-39-2.

5.1.3.9 Prohibited materials. The materials listed in TABLE VIII, and 29 CFR 1910.1001 to 1910.1101, shall not be used. Submarine atmosphere prohibited materials are specified in S9510-AB-ATM-010 and S9407-AB-ATM-010. Waivers for the use of prohibited materials may be granted in accordance with current DOD acquisition directives. Waivers shall not be granted for the use of radium and its daughter products (radioactive materials). Material requirements for militarized equipment are specified in 5.1.7.8. The use of hazardous material (see 4.7.2) as defined in FED-STD-313 must be approved by the procuring activity.

TABLE VIII. Prohibited materials.
Asbestos; asbestos compounds; and asbestos-filled molding compounds
Cadmium
Carcinogens
Chlorofluorocarbons (CFC), that is, freon
Flammable materials
Lithium and lithium compounds
Magnesium or magnesium alloys
Mercury or its compounds and amalgams

TABLE VIII. Prohibited materials.
Polychlorinated biphenyl (PCB)
Polyvinyl chloride (PVC), except when used for component leads
Radioactive material
Zinc or zinc alloys unless otherwise specified

5.1.3.9.1 Flammability. Equipment shall be noncombustible or fire retardant in the most hazardous conditions to be expected in the application. Fire retardance shall not be achieved by use of nonpermanent additives to the equipment. Cable flammability shall tested in accordance with MIL-C-17 or MIL-C-24643. Testing of other parts and materials shall be in accordance with ASTM D 568, ASTM D 635, ASTM D 1000, or MIL-STD-202, method 111, as applicable.

5.1.3.10 Safety. Safety requirements shall be in accordance with MIL-STD-454, Requirement 1, UL-478, ASTM F 1166, APPENDIX E, and as specified in 5.1.3.10.1 through 5.1.3.10.10. Waivers to safety requirements shall require the written approval of the procuring activity. Waivers may be granted only upon demonstration that the equipment has been tested in accordance with the appropriate UL, Government, or other industry consensus tests to demonstrate its safety for use in the shipboard environment.

5.1.3.10.1 Leakage current. Equipment leakage current shall be limited to 5 mA. Leakage current shall be determined using a solidly grounded power source. Equipment with EMI filters connected line-to-ground shall be balanced to ensure that the leakage current in the equipment ground does not exceed 5 mA (see 5.1.4.6). Leakage current tests shall be as specified in APPENDIX F, or equivalent UL or other industry consensus standard approved by the procuring activity. These tests shall not be performed aboard ship. The potential of the ship's electrical system floating neutral to the hull will be dependent upon the operating modes of equipment, configuration of the electrical plant, physical installation location of the equipment and so forth. Leakage current may be excessive in AC applications with unbalance EMI filters connected line-to-ground. Excessive leakage current in DC applications may be indicative of a more serious problem, for example, degraded dielectric integrity.

5.1.3.10.1.1 Isolation transformers. An isolation transformer shall be applied to equipment whose leakage current would otherwise exceed 5 mA. The isolation transformer shall be part of the equipment configuration. User equipment loads shall be isolated from AC line voltages by a DC resistance greater than 200 megohm•kW of connected load. For example, the DC resistance shall be greater than 100 megohm for a 2 kW load.

5.1.3.10.2 Protective shields. Protective shields shall be provided to protect personnel from accidental contact with parts in excess of 30 V RMS or 30 V DC during operation or maintenance actions.

5.1.3.10.3 Reference and signal voltages. Equipment utilizing external reference or signal voltages in excess of 30 V RMS or 30 V DC shall have the provision for interrupting the reference and signal voltages during maintenance actions.

5.1.3.10.4 Safety, electrical power. Switches for disconnecting avionics equipment from Wye grounded special power systems shall break all power conductors of the circuit. Switches for disconnecting all other equipment from electrical power systems shall break all power and return conductors of the circuit. The safety ground shall not be disconnected.

5.1.3.10.5 Safety ground, internal. A ground terminal shall be provided on equipment. The ground terminal shall be located on the input power connector or on the equipment terminal board and shall connect to internal chassis by means of conductors at least equal in size to one of the power input conductors. Safety grounding within the equipment shall terminate on the ground terminal.

5.1.3.10.6 Safety ground, external. When power is routed externally between individual units of an equipment, a ground conductor shall be included with the power conductors and shall connect to the ground terminal of individual units.

5.1.3.10.7 Safety ground, power cable assemblies. A safety ground conductor shall be included in power cable assemblies that connect to convenience outlets. The safety ground conductor shall be provided by utilizing three-pin connectors and three-conductor cables. The green wire shall be connected to the grounding blade or pin for the type connector used. Input power cable assemblies shall be in accordance with type I of MIL-C-28777.

5.1.3.10.8 Safety ground, drawers. A safety ground shall be included with the power cable assembly and connector of equipment drawers, such that disconnecting of the safety ground from the drawer will result in disconnecting of the power assembly.

5.1.3.10.9 Equipment tests. When tested under conditions of maximum intended load, equipment shall not attain a temperature at any location which constitutes a risk of fire, damages any materials used in the equipment, or exceeds temperature above the ambient as allowed by UL or other consensus standards for the equipment.

5.1.3.10.10 Thermal design. Equipment handle or knob temperatures, and temperature hazard markings, shall be in accordance with MIL-STD-454, Requirement 1, UL, or other consensus standards for the type of equipment (see 5.1.6.11).

5.1.3.11 Size and weight. The size and weight of the equipment shall be constrained as specified in the end item specification. Size limits may be achieved by use of separable units. Equipment mass/size/shape shall be in accordance with DOD-STD-1399, Section 071. Design of rack-mounted and console equipment shall maintain the center of gravity as low as practical.

5.1.3.12 Grounding. Equipment shall be grounded in accordance with MIL-STD-1310.

5.1.3.12.1 Digital computer grounding. When identified in the end item specification as equipment used for the processing, recording, or storage of digital or classified information, the equipment shall be compatible with the requirements of DOD-STD-1399, Section 406.

5.1.4 Electrical design and construction. Electrical design and construction of militarized equipment shall be as specified in 5.1.4.1 through 5.1.4.11.4. The specifier of ruggedized equipment shall review these requirements for design features that may be tailored for the application of the equipment.

5.1.4.1 Environmental stress (workmanship) screening. Environmental stress screening shall be developed and performed in accordance with Tri-Service Technical Brief 002-93-08. Environmental stress screening requirements shall be tailored.

5.1.4.2 Sneak circuit analysis. Sneak circuit analysis shall be applied to mission or safety critical circuitry and software. Guidance concerning the application and implementation of sneak circuit analysis is provided by NAVSO P-3634.

5.1.4.3 Electrical power. The equipment shall operate from electrical power sources as specified in 5.1.4.3.1 through 5.1.4.3.2.

5.1.4.3.1 Electrical input power connections. The input power connector contacts or pin assignments and conductor color code internal to equipment shall be as specified in TABLE IX. Input power connectors shall be as specified in the end item specification (see 5.1.7.7).

TABLE IX. Conductor designations.

EQUIPMENT POWER SUPPLY	CONDUCTOR ASSIGNMENT	CONNECTOR DESIGNATION	CONDUCTOR COLOR
Single-phase	115/440 V RMS	A	White
	115/440 V RMS	C	Black
	Safety ground	B	Green
Three-phase	Phase A	A	Black
	Phase B	B	White
	Phase C	C	Red
	Safety ground	D	Green
DC power	Positive	A	Red
	Negative	C	Black
	Ground	B	Green

Note: Shipboard electrical distribution systems are delta-connected, precluding the use of the safety ground as a power-carrying conductor. Safety ground connections for bonding and grounding are provided for EMI and personnel safety considerations.

5.1.4.3.2 Color code. The color code for conductors shall be maintained from the input power connections to all components having the same voltage and frequency as the input power.

5.1.4.4 Electrical equipment protection. Electrical equipment shall employ electrical protection as specified in 5.1.4.4.1 through 5.1.4.4.5.1.

5.1.4.4.1 Equipment interlocks. The number of personnel safety, maintenance, and equipment protective interlocks shall be kept to a minimum. Protective shields shall be provided instead of interlocks, to protect personnel from accidental contact with parts in excess of 30 V RMS or 30 V DC, as specified in 5.1.3.10.2. Mission critical equipment shall not shut down during momentary power interruptions (see 5.1.1.1.1) or contact chatter of electrical interlocks and coolant flow/level sensors during shock (see 5.1.2.14).

5.1.4.4.2 Dielectric withstanding voltage. The equipment shall prevent electrical breakdown such as corona (defined in ASTM D 1868), flash-over (surface discharge), spark-over (air discharge), or breakdown (puncture discharge) when the electrical power circuits are subjected to the dielectric test voltages shown in TABLE X for 1 minute at 60 Hz.

TABLE X. Dielectric test voltages.

CIRCUIT VOLTAGE OF EQUIPMENT TESTED (V)	RMS VALUE OF DIELECTRIC TEST VOLTAGE (V)
Less than 60	450
60 to 120	900
Above 120 and less than 240	1200
240 to 480	1500
Above 480	Twice rated plus 1000

5.1.4.4.3 Insulation resistance. Insulation resistance of the equipment shall be not less than 10 megohms at specified environmental service conditions, measured at 500 V DC. Each circuit shall be measured against all other circuits, with all other circuits connected to the chassis.

5.1.4.4.4 Clearance and leakage distance. Clearances between solder connections or bare conductors, such as on terminal strips, stand-offs, or similar connections shall be such that no accidental contact can occur between adjacent connections when subjected to service conditions of the end-item specification. Consideration shall be given to case deflections due to shock. Spacing requirements for electrical clearance and leakage distances shall be tailored in accordance with NFPA 70, Articles 384 and 710.

5.1.4.4.5 Electrical overcurrent protection. The use of circuit breakers in combat system equipment shall be minimized. Circuit breakers shall be coordinated such that the circuit breaker closest to a fault will trip before other circuit breakers trip (see 4.2.3.1.2). Multi-phase circuit breakers shall disconnect all phases when an overload occurs in any one phase. Protective devices shall not be installed in the neutral unless neutral power sensing is essential to proper operation of the equipment and the overcurrent protective device simultaneously opens all conductors of the circuit and operates such that no pole can operate independently. When electrical overcurrent protection devices are used internally, the status (that is, open or closed) shall be displayed on the operating panel and the restoration of the device shall be controllable

from the front panel. Circuit breakers used in shipboard equipment shall be in accordance with DESC Drawings 87060, 87061, or 87062, and shall be mounted in the horizontal orientation.

5.1.4.4.5.1 Fuses and circuit breakers. Fuseholders shall provide blown fuse indication. All fuses and circuit breakers shall be readily accessible from the front panel without removal of any panels. A minimum of two spare fuses shall be provided for each fuse used (that is, four fuses for each pair of fuses), mounted adjacent to the fuse holder for which the spare fuses are intended. When fuses are used, the fuses shall be electrically located on the load side of the ON-OFF switch. If extractor post type fuseholders are used, the fuseholders shall be connected in such a manner that the load is connected to the fuse terminal which terminates in the removable cap assembly.

5.1.4.5 Main power ON-OFF. The main power ON-OFF switch located on the equipment shall de-energize the equipment. The switch shall open all conductors except the safety ground. The main power ON-OFF switch shall be clearly labeled. A green lamp shall be mounted on or near the equipment to indicate when the equipment is energized. The lamp shall be connected to the load side of the switch. Unless specifically needed for overload protection, circuit breakers shall not be used for turning equipment on and off.

5.1.4.6 Equipment capacitance and EMI filters. When EMI filters are required, line-to-line filters are preferred to line-to-ground filters (see 5.1.3.10.1). AC line-to-ground capacitance shall be in accordance with MIL-STD-1399, Section 300, and MIL-STD-461. Line-to-ground capacitance of DC input power lines shall be in accordance with MIL-STD-1399, Section 390. EMI filters shall be located on the load side of the power ON/OFF switch when practical to minimize capacitive loading of the electrical system, to prevent failure of EMI filters when equipment is not in use, and to prevent potential resonant conditions.

5.1.4.7 Equipment electrical performance. Equipment electrical performance characteristics shall be as specified in 5.1.4.7.1 through 5.1.4.7.3.1.

5.1.4.7.1 Grounded input power. Under casualty conditions, and even during the day-to-day ship operations, any one of the three-phase line voltages may short to ground. The ship's power source is connected delta, with a floating neutral, specifically in order that the operations may continue with one power input line grounded. This and cathodic corrosion are the primary reasons why the ship's power source is not connected WYE. If the equipment is connected WYE, a significant voltage may exist between the neutral connection and the ship's floating neutral, creating a safety hazard and probable failure when one line voltage becomes grounded. Equipment shall be suitable for operation in each operating mode with one power input line grounded.

5.1.4.7.2 Failure tolerance. The equipment shall be designed such that failure of a component normally used for performance improvement shall not disable the equipment. The design shall allow continued operation at a reduction in performance; for example, if failure occurs in the automatic frequency control circuits of a receiver, the circuitry shall be designed to provide for operation from a manual position without increasing the probability of failure of the remaining units. Provisions for testing, including BIT, shall be such that failure of the test circuitry will not degrade the performance of the equipment.

5.1.4.7.3 Accelerated life. Equipment shall undergo an accelerated life test. An accelerated life test is specified in APPENDIX D.

5.1.4.7.3.1 Test, analyze, and fix (TAAF) testing. A TAAF test shall be conducted to identify design deficiencies of the equipment in the specified environment and to permit corrective action prior to a production commitment, tailored to the TAAF guidance document.

5.1.4.8 Switching transients. The change in load current of equipment that use solid state devices for power switching shall not exceed 10 times rated load current per millisecond for 60 Hz equipment. For example, the change in load current of equipment rated 10 A shall not exceed of 100 A per millisecond. Switching transients cause voltage spikes on the electrical distribution system and failure of other equipment. Electrical testing may not show the effects of switching transients unless the source impedance of the test apparatus is consistent with that expected for the ship.

5.1.4.9 Internal wiring practices. Internal wiring practices shall be in accordance with MIL-STD-454, Requirement 69.

5.1.4.10 Power supplies. SPS shall be used when possible and cost effective over the equipment life cycle. SPS shall be in accordance with MIL-STD-2038 and MIL-P-24764. Other power supplies shall be in accordance with MIL-P-24764, and as specified in 5.1.4.10.1 through 5.1.4.10.5. Guidance for power supply design and manufacturing is provided in NAVMAT P-4855-1 (NAVSO P-3641).

5.1.4.10.1 Power density. An output power density exceeding 0.4 W per cubic centimeter shall require the approval of the procuring activity.

5.1.4.10.2 Power supply interface. Power supplies shall be tested with the end item equipment, or shall be tested as a unit by simulating the input power and output power of the power supply as installed for operation in the end item equipment. The power source used for testing shall include the EMI filters and power line source impedance expected in the installed configuration.

5.1.4.10.3 Power supply manufacturing. Power supply manufacturing shall include random vibration and temperature cycling of every unit, under full electrical load. All low voltage regulated power supplies shall have easily removable regulator subassemblies.

5.1.4.10.4 Open and short circuit. Power supplies shall not be damaged by any load between an open circuit and a short circuit.

5.1.4.10.5 Power supply EMI design guidance. Design guidance for conforming to EMI requirements is provided in NAVMAT P-4855-1 (NAVSO P-3641) and MIL-HDBK-241.

5.1.4.11 Battery system design. SBS shall be used when possible and cost effective over the equipment life cycle. The battery system design shall be as specified in 5.1.4.11.1 through 5.1.4.11.4.

5.1.4.11.1 Battery selection. Navy primary and secondary batteries shall be in accordance with NAVSO P-3676. Batteries shall be selected from MIL-STD-454, Requirement 27, or SHARP TP-001. Rechargeable batteries shall be valve regulated/starved electrolyte type. Lithium batteries shall not be used unless it is demonstrated that no other alternative is practical. The strength of the compartment containing lithium cells shall have a force-containment safety factor equal to at least one and one-half times the maximum anticipated force generated by an explosion or venting. The application of lithium batteries requires safety certification. The application and the safety certification process shall be in accordance with TM S9310-AQ-SAF-010.

5.1.4.11.2 Battery compartment. Battery compartments shall be separate from equipment electronic circuits and shall be located for ease of battery replacement. The compartment shall be vented to avoid the buildup of gasses. The compartment shall be sized to accommodate larger batteries if load growth/emergency DC requirements are expected to increase with equipment maturity.

5.1.4.11.3 Battery charging. Charging circuits shall fail low voltage only, and shall be temperature compensated. Charging circuits shall have two modes, for normal (bulk) charging of discharged batteries, for float (trickle) charging of charged batteries.

5.1.4.11.4 Battery connection. Wires leading from load equipment to the battery shall have sufficient length to allow two replacements of battery connectors (that is, 100 millimeters to 150 millimeters).

5.1.5 Electronic design and construction. The electronic design and construction of militarized equipment shall be as specified in 5.1.5.1 through 5.1.5.3. The specifier of

ruggedized equipment shall review these requirements for design features that may be required for the application of the equipment.

5.1.5.1 DC leads. When equipment will be damaged due to a reverse bias on the DC input, the equipment shall contain reverse polarity protection for each DC input.

5.1.5.2 Electronic signal interfaces. The interface requirements for electronic signals which send and receive data shall be in accordance with 4.2.4 and as specified 5.1.5.2.1 through 5.1.5.2.4. The interface requirements shall apply to both external equipment interfaces and internal equipment interfaces such as computer bus backplanes.

5.1.5.2.1 Digital data. The equipment data format shall be in accordance with the end item specification. MIL-STD-1399, Section 502, shall be used as guidance for Naval interfaces.

5.1.5.2.2 PTTI. When specified in the end item specification, the equipment shall be compatible with the requirements of DOD-STD-1399, Section 441.

5.1.5.2.3 Synchro data. The equipment shall be in accordance with MIL-HDBK-225. Synchro capacitors shall be rated at 600 V DC for 60 Hz synchros. 400 Hz power will be provided for shipboard avionics use only. Synchro capacitors shall be rated 1000 V DC for 400 Hz synchros.

5.1.5.2.4 Synchro data transmission systems. Synchro data transmission systems shall be in accordance with the interface characteristics and constraints of MIL-STD-1399, Section 702. MIL-HDBK-225 provides tailoring guidance for specifying electrical zeroing methods.

5.1.5.3 Digital form of documentation. Printed wiring board description in digital (numerical) form shall be in accordance with IPC D 330.

5.1.6 Mechanical design and construction. The mechanical design and construction of militarized equipment shall be as specified in 5.1.6.1 through 5.1.6.11.3. The specifier of ruggedized equipment shall review these requirements for design features that may be required for the application of the equipment.

5.1.6.1 Cable entrance plates, stuffing tube. The enclosure shall be provided with cable entrance plates capable of preserving the degree of enclosure specified in the end item specification. Space shall be provided inside the enclosure between the stuffing tubes and the terminal boards such that the wiring will not be crushed or distorted when the internal subassembly is mounted in the enclosure. All stuffing tubes for an enclosure shall be mounted on a plate having sufficient area to accommodate an additional stuffing tube of the largest size mounted thereon. This

plate shall be on at least two sides of the enclosure. The unused stuffing tube mounting plate areas on the enclosure shall be covered with blank plates of the same configuration as the stuffing tube plate. Stuffing tubes shall be selected from MIL-S-19622 and installed in accordance with DOD-STD-2003-3. Cable entrances shall be located such that cables will not block equipment heat exhaust vents.

5.1.6.1.1 Cable entrance stuffing tube (cast enclosures). On cast enclosures with a wall thickness greater than 4.8 millimeters, bosses, drilled and tapped with NPT type pipe threads conforming to FED-STD-H28 and FED-STD-H28/7 for the stuffing tube to be used, shall be provided in the top, bottom, or sides of the enclosure. Plastic protective cap plugs (Ca-Plugs, or equal) shall be installed in cable entrance holes to provide protection during shipment or handling prior to equipment installation.

5.1.6.1.2 Exposed cable. When possible, the equipment connecting cables shall be routed internal to the mounting assembly to minimize the amount of cable exposed to EMP and the conduit required for connecting the equipment.

5.1.6.2 Rotating components. Motors, dynamotors, and rotating devices shall be marked to show the direction of rotation. Positive locking devices shall be used to secure gears, cams, and similar devices to shaft.

5.1.6.2.1 Balancing. Rotatable and rotating parts, except locking adjustment controls, shall be statically and dynamically balanced and supported to prevent damage or unintentional movement under any environmental condition specified herein. If weights are necessary for balancing, the weights shall be securely mounted to prevent movement or loss.

5.1.6.3 Enclosures. SES shall be used when possible and cost effective over the equipment life cycle. SES shall be in accordance with MIL-STD-2200. Other equipment enclosures shall be in accordance with MIL-STD-108 and MIL-E-2036. Enclosures shall be tested in accordance with MIL-STD-108. Enclosure survivability requirements shall be tailored from MIL-E-24762. The degree of enclosure for exposed equipment shall be watertight; drip-proof to 15 degrees for surface ship internal installations; and drip-proof to 45 degrees for submarine internal installations. The internal clearance and the equipment mounting holes of racks and panels shall be in accordance with EIA 310. The use of of NDI (english) panels on metric racks in accordance with EIA 310 may require modification of hole spacing on panels.

5.1.6.4 Equipment mounting. The method of equipment mounting shall be as specified in TABLE XI, and 5.1.6.4.1 through 5.1.6.4.6.

TABLE XI. Equipment mounting.

EQUIPMENT MOUNTING METHOD	ORDER OF PREFERENCE	MAXIMUM WEIGHT (KILOGRAMS)
Horizontal	1	No limit
Panel	2	As specified in EIA 310
Vertical	3	89
Overhead	4	23

5.1.6.4.1 Horizontal mounting. Equipment shall have mounting features which permit through bolts to be installed perpendicular to the mounting surface and additional features to provide for installing sway braces to the upper rear of the equipment when necessary for stable horizontal mounting.

5.1.6.4.2 Overhead mounting. Equipment shall incorporate mounting features located to suspend the equipment and to transmit the load to the overhead structure.

5.1.6.4.3 Panel mounting. Equipment shall incorporate a flange for securing the panel in a vertical position. The equipment shall project not greater than 40 millimeters from the face of the panel (not including operating handles). Design of rack-mounted and console equipment shall maintain the center of gravity as low as practical.

5.1.6.4.4 Sliding drawer mounting. Equipment design shall include provisions to prevent accidental derailing and detachment or pulling off slides of equipment mounted on drawer slides.

5.1.6.4.5 Vertical mounting. Equipment intended for vertical mounting (except switchboards) shall have mounting pads on the rear surfaces of the enclosure. A minimum of two pads shall be above the center of gravity of the enclosed equipment. Additional pads shall be positioned to transmit loads to the supporting structure.

5.1.6.4.6 Resilient mounts. The use of resilient mounts shall be used in accordance with the guidance of MIL-S-901. Mechanical shock mounts are preferred to resilient material because of degradation of the resiliency characteristics of the material over the equipment lifetime, and resilient material is effective in one plane of shock only. Resilient material used in the equipment shall undergo accelerated aging prior to shock testing to demonstrate that the equipment conforms to specified shock performance at the end of the design life.

5.1.6.5 Handling. The equipment shall incorporate the design features for efficient handling in accordance with ASTM F 1166.

5.1.6.6 Hazardous atmosphere. When specified in the end item specification, the equipment or portions thereof shall be protected against a hazardous atmosphere by one of the methods specified in a through c:

a. Enclosed in a heavy-duty, explosion-proof housing as defined in MIL-STD-108
b. Hermetically sealed conforming to the hermetic enclosure requirement of MIL-STD-108
c. Embedded (potted) or encapsulated. Materials shall be of a nonreversion type and shall be selected from MIL-S-8516, MIL-I-16923, MIL-S-23586, MIL-M-24041 and MIL-I-81550

5.1.6.7 Pockets, wells, and traps. Pockets, wells, and traps in which water or condensate could collect when the equipment is in normal position shall be avoided.

5.1.6.7.1 Moisture pockets. When moisture pockets are unavoidable in unsealed equipment, provisions shall be made for drainage of such pockets. Desiccants or moisture-absorbent materials shall not be used within moisture pockets. Waveguides shall include a method to purge moisture from low points in the waveguide.

5.1.6.8 Mounting bolts. Calculations for the proper size of deck and bulkhead attachment bolts shall be based on the minimum elastic-proof load for Grade 2 carbon and alloy steel in accordance with MIL-S-1222.

5.1.6.8.1 Through bolting. Through bolting or through threading into watertight enclosures shall not be permitted. Bosses shall be provided in cast enclosures to preclude through bolting or threading. Blind tapped continuous welded buttons shall be used in sheet metal enclosures.

5.1.6.9 Mounting of electric receptacles. When practical, when receptacles are mounted on a vertical surface, the largest polarizing or prime key or keyway of the receptacle shall be at the top center of the shell of the receptacle.

5.1.6.9.1 Adjacent locations. The use of identical connectors in adjacent locations shall be avoided. When the use of connectors of the same shell size in adjacent locations cannot be avoided, differences in the keying arrangement shall be used to prevent mismating.

5.1.6.9.2 Location. External connections (excluding test connections) shall not be located on the front of the equipment.

5.1.6.9.2.1 External connections. The method of external connections to equipment enclosures shall be made by the use of connectors and shall be in accordance with applicable requirements. EMP protected equipment shall be provided with back shells that can accept MIL-C-24758 conduit end fittings to provide 360 degrees grounding of the cable shield. Terminal boards or stuffing tubes (see 5.1.6.1) shall be used when specified in the end item specification and the applicable requirements. Terminal boards are not preferred since the terminal boards may loosen under vibration conditions. External connections, excluding test connections, shall not be located on the front of the enclosures.

5.1.6.9.2.2 Terminal board accessibility. Access to terminal boards and test points shall not be dependent upon removal of cable entrance plates and cables.

5.1.6.10 Sealed equipment. In sealed equipment or assemblies such as waveguides, the use of desiccants or other methods, such as gas purging, is permitted.

5.1.6.10.1 Watertight joints. Gaskets for watertight joints shall not be displaced when the door or cover is removed. The design shall prevent lateral flow of the gasket when under compression.

5.1.6.11 Thermal design and construction. Thermal design shall be in accordance with the guidance of MIL-HDBK-251, 5.1.3.10.10, and 5.1.6.11.1 through 5.1.6.11.3. Equipment shall be tested in accordance with APPENDIX D.

5.1.6.11.1 Cooling method. For surface ships, the order of preference for cooling is natural convection, forced air cooling, solid state cold plates and heat pipes, and chilled water. The installation may be such that exhaust heat is directed to return air ducts. For submarines, cooling by chilled water is preferred to forced air cooling to reduce the acoustic signature of the ship. The method of cooling selected shall consider available cooling systems, density, space, weight, and structureborne noise caused by fans and pumps.

5.1.6.11.2 Inlet/outlet location. The inlet air port shall be located not less than 300 millimeters from the floor. Air exhaust shall be directed away from operating personnel.

5.1.6.11.3 Fans and blowers. Exhaust and recirculating fans and blowers shall be driven by ac brushless motors. Miniature blowers shall be in accordance with MIL-B-23071.

5.1.7 Parts. Parts selected in accordance with the end item specification shall not relieve the contractor of the responsibility for compliance with the equipment performance requirements and the other requirements of the end item specification. Parts used in militarized equipment shall be as specified 5.1.7.1 through 5.1.7.8.2.2.

Standard hardware shall be used when possible (see 4.1.2.1.1). The specifier of ruggedized equipment shall review the requirements for design features that may be required for the application of the equipment.

5.1.7.1 Obsolescence or nonavailability. The contractor's design and method of part selection shall minimize the impact of parts obsolescence or nonavailability, as specified in the end item specification or contract.

5.1.7.2 Parts control. The parts to be incorporated in the equipment shall be controlled in accordance with MIL-STD-965, procedure I or II to the extent specified in the end item specification.

5.1.7.3 Parts derating. Parts derating shall be in accordance with TE000-AB-GTP-010.

5.1.7.4 Parts replacement. The arrangement of parts on repairable items shall be such that replacement of any part can be accomplished without removal of or damage to adjacent parts. Accessibility shall be in accordance with MIL-STD-454, Requirement 36.

5.1.7.5 Parts tolerances. When a specification provides more than one grade, characteristic, or tolerance of a part, the selection shall be parts of the lowest grades, broadest characteristics, and widest tolerances which will enable the equipment to conform to the performance and other requirements of the end item specification. The tolerances of parts shall allow for the effects of long term drift to ensure adequate performance of the equipment to the end of the intended service life.

5.1.7.6 Used or damaged parts. Used or damaged parts or materials shall not be used.

5.1.7.7 Parts, general requirements. Parts shall be as specified in TABLE XII, and as specified 5.1.7.7.1 through 5.1.7.7.16. The use of other parts shall require the approval of the procuring activity, and shall have a demonstrated parts defect rate of 100 parts per million or less.

TABLE XII. Parts.

Item	Requirement
Bearings	Shall be in accordance with MIL-STD-454, Requirement 6. Bearings for use in noise critical applications shall be in accordance with MIL-B-17931.
Circulators	Shall be in accordance with MIL-C-28790.

TABLE XII. Parts.

Item	Requirement
Clamp, cable entrance	Shall be in accordance with W-F-406.
Connectors	See 5.1.7.7.7. Banana plugs and jacks shall not be used. Pressure proof connectors, for submarine hull penetration, shall be in accordance with MIL-C-24231.
Controllers, electric motors	Shall be in accordance with MIL-C-2212.
Controls	Shall be in accordance with MIL-STD-454, Requirement 28.
Dial window gaskets and seals	Shall be in accordance with MIL-R-2765 for other than low temperature (-30°C minimum) applications.
Fastener hardware	Shall be in accordance with MIL-STD-454, Requirement 12.
Filters, electrical	Shall be in accordance with MIL-STD-1395.
Gears and cams	Positive locking devices shall be used to secure gears, cams, collars, and similar devices to shaft. When not operating in a lubricant bath containing a corrosion inhibiting additive, gears shall be made of corrosion resistant materials.
Grommets	Shall be in accordance with MIL-G-3036 or MIL-G-22529.
Gyroscopes, rate integrating	Shall be in accordance with MIL-G-81168.
Indicator lights	Shall be in accordance with MIL-STD-454, Requirement 50, and the color coding requirements of ASTM F 1166.
Meters, electrical indicating	Meters shall be selected and applied in accordance with MIL-STD-1279. Meters shall not be the electrochemical type.
Motors, dynamotors, and rotating devices	Shall be in accordance with MIL-STD-454, Requirement 46, and marked to show the direction of rotation
Readouts	Shall be in accordance with MIL-R-28803, or MIL-D-87157, quality level A or B.

TABLE XII. Parts.

Item	Requirement
Relays	Shall be in accordance with MIL-STD-454, Requirement 57.
Servo devices	Shall be in accordance with MIL-STD-454, Requirement 56.
Shunts	Shall be in accordance with MIL-S-61 or MIL-I-1361, as applicable.
Sockets and accessories	Shall be in accordance with MIL-STD-454, Requirement 60.
Solenoids	Shall be in accordance with MIL-S-4040.
Springs	Shall be in accordance with MIL-STD-454, Requirement 41.
Switches	Shall be selected and applied in accordance with MIL-STD-1132. Switches required other than those specified in MIL-STD-1132 shall be in accordance with MIL-S-12285, MIL-S-15743, MIL-S-18396, or MIL-S-83731.
Terminations	Shall be in accordance with MIL-STD-454, Requirement 19.
Tubes, electron	Shall be selected and applied in accordance with MIL-STD-200.
Vibrator power supply	Shall not be used.
Coaxial cable	Shall be in accordance with MIL-C-17, MIL-L-3890, MIL-C-22931, or MIL-C-23806.
Flat cable	Shall be in accordance with MIL-C-49055 for cables with round conductors and MIL-C-49059 for cables with flat conductors.
Interconnecting cable	Shall be in accordance with MIL-STD-454, Requirement 71. Cables shall be selected from MIL-C-24643. Lightweight cables with conductor sizes American Wire Gage (AWG) 12 or smaller shall be selected from MIL-C-24640.
Cable multiconductor (internal)	Shall be in accordance with MIL-STD-454, Requirement 66.

TABLE XII. Parts.	
Item	Requirement
Waveguides and related devices	Shall be in accordance with MIL-STD-454, Requirement 53.
Wire internal, hook-up	Shall be in accordance with MIL-STD-454, Requirement 20.
Wire magnet	Shall be in accordance with J-W-1177.

5.1.7.7.1 Electronic parts. SEM shall be used when possible and cost effective over the equipment life cycle. SEM shall be in accordance with MIL-STD-1378, MIL-HDBK-246, and certified in accordance with MIL-M-28787. To prevent large numbers of SEM A and SEM B modules, SEM D and larger modules shall be used. Other electronic parts shall be selected from MIL-STD-242, MIL-STD-454, Requirement 64 (microelectronic devices), MIL-STD-701 (semiconductors) and the GFB. Guidance on the GFB is provided in MIL-STD-965. The order of preference for electronic part selection shall be in accordance with TABLE XIII.

TABLE XIII. Electronic Parts Selection.	
Preference	Description
1	SEM
2	Part listed in GFB and conforms to military specification
3	Part listed in GFB only
4	Part not listed in GFB but conforms to military specification
5	Part not listed in GFB but conforms to DESC drawing
6	Part is commercial but can conform to military specification

5.1.7.7.2 Printed circuits. Printed circuits and printed circuit wiring boards shall be in accordance with MIL-STD-454, Requirement 17, MIL-STD-275, and MIL-P-55110. Thick film ceramic boards with leadless components shall be in accordance with NAVSO P-3651.

5.1.7.7.3 Wire and cable. Aluminum wire shall not be used.

5.1.7.7.4 Air filters. Air filters shall be in accordance with MIL-F-16552. Filters shall be removable for cleaning without disassembly of the equipment.

5.1.7.7.5 Convenience power receptacles. Convenience power receptacles shall not be provided.

5.1.7.7.6 Capacitors. Capacitors shall be in accordance with MIL-STD-198, and as specified in 5.1.7.7.6.1 through 5.1.7.7.6.3.

5.1.7.7.6.1 Electrolytic capacitors. Electrolytic (aluminum foil) capacitors shall not be used in AC applications.

5.1.7.7.6.2 Paper capacitors. Paper or paper-plastic fixed capacitors with nonmetallic cases shall not be used, except that nonmetallic-plastic wrapped capacitors in accordance with MIL-C-55514 may be used in encapsulated or hermetically sealed assemblies.

5.1.7.7.6.3 Paper dielectric capacitors. Fixed paper dielectric capacitors shall not be used except as feed through radio interference capacitors, and shall be in accordance with MIL-C-11693.

5.1.7.7.7 Connectors. Connectors shall be in accordance with MIL-STD-454, Requirement 10, and as specified in 5.1.7.7.7.1 through 5.1.7.7.7.7.

5.1.7.7.7.1 Connector type. Connectors shall be of the type that will not disconnect or become loose under the environmental conditions specified herein and during the service life of the equipment. For example, connectors with threaded shells, ring tongue terminal connectors for terminal strips, and connectors that rotate to a locking position may be specified.

5.1.7.7.7.2 Connector selection and application. MIL-C-5015, MIL-C-28840, and MIL-C-28731 connectors shall be selected and applied in accordance with MIL-STD-1683.

5.1.7.7.7.3 Connector contacts, energized. Connector plug or receptacle contacts which remain energized after unmating shall be inaccessible to personnel.

5.1.7.7.7.4 Connectors, crimped type. Crimped type connectors used internal or external to the equipment shall be of a type whose contacts can be crimped with a tool conforming to MIL-C-22520.

5.1.7.7.7.5 Connector keying. Multi-contact connectors, including printed circuit assembly connections, shall be keyed, polarized, or of a contact configuration to prevent improper connection positioning or mating.

5.1.7.7.7.6 Mating connector plugs. Mating connector plugs and backshells shall be furnished with connector receptacles. The mating connector plugs and backshells

shall be compatible with the cables required by TABLE XII without modification of either the connector or the cable, and without the use of adapters (except RF) or special tools (other than crimping tools in accordance with MIL-C-22520).

5.1.7.7.7 Protective caps. Protective caps shall be provided for cable entrance holes and equipment connectors to provide protection during shipment or handling prior to equipment installation.

5.1.7.7.8 Gaskets. Gaskets on exposed equipment shall provide grounding along the perimeter of the gasket for EMP protection. Gaskets shall be in accordance with 5.1.7.7.8.1 and 5.1.7.7.8.2.

5.1.7.7.8.1 Flat gaskets. The use of flat gaskets shall be held to a minimum and shall be used only between smooth regular surfaces. Flat gaskets shall be in accordance with MIL-R-15624. Consideration shall be given to the degree of enclosure required and the accessibility required. Gaskets which are not penetrated by mounting screws are preferred.

5.1.7.7.8.2 O-ring gaskets. Installation of O-ring gaskets shall be in accordance with MIL-G-5514. Lubrication shall be in accordance with MIL-S-8660, except when lubrication in service is required which shall be as provided for pneumatic seals specified in MIL-G-5514. O-ring gaskets in accordance with MIL-P-25732 or MIL-P-83461 shall be used for static seals (between case and cover), reciprocating motion seals (push-button shafts), and for rotary motion seals when the rotational speed is less than 10 revolutions per minute. The inside radius of corners for static seals shall be greater than 3 millimeters.

5.1.7.7.9 Glass. Glass shall be used in accordance with MIL-HDBK-722, and shall be in accordance with class 1, type I, MIL-G-3787.

5.1.7.7.9.1 Securing glass windows. When operating controls are arranged so as to require the reading of dials through windows in the panels or the control housings, the window shall be provided with glass secured to the panels by means of clips or other mechanical devices. The use of cement alone for securing the glass is not acceptable.

5.1.7.7.10 Dials and pointers for units not having self-contained illumination. Dials and pointers shall have white faces with black numerals, graduations, and lettering. In units having a single indicator, the pointer shall be black. In units having two concentric indicators, the numeral and pointer colors shall be in accordance with the end item specification.

5.1.7.7.11 Dials and pointers for interior communications, order, and indicating systems. The markings shall be free from distortion with clear and sharp edges. The

width of the pointer tip shall be the same width as the minimum dial graduations. The pointer shall not cover the graduations to which the pointer refers but shall extend only to the nearer edge of the graduations.

5.1.7.7.12 Illuminated devices. Illuminated controls, switches, and dials shall be illuminated by lighting sources integral to associated equipment. Dials and other displays illuminated with white light shall be readable in all levels of incident illumination below 300 lux. Red illuminated dials and displays shall be readable in all levels of incident illumination up to 0.3 lux. When the observation of an object or surface is critical to the operation of equipment, the illumination shall be from two or more sources.

5.1.7.7.12.1 Design for dark adapted areas. Equipment designed for use in dark adapted areas shall use clear lamps with red filters and stencil type material having transmission characteristics as shown on FIGURE 5. There shall be no bright reflective surface visible to the equipment operator.

5.1.7.7.12.2 Illuminated panels. Integrally illuminated panels shall be in accordance with MIL-P-7788.

5.1.7.7.12.3 Lamps. Light emitting diodes are preferred to incandescent lamps for maintenance and reliability considerations. Lamps for controls, switches, and dials shall be energized from the secondary of a transformer, and the lighting circuit shall be equipped with a control device to vary light intensity from maximum value to minimum discernible intensity when all lamps or when 50 percent of the lamps are operative. The control device may be electrical or optical. The lamp socket voltage shall not exceed the rated value of the lamp under any operating condition.

5.1.7.7.12.4 Lamp/display test feature. A lamp/display test feature shall be provided. Incandescent lamps shall be replaceable from the front panel.

5.1.7.7.12.5 Dials and pointers for units having self-contained red illumination. Dials and pointers shall have dark faces and white numerals, graduations and lettering when viewed under high level ambient illumination. Dials and pointers shall present red numerals, graduations and lettering when the internal illumination is energized and viewed under low level ambient illumination. In units having a single indication, the pointer shall have a white border. In units having two concentric indications, distinctive numerals and shapes in addition to a white border shall be in accordance with the end item specification. Transmission cut-off characteristics shall be as shown on FIGURE 5. The transmission cut-off shall be 590 nanometers with a peak of 700 nanometers.

5.1.7.7.13 Terminal lugs. Terminal lugs for fitting to ships cables shall not be supplied.

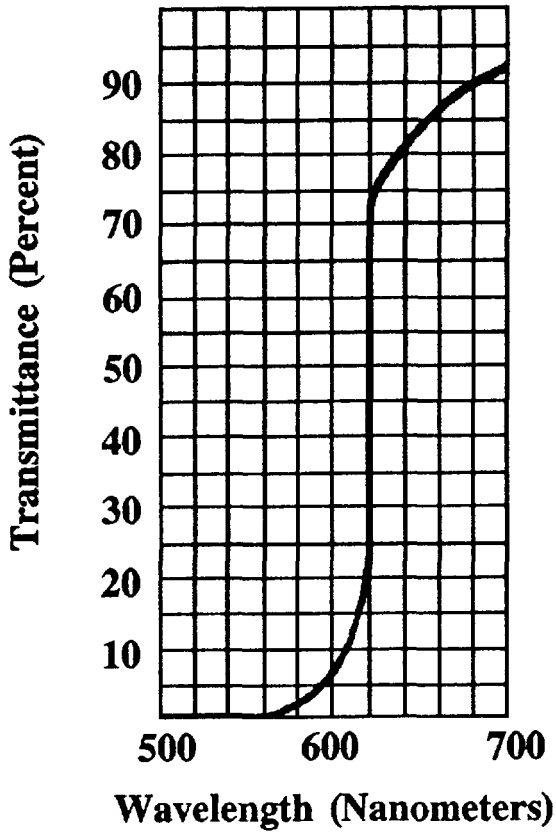


FIGURE 5. Curve of light transmission of red material.

5.1.7.7.14 Elapsed time indicators. Elapsed time indicators shall be provided to indicate the elapsed time for each equipment operating mode, and shall be of the solid state type in accordance with MIL-M-7793. Elapsed time indicators shall not be mounted on removable assemblies. The preferred method of recording shall be an automated system using a centralized computer. Meters shall have a MTBF of at least two times that of the equipment being monitored.

5.1.7.7.15 Transformers, inductors and coils. Selection of transformers, inductors, and coils shall be in accordance with MIL-STD-1286.

5.1.7.7.15.1 Variable transformers. Variable transformers shall be in accordance with MIL-T-83721.

5.1.7.7.15.2 Intermediate frequency, RF, and discriminator transformers. Intermediate frequency, RF, and discriminator transformers shall be in accordance with Grade 1, 2, or 4 of MIL-T-55631. The use of Grade 3 transformers shall be limited to hermetically sealed or encapsulated assemblies. When equipment is required to operate at an

internal operating temperature of 65°C or higher, transformers and inductors shall be in accordance with a through c:

a. MIL-T-27 transformers and inductors shall be selected from Class S, T, U, or V.
b. MIL-T-27, Grade 4 transformers and inductors shall not be potted or liquid filled.
c. Items that are selected from any other source shall have an operating temperature of 130°C or greater.

5.1.7.7.16 Tuning dial mechanisms. Tuning dial mechanisms shall be in accordance with MIL-STD-454, Requirement 42.

5.1.7.8 Materials. Prohibited materials are specified in 5.1.3.9. Materials shall be in accordance with TABLE XIV, and as specified in 5.1.7.8.1 through 5.1.7.8.2.2.

5.1.7.8.1 Brittle materials. Brittle materials are of concern due to performance under shock and fatiguing. General guidance is provided in the notes section of MIL-S-901 for elongation requirements. Castings for equipment mounted on the mast shall have no less than 10 percent elongation. This may be achieved with properly fabricated alloys of the ALMAG family.

5.1.7.8.2 Metals and alloys. Metals and alloys shall be corrosion-resistant or shall be given a corrosion-resisting treatment or coating in accordance with MIL-STD-1516.

5.1.7.8.2.1 Dissimilar metals. The selection of metals for use in electronic equipment shall be made in accordance with MIL-STD-889. When electronic design requirements preclude the insulation of incompatible metal combinations as identified in MIL-STD-889, specific attention shall be paid to isolating the combination from the exterior environment.

5.1.7.8.2.2 Insulation of dissimilar metals. When the design requires that dissimilar metals be in contact, an insulating material compatible to each metal shall be used to separate the metals. Insulating material is not required between corrosion-resisting steel inserts and aluminum castings when the inserts are integrally cast in the aluminum.

TABLE XIV. Materials.

Item	Requirement
Aluminum alloy bars, rods,and shapes	Shall be in accordance with QQ-A-200, QQ-A-200/1, QQ-A-200/4, QQ-A-200/8, QQ-A-225, QQ-A-225/2, QQ-A-225/7, or QQ-A-225/8.

TABLE XIV. Materials.

Item	Requirement
Aluminum alloy castings	QQ-A-591, alloys 360, 13, 218; QQ-A-596, alloys 214A, 356A, 413; ASTM B 26 or MIL-A-21180, alloys A356, A357, 359.
Aluminum alloy plates, and sheet	Shall be in accordance with QQ-A-250, QQ-A-250/2 QQ-A-250/8 or QQ-A-250/11.
Aluminum alloy tubing	Shall be in accordance with WW-T-700, WW-T-700/2, WW-T-700/4, or WW-T-700/6.
Arc resistant	Shall be in accordance with MIL-STD-454, Requirement 26.
Beryllium-beryllium compound	Shall be identified as containing beryllium (by labeling, and so forth). Label shall contain health hazard warning concerning dust that may arise from grinding, cutting, filing, or drilling.
Brass	Shall be in accordance with QQ-B-639, ASTM B 16, ASTM B 21, ASTM B 36, ASTM B 121, or ASTM B 124.
Bronze	Shall be in accordance with ASTM B 139 or ASTM B 138.
Copper	Shall be in accordance with QQ-C-502.
Copper-beryllium alloy	Shall be in accordance with ASTM B 194, ASTM B 196, ASTM B 197, or MIL-C-22087.
Copper-nickel alloy	Shall be in accordance with MIL-C-15726 or MIL-C-20159.
Copper-nickel-zinc alloy	Shall be in accordance with MIL-C-17112, ASTM B 122, ASTM B 151, or ASTM B 206.
Desiccants	Shall be in accordance with MIL-D-3464.
Fungus-inert	Shall be in accordance with MIL-STD-454, Requirement 4.
Hydraulic fluid	Shall be in accordance with MIL-F-17111 or MIL-H-19457.
Hydraulic or pneumatic packing	Shall be in accordance with MIL-G-5514 or ASTM F 104.
Insulation, electrical	Shall be in accordance with MIL-STD-454, Requirement 11.

TABLE XIV. Materials.	
Item	Requirement
Lubricants	Shall be in accordance with MIL-STD-454, Requirement 43.
Nickel-copper alloy	Shall be in accordance with QQ-N-281, QQ-N-286, ASTM A 494, or MIL-C-24723.
Plastic	Shall not be used for viewing windows. Shall be selected from MIL-HDBK-700. Shall be coated with varnish conforming to MIL-V-173, if porous.
Silver brazing alloys	Shall be in accordance with QQ-B-654.

5.1.8 Painting. The interior of treated aluminum enclosures for sheltered locations shall not be painted. The exterior and interior surfaces of metallic enclosures shall be painted as specified in 5.1.8.1 through 5.1.8.8. Tailoring guidance on painting requirements is provided in S9086-VD-STM-101/CH-631 V1, S9086-VD-STM-101/CH-631 V2, and S9086-VD-STM-101/CH-631 V3. Prior to painting, the applicable pretreatment and primer shall have been completed. Plastic enclosures normally will not be painted. The surface preparation shall result in at least a 0.050 millimeter surface profile. The specifier of ruggedized equipment shall review the requirement for design features that may be required for the application of the equipment.

5.1.8.1 Aluminum and aluminum alloy pretreatment. Aluminum and aluminum alloy pretreatment shall be as specified in a though c:

a. Cleaning. The basic metal shall be cleaned to remove grease, oil, welding flux, or other foreign matter.
b. Application, protected equipment. Aluminum and aluminum alloy parts shall be anodized in accordance with MIL-A-8625, primed with material conforming to TT-P-645. The topcoat shall match the surrounding structure.
c. Application, exposed equipment. Aluminum and aluminum alloys shall be coated in accordance with 5.1.8.4.

5.1.8.2 Ferrous metal pretreatment. Ferrous metal pretreatment shall be as specified in a and b:

a. Cleaning. After all machining, welding, and brazing operations are completed, rust or other corrosion products and flux shall be removed by abrasive blasting, sanding, wire brushing, or other mechanical means. Surfaces shall be cleansed of all grease, oil, and dirt by solvent wiping and rinsing, vapor degreasing, or caustic washing followed by rinsing.

b. Application. Ferrous metals shall be pretreated in accordance with type I or III of TT-C-490.

5.1.8.3 Protected equipment. Protected equipment shall be finished as specified in 5.1.8.3.1 and 5.1.8.3.2.

5.1.8.3.1 Primer. One coat of primer in accordance with TT-P-645 or TT-P-664. The primer shall have a dry film thickness of 0.015 millimeters to 0.020 millimeters.

5.1.8.3.2 Enamel. Enclosures shall be painted with two continuous film coats of enamel in accordance with MIL-E-15090. Each coat shall have a minimum thickness of 0.025 millimeters, dry film thickness. Enamel for shipboard portable equipment enclosures shall be in accordance with MIL-E-15090, class 1. Enamel for other protected equipment enclosures shall be in accordance with MIL-E-15090, class 2.

5.1.8.4 Exposed equipment. Equipment or units thereof, exposed to the weather shall be finished with four coats of paint in accordance with a through c:

a. First coat: Epoxy-polyamide primer in accordance with MIL-P-24441 and MIL-P-24441/1 (0.075 millimeters to 0.100 millimeters dry film thickness).
b. Second coat: Epoxy-polyamide top coat in accordance with MIL-P-24441/6 or MIL-P-24441/3 (0.050 millimeters to 0.075 millimeters dry film thickness).
c. Third and fourth coat: Silicone alkyd enamel in accordance with MIL-E-24635, color 26270 in accordance with FED-STD-595 (0.025 millimeters to 0.040 millimeters dry film thickness). The total dry film thickness shall be 0.18 millimeters to 0.25 millimeters.

5.1.8.5 Marine Corps equipment. The following requirements apply only to equipment subjected to extreme conditions for which a urethane coating system is the only acceptable option. The primer contains chromate which is a hazardous material; the topcoat contains urethane and isocyanate which are hazardous materials and require compliance with local air pollution control regulations. Maintenance of these coatings is considered a depot-level task. Application shall be as specified in 5.1.8.5.1 through 5.1.8.5.2.

5.1.8.5.1 Primer. Primer in accordance with MIL-P-23377 shall be applied with a dry film thickness of 0.015 millimeters to 0.025 millimeters.

5.1.8.5.2 Topcoat. Two coats of urethane enamel in accordance with MIL-C-83286 shall be applied. Each coat shall have a minimum thickness of 0.025 millimeters.

5.1.8.6 Colors. Colors for the painting of equipment shall be selected in accordance with FED-STD-595.

5.1.8.7 Paint systems. When alternative paint schemes are be specified, the treatment, prime coat, and topcoat chosen shall be compatible and shall be selected in accordance with MIL-T-704. The use of hazardous materials shall be avoided wherever possible; the use of lead- and chromate-containing coatings shall be avoided when an approved alternative exists. Consideration shall be given to the field maintenance of paint systems.

5.1.8.8 Paint system test. Equipment shall be tested in accordance with APPENDIX D. Paint systems shall show no blistering or adhesive failure.

5.1.9 Processes. The specifier of ruggedized equipment shall review the requirement for design features that may be required for the application of the equipment. Processes shall be as specified in TABLE XV and as specified in 5.1.9.1 through 5.1.9.2.

TABLE XV. Processes.

Item	Requirement
Anodizing for painted surfaces	Shall be in accordance with MIL-A-8625 or chemical treatment conforming to MIL-C-5541.
Brazing	Shall be in accordance with MIL-B-7883.
Castings	Shall be in accordance with MIL-STD-454, Requirement 21. Zinc alloy and magnesium alloy castings shall not be used.
Chromium plating	Shall be in accordance with QQ-C-320.
Copper plating	Shall be in accordance with MIL-C-14550.
Gold plating	Shall be in accordance with type II or type III of MIL-G-45204, depending on application.
Nickel plating	Electroplating shall be in accordance with QQ-N-290. Electroless shall be in accordance with MIL-C-26074.
Passivation	Shall be in accordance with QQ-P-35
Phosphate coating	Shall be in accordance with DOD-P-16232.
Rhodium plating	Shall be in accordance with class 3 of MIL-R-46085.
Silver plating	Shall be in accordance with QQ-S-365.

TABLE XV. Processes.	
Item	Requirement
Soldering	Shall be tailored in accordance with MIL-STD-2000. The conformal coating requirement of MIL-STD-2000 shall not apply.
Tin plating	Shall be in accordance with ASTM B 545.
Aliphatic urethane plating	Shall be in accordance with MIL-C-83286.
Welds, resistance	Shall be in accordance with MIL-W-8939.
Zinc coating	Shall be in accordance with ASTM A 153 (hot dip galvanizing), ASTM B 633 (electrodeposited), or MIL-C-81562 (mechanically deposited).
Zinc plating	Shall be in accordance with QQ-Z-301 (Wrought zinc alloys)

5.1.9.1 Protective plating or coating. A protective plating or coating shall be applied to all metals which are not corrosion-resistant except as specified in a through d:

a. Items bathed in lubricants.
b. Interior surfaces of relay or coil shields.
c. Items which are potted, encapsulated or hermetically sealed.
d. When electric grounding through the surface is required.

5.1.9.2 Welding. Welding shall be in accordance with MIL-W-18326 and MIL-W-6858, as applicable. Samples representative of production and welded on production machines shall be tested to destruction to determine conformance to this requirement. Brittle materials shall not be used for castings or weldments. All weldments of equipment which is mounted on masts shall pass a non-destructive test using either radiographic or ultrasonic procedures.

5.2 Space equipment. The constraints inherent in space vehicles and space environment pose unique requirements on the design of electronic equipment. The following sections provide the detailed criteria which establish the boundaries of the requirements which are applicable to space platforms. Sections 5.2.1, 5.2.2, and 5.2.11 provide specific requirements applicable to COTS, ruggedized and militarized equipment, while 5.2.3 through 5.2.10 are design requirements applicable to militarized equipment. These requirements may be adopted for ruggedized and COTS

equipment. All equipment shall be in accordance with the minimal acceptance limits for all space environmental conditions to which the equipment will be subjected; mission critical equipment, and other equipment for Class I systems shall be fully hardened such that the equipment will operate under the full range of applicable environment conditions. Further guidance for equipment to be designed as fully hardened is provided in 1.6.1. The program manager shall tailor requirements to the application of the equipment (see 4.1.4) in a cost effective manner. A protoflight test program (see APPENDIX A) may be substituted for a qualification test program. Systems requiring the highest levels of confidence and probability of success shall use a separate qualification test for design verification.

5.2.1 Electrical power. Equipment shall be fully operational for the electrical power conditions specified in MIL-STD-1539. Other system voltages may be specified by the procuring activity.

5.2.1.1 Warmup time. Warmup time is the time period required to reach the specified operational performance capability from a nonoperational condition and environment. Equipment warm-up times shall be minimized.

5.2.1.2 Electrical overload protection (unmanned space vehicles). Electrical overload protection shall not be provided in individual boxes or components receiving power. When required, overload protection shall be a part of the space vehicle electrical power systems. Circuit breakers shall be of the automatic reset or remote reset type.

5.2.1.3 Electrical overload protection (manned space vehicles). Overload protection shall be provided for individual boxes or components receiving power, either as part of the equipment or part of the space vehicle electrical power system. Circuit breakers shall be of the manual reset or remote reset type.

5.2.2 Environmental design requirements. Equipment shall be suitable for environmental conditions that exceed the maximum levels predicted during its service life. This includes mildly corrosive conditions to which equipment may be exposed while unprotected during manufacture or handling. Environmental conditions shall be predicted in accordance with MIL-STD-1540, using the guidelines of MIL-HDBK-340. These requirements shall be tailored to reflect the installation and use of the equipment (see 4.1.4).

5.2.2.1 Launch environment. Equipment shall withstand maximum launch and other nonorbital service conditions. Unless otherwise specified, equipment shall not be operational during launch and other nonorbital service conditions.

5.2.2.1.1 Temperature. Temperatures under launch conditions shall be predicted in accordance with MIL-STD-1540, using the guidelines of MIL-HDBK-340. Predicted

temperatures shall include a thermal uncertainty margin in accordance with MIL-STD-1540.

5.2.2.1.1.1 Fully hardened. Equipment shall be suitable for operation between 10°C above the maximum predicted temperature and 10°C below the minimum predicted temperature. As a minimum temperature range, equipment shall be suitable for operation between -34°C to 71°C.

5.2.2.1.1.2 Minimal acceptance. Equipment shall be suitable for operation between maximum and minimum predicted temperatures. As a minimum temperature range, equipment shall be suitable for operation between -24°C to 61°C.

5.2.2.1.2 Vibration. Vibration under launch conditions shall be predicted in accordance with MIL-STD-1540, using the guidelines of MIL-HDBK-340. Vibration shall be considered to persist for three times the exposure duration associated with environmental amplitudes that are greater than one half the maximum predicted environmental amplitudes, but for not less than three minutes, along each of the three orthogonal axes.

5.2.2.1.2.1 Fully hardened. Equipment shall be suitable for an environmental condition that is 6 dB above the maximum predicted vibration level, to be no less than 12 g RMS.

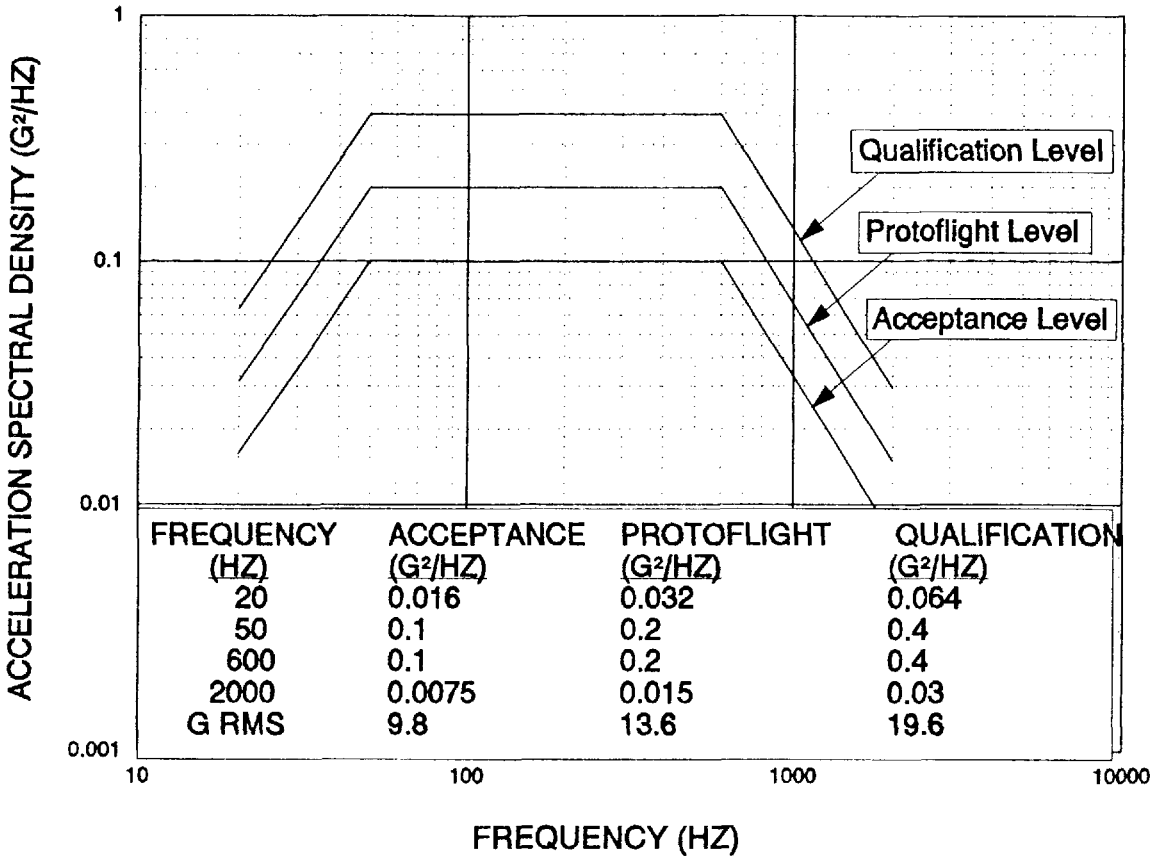
5.2.2.1.2.2 Minimal acceptance. Equipment shall be suitable for an environmental condition at the maximum predicted vibration level, to be no less than 9 g RMS. For design considerations, typical random vibration levels experienced during launch are shown on FIGURE 6. FIGURE 6 is provided for information only, and shall be tailored to specific launch vehicles.

5.2.2.1.3 Acoustic noise. Acoustic noise under launch conditions shall be predicted in accordance with MIL-STD-1540, using the guidelines of MIL-HDBK-340.

5.2.2.1.3.1 Fully hardened. Equipment shall be suitable for an environmental condition that is 6 dB above the maximum predicted acoustic level, to be no less than 144 dB.

5.2.2.1.3.2 Minimal acceptance. Equipment shall be suitable for an environmental condition that is at the maximum predicted acoustic level, to be no less than 141 dB. For design considerations, typical acoustic noise levels experienced during launch are shown on FIGURE 7 and in TABLE XVI. FIGURE 7 and TABLE XVIII are provided for information only, and are to be tailored to specific launch vehicles.

5.2.2.1.4 Sinusoidal vibration. Sinusoidal vibration under launch conditions shall be predicted in accordance with MIL-STD-1540, using the guidelines of MIL-HDBK-340.



FREQUENCY (HZ)	ACCEPTANCE (G²/HZ)	PROTOFLIGHT (G²/HZ)	QUALIFICATION (G²/HZ)
20	0.016	0.032	0.064
50	0.1	0.2	0.4
600	0.1	0.2	0.4
2000	0.0075	0.015	0.03
G RMS	9.8	13.6	19.6

FIGURE 6. Typical random vibration during launch.

5.2.2.1.4.1 Fully hardened. Equipment shall be suitable for an environmental condition that is 6 dB above the maximum predicted sinusoidal level.

5.2.2.1.4.2 Minimal acceptance. Equipment shall be suitable for an environmental condition that is at the maximum predicted sinusoidal vibration level. For design considerations, typical sinusoidal vibration levels experienced during launch are shown in TABLE XVII. TABLE XIX is provided for information only, and shall be tailored to specific launch vehicles.

5.2.2.1.5 Shock. Shock levels under launch conditions shall be predicted in accordance with MIL-STD-1540, using the guidelines of MIL-HDBK-340.

5.2.2.1.5.1 Fully hardened. Equipment shall be suitable for an environmental condition that is 6 dB above the maximum predicted shock level.

5.2.2.1.5.2 Minimal acceptance. Equipment shall be suitable for an environmental condition that is at the maximum predicted shock level. For design considerations, typical levels of mechanical shock experienced during launch are 30 g, half-sine, 8

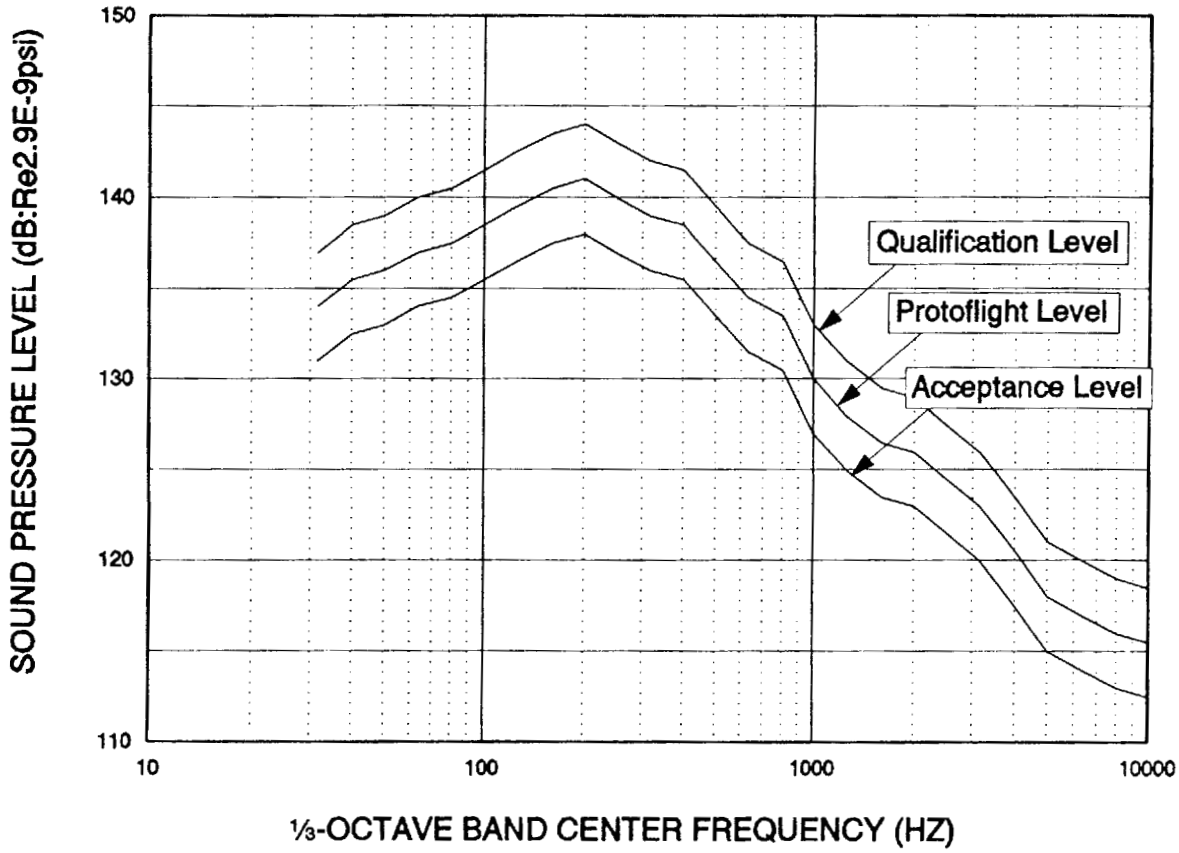


FIGURE 7. Acoustic loading environment for typical launch vehicle.

milliseconds in each of the principal equipment axes. Typical levels of pyroshock experienced during launch are shown on FIGURE 9. These levels of pyroshock are provided for information only, and are to be tailored to specific launch vehicles. The maximum predicted pyroshock environment is specified as a maximum absolute shock response spectrum determined by the response of a number of single-degree-of-freedom systems using Q = 10. The Q is the acceleration amplification factor at the resonant frequency for a lightly damped system. This shock response spectrum is determined at frequency intervals of one-sixth octave or less over a frequency range of 100 Hz to 10000 Hz. When sufficient data are available, the maximum predicted environment may be derived using parametric statistical methods. The data must be tested to show a satisfactory fit to the assumed underlying distribution. The maximum predicted environment is defined as equal to or greater than the value at the 95th percentile value at least 50 percent of the time. When there are less than three data samples, a minimum margin of 4.5 dB is applied to account for the variability of the environment.

TABLE XVI. Acoustic loading environment for typical launch vehicle.			
⅓-Octave Band Center Frequency	Sound pressure level (dB: Re 190 millipascals)		
	Acceptance 147 dB OASPL	Protoflight 150 dB OASPL	Qualification 153 dB OASPL
31.5	131.0	134.0	137.0
40.0	132.5	135.5	138.5
50.0	133.0	136.0	139.0
63.0	134.0	137.0	140.0
80.0	134.5	137.5	140.5
100.0	135.5	138.5	141.5
125.0	136.5	139.5	142.5
160.0	137.5	140.5	143.5
200.0	138.0	141.0	144.0
250.0	137.0	140.0	143.0
315.0	136.0	139.0	142.0
400.0	135.5	138.5	141.5
500.0	133.5	136.5	139.5
630.0	131.5	134.5	137.5
800.0	130.5	133.5	136.5
1000.0	127.0	130.0	133.0
1250.0	125.0	128.0	131.0
1600.0	123.5	126.5	129.5
2000.0	123.0	126.0	129.0
2500.0	121.5	124.5	127.5
3150.0	120.0	123.0	126.0
4000.0	117.5	120.5	123.5
5000.0	115.0	118.0	121.0
6300.0	114.0	117.0	120.0
8000.0	113.0	116.0	119.0
10000.0	112.5	115.5	118.5

TABLE XVII. Typical sinusoidal vibration during launch.	
Frequency (Hz)	Level
5 - 17	1.27 centimeters, double amplitude
17 - 22	7.0 g peak
22 - 400	5.0 g peak
400 - 2000	7.5 g peak

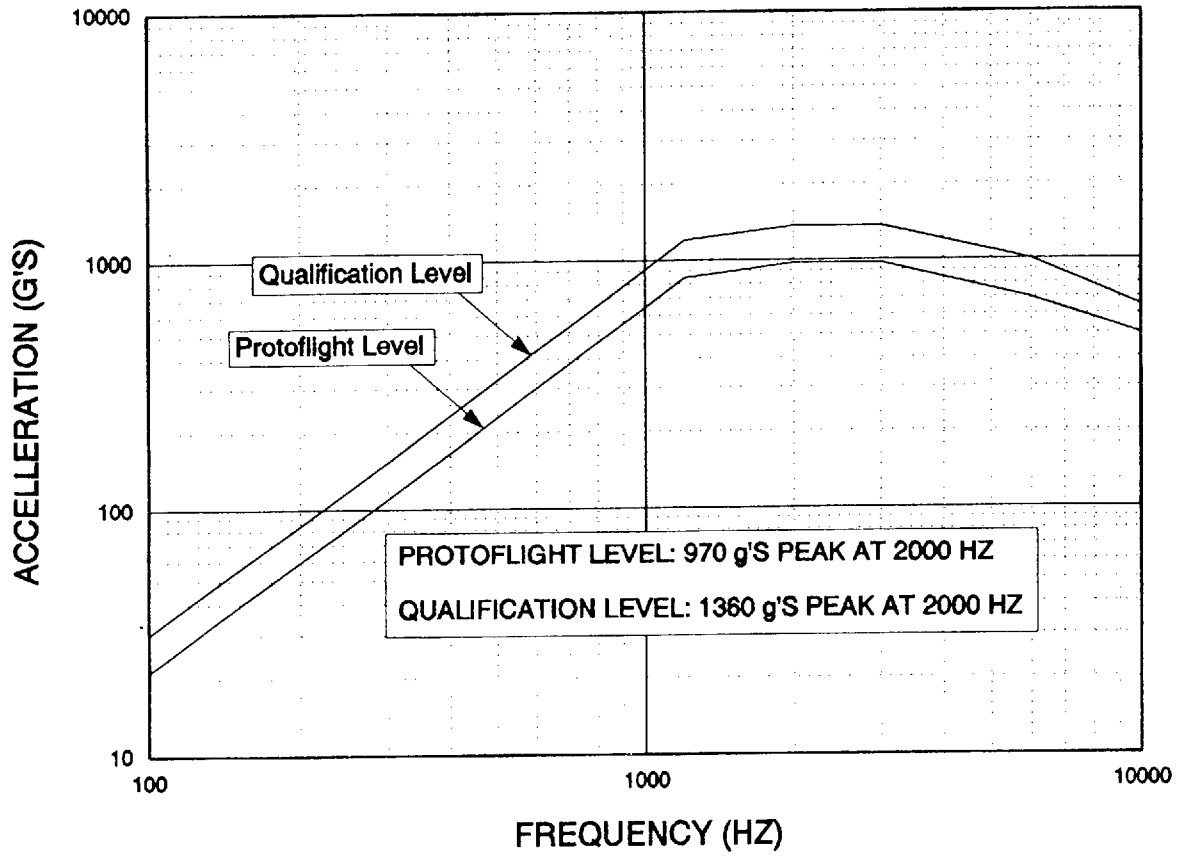


FIGURE 9. Pyroshock environment for typical launch vehicle.

5.2.2.1.6 Acceleration. The cross-axis acceleration shall include the acceleration due to rotation. Acceleration levels under launch conditions shall be predicted in accordance with MIL-STD-1540, using the guidelines of MIL-HDBK-340.

5.2.2.1.6.1 Fully hardened. Equipment shall be suitable for an environmental condition that is 37.5 percent above the maximum predicted acceleration level for unmanned space vehicles, and 54.0 percent above the maximum predicted acceleration level for manned space vehicles.

5.2.2.1.6.2 Minimal acceptance. Equipment shall be suitable for an environmental condition that is at the maximum predicted acceleration level. For design considerations, typical acceleration levels experienced during launch conditions are 8.5 g, 6.5 g, and 6.5 g simultaneously applied in each of three orthogonal axes oriented in any direction. These levels of acceleration are provided for information only, and are to be tailored to specific launch vehicles.

5.2.2.1.7 Atmospheric pressure. Equipment shall be suitable for a change in ambient pressure from sea level to 0.133 millipascals in 3 minutes. Equipment shall be suitable for a sustained exposure to an ambient pressure between sea level and 0.133 millipascals.

5.2.2.1.8 Humidity and salt fog. Requirements shall be as specified in 5.2.2.1.8.1 through 5.2.2.1.8.2.

5.2.2.1.8.1 Fully hardened. Equipment shall be suitable for exposure to 100 percent relative humidity for 12 hours. Salt fog tests shall be tailored shall be tested for salt fog in accordance with MIL-STD-810, Method 509, and IEC 68-2-11Ka. Humidity tests shall be tailored in accordance with MIL-STD-810, Method 507, or IEC 68-2-30Db. Approval of the procuring activity is required for special environmental controls.

5.2.2.1.8.2 Minimal acceptance. Equipment shall be capable of operation in an environment conforming to the full range of requirements for data processing spaces of the ASHRAE Handbook (HVAC Systems and Application Volume).

5.2.2.2 On-orbit environment. Equipment shall withstand maximum orbital service conditions. When appropriate, equipment shall be fully operational during orbital service conditions.

5.2.2.2.1 Atmospheric pressure. Equipment shall be suitable for sustained exposure to a minimum ambient pressure of 0.133 millipascals.

5.2.2.2.2 Temperature. The application of thermal controls or thermal coating to achieve the desired operating temperature range in the space environment shall be based upon a thermal analysis of the particular space vehicle under planned operating conditions. This analysis shall include vehicle checkout, launch conditions, and on-orbit conditions, including various load groups cycled on or off, sunlight and eclipse conditions, high and low electrical bus voltage, various orientations of the space vehicle, and other predictable operating conditions.

5.2.2.2.2.1 Fully hardened. Equipment shall be suitable for an environmental condition that is 10°C above the maximum predicted temperature, and for an environmental condition that is 10°C below the minimum predicted temperature, to be no less than -34°C to 71°C. Equipment shall operate satisfactorily when exposed to 24 thermal cycles when the ambient temperature varies at a nominal rate of 3°C per minute from one extreme to the other.

5.2.2.2.2.2 Minimal acceptance. Equipment shall be suitable for an environmental condition that is between the minimum and maximum predicted temperatures. When practical, components shall be suitable for operation over a temperature range of -24°C to 61°C. Equipment shall operate satisfactorily when exposed to 24 thermal

cycles when the ambient temperature varies at a nominal rate of 3°C per minute from one extreme to the other.

5.2.2.2.3 Radiation. Guidance and numerical models for space radiation environment are provided in MIL-STD-1809. There may be program specific radiation threats such as nuclear weapon effects.

5.2.2.2.3.1 Fully hardened. Equipment shall have a large design margin above the maximum predicted radiation level consistent with required probability of mission success.

5.2.2.2.3.2 Minimal acceptance. Equipment shall be suitable for environmental conditions that are at the maximum predicted radiation level, for the service life of the equipment.

5.2.2.3 Fabrication, storage, transportation, and handling. Fabrication and handling of equipment shall be accomplished in a clean room environment with an air cleanliness that is in accordance with metric system class 3500 (English system class 100,000) or better, as specified in FED-STD-209. Environmental conditions during processing and during storage, prior to acceptance testing, shall be within the limits specified in a and b:

a. Temperature: 0°C to 40°C
b. Humidity: 10 percent to 90 percent relative humidity

Storage, handling, and transportation conditions to which items are to be subjected subsequent to acceptance testing, and prior to flight, shall be maintained within maximum predicted requirements imposed by launch, flight, or the specified acceptance tests.

5.2.2.4 Transportability. Equipment shall be designed for ground transportability and for air transportability. The equipment shall be capable of being transported and handled in both the vertical and horizontal attitude. Lifting eyes or other means shall be provided for transportation and handling of assemblies weighing more than 100 kilograms. The modes of transportation, support, and types of protective covers used shall be chosen to assure that transportation and handling do not impose thermal, vibration, acoustic, or shock environmental conditions which exceed the conditions specified in 5.2.2.

5.2.2.5 Pressurization. Equipment that does not require pressurization to conform to performance requirements is preferred.

5.2.2.6 EMC. Equipment and subsystems installed aboard spacecraft and launch vehicles, including associated ground support equipment, shall be in accordance with

MIL-STD-461 when tested in accordance with MIL-STD-462. System level requirements shall be verified in accordance with MIL-STD-1541.

5.2.2.7 Corona and RF electrical breakdown prevention. High voltage circuits shall use insulation materials that are corona resistant with a dielectric constant of less than 3.5. Insulation materials without discontinuities or air gaps in the dielectric material are preferred. Sharp edges in microwave cavities, and voids and bubbles in encapsulation, shall be avoided to minimize high voltage field stress. When the frequency-distance product is greater than 0.7 megahertz-m, multipacting shall be a design consideration, and a through c shall be considered:

a. The use of encapsulation shall be considered to raise the voltage required to start electrons resonating.
b. The area shall be vented to allow any gas generated by multipacting to escape and thereby reduce corona.
c. The use of an electrical or magnetic bias shall be considered to sweep away ions.

5.2.2.8 Explosion-proofing. Equipment shall be made explosion-proof as applicable. To prevent generating a possible ignition source, the temperature of any part exposed to the atmosphere shall not exceed 178°C. Equipment or parts thereof which do not cause ignition of an ambient explosive gaseous mixture in air or other specified oxidizing atmosphere, when operated in such an atmosphere long enough to be permeated by that atmosphere, shall be considered explosion-proof.

5.2.3 Equipment design.

5.2.3.1 Limited life items. Limited life items such as batteries, fillers, and other consumables shall be identified.

5.2.3.2 Durability. Equipment shall be designed and constructed to ensure that no fixed part or assembly can become loose, no movable part or assembly can become free or sluggish, and no degradation can occur during operation.

5.2.3.3 Circuit selection. The specifier shall consider using circuits and methods of construction which permit the use of the same subassemblies in other equipment having similar circuits and functions. To permit flexibility in the arrangement or assembly of modules and subassemblies, interconnecting leads involving circuits considered susceptible to radiated interference or capable of radiating interferences shall be shielded and shall have low impedance. All other connections (such as power) shall be shielded or bypassed internally to prevent radiation or pickup of extraneous fields.

5.2.3.4 Propagation of failures. The design of Class I and Class II equipment shall be such that a failure does not propagate to other components, subassemblies, or subsystems. Class I equipment shall be capable of initiating protective measures to avoid loss of mission capability or loss of the host space vehicle. As a minimum, payloads shall be such that a failure will not propagate to the host space vehicle.

5.2.3.5 Detailed mechanical and electrical design. The design layout and assembly of the components and parts shall be in such a manner as to facilitate production based on the quantity of the order, and to result in optimum size and weight consistent with the specified requirements. If redundant parts, circuits, or equipment are housed in a single enclosure, the design shall be such that a failure in one of the components does not propagate to the other unit. When designing new equipment, designers shall consider, when practical, computer-aided designs and designs that have been or can be reproduced by mechanized or semi-mechanized production facilities consistent with the state of the art. The procuring activity shall be kept informed of the types of circuits selected and the type of facility required to produce such circuits. The types of mechanized or semi-mechanized construction specified in a through d shall be considered:

a. Subassemblies using printed wiring upon which the parts are printed or placed and electrically connected.
b. Construction in which several ceramic or plastic wafers are placed one above the other and parts printed or mounted thereon.
c. Three-dimensional or folded-type construction in which the parts are mechanically placed and electrically connected.
d. Microcircuits using deposited or printed techniques, including circuits employing combinations of the above processes and discrete parts.

5.2.3.6 Failure modes and effects. Required performance and reliability shall be ensured based a failure mode, effects, and criticality analysis. The failures to be considered shall include, but are not limited to, power outage, low-voltage conditions, over-voltage conditions, over-temperature conditions, excessive temperature gradients, part failure, and failure in wiring. Redundancy in the design to achieve the required reliability shall be considered during the failure mode, effects and criticality analysis. Failure modes established for the assembly shall be used as a basis for selecting in-flight telemetry monitoring points to be used for ground diagnostic analysis should an anomalous condition occur. MIL-STD-1629 provides procedures for performing a failure mode, effects, and criticality analysis.

5.2.3.7 Single point failures. Where practical, single point failure modes shall be avoided by such means as use of redundant circuitry. When redundancy is provided, the redundant portion of the assembly shall be in accordance with this standard as tailored for the application. When it is not practical to avoid single point failure modes, the designer shall ensure a satisfactory design based on an assessment of the mishap

risk, and appropriate substantiating analyses and tests. The assessment and analyses shall be include the items specified in a through c.

a. An estimate of the reliability for the design life of the assembly.
b. An assessment of the risk involved should the assembly fail.
c. An assessment of the penalty to the space vehicle by incorporation of redundancy or backup modes of operation. The assessment shall include consideration of complexity, safety, reliability, weight, volume, and electrical power.

5.2.3.8 Off-nominal operation. The sensitivity of the design and operational performance to changes in various parameters shall be considered and minimized in the design. The design sensitivity shall be substantiated by analysis or tests conducted to determine the effects of various off-nominal parameters which are beyond design requirements.

5.2.4 Electrical design and construction.

5.2.4.1 Electronic parts, materials and processes. Electronic parts, materials and processes shall be in accordance with MIL-STD-1547.

5.2.4.2 Grounding, bonding, and shielding. Grounding, bonding, and shielding shall be in accordance with MIL-STD-1818 for Air Force use, and MIL-B-5087 for all other uses.

5.2.4.3 External wire harnesses and cable assemblies. External wire harnesses and cable assemblies shall be in accordance with MIL-W-83575.

5.2.4.4 Internal interconnecting cable. Internal cable and interconnect or hookup wire shall be in accordance with MIL-STD-1547, or be of a type with insulation that has adequate resistance to cold flow. Adequate controls shall be included in the design and assembly procedures to avoid cold flow failure mechanisms. The size of wire leads supplied with parts shall be controlled by the applicable part specification.

5.2.4.5 Welds (electrical interconnections). Electrical interconnection resistance welds shall be in accordance with MIL-W-8939, except the minimum weld strength shall be greater than 13 newtons in either shear or peel mode. Weld strengths need not be based on parent metal breaking strength.

5.2.4.6 Potted modules. Potted modules are not preferred for new designs.

5.2.4.7 Electric motors. Electric motors shall be in accordance with MIL-A-83577.

5.2.4.8 Tape (electrical). Glass cloth, teflon-glass, and polyamide film tapes may be used. If the application requires pressure-sensitive adhesive tapes, the adhesive shall provide appropriate bond strengths with the surface with which the tape is applied , at the minimum and maximum temperatures specified. Other types of tapes may be used, provided the tapes are in accordance with the outgassing requirements of 5.2.8.2 and the tapes have been approved for use by the procuring activity.

5.2.4.9 Enclosures. Enclosures shall not impede on the proper deployment of any antenna system (see 5.2.5.4) or other system that may be deployed. Enclosures for all electronic equipment shall be electrically conducting and shall be designed as an electromagnetic shield to minimize electromagnetic propagation out of the enclosure, and electromagnetic pickup inside the enclosure from external sources. The provisions for mounting or installation in the space vehicle shall be such that there is a continuous, low-impedance path from the equipment enclosure to the ground of the space vehicle to permit bonding of the equipment. The DC resistance from enclosure to ground shall not exceed 2.5 milliohms. Mechanical discontinuities in the enclosure, such as covers, inspection plates, and joints, shall be kept to a minimum. Covers shall be secured by methods that prevent conductive metal particles, generated from screw threads or EMI gaskets, from becoming mobile within the enclosure. A low-impedance current path shall be provided across the interface of each discontinuity so as not to degrade the electromagnetic shielding effectiveness of the enclosure. Positive, self-locking fasteners, sized appropriately for the weight of the equipment, shall be used.

5.2.4.10 Connector selection. Connectors shall be selected in accordance with MIL-W-83575. Connectors shall be of the rear insertable, removable-crimp contact and quick disconnect type when practical. Male connector contacts shall be used for input power and input signal applications. Female connector contacts shall be used for output power and output signal applications. Connectors shall be as specified 5.2.4.10.1 through 5.2.4.10.14.

5.2.4.10.1 Connector type. Unless otherwise specified, connectors shall be in accordance with MIL-C-38999, MIL-C-83723, Series III, MIL-C-83733, Class S, or 40M38277. MIL-C-24308 connectors shall be used in environmentally protected areas only.

5.2.4.10.2 Existing wiring harness connectors. MIL-C-26482 Series II, MIL-C-81703, or 40M38298 or 40M39569 connectors shall be used when required to connect to existing wiring harness connectors.

5.2.4.10.3 Coaxial connectors. Coaxial connectors shall be in accordance with MIL-C-39012.

5.2.4.10.4 Connector shells. Connector shells shall have a conductive finish. Cadmium plating shall not be used.

5.2.4.10.5 RF and EMP connectors. Connectors to be used in a high level RF environment or an EMP environment shall be suitable for accepting RF finger stock at the connector-receptacle interface to provide for shield continuity, and shall be mechanically capable of being subjected to the coupling nut torquing.

5.2.4.10.6 Connector mounting. Connectors shall be mounted in such a manner as to provide a path through the enclosure to ground. The DC resistance measured from the connector shells to the enclosure shall not exceed 2.5 milliohms. Connectors that are not self-locking shall include safety wires to prevent disconnection.

5.2.4.10.7 Connector location. Connectors shall be located near the middle of the enclosure side or face with a minimum of a 25 millimeter clearance between connector shells to allow access during connecting and disconnecting. Connectors for electroexplosive device circuits shall be located a minimum of 50 millimeters from other connectors. Connectors located on the same equipment enclosure shall have different shell sizes or keying to prevent connector mismating. Connectors located on the same equipment enclosure and having the same shell sizes shall have multiple keyways, with the master keyways on each connector rotated to different positions. Provisions for different keying arrangements shall be provided when similar equipment or connectors are physically located in adjacent areas of the same vehicle. When redundant equipment is housed in a single enclosure, separate connectors shall be provided for each equipment.

5.2.4.10.8 Power contacts. A minimum of two connector contacts shall be provided for each power input and power return. Each connector contact shall be rated to carry the maximum load. When the contact rating is such that two (or more) contacts are required to carry the maximum load, the minimum number of connector contacts for each power input and power return shall be one more than the number required to carry the maximum load.

5.2.4.10.9 Shielded wire. For electroexplosive device circuits and circuits subjected to an EMP environment, the external harness wire shields shall be bonded around the circumference, and preferably within the shell, of the connectors. External harness wire shields shall not be carried to ground through connector contacts or pins. When the external wiring harness is not exposed to an EMP environment, the harness wire shields may be designed to be connected to contacts adjacent to the signal contact. Shield grounding to equipment shall be in accordance with MIL-W-83575.

5.2.4.10.10 Circuit isolation. Circuit isolation shall be in accordance with MIL-W-83575. When wires from isolated circuits use the same connector, the pin assignments and layout shall maintain isolation between the wires.

5.2.4.10.11 Twisted wire contacts. Contacts for twisted wires shall be adjacent.

5.2.4.10.12 Spare contacts. Spare contacts shall be located on the outer periphery of the connector and shall be grounded. Connectors with less than 25 contacts shall have a minimum of two spare contacts. When practical, at least 10 percent of the connector contacts in connectors with more than 25 contacts shall be spare. Contacts that are grounded to provide signal isolation shall not be counted as spare contacts. Empty holes shall not be left in connectors when there are unused contacts. In such cases, the connector insert shall be filled with a full complement of contacts and unused contact holes in the connector grommet shall be filled with sealing plugs. Connector inserts shall be filled with a full complement of contacts and sealing plugs.

5.2.4.10.13 Protective caps. Protective caps shall be provided for cable entrance holes and equipment connectors to provide protection during shipment or handling prior to equipment installation.

5.2.4.10.14 Connector savers. Connector savers shall be provided and used during ground operations for those connector applications subject to frequent connect/disconnect operations, such as connectors used during testing.

5.2.4.11 Fasteners and locking. Fastening systems shall be in accordance with MIL-STD-1515.

5.2.4.12 Threaded parts. Threaded parts shall be in accordance with MIL-S-7742 or MIL-S-8879. A minimum engagement of five full threads is required for threaded attachments; for through-bolts, the threaded ends shall protrude a minimum of two full threads beyond the end of the nut. Screw sizes smaller than 3.6 millimeters (No. 8) in diameter shall be avoided. Blind holes shall be considered for areas which may be sensitive to debris generated during assembly of threaded parts. Tolerances shall be controlled to prevent threaded parts from bottoming in blind holes. The types, sizes, and quantities of fasteners used shall be minimized. When selecting the type of fastener, consideration shall be given to the frequency of access or use during maintenance, operation, and so forth.

5.2.4.13 Locking devices. Positive locking devices shall be used on all fasteners. Preferred positive locking devices are bent tab washers, cotter pins, safety wire, self-locking threads, or self-locking provisions by means of plastic material contained in the nut, bolt, or screw. Self-locking nuts are preferred to bolts or screws that contain plastic material for use as a locking device. When other locking devices are practical, locking compounds shall not be used on fasteners to provide locking. Self-locking devices which depend upon an interference fit between metallic threads shall be avoided practical, in applications when particulate contamination may cause damage or degradation to the equipment or vehicle. When preload in fasteners is critical, strain gauges, crush washers, or equivalent techniques shall be used in lieu of

torque wrench setting of the preload. Safety wiring and cotter pins shall be in accordance with MS-33540. Drawings shall clearly depict the safety wiring method and configuration used. Through-bolts or screws with lock-nuts are preferred to threaded inserts. Threaded inserts shall be used in applications that require tapped holes in aluminum, magnesium, plastic, or other materials that are susceptible to galling or thread damage. When self-locking features are used, the screw length shall be sufficient to fully engage the locking device with a minimum of five turns. When self-locking features are used, an allowable range of run-in torque, or the maximum number of reuses that would still ensure an adequate lock, shall be specified. Spring-type or star-type lock washers shall not be used. Adjustable fittings or mounting plates which use oversized holes or slotted holes to provide adjustment shall not be dependent upon friction between the fitting or mounting plate and the mounting surface to provide locking. Diamond type serrations shall not be used.

5.2.4.14 Controls. Adjustment, alignment, or calibration controls shall not be provided external to the enclosures.

5.2.4.15 Moving mechanical assemblies. Moving mechanical assemblies, and their constituent parts and materials, shall be in accordance with MIL-A-83577.

5.2.4.16 Electroexplosive devices. Electroexplosive devices shall be in accordance with DOD-E-83578.

5.2.4.17 Printed wiring boards. Rigid printed wiring boards shall be in accordance with . IPC RB 276.

5.2.4.18 Internal electrical connections. Removable printed wiring boards shall be connected into the equipment by means of connectors. Printed wiring boards utilizing the conductor pattern as the direct contact shall not be used.

5.2.4.19 Mounting and installation of parts. Mounting and installation of parts shall be in accordance with MIL-STD-2000 and MIL-STD-1547, and as specified in 5.2.4.19.1 through 5.2.4.19.4. Unless approved by the procuring activity, solder shall not be used for mechanical strength. Care shall be taken to discharge or neutralize any charge buildup of the printed wiring boards prior to mounting charge-sensitive devices on the boards.

5.2.4.19.1 Sleeving. Fragile parts shall be fitted with sleeving or a buffer coat to prevent damage.

5.2.4.19.2 Hermetic seals. All hermetically sealed devices with glass-to-metal seals shall be subjected to a hermetic seal test following machine formation of the leads, such as specified in MIL-STD-810, Method 500.

5.2.4.19.3 Terminals. When the mounting of terminals on printed wiring boards is required, the terminals shall not be mounted on active circuit traces or in active plated through-holes of the printed wiring board. When terminals are used as an electrical interface to printed wiring, a redundant wire shall be used for circuit attachment to an adjacent plated through-hole. An alternate to redundant wiring is step soldering of the terminal to the printed wiring board to preclude solder reflow during subsequent soldering operations.

5.2.4.19.4 Power device mounting. Metallurgical connection to the case is preferred to compression connections. All metal power packages requiring electrical connection to the case shall be mounted with stressed hardware appropriately torqued to assure electrical contact during expansion and contraction of the printed wiring board during thermal excursion.

5.2.4.20 Soldering. Soldering shall be in accordance with MIL-STD-2000. The period of exposure of any printed wiring board to a solder bath shall be limited to a duration that does not result in damage to the board or to the parts mounted thereon.

5.2.4.21 Conformal coating. Printed wiring board shall be conformally coated in accordance with MIL-I-45208. Conformal coating shall be in accordance with a through e:

a. The selection of conformal coatings shall consider outgassing that may cause contamination of optical and thermal control surfaces.
b. A technique of applying conformal coating shall be used that prevents stressing of solder joints. The underside of parts that are spaced off the printed wiring board shall be coated without filling the space between the printed wiring board surface and the underside of the parts.
c. Coated assemblies shall exhibit no blisters, cracking, crazing, peeling, wrinkles, measling, or evidence of reversion or corrosion. A pinhole, bubble, or combination thereof may not bridge more than 50 percent of the distance between non-connecting conductors, while maintaining the minimum dielectric spacing. Bridging of greater than 50 percent shall be reworked to conform to this requirement. For any of the cited coated assembly anomalies the maximum number of reworks which can be performed without approval of the procuring activity is two.
d. If rework of a coated assembly is required, only mechanical means may be used to remove coatings other than Type AR (MIL-I-46058) and solvent removable parylene (paraxylene) coatings.
e. Conformal coating for printed wiring boards containing devices sensitive to ESD shall be accomplished at a static-free station using MIL-STD-1686 and MIL-HDBK-263 for guidance.

5.2.5 Waveguides, antennas, and RF devices.

5.2.5.1 Waveguide material. Aluminum or magnesium alloys or castings are preferred for waveguide and related equipment due to weight. If castings are utilized, the castings shall exhibit no porosity or gas holes when penetrant tested in accordance with MIL-STD-6866. If the application requires minimum attenuation at frequencies above 12 gigahertz, the waveguide or waveguide component shall be constructed of coin silver (90 percent silver, 10 percent copper) conforming to Grade C of MIL-S-13282 with a Rockwell B hardness between 45.0 and 80.0. Aluminum or magnesium waveguides and coin silver waveguides shall not be in contact unless the aluminum or magnesium waveguide is silver-plated or both are plated with a common metal. Silver plating shall be electrodeposited using a periodic reverse process to minimize porosity, with a minimum silver plate thickness of 5 micrometers. Silver plating shall be over-plated with rhodium, palladium, or gold to a thickness between 0.25 micrometers and 0.75 micrometers.

5.2.5.2 Waveguide assemblies. The face of assembled flanges for waveguides with a cross-section of 25 millimeters by 10 millimeters or larger shall make an angle of 90 degrees plus or minus 0.50 degrees with internal waveguide surfaces. For smaller waveguides, the face of the flange shall make an angle of 90 degrees plus or minus 0.25 degrees with internal surfaces. The centers of openings for assembled waveguide sections shall be in axial alignment within 2 percent of the maximum waveguide cross-sectional dimension. When practical, grooves shall be oriented downward to prevent moisture accumulation. The smallest practical number of waveguide couplings and flexible assemblies shall be used, such as by the use of preformed bends, to minimize system voltage standing-wave ratio. Long waveguide runs shall be strain-relieved by suitable clamping devices spaced along the length of the waveguide. Flexible waveguide shall not be forced to bend beyond its natural stop position and repeated flexing shall be minimized. Waveguide assemblies, including choke flanges and couplings, shall be free of dirt, metal filings, loose solder particles, and other contamination. The open ends of assemblies shall be suitably sealed to prevent ingress of moisture and contamination.

5.2.5.3 Stripline transmission assemblies. Stripline transmission material shall be in accordance with IPC L 125. Bonded stripline circuit boards are preferred to boards assembled by eyelets or screws. The unclad surfaces of the dielectric materials of circuit boards to be laminated into a stripline device shall be chemically etched or otherwise primed for bonding. The design of stripline microwave equipment shall be such that stresses on solder joints are in shear, and the shear stress shall be no greater than 6800 Newtons per square meter at the highest temperature to which the equipment will be subjected. Connections between stripline assemblies and coaxial lines shall be designed to accommodate the maximum predicted thermal expansion and contraction of the coax center conductor.

5.2.5.4 Antennas. Radiating elements intended to operate over a ground plane shall be designed for installation on a homogeneous counterpoise or ground plane of

negligible impedance within the operating frequency range of the equipment. The ground plane or counterpoise shall be of adequate dimensions to ensure satisfactory radiation patterns. When coaxial antenna transmission lines are used, provisions shall be made for circumferential RF continuity between the outer conductor and the ground plane of the antenna. When efficient operation depends upon a low-resistance return current path from the ground plane to metal portions of the antenna, the design shall provide for a low-impedance, homogeneous external surface as the ground plane, with a minimum length connection to the appropriate portion of the antenna. All antennas, whether using a ground plane or not, shall be designed to provide satisfactory radiation patterns in the presence of all space vehicle components for all configurations and attitudes to be encountered during operation of the antenna.

5.2.6 Operational checkout provisions. The test points and operational checkout provisions shall accommodate a continuity of critical test parameter measurements from box acceptance test through subsystem test, vehicle acceptance test, pre-launch checkout, and on-orbit test measurements as applicable.

5.2.6.1 Instrumentation. Sufficient diagnostic instrumentation shall be provided as part of the equipment to determine the mode of failure should an on-orbit failure occur, using such devices as strain gauges, temperature sensors, pressure transducers, position indicators, potentiometers, switches, tachometers, accelerometers, or current monitors. When an electrical motor, other than a stepper motor, is used, the motor current shall be instrumented such that torque can be determined during acceptance and qualification testing. When switches are used as indicating devices, the switch mounting and orientation shall be such that wrong adjustment of the switch shall not prevent full travel of the device to its deployment stop. In no case shall the direction of actuation of a switch be the same as the direction of motion of the mechanism. Cam-operated switches using ramps are preferred when the final position of the switch on the ramp is incapable of depressing the switch further than its normal operating range. When switches are used, levers or other suitable devices shall be provided to decrease the sensitivity to adjustment of the switch and to ensure that sufficient over-travel is provided after actuation of the switch. Switches shall be hermetically sealed. Sufficient on-orbit instrumentation shall be provided to measure critical temperatures and to detect off-nominal thermal conditions.

5.2.6.2 Test points and test parameters. The test equipment shall assure that the critical performance parameters can be measured to the required accuracy. Test points shall be provided to accommodate a continuity of critical test parameter measurements from component acceptance tests through subsystem tests, vehicle acceptance tests, pre-launch checkout, and on-orbit test measurements. Provisions for on-orbit tests shall be tailored from NASA-STD-3000. Test points shall be provided, when practical, as telemetry points on connector contacts or pins. Test points shall be short-circuit protected. The test parameters shall be chosen to provide assurance of satisfactory equipment performance and to isolate faults should they occur. The

parameter test limits shall be established such that the measurements are made to an expanding accuracy tolerance that avoids the possible rejection of equipment which has passed tests conducted at lower levels of assembly. The on-orbit instrumentation and measurement techniques shall be used during ground tests to provide a database that would permit parameter traceability with respect to variations in environmental conditions.

5.2.7 Materials and process controls. Equipment acceptance and flight certification is primarily based on an evaluation of data from the manufacturing process. The manufacturing of equipment shall be accomplished in accordance with documented procedures and process controls which assure the reliability and quality required for the mission. These manufacturing procedures and process controls shall be documented to give visibility to the procedures and specifications by which all processes, operations, inspections, and tests are to be accomplished by the manufacturer. This documentation shall include the name of each part or component, each material required, the point it enters the manufacturing flow, and the controlling specification or drawing. The documentation shall indicate required tooling, facilities, and test equipment; the manufacturing check points; the quality assurance verification points; and the verification procedures corresponding to each applicable process or material listed. The specifications, procedures, drawings, and supporting documentation shall reflect the specific revisions in effect at the time the items were produced. These flow charts and the referenced specifications, procedures, drawings, and supporting documentation become the manufacturing process control baseline and shall be retained by the manufacturer for reference. It is recognized that many factors may warrant making changes to this documented baseline; however, all changes to the baseline processes used, or the baseline documents used, shall be recorded by the manufacturer following establishment of the manufacturing baseline or following the manufacture of the first item or lot of items. These changes provide the basis for flight accreditation of the items manufactured or of subsequent flight items. The manufacturing process and control documents shall provide a baseline that assures that any subsequent failure or discrepancy analysis that may be required can identify the specific manufacturing materials and processes that were used for each item.

5.2.8 Materials. When practical, materials shall be selected that have demonstrated their suitability for the intended application. Care shall be exercised in the selection of materials and processes to avoid fatigue failure, stress corrosion cracking, and brittle fracture failure modes in highly stressed parts, and to preclude failures induced by hydrogen embrittlement. Wherever practical, the materials listed in MIL-HDBK-5 shall be used.

5.2.8.1 Prohibited materials. Mercury, compounds containing mercury, zinc parts, zinc plating, cadmium parts, and cadmium-plated parts shall not be used, except as may be required for the internal functioning of batteries or other devices. Corrosive (acetic

acid evolving) silicone sealants, adhesives, and coatings shall not be used. Pure tin or tin electroplate shall not be used. Combustible materials or materials that can generate toxic outgassing or toxic products of combustion shall not be used. To minimize possible interactions with payloads or with the Earth's magnetic field, magnetic materials, including ferri-magnetic and ferro-magnetic alloys, shall be used only when necessary for equipment operation. The use of hazardous material (see 4.7.2) as defined in FED-STD-313 shall be approved by the procuring activity upon submission of justification to prove a through c:

a. There is no safer substitute to conform to specifications.
b. The material is or is not recyclable.
c. Non-recyclable material may be safely disposed of in such a manner as to minimize hazardous waste and the cost of alternative approaches is not practical, including life-cycle cost for use and disposal of the hazardous waste including employee training.

5.2.8.2 Outgassing. For each material used, the total mass loss shall be less than 1.00 percent, and the collected volatile condensable material shall be less than 0.10 percent by weight when heated in vacuum to 125°C for a minimum of 24 hours, and collected between 21°C and 25°C. Parts and materials shall not liberate gases which produce an explosive atmosphere under specified service conditions. The hygroscopic nature of many materials such as composites, electroformed nickel, and anodic coatings for aluminum emit water in a vacuum and may be unsuitable for some applications. Analytical contamination models shall be used to evaluate performance impacts of outgassing on adjacent critical equipment. NASA Reference Publication 1061 provides further guidance (see 5.2.10.2).

5.2.8.3 Fungus-inert material. Equipment shall not support fungal growth. Fungus tests shall be tailored in accordance with MIL-STD-810, Method 508. When practical, fungus-inert materials shall be used.

5.2.8.4 Adhesives. Adhesives shall be selected based on their strength with respect to specifically-prepared surfaces of the materials with which the adhesives are to be used in the appropriate failure mode (shear, peel, flatwise, or tensile), under specified environmental temperature conditions (see 5.2.2). Adhesives shall be selected that are not subject to depolymerization (reversion) during the service life of the application.

5.2.8.5 Insulators, insulating materials, and dielectric materials. For external surfaces on space vehicles that are required to operate at altitudes above 1000 kilometers, insulating materials or finishes having a resistivity greater than 10 megohm-m shall not be used. NASA Technical Paper 2361 provides further guidance. For space vehicles that are required to operate at low earth orbit, insulating materials and finishes that are in locations that may be exposed to atomic oxygen shall be selected to assure that

excessive atomic oxygen degradation does not occur during the service life of the application.

5.2.8.6 Castings. Aluminum alloy castings shall be in accordance with MIL-A-21180. Magnesium alloy castings shall be in accordance with ASTM B 80 or MIL-M-46062. For applications when minimum outgassing is permitted, or when hermeticity in vacuum is required, the allowed casting porosity shall be such that impregnation is not required. Impregnation shall not be used to seal the porosity.

5.2.8.7 Aluminum alloys. When bonding or grounding to an aluminum alloy is required, aluminum 1100, alloys 3003, 5052, 6053, 6061, 6063, or 7072 shall be used.

5.2.8.8 Magnesium and magnesium alloys. Magnesium shall be used only when required for damping or weight reduction. Care shall be taken to avoid corrosion or galvanic coupling with other conductive materials.

5.2.8.9 Dissimilar metals. The selection of metals for use in electronic equipment shall be made in accordance with MIL-STD-889. When electronic design requirements preclude the insulation of incompatible metal combinations as identified in MIL-STD-889, specific attention shall be paid to isolating the combination from the exterior environment. When the design requires that dissimilar metals be in contact, an insulating material compatible to each metal shall be used to separate the metals.

5.2.8.10 Composites. Use of composites shall be based on prior experience or complete development and qualification efforts for the intended application. Unless used as part of a sandwich structure, composite laminates shall be completely balanced in layup ply orientation.

5.2.8.11 Elastomers and thermoplastics. Elastomers and thermoplastics shall be selected based on compatibility with the environment and with attention to the possible effects of long-term aging, including radiation, compression-set, or cold flow in the applied configuration.

5.2.8.12 Honeycomb sandwich structures. Honeycomb sandwich structures shall be designed to permit venting of air or other volatiles from within the honeycomb core.

5.2.8.13 Surface treatments. Any surface treatments or coatings used shall be such that completed components shall be resistant to corrosion. The design goal shall be such that there would be no harmful corrosion of the completed components or assemblies when exposed to specified environmental conditions (see 5.2.2). Protective methods and materials for cleaning, surface treatment, and applications of finishes and protective coating shall be in accordance with MIL-F-7179. Finishes of bleached chromate shall not be used.

5.2.8.14 Plating and special materials. Chromium plating shall be in accordance with QQ-C-320. Nickel plating shall be in accordance with QQ-N-290. Electroless nickel plating shall be in accordance with MIL-C-26074. Gold, nickel, chromium, rhodium, lead-tin alloys, or plating of these materials do not require additional protection or treatment other than buffing or cleaning. In applications requiring gold, rhodium, or chromium plated finishes, plating shall be applied over a low-stress nickel underplate with a minimum thickness of 1.3 micrometers.

5.2.9 Processes.

5.2.9.1 Finishes for fasteners and assembly screws. Exposed surfaces of external fasteners and assembly screws which are manipulated, loosened, or removed in the normal processes of servicing and installing of equipment, shall be in a noncorrosive black or bright finish, so as to provide strong contrast with the color of the surface upon which they are used. Other external fasteners and assembly screws used for securing the internal parts to the chassis shall be similar in color to the surface upon which they are used.

5.2.9.2 Finishes for aluminum alloy surfaces. The surface of parts fabricated from wrought aluminum 1100; or wrought aluminum alloys 3003, 5052, 6053, 6061, 6063 or 7072; or cast aluminum alloys 356, A356, 357, and A357 after a suitable deoxidizing treatment do not require an anodize or conversion coating. The surfaces of parts fabricated of other wrought or cast aluminum alloys which contain more than 1 percent (nominal) copper, or magnesium or both, shall be anodized in accordance with MIL-A-8625 or conversion-coated in accordance with MIL-C-5541. When bonding or grounding is not necessary and exposure to repeated high tensile stress will not occur, hard anodic finishes conforming to number E514 of MIL-F-14072 may be applied.

5.2.9.3 Finishes for magnesium and magnesium alloys. Magnesium and magnesium alloys shall be finished in accordance with MIL-M-3171 or MIL-M-45202. Magnesium and its alloys shall be subsequently painted.

5.2.9.4 Finishes for bonding and grounds. The surface finish for electrical bonding shall be bare metal or a qualified conductive finish such as Iridite 14 or Alodine 1000. Nonconductive coatings shall not be used. If abrasives or scrapers are used to remove any protective finish, the abrasives or scrapers shall be of the type that produces a clean smooth surface without removing excessive materials under the finish. Abrasives that would cause corrosion if embedded in the metal, such as steel wool, shall not be used.

5.2.9.5 Surface finish for ESD control. Electrostatic charging shall be minimized by avoiding the use of near ideal dielectric materials at the outer surface of vehicles. Grounded semiconductive surface coatings or other forms of charge leakage paths

shall be provided if practical. Surface resistivity shall be in accordance with a through c:

a. For a grounded semiconductive coating over an insulating material, the surface resistivity shall not exceed 10^8 ohms per square.
b. For a painted surface over a grounded semiconductive material over a dielectric, the surface resistivity of the semiconductive material shall not exceed 4.6×10^7 ohms per square. The paint thickness shall not exceed 0.125 millimeters, and the volume resistivity shall not exceed 10^{11} ohm-mm.
c. The volume resistivity of a coating over a grounded metal conductor shall not exceed $(2.5/t) \times 10^9$ ohm-mm, when t is the coating thickness in centimeters.

5.2.10 Fabrication and handling. Fabrication and handling shall be in a clean environment. Attention shall be given to avoiding nonparticulate (chemical) as well as particulate air contamination. To avoid safety and contamination problems, the use of liquids shall be minimized in areas when initiators, explosive bolts, or any loaded explosive devices are exposed.

5.2.10.1 Cleanliness. Product particulate cleanliness shall be in accordance with MIL-STD-1246, Level 500. External surfaces shall be visibly clean.

5.2.10.2 Baking (outgassing). Items that may produce deleterious outgassing while on orbit shall be baked for a sufficient time to drive out all but an acceptable level of outgassing products (see 5.2.8.2) prior to installation in the payload or space vehicle.

5.2.10.3 Mechanical templates. When practical, a common interface drill template shall be used to assure correct mechanical mating, particularly for interfaces external to the equipment.

5.2.11 Computer resources. Computer resources shall be capable of performing the required real time computational functions of the equipment and of the associated ground equipment. Real time functions include data processing, communications, display, and control functions. Computer resources shall perform the required non-real-time data processing and support functions. Excess capacities specified are to allow for contingency growth and unpredicted demands on resources.

5.2.11.1 Computational equipment. The computational equipment includes processing units; special purpose computational devices; interface devices; main storage; peripheral data storage; I/O units such as printers, graphic displays, and video display devices; and other associated devices. To the extent practical, the associated ground equipment computational capability shall be provided by COTS general purpose computer equipment.

5.2.11.1.1 Computer instruction performance rate. Each processing unit shall perform instructions at a rate which is at least twice that required to perform specified functions.

5.2.11.1.2 Data channel capacity. The maximum input data rate capability and the maximum output data rate capability, when operating with the application computer programs, shall be at least twice that required to perform specified functions.

5.2.11.1.3 Main storage (primary memory). The capacity of the main storage (primary memory) in each computer shall be at least 150 percent of the basic capacity required to perform specified functions.

5.2.11.1.4 Automatic initialization and start-up. Each computer shall have facilities to establish support capabilities in response to a single control action. These facilities shall provide for the automatic loading, initialization, and starting of both the operating system and the application computer programs.

5.2.11.2 Operating systems used in computers. When practical, the operating system for each computer shall support an OSA with a demonstrated record of reliable performance. Operating systems which require development shall be developed in accordance with the standards, conventions, and development requirements for application programs contained herein. When applicable, the operating systems shall provide the scheduling, task switching (on a priority basis), I/O control, data management, and memory management capabilities required to support the real time computational and control functions of the computational components. The operating system shall be capable of exploiting the excess capacity specified for the computational equipment without necessitating any modifications. Program peculiar changes, modifications, additions, or enhancements to vendor supplied and maintained operating systems shall require approval by the contracting officer prior to implementation.

5.2.11.3 Firmware. Computer programs and data stored in a class of storage that cannot be dynamically modified by the computer during processing shall be considered firmware. Firmware shall be as specified in 5.2.11.8.2 and 5.2.11.9.

5.2.11.4 Application computer programs.

5.2.11.4.1 Programming language. When practical, application computer programs for equipment shall be written in Ada in accordance with MIL-STD-1815, MIL-STD-1838, or FIPS PUB 119. Assembly language, including machine code, shall be used only when its use is necessary for the satisfaction of system performance requirements or when its use is cost effective over the life of the system.

5.2.11.4.2 Computer program structure. The computer program structure shall consist of a CSCI at the highest level. A top-level CSCI may consist of one or more lower level CSCI, of one or more Computer Software Components, or a combination of both. The lowest level CSCI may consist of one or more Computer Software Components. Each Computer Software Component shall consist of one or more lower level Computer Software Units.

5.2.11.4.3 Structure of units. Computer Software Units shall be organized into an interface part and an implementation part.

5.2.11.4.3.1 Interface part. The interface part shall characterize the capabilities the module makes available to other modules or to other interfacing system items, such as devices or human operators.

5.2.11.4.3.2 Implementation part. The implementation part of each module shall define how the operations specified for the interface are to be provided.

5.2.11.4.4 Hierarchical program design. Computer programs shall be designed in a hierarchical manner, and the levels of the hierarchy shall correspond to the levels of abstraction of the tasks performed by the program. Each level of the program shall be complete in itself. Provisions for incorporating existing units into the hierarchy shall be made so as to maximize the reuse of previously developed computer programs.

5.2.11.4.5 Standardized control structures. Closed control structures have a single entry point and a single exit point, such as a simple sequence, a conditional selection and an iteration. Only closed control structures shall be used in the construction of program units.

5.2.11.4.6 Program coding conventions. All computer programs shall be in accordance with the coding conventions specified in a through d:

a. The structure of the source code shall reflect the design of the program.
b. Each line of source code shall contain no more than three statements, that is, no more than three semicolons in Ada. Each statement in a line with multiple statements shall have no more than three operations.
c. To the extent practical, names used in computer programs shall be consistent with those used in the system design.
d. The code shall be written such that no code is modified during execution.

5.2.11.4.7 Program comments. Comments shall be incorporated throughout each computer program to self-document the organization and logic of the program.

Computer programs shall adhere to the commenting standards specified in a through c:

a. Banners. A banner shall be the first item in each computer program listing. The banner for a CSCI listing shall state the CSCI title, the titles of all sub-tier CSCI, and the titles of all sub-tier Computer Software Components. The banner for a Computer Software Component listing shall state the title for the parent CSCI, the component title, and the title of all units in the component. The banner for each of the two parts of a unit listing shall state the title for the parent CSCI, the title for the parent component, the title for the parent units, the title of the unit, and whether the part is the interface or the implementation part of the unit.
b. Headers. A header shall follow the banner in each source code listing to facilitate the understanding and readability of the listing, and shall consist of a consecutive block of comments. The header shall provide a prose abstract of the declarations and processing activities to assist in understanding the program code.
c. Special Comments. Special comments shall be included within the source code listing to assist in reading particularly subtle or confusing code. Special comments may supplement header comments, but they shall not replace the header comments. Special comments shall be included for every logic branch and join point to characterize the intended operation of the program to that point.

5.2.11.4.8 Message generation. Ground equipment computer programs shall generate error and diagnostic messages on-line to facilitate real-time fault isolation of faults that degrade operational performance. Ground equipment computer programs shall generate off-line error and diagnostic messages for the logging of fault messages onto system files for faults which require isolation and correction but can be addressed off-line and do not degrade operational performance. The required processing time to identify and generate error and diagnostic messages shall not degrade the performance of the system. Messages shall be in accordance with a through d:

a. With the exception of lengthy diagnostic procedures for use following an abnormal condition, processor message and advisory formats shall not require additional interpretation by the operator. For example, tables and references to documentation shall not be required.
b. Every message and advisory shall include a unique description of the condition which prompted it.
c. On-line error messages shall contain, as a minimum, the information provided in 1 through 3:
    1. Time error was detected.
    2. Textual description of error condition.
    3. Required operator action when applicable.

d. Off-line error messages shall contain, as a minimum, the information provided in 1 through 6:

1. Time error was detected
2. Textual description of error condition
3. Required operator action when applicable
4. Identification of triggering module
5. Identification of source program operation being performed at the time of the error
6. Computer program or system execution status following the error

5.2.11.4.9 Character set standards. Character sets shall be in accordance with FIPS PUB 1-2.

5.2.11.4.10 Excess capacity. Application computer programs shall satisfy performance requirements without the use of the excess capacity specified herein. Application programs shall be designed to be capable of exploiting the excess capacity specified herein.

5.2.11.5 Computer resource utilization monitoring. Ground equipment computer resources shall provide a means for operator control to monitor, record, display, and print the utilization of the computer resources. The computer resource utilization that shall be measurable and recordable during real-time operations shall include a through e:

a. Job timing, that is, overall utilization of the central processing unit
b. Task timing, that is, the seconds used by each program in the central processing unit
c. Computer main storage (primary memory) utilization
d. Peripheral data storage (secondary memory) utilization
e. A trace of the program execution sequence

The operator shall have control over variable time intervals between recording samples, and optional types of data to be collected.

5.2.11.6 Computer resource documentation. All computer resource documentation shall satisfy the requirements of DOD-STD-2167. Unless otherwise authorized by the procuring activity, non-developmental software shall be in accordance with DOD-STD-2167.

5.2.11.7 Configuration management. Configuration management activities shall be in accordance with MIL-STD-973.

5.2.11.8 Computer program maintenance resources. Computer program maintenance resources are required to support software development and to validate changes

throughout the development and operational use of the software, including on-orbit operations. The need for computer program maintenance resources is dependent on the complexity of the software and the time that on-orbit operational support of the equipment is required.

5.2.11.8.1 Computational equipment for computer program maintenance. Computational equipment for computer program maintenance is that equipment required to develop and test changes to the computer programs used in the equipment and in any related training equipment. To the extent practical, this equipment shall be identical to the computational equipment used for computer program development to facilitate transition of computer program development equipment to a computer program maintenance facility. Without necessitating major hardware modifications, the computer program maintenance equipment shall be capable of accommodating the excess capacity of the computational equipment.

5.2.11.8.2 Computer programs for computer program maintenance computers. Without necessitating any major modifications, the operating system for each computer used in the maintenance of computer programs shall be capable of exploiting the excess capacity specified for the computational equipment. Maintenance of the computer programs shall be supported by utility programs and other computer programs running with the operating system and computer specifically identified for computer program maintenance. To the extent practical, the operating system, computer programs, and firmware used for computer program maintenance shall be the same as that used for computer program development. The operating system and computer programs used for computer program maintenance shall provide the interactive capabilities specified in a through l:

a. Editing
b. Compilation which produces relocatable object code
c. If applicable, assembly which produces relocatable object code
d. Linking type loader
e. Generation, maintenance, and initialization of storage media for programs and data
f. Diagnostics to support fault isolation
g. Debugging tools
h. Program library facilities for both source and object code
i. Configuration control capability
j. Software design tools
k. Document generation and maintenance tools
l. Test tools

5.2.11.8:3 Computer resource utilization monitoring. The computer resources used for computer program maintenance shall provide a capability to monitor, record, display, and print the simulated utilization of the computer resources in the equipment under

simulated flight conditions. This capability is to provide a means for making measurements that would assure that adequate growth margins can be maintained as changes are incorporated into the computer resources.

5.2.11.8.4 Excess capacity. Computer resources used for computer program maintenance shall be capable of accommodating the excess capacity of the computer resources without necessitating any major modifications.

5.2.11.8.5 On-orbit reprogramming. Consideration shall be given to providing the means for on-orbit reprogramming of computer resources.

5.2.11.9 Tools for computer program maintenance. Tools required for the development of the equipment computer programs and firmware shall be organized into a library and facility for subsequent reuse in testing and validating changes to the computer programs. These tools include configuration-controlled masters of the released computer programs and firmware, the associated documentation, as well as the test drivers, simulated data, and other special purpose devices. For example, when a Microprocessor Development System is used to develop firmware, the Microprocessor Development System, associated computer programs, and documentation shall be controlled and retained as part of the computer program maintenance resources to support possible change activity during the operational service life of the system.

6. NOTES.

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

6.1 Intended use. MIL-STD-2036 is intended to be used by the specifier to assist with the preparation of end item specifications for COTS, ruggedized, and militarized equipment, for ship (including submarines) and space applications.

6.2 Applications. Requirements for shore (land-based), mobile, and airborne applications will be promulgated as revisions to this standard.

6.3 Subject term (keyword listing).

Commercial
COTS
Commercial off-the-shelf
Electronic
Militarized
NDI
Non-developmental Item
Ruggedized
Tailoring

Custodian:
NAVY - SH
AIR FORCE - 11
ARMY - CR

Preparing activity:
NAVY - SH
(Project GDRQ-0151)

Review activities:
NAVY - EC, OS, MC (MARCORSYSCOM C4IN)
ARMY - AR, AV, ME, MI, TE
AIR FORCE - 17, 19, 85
COAST GUARD - CTES, G-ER
DLA - ES (DESC-EPE)
DOT - FAA
NASA - NA

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APPENDIX A

Quality Assurance

10. GENERAL

10.1 Scope. This APPENDIX provides quality assurance requirements. This APPENDIX is a mandatory part of the standard. The information contained herein is intended for compliance.

20. APPLICABLE DOCUMENTS

20.1 Government documents.

20.1.1 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 listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

MILITARY

MIL-STD-1556 Government/Industry Data Exchange Program (GIDEP) Contractor Participation Requirements.

(Unless otherwise indicated, copies of Federal and military specifications, standards, and handbooks are available from the DODSSP - Customer Service, Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

30. DEFINITIONS

This section is not applicable to this APPENDIX.

40. GENERAL REQUIREMENTS (SHIP)

40.1 Responsibility for inspection. The contractor is responsible for the performance of all inspection requirements as specified herein. The contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein. The Government reserves the right to perform any of the inspections set forth in the specification when such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

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Quality Assurance

40.2 Responsibility for compliance. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

40.3 Government verification. All quality and safety assurance operations performed by the contractor will be subject to Government verification at any time. Verification will consist of a through c:

a. Surveillance of the operations to determine that practice, methods, and procedures of the quality and safety program requirements are being properly applied,

b. Government product inspection to measure quality and safety of product to be offered for acceptance, and

c. Government inspection of delivered items to assure compliance with this specification (not excluding any requirement of the specification for which detailed tests are not specified herein).

TABLE XVIII provides a sample matrix of selected requirements versus verification method. Alternative methods for Government inspection are as specified in d and e:

d. Hardware:

1. Test - Qualification through systematic exercising of the item under appropriate conditions. Performance is quantitatively measured either during or after the controlled application of either real or simulated functional or environmental stimuli. The analysis of data derived from a test is an integral part of the test and may involve automated data reduction to produce the necessary results.

2. Demonstration - Qualification by operation, adjustment, or reconfiguration of items performing their designed functions under specific scenarios. The items may be instrumented and quantitative limits or performance monitored, but only check sheets rather than actual performance data are required to be recorded.

3. Visual inspection - Qualification by a visual examination of the item, reviewing descriptive documentation, and comparing the appropriate

characteristics with predetermined standards to determine conformance to requirements without the use of special laboratory equipment or procedures. This type of inspection requires the use of check-off lists, which indicate accept/reject criteria for each item type.
4. Analysis - Qualification by technical or mathematical evaluation, mathematical models or simulation, algorithms, charts, graphs, or circuit diagrams, and representative data.

e. Software:

1. Test - Specified values of input will be used to exercise specific segments of code. The test item and the associated requirement will then be verified by examination and comparison of obtained output and predetermined output values.
2. Demonstration - The result of reactions of the code will be observed and recorded or logged. The examination of the data and witnessing of events will verify that the associated requirements have been met.
3. Visual inspection - Qualification by a visual examination of the item, reviewing descriptive documentation, and comparing the appropriate characteristics with predetermined standards to determine conformance to requirements without the use of special laboratory equipment or procedures.
4. Analysis - Qualification by technical or mathematical evaluation, mathematical models or simulation, algorithms, charts, graphs, or circuit diagrams, and representative data.

TABLE XVIII. Sample verification matrix for selected requirements

SECTION	REQUIREMENT	TEST	DEMO	ANALYSIS	INSPECT
4.2.2	Survivability			X	
4.2.2.1	Battleshort		X		

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TABLE XVIII. Sample verification matrix for selected requirements		TEST	DEMO	ANALYSIS	INSPECT
SECTION	REQUIREMENT				
4.2.2.1.3	Catastrophic Fault Indication		X		
4.2.2.2	Smart Loadshed		X		
4.2.3.1.2, 5.1.4.4.5	Fuses/Circuit Breakers			X	X
4.2.4	Computer Applications				X
4.4 TEMPEST				X	X
4.9 Reliability		X		X	
4.10	Maintainability		X	X	
4.8 A_o				X	
4.10.5.1	Testability		X	X	
4.11	Training		X		
4.14	Human Engineering				X
4.15	Serial numbers				X
4.16	Marking Requirements				X
4.16.1	Mounting and Location				X
4.7.2	Hazardous Materials				X
4.16.3	Marking (Lubrication Points)				X
4.16.4	Nomenclature				X
4.16.6	Electrical Power Source Plates				X
4.17	ESD	X			X

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Quality Assurance

TABLE XVIII. Sample verification matrix for selected requirements		TEST	DEMO	ANALYSIS	INSPECT
SECTION	REQUIREMENT				
4.19	Packaging				X
4.20	Quality Assurance				X
5.1.1	Auxiliary Support Services				X
5.1.1.1, 5.1.3.3	AC Power	X			
5.1.2.1	Altitude, Non-Operating	X			
5.1.2.2	DC Magnetic Field Environment	X			
5.1.2.3, 5.1.3.5	EMC	X			
5.1.2.7	Humidity	X			
5.1.2.11	Nuclear Hardening	X		X	
5.1.2.13	Ship Motion/Attitude	X			
5.1.2.14, 5.1.6.4.6	Shock	X		X	
5.1.2.16	Spray Tight Enclosure		X		
5.1.2.17	Temperature Ranges	X			
5.1.2.19	Vibration	X			
5.1.3.1	Airborne Noise	X			
5.1.3.2	Structureborne Noise	X			
5.1.3.5.1	EMCON Requirements	X			
5.1.3.7	Fungus	X			
5.1.3.8	Toxic Hazards			X	

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TABLE XVIII. Sample verification matrix for selected requirements		TEST	DEMO	ANALYSIS	INSPECT
SECTION	REQUIREMENT				
5.1.3.9	Prohibited Materials			X	
5.1.3.10	Safety (MIL-STD-454, Req't 1, ASTM F 1166)			X	
5.1.3.10.1	Leakage Current	X			
5.1.3.10.2	Protective Shields			X	X
5.1.3.10.3	Reference/Signal Voltages		X		
5.1.3.10.4, 5.1.4.5	Main Power ON-OFF				X
5.1.3.10.5	Safety Ground, Internal				X
5.1.3.10.6	Safety Ground, External				X
5.1.3.10.8	Safety Ground, Drawers				X
5.1.3.10.9	Equipment Tests	X			
5.1.3.10.10	Thermal Design	X			
5.1.3.11	Size Limitations				X
5.1.3.12	Grounding			X	X
5.1.4.1	Environmental Stress Screening	X			
5.1.4.4.2	Dielectric Withstanding Voltage (Chassis wire harness)	X			
5.1.4.4.3	Insulation Resistance (Chassis wire harness)	X			
5.1.6.4	Equipment Mounting				X
5.1.6.4.4	Sliding Drawer Mounting				X

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TABLE XVIII. Sample verification matrix for selected requirements SECTION REQUIREMENT	TEST	DEMO	ANALYSIS	INSPECT
5.1.6.9.1 Adjacent Connectors				X
5.1.6.9.2 Connector Location				X

40.4 Failure criteria. The equipment, or portions thereof, subjected to a test specified herein shall be considered to have failed the tests when any of the conditions specified in a through q occur:

a. Failed to conform to specification.
b. Process out of control.
c. Failure to test.
d. Incorrect specification.
e. Safety condition.
f. Primary failed item (not failures due to secondary effects).
g. Failure occurred within specified limits.
h. Failure resulted from wrong product supplied.
i. Failure resulted from operator error.
j. Failure resulted from deficient process.
k. Failure resulted from deficient inspection.
l. Failure resulted from deficient testing.
m. Failure resulted from deficient labeling.
n. Failure resulted from deficient design.
o. Failure resulted from deficient part.
p. Failure resulted from deficient workmanship.
q. Failure resulted from handling and packaging.

40.5 Problem/failure reporting and corrective action. Problem/failure reporting and corrective action of any failure shall be in accordance with MIL-STD-785. In addition, the contractor shall determine and report the yield or percentage of failures that

occurred for each level of hardware. For correction, consideration shall be paid to GIDEP data utilization in accordance with MIL-STD-1556.

40.6 Design qualification testing. The item designated for design qualification testing will normally be an engineering development model or equivalent. Design qualification testing shall be performed prior to commitment to production.

40.7 First article inspection. The first article inspection shall be performed in conjunction with production contracts only. First articles shall be representative of items which will be produced under the production contract, and may include initial production samples, first lots, pilot models, and pilot lots. The items designated for first article inspection shall be subjected to examinations and tests to determine compliance with this specification and the individual equipment specification.

40.8 Quality conformance inspection. Quality conformance inspection and testing shall be performed on each item offered for delivery. It shall comprise examination and testing to prove the workmanship and reveal omissions or errors in the production process such as functional and performance tests which detect deviation from design, tests of controls and adjustments, and manufacturing screening testing for the purpose of stimulating latent defects in both parts and workmanship.

40.9 Production quality conformance sampling inspection. Sampling for production quality conformance inspection shall be in accordance with the individual equipment specification. The inspection shall consist of examination and tests which encompass functional and performance tests throughout the entire range of operation. The inspection shall include tests which will detect any deterioration of the design by wear of such items as dies, molds, and jigs, and by the substitution of parts, tests which detect deviations in the processing of materials, and tests to determine temperature rise produced in equipment operation and the ability of equipment to withstand this heat.

40.10 Design requalification. Additional testing shall be performed when the design of, or material used in, the equipment is changed and such change may affect the equipment's ability to comply with one or more of the environmental test requirements.

40.11 Screening of potential NDI equipment. NDI candidate equipment shall be screened against the application specifications. The screen shall include an engineering evaluation of design, production, and test specifications; inspections of visual attributes; and tests of performance, environmental, and suitability

characteristics. The engineering evaluation shall determine what characteristics can be accepted from available data and what characteristics shall be verified by tests. The NDI supplier shall submit design and test data as required by the procuring activity to support the engineering evaluation. When the available data or visual inspection is insufficient to determine the ability of the equipment to conform to an application requirement, a suitable test shall be conducted to assess the equipment's capability against the application requirement; application critical performance characteristics shall be tested regardless of available data. Screening tests employing combined functional and environmental performance are preferred over individual tests of attributes. The test articles shall be selected at random from production lots of NDI equipment. The NDI supplier shall normally be entitled to all test and evaluation data specific to the equipment, unless otherwise specified in the solicitation, order, or contract. The evaluation of suitability characteristics shall consider the acquisition strategy, including maintenance and support provisions and warranties. Note: Normally at least three test articles are required to satisfy all screening test requirements; screening tests normally require from 90 to 180 days. Mission critical equipment may require more test articles or longer test durations.

50. GENERAL REQUIREMENTS (SPACE)

50.1 Craftsmanship. Equipment shall be manufactured, processed, tested, and handled such that the finished items are of sufficient quality to ensure reliable operation, safety, and service life. The items shall be free of defects that would interfere with operational use such as excessive scratches, nicks, burrs, loose material, contamination, and corrosion.

50.2 Responsibility for inspections and tests. Unless otherwise specified, the manufacturer is responsible for the performance of all inspection and test requirements specified herein. The manufacturer may use any facility approved by the procuring activity suitable for the performance of the inspection and test requirements specified herein. The procuring activity reserves the right to perform any of the inspections specified herein at any time.

50.3 Responsibility for compliance. The inspections set forth in this specification shall become a part of the manufacturer's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the manufacturer of the responsibility of assuring that all products or supplies submitted to the procuring activity for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to

ascertain conformance to requirements; however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the procuring activity to accept defective material.

50.4 Records. Unless otherwise specified, records documenting the accreditation status of equipment for space applications shall be maintained following assignment of serial numbers. Each space item shall have inspection records and test records maintained by serial number to provide traceability from system usage to assembly lot data for the devices. Complete records shall be maintained for the space items and shall be available for review during the service life of the system. The records shall indicate all relevant test data, all rework or modifications, and all installation and removals for any reason.

50.5 Manufacturing screens. Each critical subassembly, component, and vehicle shall be subjected to in-process manufacturing and assembly screens to assure compliance with the specified requirements to the extent practical. Compliance with the documented process controls, documented screening requirements, required hardware configuration, and general workmanship requirements shall be verified. At each level of assembly, each completed unit shall be subjected to visual inspection to assure that it is free of obvious defects and is within specified physical limits.

50.6 Assembly lots. To the extent practical, parts for use in equipment shall be grouped together in individual assembly lots during the various stages of their manufacture to insure that all devices assembled during the same time period use the same materials, tools, methods, and controls. Parts and devices for equipment that cannot be adequately tested after assembly without destruction of the item, such as explosive ordnance devices and complex electronic circuits, shall have lot controls implemented during their manufacture to assure a uniform quality and reliability level of the entire lot. Each lot shall be manufactured, tested, and stored as a single batch. Sequential lot numbers that indicate the date of manufacture shall be assigned to each lot. (Typically, use three digits for the day of the year and two digits for the year.)

50.7 Test equipment and inspection facilities. The manufacturer shall insure that test and inspection facilities of sufficient accuracy, quality, and quantity are established and maintained to permit performance of required inspections.

50.8 Parts, materials, and process controls. To ensure that a reliable electronic assembly is fabricated in accordance with qualified baseline procedures, all parts, materials, and manufacturing aids shall be adequately identified, controlled, and

inspected prior to assembly (see 5.2.4.1). During fabrication, the tools and processes, as well as parts and materials, shall be adequately controlled and inspected to ensure compliance with the approved manufacturing processes and controls.

50.9 Reusable flight hardware tests. Equipment intended for reuse on subsequent missions shall be subjected to repeated exposure to test, launch, flight, and recovery conditions throughout its life. Qualification testing of reusable hardware shall be conducted at environmental levels and durations that will ensure equipment integrity after repeated environmental exposures. Methods for avoiding fatigue failures is presented in MIL-HDBK-340.

50.10 Inspection of parts and materials. All parts used in critical electronic assemblies, and parts, materials, or fasteners comprising single point failures, shall be subjected to 100 percent inspection and acceptance tests (see 50.15) to ensure that no defects exist which could lead to degraded performance or failure. Special attention shall be given to the control of composite materials, including receiving inspection, in-process controls, and end-item inspections. Load-carrying honeycomb sandwich structures shall be subject to nondestructive inspection and appropriate proof-loading tests. Panels using embedded heat pipes shall be inspected to ensure that thickness dimensions of the honeycomb core and heat pipe are closely controlled to prevent voids, gaps, or discontinuities in the adhesive bondlines.

50.10.1 Microwave printed boards. Microwave printed boards shall be inspected and tested in accordance with IPC HF 318.

50.11 Inspection of assemblies. The dimensions, weight, finish, identification markings, and cleanliness of each electronic assembly shall be inspected, as appropriate, prior to acceptance testing and prior to installation on the space vehicle. These inspection processes shall include, but are not limited to, the following:

50.11.1 Scratched or damaged surfaces. If surface damage is sufficient to affect the intended function of the assembly, or the performance is degraded (such as damaged thermal control surfaces or contamination due to debris), the electronic assembly shall be rejected.

50.11.2 Surface finish. Any parts, materials, or fasteners exhibiting rust, corrosion, distortion, peeling of surface coatings, or severe discoloration shall be rejected.

50.11.3 Handling damage. Parts and materials shall be visually inspected for damage and contamination.

50.11.4 Fastener torque. Fasteners shall be visually inspected for looseness. In addition, the torque shall be checked on preselected fasteners before and after exposure to environmental test conditions.

50.11.5 Cleanliness. Product particulate cleanliness shall be in accordance with MIL-STD-1246, Level 500. External surfaces shall be visibly clean.

50.11.6 Wiring harnesses. Wiring harnesses shall be inspected to verify that they are properly secured and to verify that the proper configuration is maintained (see 5.2.4.3).

50.11.7 Electrical connectors. Connectors shall be inspected to verify dust caps are installed on unused connectors during shipment or test. Although unnecessary disconnecting and reconnecting of connectors shall be avoided, inspection for connector out of roundness and broken or loose connector contacts or pins shall be made, when practical.

50.11.8 Safety wire. Fasteners utilizing safety wire shall be inspected to ensure that the wire is properly installed and that such wire cannot result in interference with other parts.

50.11.9 Alignment. Alignment shall be inspected as appropriate.

50.11.10 Clearances. Clearances shall be inspected to ensure compliance with the specified requirements.

50.12 Lot certification testing. Space parts, materials, and subassemblies that cannot be adequately tested after assembly, and must rely upon the process controls and in-process screening to assure satisfactory performance and reliability, shall have appropriate lot certification tests imposed prior to installation into higher level assemblies. Lot certification testing is that testing performed to demonstrate that a lot of parts, materials, or subassemblies that have passed the in-process screening conform to the other quality and performance requirements. All items submitted for lot certification shall have been manufactured using the same supplier-documented processes and controls. Certification of a lot is achieved by the satisfactory completion without failure of the applicable tests. Note that lot certification testing should be performed by the supplier and need not be repeated by the user.

50.13 Non-conforming material. Non-conforming material, components, or assemblies that do not conform to the established tolerance limits set as the acceptance limits in the in-process screens shall be rejected for use. Any rejected material, component, or assembly may be reworked and screened in accordance with established, documented procedures if system reliability is not jeopardized. Non-conforming material or assembled units may be reworked and screened in accordance with established procedures if the rework is not so extensive as to jeopardize the lot identity of the material or assembled unit. If reworked material or assembled units that were lot-controlled subsequently pass the in-process screens, they can again be considered part of the lot. Reassignment of units that were lot controlled to a different lot shall not be made. Non-conforming material or assembled units that do not satisfy these rework criteria shall be considered scrap.

50.14 Development tests. Developmental testing shall be used to validate new design concepts for critical parts and assemblies as a prelude to qualification testing. The nature and extent of developmental testing on parts, subassemblies, and complete electronic assemblies shall be sufficient to ensure that qualification testing of new designs will produce minimal failures which would then require redesign. The development tests are performed as required to yield information necessary to determine a through k:

a. Design feasibility.
b. Adequacy of basic design approaches.
c. Functional parameters.
d. Thermal and structural data with particular emphasis on deployment, separation, latching mechanisms, clearances, structural dynamic characteristics, and math model verification.
e. Mass properties.
f. Packaging and fabrication techniques.
g. Stabilization performance.
h. EMC and TEMPEST.
i. Safety.
j. Cleanliness requirements and contamination compatibility.
k. Power consumption.
l. Reliability.

50.14.1 Current margin. Electrical current margins on all electroexplosive device ordnance circuits shall be demonstrated. The test shall verify that no less than the minimum recommended firing current (twice all-fire) would be delivered to the

electroexplosive devices under worst conditions of minimum voltage and maximum circuit and electroexplosive device resistance. The test shall verify that the maximum current delivered to the electroexplosive device does not exceed its maximum qualified firing current under conditions of maximum voltage and minimum circuit and electroexplosive device resistance.

50.14.2 Mechanism motion test. Erection, deployment, latching, and jettison features shall be tested to demonstrate adequate functioning under the full range of environmental conditions.

50.14.3 Shock. Equipment susceptible to shock shall be evaluated for bench handling (nonoperating) and while operating for possible pyroshock effects.

50.14.4 Outgassing. The outgassing properties of parts, materials, and components whose outgassing properties are not known shall be determined in accordance with ASTM E 595.

50.15 Acceptance tests. The configuration and workmanship of the completed hardware shall be verified by inspection prior to the start of acceptance testing. Each electronic assembly shall be subjected to functional and environmental tests that are in accordance with the applicable component acceptance test requirements of MIL-STD-1540. Functional tests shall be structured to demonstrate that the electronic assembly is capable of operating in such a manner that all performance requirements are satisfied. Functional tests are required before and after exposure to environmental test conditions in order to establish whether damage or degradation in performance has occurred. These tests shall be sufficiently comprehensive and shall include sufficient measurements to determine whether performance specifications are met. The initial functional testing shall be used as a baseline to which subsequent performance is compared. Functional tests shall be conducted in the appropriate environment to demonstrate performance requirements are met. All command functions shall be exercised during functional testing. Electronic assemblies shall be tested in their launch or in their on-orbit configurations corresponding to the environment being simulated. Electronic assemblies shall be passive or operating corresponding to their state during the launch or on-orbit operational phases. Assemblies that contain redundancy in their design shall, when practical, demonstrate performance to their requirements in each redundant mode of operation. Functional operation and alignment of each electronic assembly, including instrumentation that is an integral part of the assembly, shall be tested and checked, when practical, before and after exposure to each environmental acceptance test. No disassembly,

adjustments, or repair shall be made on electronic assemblies during functional and environmental acceptance testing or after completion of testing unless approved by the contracting officer.

50.16 Qualification tests. The qualification tests of the electronic assemblies shall consist of all tests deemed necessary to determine that the equipment conforms to all requirements of the specification and of the contract. Qualification tests shall be performed on one unit of equipment (more than one if required by the equipment specification or the contract) representative of the equipment to be supplied under the contract in accordance with the approved test procedures. All qualification tests shall be performed in accordance with written procedures. The qualification tests of the electronic assemblies shall be conducted in accordance with the qualification test requirements of MIL-STD-1540. When the actual qualification or acceptance test tolerances can be shown to be less than those specified in MIL-STD-1540, the qualification test levels may be appropriately reduced in accordance with provisions in this standard. The qualification tests shall incorporate the design life verification test, functional test, and environmental test requirements stated herein. The qualification tests shall be structured to demonstrate the design adequacy and design margins. Equipment having constraints on allowable outgassing shall qualify to that requirement either by test, or by an analysis using applicable materials test data, to determine the estimated total mass loss and the estimated loss of volatile condensable materials. An acceptance test shall precede the qualification tests. The general test measurements and test configurations used for qualification tests shall be similar to those used for acceptance tests. Assemblies that contain redundancy in their design shall, when practical, demonstrate performance to their requirements in each redundant mode of operation during the qualification test. Functional operation and alignment of each electronic assembly, including instrumentation that is an integral part of the assembly, shall, when practical, be tested and checked, before and after exposure to each qualification test. Satisfactory completion of these tests or equivalent proven space vehicle operational performance is required for flight certification or qualification. Compliance with all or portions of the qualification requirements based upon tests of similar items or upon equivalent space vehicle operational performance shall require approval of the contracting officer.

50.17 Protoflight test program. When the contracting officer deems it fiscally prudent, a protoflight test program is specified for some conditions such that the end item can be used as a flight unit. For example: acceleration, sinusoidal vibration, random vibration, pyroshock and acoustic noise.

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50.18 Design life tests. The design life tests are intended to evaluate life cycle margins and avoidance of fatigue. One or more items of each of the electronic assemblies, produced with production equipment and procedures, shall be subjected to a design life verification test. The number of units to be tested shall be sufficient to achieve the desired confidence level for the test results (see 1.6.1). These tests shall be conducted to simulate operational use within the range of the maximum predicted operational conditions. The items shall be subjected to tests which demonstrate the capability to perform the full operational life cycle. Masses, loads, and stiffness of support structure shall be actual or simulated operational values, and any interfacing equipment such as thermal heaters, cabling, or hoses shall be in place such that operational conditions are simulated. The test and criteria for performance adequacy shall be approved by the procuring activity. For items having a relatively low percentage duty cycle, it shall be acceptable to compress the operational cycle into a tolerable total test duration. For assemblies which operate continuously on-orbit, or at very high percentage duty cycles, accelerated test techniques may be employed if such an approach can be shown to be valid. The electronic assemblies used for life test shall be identical to the flight items with those changes necessary for incorporation of test instrumentation. These changes shall not jeopardize the validity of the tests with respect to the flight hardware. Sufficient instrumentation shall be used to provide knowledge of the operating conditions within the assemblies during life testing, such as internal temperatures and temperature gradients. The instrumentation shall be similar to that employed in other test phases to provide a basis for comparison of the design life test conditions with those of other selected ground tests and with those during orbital operations. The design life test electronic assembly shall be operated as expected in flight with equipment operating in accordance with the predicted duty cycle. The tests shall include variations of the expected flight usage, such as power-down modes to check low temperature operation of the system to the degree practical, without exceeding the thermal limits of the equipment. All electrical slip-ring and commutator assembly tests shall be conducted with representative levels of electrical current at the rated voltage across the interface. A functional test shall be conducted after the design life verification test has been completed and the assembly shall be disassembled and inspected for anomalous conditions. The critical areas of parts which may be subject to fatigue failure shall be inspected to determine if failure has occurred.

50.19 Service life verification tests. Service life verification tests are defined as those tests conducted on limited life devices to demonstrate that flight devices would perform satisfactorily during their specified service life. Explosive ordnance devices and other components whose performance may degrade with time shall have life

certification or extensions based upon passing either an aging surveillance test or an accelerated aging test as described in the applicable sub-tier specifications.

50.20 Functional and environmental qualification. One item of each of the electronic assemblies, produced with production equipment and procedures, shall be subjected to environmental qualification testing to verify satisfactory performance at the design environmental levels. Tests shall be in accordance with the applicable qualification test requirements of MIL-STD-1540. The electronic assemblies shall be tested in their launch or in their on-orbit configurations corresponding to the environment being simulated. They shall be passive or operating corresponding to their state during the launch or on-orbit operational phases. Test procedures, test time, and criteria for performance adequacy shall be as approved by the contracting officer.

50.21 Modifications, rework, and retesting. Completed electronic assemblies shall be modified and reworked with the same high quality assurance provisions and criteria as the original assembly. Unless specifically limited by the approved change proposal, the inspection and retesting requirements following modification shall not be limited to the changes or modifications, but the complete equipment must be retested including the changes. Inspection and retesting requirements following rework shall be consistent with the type and extent of the rework, the location when the rework is accomplished, and the inspection and testing criteria for the original equipment. Before resubmitting reworked equipment for acceptance, full particulars concerning previous rejection and the action taken to correct the defects found in the original shall be reviewed. Units rejected after retest shall not be resubmitted without the specific approval of the contracting officer. Electronic assemblies that have successfully completed acceptance tests and are not assembled on a space vehicle, but are placed in storage for more than two years shall undergo thermal or thermal vacuum acceptance tests prior to use.

50.22 Retest. Retest guidelines shall be in accordance with MIL-STD-1540.

50.23 Qualification of existing designs. Re-qualification is required for items that incorporate extensive changes in design, manufacturing processing, environmental levels, or performance requirements. However, methodology presented in MIL-HDBK-340 may be used to show that existing designs, or items previously qualified for other applications, have adequately demonstrated compliance to all qualification requirements for the new designs. Deficiencies in conform to requirements may be fulfilled by supplementing existing data with new test data. However, qualification by similarity shall be permitted only with the concurrence of the

contracting officer. Waiver of qualification or re-qualification requirements requires the approval of the contracting officer.

50.24 Mass properties. Actual weight and center of gravity measurements are required at the component and at each higher level of assembly to verify predictions and to ensure that the equipment conforms to final weight and center of gravity requirements.

50.25 Power management. Actual power consumption measurements are required at the component and at each higher level of assembly to verify predictions and to ensure that the equipment conforms to final power consumption requirements.

50.26 High pressure. Tests of all pressure subsystems of the integrated equipment shall be performed in accordance with MIL-STD-1540, NHB 1700.7, and SAMTO HB S-100 (KHB 1700.7).

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APPENDIX B

Ruggedized and COTS Features

10. GENERAL

10.1 Scope. This APPENDIX provides militarized requirements that may be specified for COTS and ruggedized equipment. This APPENDIX is not complete, and only provides suggestions for specifiers. The specifier is encouraged to review all militarized equipment requirements for requirements that may be suitable for the end item specification. This APPENDIX is not a mandatory part of the standard. The information contained herein is intended for guidance only.

20. APPLICABLE DOCUMENTS

This section is not applicable to this APPENDIX.

30. DEFINITIONS

This section is not applicable to this APPENDIX.

40. GENERAL REQUIREMENTS

40.1 Ruggedized and COTS features. The following requirements may be adopted to ruggedized and COTS acquisition options.

Description	Paragraph
Marking	4.16
Environmental Stress Screening.	5.1.4.1
Electrical overcurrent protection.	5.1.4.4.5
Electronic signal interfaces	5.1.5.1, 5.1.5.2
Digital computer grounding.	5.1.3.12.1
Connectors.	5.1.7.7.7
Illuminated devices.	5.1.7.7.12
Enclosures	5.1.6.3

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APPENDIX C

Navy Standard Electronic Power System

10. GENERAL

10.1 Scope. This APPENDIX provides a description of a survivable approach for providing power to electronic equipment. This APPENDIX is not a mandatory part of the standard. The information contained herein is intended for guidance only.

20. APPLICABLE DOCUMENTS

This section is not applicable to this APPENDIX.

30. DEFINITIONS

This section is not applicable to this APPENDIX.

40. GENERAL REQUIREMENTS

40.1 Navy Standard Electronic Power System. The Navy Standard Electronic Power System places a 155 V DC bus between the electrical circuits within the combat system equipment and the ship's electrical distribution system. This bus may either be internal to a single equipment or external and common to a group of functionally compatible equipment. A block diagram of the Navy Standard Electronic Power System is shown on FIGURE 10.

40.1.1 Rectifier conditioner. The rectifier conditioner is a polyphase transformer diode bridge, and low-pass filter; or another form of a unity power factor power supply. This conditioner rectifies the AC line to 155 V DC while conforming the 3 percent current harmonic limit, 5 percent load current unbalance and 2500 V spike requirements specified in MIL-STD-1399, Section 300.

40.1.2 100 millisecond holdup module. The 100 millisecond holdup module provides ride through of momentary power interruptions of up to 100 milliseconds duration, and uses capacitors for energy storage. It is not effective to use batteries for this module due to the internal voltage drop of the batteries.

40.1.3 5 minute holdup module. The 5 minute holdup module provides power to critical circuits during short term power interruptions of 5 minutes or less. The 5 minute holdup module uses batteries for energy storage. Because of the weight penalty associated with the batteries, 5min holdup will be provided only for those critical circuits needing continuous power for rapid restart following restoration of

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Navy Standard Electronic Power System

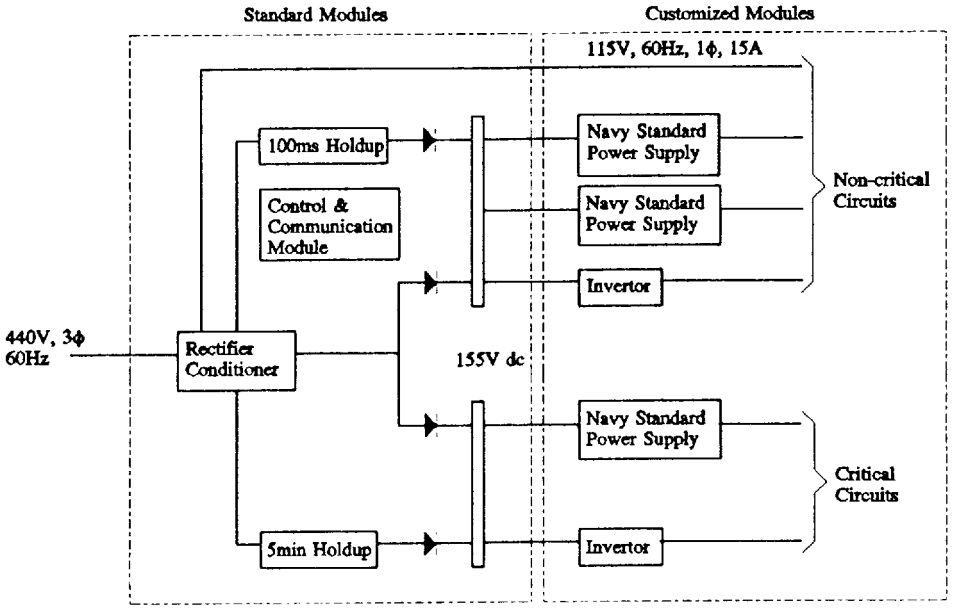

FIGURE 10. Navy standard electronic power system.

power.

40.1.4 SPS. Conversion of the 155 V DC bus to working voltages needed within the equipment shall be accomplished using SPS (see 5.1.4.10). These units are suitable for operation from either 155 V DC or from 115 V AC, type I power as specified in MIL-STD-1399, Section 300. SPS provide the working voltages needed by the equipment, and enable the equipment to ride through the wide voltage variations seen on the ac line.

40.1.5 Inverters. When special frequency power or clean 60 Hz power is required by equipment, a solid state invertor powered from the 155 V DC bus shall be used. The input power specifications for the invertor shall be the same as specified for SPS in MIL-P-24764.

APPENDIX D

Equipment Tests

10. GENERAL

10.1 Scope. This APPENDIX provides test requirements. This APPENDIX is a mandatory part of the standard. The information contained herein is intended for compliance.

20. APPLICABLE DOCUMENTS

20.1 Government documents.

20.1.1 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 listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

FEDERAL

FED-STD-141 Paint, Varnish Lacquer and Related Materials: Methods of Inspection, Sampling and Testing.

(Unless otherwise indicated, copies of Federal and military specifications, standards, and handbooks are available from the DODSSP - Customer Service, Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

20.2 Non-Government publications. The following document(s) 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 cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM D 714 Standard Method of Evaluating Degree of Blistering of Paints.
ASTM D 1141 Standard Specification for Substitute Ocean Water.

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

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APPENDIX D

Equipment Tests

30. DEFINITIONS

This section is not applicable to this APPENDIX.

40. GENERAL REQUIREMENTS

40.1 Thermal test. The test shall include the measurement and recording of the information specified in a through d:

a. Operating temperature of parts that operate at 75 percent or more of rated value.
b. Operating temperature of parts that dissipate 10 percent or more of the total power dissipated by the unit in which they are installed.
c. Surface temperature of enclosures, front panels, and controls.
d. Hotspot temperatures.
e. Inlet and outlet temperature differentials when forced air cooling is utilized.

Upon completion of the thermal performance test, a visual examination shall be made to detect evidence of deterioration of parts and materials used in the equipment.

40.1.1 Test conditions. The thermal test shall be performed on equipment under the conditions specified in a through d.

a. Maximum operating temperature of the range, as specified herein.
b. Operating mode which will cause the maximum steady state power dissipation.
c. Continuous equipment operation for a time span that will achieve thermal stabilization. The condition under which equipment is to have achieved thermal stabilization, for example, temperature does not change more than 1°C per hour, shall be tailored.
d. Equipment cabinets closed.

40.1.2 Thermal instrumentation. Thermal instrumentation such as thermocouples, infrared photography, chemicals or calibrated thermal sensitive materials that will measure temperatures shall be used in the test. The method used to measure temperatures shall not affect the accuracy of the measurement.

40.2 Inclination. The equipment shall be subjected to the test limits specified herein. The equipment shall be energized and fully operating during the applicable test. The equipment shall be inclined at the rate of 5 to 7 cycles per minute in one phase to angles of 45 degrees on both sides of the vertical for surface ships, 60 degrees for submarines, for a period of not less than 30 minutes. During the inclination testing, equipment with drawer slides shall be extended on its slides, to verify that the slides have sufficient lateral strength to support the equipment with inclination in all test directions. For equipment whose operation is degraded when the drawer is extended, for example, due to interlocks, the tests shall be performed with the drawer slides closed. The test shall be repeated with the equipment reoriented 90 degrees to the plane in which it was originally tested. At the conclusion of these cyclic tests, the cyclic motion shall be stopped and the inclination adjusted to an angle of 15 degrees. The equipment shall then be operated for a sufficient period to ensure that the continuous operation can be maintained. The equipment shall then be rotated through the vertical to 15 degrees in the opposite direction and the test for continuous operation repeated. The test shall be repeated with the equipment reoriented 90 degrees to the plane in which it was originally tested.

40.3 Accelerated life tests. Accelerated life tests shall be as specified in 40.3.1 through 40.3.3.

40.3.1 Initial test conditions.

a. Equipment shall be set up in a temperature-controlled chamber at 25 ± 5°C. Maintain 45 percent to 55 percent relative humidity unless otherwise indicated.
b. Equipment energized and frequency specified.
    1. Nominal line voltage and frequency specified.
    2. Cooling system in normal operation.
    3. Fully operational for 2 hours.
c. When equipment internal temperature has stabilized, performance parameters shall be measured and recorded as reference test data for comparison with subsequent tests.

40.3.2 Temperature conditions. Temperature conditions shall be established as specified in a through i:

a. Reduce chamber temperature, at a uniform rate in not less than 4 hours, to the lowest operating temperature of the range specified.

b. Maintain chamber temperature at the lowest operating temperature of the range for 10 hours.
c. Near the end of the 10 hour period, measure and record the performance parameters.
d. Increase chamber temperature, at a uniform rate in not less than 6 hours, to the highest operating temperature of the range specified.
e. Maintain chamber temperature at the highest operating temperature of the range specified for 8 hours.
f. Near the end of the 8 hour period, measure and record the performance parameters.
g. Reduce chamber temperature, at a uniform rate in not less than 6 hours, to the lowest operating temperature of the range specified.
h. Maintain chamber temperature at the lowest operating temperature of the range specified for 2 hours.
i. Near the end of the 2 hour period, measure and record the performance parameters.

40.3.3 Voltage and frequency cycling conditions. Voltage and frequency cycling conditions shall be established as specified in a through v:

a. After completion of the low temperature conditioning period specified in 40.3.2 (i), decrease the input voltage to the lower limit of the equipment voltage tolerance band.
b. Operate for 1 hour and record performance parameters.
c. Return input voltage to nominal value. Decrease input frequency to the lower limit of the equipment frequency tolerance band.
d. Operate for 1 hour and record performance parameters.
e. Return input frequency to nominal value.
f. Increase temperature to 25 ± 5°C, at a uniform rate in not less than 6 hours. Maintain this condition for 2 hours and record performance parameters.
g. With equipment operating at 25 ± 5°C, decrease input voltage and frequency to the lower limits of the equipment voltage and frequency tolerance bands. Maintain this condition for 1 hour and record performance parameters.
h. Repeat (g) with input voltage at the upper limit of the equipment voltage tolerance band and input frequency at the lower limit of the equipment frequency tolerance band.
i. Repeat (g) with input voltage and frequency at the upper limits of the equipment voltage and frequency tolerance bands.

j. Repeat (g) with input voltage at the lower limit of the equipment voltage tolerance band and input frequency at the upper limit of the equipment frequency tolerance band.
k. Increase chamber temperature, at a uniform rate in not less than 6 hours, to the highest operating temperature of the range specified.
l. Record performance parameters at the end of the uniform temperature rise test of (k).
m. Maintain chamber temperature and frequency conditions of (k), increase input voltage to the upper limit of the equipment voltage tolerance band.
n. Operate for 8 hours and record performance parameters.
o. Maintain voltage, and frequency conditions of (m) with 90 percent to 95 percent relative humidity.
p. Operate for 2 hours and record performance parameters.
q. Maintain frequency and relative humidity conditions of (o), but decrease input voltage to the lower limit of the equipment voltage tolerance band.
r. Operate for 1 hour and record performance parameters.
s. Maintain high temperature and humidity conditions of (q), but return input voltage and frequency to nominal values.
t. Operate for 1 hour and record performance parameters.
u. Repeat high temperature voltage and frequency cycling tests of (o) through (t) for not less than 59 cycles.
v. Repeat high temperature voltage and frequency cycling tests of (o) through (t) with 10 percent to 20 percent relative humidity for not less than 15 cycles.

40.4 Paint system test. Test panels composed of the same material as the exposed equipment shall be prepared and painted using the same methods that will be used on the equipment to be delivered. When more than one type of material is used, test panels of each type shall be prepared and tested in accordance with one of the following procedures as specified in the individual equipment specification.

40.4.1 Procedure I:

a. Panels shall be subjected to the salt fog test in accordance with MIL-STD-810, Method 509, except that a 20 percent salt solution shall be used, the duration of exposure shall be 5 days, and the following shall be performed after the wash in running water.
b. Immerse panels in a 5 percent (by weight) solution of sulfuric acid for 30 minutes.

c. Remove panels from the sulfuric acid solution and place them in a dry heat oven at 93°C for 1 hour.
d. Remove panels from the oven and immediately immerse them in cold (9 to 14°C) water for 10 minutes.
e. Remove panels from the cold water and immerse them for 2 days in hot (80°C) synthetic seawater, conforming to ASTM D 1141.
f. Determine adhesion and degree of blistering, as specified herein.

40.4.2 Procedure II:

a. Condition panels for 1 week at 23 ± 3°C after application of the final coat.
b. Immerse panels for 12 weeks in hot synthetic seawater conforming to ASTM D 1141.
c. Determine adhesion and degree of blistering as specified herein.

40.4.3 Blistering. The degree of blistering shall be determined in accordance with ASTM D 714. Blisters appearing within 6.5 millimeters from the edge of the panel shall be disregarded.

40.4.4 Adhesion. The loss of paint adhesion on both sides of each panel shall be determined in accordance with method 6301 of FED-STD-141, except the requirement for panel immersion shall be omitted.

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APPENDIX E

Safety

10. GENERAL

10.1 Scope. This APPENDIX provides safety requirements. This APPENDIX is a mandatory part of the standard. The information contained herein is intended for compliance.

20. APPLICABLE DOCUMENTS

20.1 Government documents.

20.1.1 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 listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

STANDARDS

MILITARY

MIL-STD-1425	Safety Design Requirements for Military Lasers and Associated Support Equipment.

HANDBOOKS

MILITARY

MIL-HDBK-600	Guidelines for Identification, Marking, Labeling, Storage and Transportation of Radioactive Commodities.

(Unless otherwise indicated, copies of Federal and military specifications, standards, and handbooks are available from the DODSSP - Customer Service, Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

20.1.2 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 cited in the solicitation.

PUBLICATIONS

CHIEF OF NAVAL OPERATIONS

OPNAVINST 5100.19 Navy Safety Precautions for Forces Afloat.

(Application for copies should be addressed to the Chief of Naval Operations, OP-461, Washington, DC 20350)

SPACE AND NAVAL WARFARE SYSTEMS COMMAND

SPAWARINST 5100.12 Navy Laser Radiation Hazards Prevention Program.
NAVELEX 0967-LP-624-6010 Electromagnetic Radiation Hazards.

(Application for copies should be addressed to the Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120)

FEDERAL REGULATIONS

10 CFR 20 Code of Federal Regulations, Title 10, Part 20.
21 CFR 1000-1050 Code of Federal Regulations, Title 21, Parts 1000-1050.

(The Code of Federal Regulations (CFR) and the Federal Register (FR) are for sale on a subscription basis by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.)

20.2 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 which are DOD adopted is that listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C95.1 Safety levels with respect to human exposure to radio frequency electromagnetic fields, 300 K Hz to 100 G Hz.

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Safety

ANSI C95.2 Radio frequency radiation hazard warning symbol.
ANSI C95.3 Techniques and Instrumentation for the Measurement of Potentially Hazardous Electromagnetic Radiation at Microwave Frequencies.
ANSI Z53.1 Safety color code for marking physical hazards.
ANSI N2.1 American National Standard for Warning symbols-Radiation symbol.

(Applications for copies should be addressed to the American National Standards Institute, 11 West 42 Street, New York, NY 10036.)

30. DEFINITIONS

This section is not applicable to this APPENDIX.

40. GENERAL REQUIREMENTS

40.1 Radioactive commodities. Materials that emit alpha and beta particles and gamma rays may be absorbed and deposited within the body. These particles and rays act as damaging agents that injure or destroy blood-forming organs and other tissue. Marking and labeling requirements for identification in use, storage and transportation of radioactive commodities, their packages and shipping containers shall be in accordance with MIL-HDBK-600.

40.2 X-radiation and laser radiation. X-radiation tests shall be in accordance with 21 CFR 1010.2, 21 CFR 1010.3, 21 CFR 1020.10, and applicable UL or other consensus standards. Laser tests shall be in accordance with 21 CFR 1010.2, 21 CFR 1010.3, 21 CFR 1040, or Government test laboratory in accordance with MIL-STD-1425 and SPAWARINST 5100.12.

40.2.1 X-radiation. Radiation levels shall be limited to not greater than 2 milliroentgen (mR) in any one hour, and 100 mR in any 7 consecutive days at the operator's position or within 50 millimeters from the equipment (whichever is closer) in any unrestricted area accessible to personnel. In addition, these levels shall be reduced whenever necessary to ensure that exposed personnel never receive an absorbed dose to the whole body or any critical organ in excess of 125 millirem per calendar quarter or 500 millirem per year. Other exposure shall be based on application criteria and limits as required by 10 CFR 20; 29 CFR 1910.96; and 21 CFR, Chapter I, Subchapter J, Radiological Health. Equipment which, when shields, covers, and doors are removed, will allow X-radiation to exceed 2.0 mR per hour, shall be provided with nonbypassable interlocks. Shields which protect personnel from irradiation shall be

labeled in accordance with 21 CFR and a warning located when the barrier or access door is removed.

40.2.2 Laser radiation. Laser equipment and system design, installation, and operational and maintenance procedures shall be in accordance with 21 CFR 1040.10. Exempt military lasers or military lasers not covered by 21 CFR 1040.10 shall use the hazard classification of 21 CFR 1040 which indicates the level of control required to minimize personnel injury potential based solely on laser accessible emission levels. The safety design requirements for exempted lasers and associated support equipment shall be in accordance with MIL-STD-1425.

40.3 Color code, human exposure to RF fields in high frequencies, and RF radiation. The safety in COTS equipment and systems shall include a through e:

a. The establishment of a safety color code that will alert and inform persons to take precautionary action in the presence of hazards shall be in accordance with ANSI Z53.1.
b. The prevention of harmful effects in human beings exposed to electromagnetic fields in the frequency range from 300 kHz to 100 gHz shall be in accordance with ANSI C95.1.
c. The warning of biological detriment and direct and indirect cause of ignition of explosive materials or vapors from hazardous levels of nonionizing electromagnetic radiation shall be in accordance with ANSI C95.2.
d. Techniques for measurement of potentially hazardous electromagnetic radiation at microwave frequencies shall be in accordance with ANSI C95.3.
e. Radiation symbol shall be in accordance with ANSI N2.1.

40.4 Electromagnetic radiation hazards (RADHAZ). Personnel concerned with the design, installation, and operation of electronic equipment capable of producing or being susceptible to electromagnetic RADHAZ shall be in accordance with the guidance of OPNAVINST 5100.19, NAVELEX 0967-LP-624-6010 on the aspects specified in a through e:

a. Biological effects with precautionary safety measures.
b. Safe distance and time of exposure levels of RF for personnel on ship.
c. Fire and personnel protection criteria.
d. Methods and procedures for the prediction of electromagnetic radiation.
e. Susceptibility of electroexplosive devices and ordnance to electromagnetic radiation.

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APPENDIX F

Leakage Current Tests

10. GENERAL

10.1 Scope. This APPENDIX provides test methods for measuring leakage current. This APPENDIX is a mandatory part of the standard. The information contained herein is intended for compliance.

20. APPLICABLE DOCUMENTS

This section is not applicable to this APPENDIX.

30. DEFINITIONS

This section is not applicable to this APPENDIX.

40. GENERAL REQUIREMENTS

40.1 Leakage current. Leakage current shall be measured at maximum steady state power line voltage and frequency, for each voltage and frequency at which the equipment is designed to operate.

WARNING

THIS TEST MAY BE HAZARDOUS DUE TO THE UNGROUNDED CONDITION OF THE EQUIPMENT DURING THE TEST. DO NOT TOUCH EXPOSED METAL SURFACES WITHOUT ADEQUATE ELECTRIC SHOCK PROTECTION.

THE UNITED STATES GOVERNMENT NEITHER ASSUMES NOR ACCEPTS RESPONSIBILITY FOR ANY INJURY OR DAMAGE THAT MAY OCCUR DURING OR AS A RESULT OF THIS TEST.

40.2 Equipment test connection. After power removal, each equipment directly connected to an external power source and units deriving power from the equipment shall be placed on an insulated surface. All safety ground conductors between the equipment and units deriving power from the equipment shall be intact. The safety ground conductor between the equipment and the source power shall be opened during the test. OBSERVE WARNING STATEMENT. The equipment shall be connected as shown on FIGURE 11 if connected to single phase power, as shown on

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Leakage Current Tests

FIGURE 12 if connected to 3-phase power, and as shown on FIGURE 13 if connected to DC power.

40.3 Measurement. Leakage current shall be measured on equipment in its normal operating configuration. Equipment controls in each operating mode shall be such that maximum power will be utilized during leakage current measurements. The leakage current shall be determined by the voltage-drop method. A True RMS Voltmeter shall be used. With 5 mA of leakage current, the voltage drop across the 1500 ohm resistor in parallel with the 0.15 microfarad capacitor will be 7.5 V DC at DC, 7.5 V RMS at 60 Hz, and 6.53 V RMS at 400 Hz. The overall measurement error shall not exceed 5 percent. The safety ground shall be connected to the source power ground through an impedance not to exceed 1 Ohm. An insulated probe shall be used on all external conducting parts such as case, connector housings, recessed calibration or adjustment controls, and control shafts with knobs removed. The voltage shall be measured from each part to ground for every combination of switch positions available in the test diagram. The open safety ground conductor shall be reconnected immediately after the test is completed.

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Leakage Current Tests

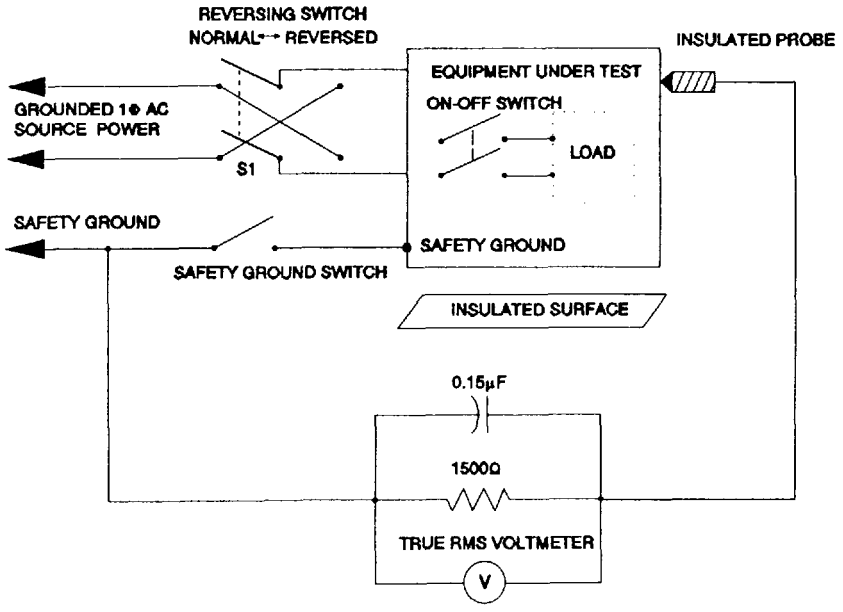

FIGURE 11. Single-phase test diagram for leakage current measurement.

GENERAL ORDER OF TESTS:

1. Source power OFF. Connect equipment per diagram.
2. ON-OFF SW OFF. Safety ground switch CLOSED. S1 SW NORMAL. Source power ON.
3. OBSERVE WARNING. Safety ground switch OPEN. ON-OFF Switch ON.
4. For each probe point, record voltmeter reading (CASE, CONNECTORS, CONTROLS, SHAFTS).
5. ON-OFF Switch OFF. Repeat Step 4.
6. S1 Switch REVERSED.
7. ON-OFF Switch OFF. Repeat Step 4.
8. Safety ground switch CLOSED. S1 Switch normal.
9. Repeat Step 3 THROUGH 8 for each mode of operation.
10. Source power OFF. Disconnect equipment. Sign record sheet.

NOTE:1. All three phases shall be connected during measurement.
2. The safety ground conductor shall not carry load current.

WARNING - DO NOT TOUCH EXPOSED METAL SURFACES. THIS TEST MAY BE HAZARDOUS DUE TO THE UNGROUNDED CONDITION OF THE EQUIPMENT DURING THE TEST. THE UNITED STATES GOVERNMENT NEITHER ASSUMES NOR ACCEPTS RESPONSIBILITY FOR ANY INJURY OR DAMAGE THAT MAY OCCUR FROM THE USE OF THIS DIAGRAM FOR LEAKAGE CURRENT MEASUREMENT.

Appendix F
Leakage Current Tests

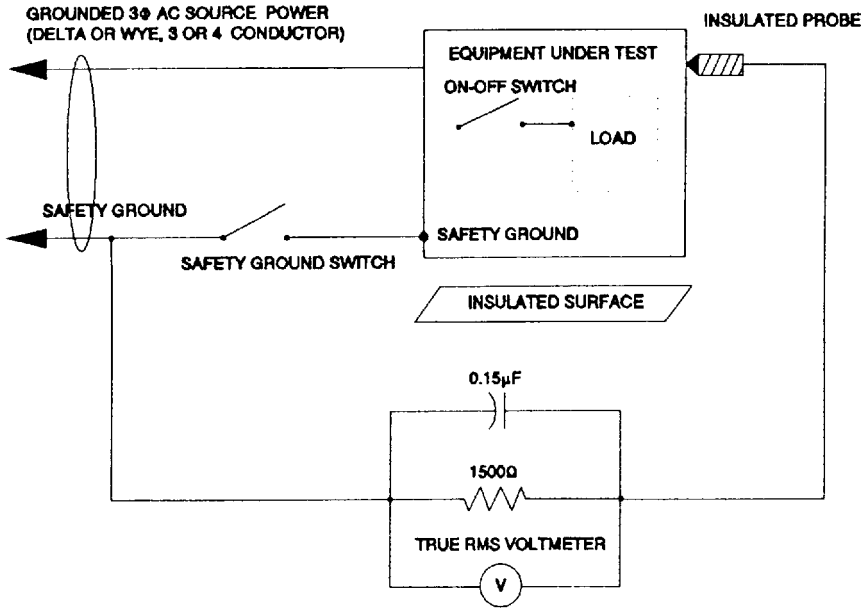

FIGURE 12. Three-phase test diagram for leakage current measurement.

GENERAL ORDER OF TESTS:

1. Source power OFF. Connect equipment per diagram.
2. ON-OFF Switch OFF. Safety ground switch CLOSED. Source power ON.
3. OBSERVE WARNING. Safety ground switch OPEN. ON-OFF Switch ON.
4. For each probe point, record voltmeter reading (CASE, CONNECTORS, CONTROLS, SHAFTS).
5. ON-OFF Switch OFF. Repeat Step 4.
6. Safety ground switch CLOSED.
7. Repeat Step 3 THROUGH 6 for each mode of operation.
8. Source power OFF. Disconnect equipment. Sign record sheet.

NOTE:1. All three phases shall be connected during measurement.
2. The safety ground conductor shall not carry load current.

WARNING - DO NOT TOUCH EXPOSED METAL SURFACES. THIS TEST MAY BE HAZARDOUS DUE TO THE UNGROUNDED CONDITION OF THE EQUIPMENT DURING THE TEST. THE UNITED STATES GOVERNMENT NEITHER ASSUMES NOR ACCEPTS RESPONSIBILITY FOR ANY INJURY OR DAMAGE THAT MAY OCCUR FROM THE USE OF THIS DIAGRAM FOR LEAKAGE CURRENT MEASUREMENT.

Appendix F
Leakage Current Tests

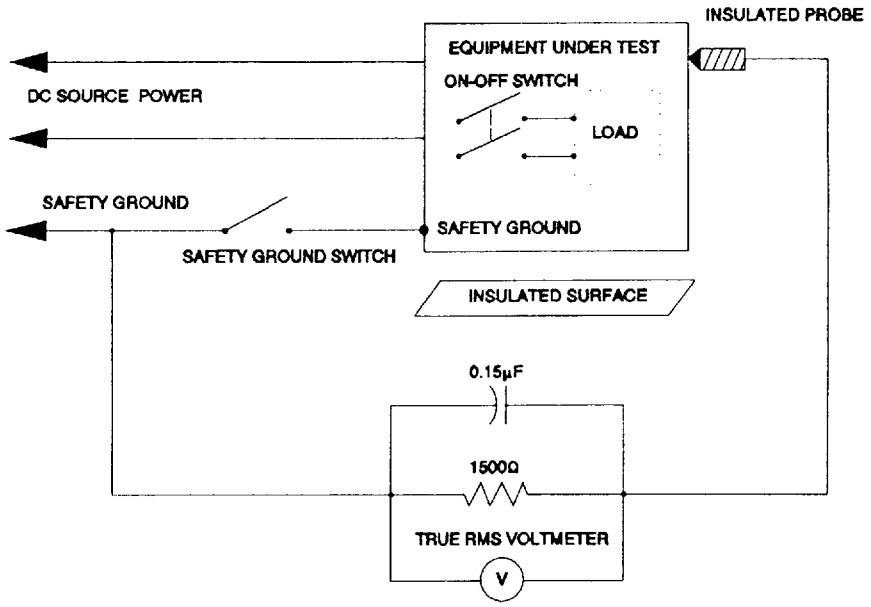

FIGURE 13. DC test diagram for leakage current measurement.

GENERAL ORDER OF TESTS:

1. Source power OFF. Connect equipment per diagram.
2. ON-OFF Switch OFF. Safety ground switch CLOSED. Source power ON.
3. OBSERVE WARNING. Safety ground switch OPEN. ON-OFF Switch ON.
4. For each probe point, record voltmeter reading (CASE, CONNECTORS, CONTROLS, SHAFTS).
5. ON-OFF Switch OFF. Repeat Step 4.
6. Safety ground switch CLOSED. ON-OFF Switch ON. Repeat Step 4 AND 5.
7. Source power OFF. Disconnect equipment. Sign record sheet.

WARNING - DO NOT TOUCH EXPOSED METAL SURFACES. THIS TEST MAY BE HAZARDOUS DUE TO THE UNGROUNDED CONDITION OF THE EQUIPMENT DURING THE TEST. THE UNITED STATES GOVERNMENT NEITHER ASSUMES NOR ACCEPTS RESPONSIBILITY FOR ANY INJURY OR DAMAGE THAT MAY OCCUR FROM THE USE OF THIS DIAGRAM FOR LEAKAGE CURRENT MEASUREMENT.

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