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DEPARTMENT OF DEFENSE
HANDBOOK

PREPARATION OF
ELECTRONIC EQUIPMENT SPECIFICATIONS

AMSC N/A AREA GDRQ

This handbook is for guidance only. Do not cite this document as a requirement.

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FOREWORD

1. This handbook provides guidance to specifiers and the acquisition community for the development of requirements for end-item specifications and commercial item descriptions. This handbook also provides quidance for the evaluation of commercial-off-the-shelf (COTS) equipment and nondevelopmental items (NDI) as to their suitability for use in military environments.

2. This handbook is for guidance only. This handbook cannot be cited as a requirement. If it is, the contractor does not have to comply.

3. This document incorporates the guidelines of the Acquisition Reforms, as outlined in the Process Action Team (PAT) on Military Specifications and Standards report, "Blueprint for Change," of April 94; SECDEF memorandum, "Specifications and Standards - a New Way of Doing Business," of 29 June 1994; and OASN (RD&A) memorandum, "Navy Implementation of DOD Policy on Specifications and Standards Reform," of 27 July 1994. Although many of these initiatives were defined herein prior to this revision, many changes are substantial, as indicated in a through e.

a. Requirements are to be stated in performance terms. Accordingly, the body of the handbook deals with the tailoring of performance requirements. For those infrequent instances in which a detail specification is necessary, guideform design and process requirements and have been placed in an appendix for guidance.

b. Invoking of detail military standards and specifications requires a waiver.

c. Programmatic and logistics requirements have been deleted from this document.

d. Definitions and selected requirements have been extracted from source references, converted to performance terms, or identified as unnecessary cost drivers and deleted.

e. The PAT report provided a recommended list of prohibited references for ACAT programs, this guidance has been incorporated.

4. 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, NAVSEA 03R4, 2531 Jefferson Davis Highway, Arlington, VA 22242-5160 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 document provides guidance for the tailoring of general and detailed requirements which must be addressed in the preparation of specifications for electronic equipment used in ships (including submarines), space, mobile (vehicular), and land applications.

1.2 Use. Requirements in end-item specifications should be tailored for all applications (see 4.1.3). This does not allow the specifier to disregard a performance characteristic. All equipment characteristics addressed herein should be considered and evaluated by the specifier in the development and tailoring of requirements. Tailoring should not be based solely on the capabilities of the equipment being procured and the subjective opinion of the specifier. Rather, tailoring decisions should be based on evaluation of the equipment mission, and the projected operating environment of the equipment based upon analytical and/or measured field data, and should reflect unique platform requirements, such as noise and hazardous material requirements for submarines, and requirements for operation and maintenance by personnel.

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 should be dependent upon the expectations for the equipment, availability of nondevelopmental item (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 shapes of the COTS and ruggedized areas shown on figure 1 are intended to show that more equipment is available that conforms to the minimal acceptable criteria than that which conforms 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 shut down or go into a standby mode when specified operating limits are exceeded. As long as the support services and other interfaces remain within their specified limits, the equipment should not be damaged by such excursions. The procuring activity should coordinate requirements with platform integration activities to ensure that specification requirements conform to platform unique constraints. The specific requirements for each acquisition are the responsibility of the program manager and should be tailored within the range of acceptable limits provided herein (see 4.1.3).

1.4 Specifications. End item specifications should be prepared in accordance with MIL-STD-961. To the greatest extent possible, requirements should be stated in terms of performance. For situations in which a detail specification is the only option, drafting guidance and guideform requirements are provided in Appendix A.

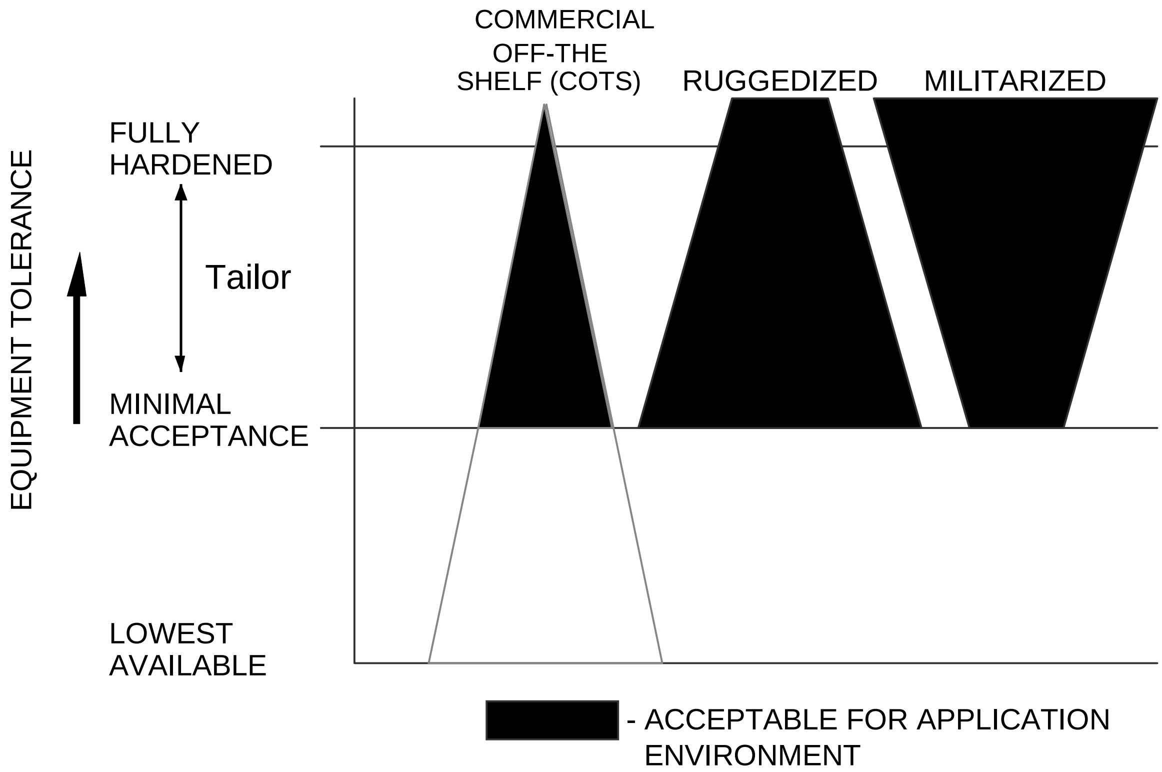


FIGURE 1. Acquisition options.

1.5 System classification (ship). Equipment should be classified as mission critical or nonmission critical, sheltered or unsheltered, and nuclear hardened or non-nuclear hardened (see 4.1.3.1).

1.6 System classification (space). Systems should be classified as Class I, Class II, Class III, or Class IV in accordance with Table I (see 4.1.3.2).

TABLE I. Space 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

1.7 System classification (mobile). Requirements should apply to electronic equipment mounted in/on vehicles, and equipment normally transported in/on vehicles for use at a remote site. Equipment should be classified as portable or non-portable, mission critical or nonmission critical, mounted interior or exterior to the vehicle, on-road or off-road, and nuclear hardened or non-nuclear hardened (see 4.1.3.3). Mobile equipment which is mounted under canvas or other non-rigid material should be considered to be exterior mounted.

1.8 System classification (land-based). Equipment should be classified as mission critical or nonmission critical, sheltered or unsheltered, and nuclear hardened or non-nuclear hardened (see 4.1.3.4).

2. APPLICABLE DOCUMENTS.

2.1 General. The documents listed below are not necessarily all of the documents referenced herein but are the ones that are needed in order to fully understand the information provided by this handbook.

2.2 Government documents.

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

SPECIFICATIONS

DEPARTMENT OF DEFENSE

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.

STANDARDS

DEPARTMENT OF DEFENSE

MIL-STD-167-1	Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type II - Internally Excited).
MIL-STD-210	Climatic Information to Determine Design and Test Requirements for Military Systems and Equipment.
MIL-STD-461	Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility.
MIL-STD-462	Measurement of Electromagnetic Interference Characteristics.
MIL-STD-464	Electromagnetic Environmental Effects Requirements for Systems.
MIL-STD-469	Radar Engineering Design Requirements, Electromagnetic Compatibility.
MIL-STD-740-2	Structureborne Vibratory Acceleration Measurements and Acceptance Criteria of Shipboard Equipment.
MIL-STD-810	Environmental Test Methods and Engineering Guidelines.

MIL-STD-961	Defense Specification Practices.
MIL-STD-1275	Characteristics of 28 Volt DC Electrical Systems in Military Vehicles.
DOD-STD-1399, Section 071	Interface Standard for Shipboard Systems, Mass/Size/Shape, Shipboard Units. (Metric)
MIL-STD-1399, Section 072.1	Interface Standard for Shipboard Systems, Blast Environment, Missile Exhaust.
MIL-STD-1399, Section 072.2	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)
DOD-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 532	Interface Standard for Shipboard Systems, Cooling Water for Support of Electronic Equipment. (Metric)
MIL-STD-1425	Safety Design Requirements for Military Lasers and Associated Support Equipment.
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-1809	Space Environment for USAF Space Vehicles.

DOD-STD-2143	Magnetic Silencing Requirements for the Construction of Nonmagnetic Ships and Craft. (Metric)

HANDBOOKS

DEPARTMENT OF DEFENSE

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. (limited distribution)
MIL-HDBK-235-3	Electromagnetic Radiation Environment From Hostile Force Emitters. (limited distribution)
MIL-HDBK-235-4	Electromagnetic Radiation Environment, Army Installations.

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

2.2.2 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 should 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 should be those in effect on the date of the solicitation.

PUBLICATIONS

ASSISTANT SECRETARY OF DEFENSE

SD-2	Nondevelopmental Item Program, Buying NDI.
SD-14	Listings of Toxic Chemicals, Hazardous Substances, and Ozone Depleting Chemicals.

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

DEPARTMENT OF COMMERCE (DOC)

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.)

FEDERAL REGULATIONS

21 CFR 1040	Code of Federal Regulations, Title 21, Chapter I (Food and Drug Administration, Department of Health and Human Services), Part 1040. (Performance Standard for Light Emitting Products)
29 CFR 1910	Code of Federal Regulations, Title 29, Chapter XVII (Occupational Safety and Health Administration, Department of Labor), Part 1910 (Occupational Safety and Health Standards).
47 CFR 15	Code of Federal Regulations, Title 47, Chapter I (Federal Communications Commission), Part 15 (Radio Frequency Devices).
40 CFR Chapter I	Code of Federal Regulations, Title 40, Chapter I (Environmental Protection Agency).

(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)

NAVSO P-6071	Best Practices.

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

JOINT CHIEFS OF STAFF (JCS)

Tri-Service Technical Brief 002-93-08	Environmental Stress Screening.

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

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

NASA-STD-3000	Manned System Integration Standard.

(Application for copies should be addressed to the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 1911-5094.)

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

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), Arlington, VA 22242-5160)

(Unless otherwise indicated, copies of documents are available to Government agencies from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094. Copies of documents are available to non-Government agencies from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22151.)

NAVAL SURFACE WARFARE CENTER DAHLGREN DIVISION (NSWCDD)

NSWC TR 87-192	Suggested Electronic Equipment Standards for Nuclear Weapons Environment.
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.)

2.3 <u>Non-Government publications</u>. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents should 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 should be those in effect on the date of the solicitation.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI N2.1	Warning Symbols - Radiation Symbol.
ANSI S2.15	Specification for the Design, Construction, and Operation of Class HI (High-Impact) Shock-Testing Machine for Lightweight Equipment.
ANSI C62.41/IEEE 587	Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
ANSI/IEEE C63.16	American National Standard Guide for Electrostatic Discharge Test Methodologies and Criteria for Electronic Equipment.
ANSI C84.1	Electric Power Systems and Equipment - Voltage Ratings (60Hz).
ANSI/IEEE C95.1	Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 kHz to 100 GHz.
ANSI C95.2	Radio Frequency Radiation Hazard Warning Symbol
ANSI Z136.1	Safe Use of Lasers.
ANSI/NEMA Z535.1	Safety Color Code.
ANSI/NEMA Z535.2	Environmental and Facility Safety Signs.
ANSI/NEMA Z535.3	Criteria for Safety Symbols.
ANSI/NEMA Z535.4	Product Safety Signs and Labels.

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

AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR CONDITIONING ENGINEERS (ASHRAE)

ASHRAE Handbook	HVAC Systems and Applications.

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

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 117	Standard Test Method of Salt Spray (Fog) Testing.
ASTM D 568	Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Flexible Plastics in a Vertical Position.

ASTM D 635	Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position.
ASTM D 1000	Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.
ASTM D 1654	Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments.
ASTM D 3951	Standard Practice for Commercial Packaging.
ASTM D 4169	Standard Practice for Performance Testing of Shipping Containers and Systems.
ASTM G 7	Standard Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials.
ASTM G 31	Standard Practice for Laboratory Immersion Corrosion Testing of Metals.
ASTM G 50	Standard Practice for Conducting Atmospheric Corrosion Tests on Metals.
ASTM G 52	Standard Practice for Exposing and Evaluating Metals and Alloys in Surface Seawater.

(Application for copies should be addressed to the American Society for Testing and Materials, 100 Bar Harbor Drive, West Conshohaken, PA 19428-29597.)

ELECTRONIC INDUSTRIES ASSOCIATION (EIA)

EIA RS-310	Cabinets, Racks, Panels, and Associated Equipment.
EIA RS-471	Symbol and Label for Electrostatic Sensitive Devices.

(Application for copies should be addressed to the Electronic Industries Association, 2500 Wilson Blvd., Arlington, VA 22201-3834.)

INSTITUTE OF ENVIRONMENTAL SCIENCES (IES)

ISBN 1-877862-02-9	Environmental Stress Screening Guidelines for Assemblies.

(Application for copies should be addressed to the Institute of Environmental Sciences, 940 East Northwest Highway, Mount Prospect, Illinois, 60056.)

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 68-2-3	Basic Environmental Testing Procedures, Part 2: Tests, Test Ca: Damp Heat, Steady-state.
IEC 68-2-6	Basic Environmental Testing Procedures, Part 2: Tests, Test FC: Vibration (Sinusoidal).
IEC 68-2-11	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 68-2-30	Basic Environmental Testing Procedures, Part 2: Tests, Test Db and Guidance: Damp Heat, Cyclic (12 + 12 hour cycle).
IEC 68-4	Basic Environmental Testing Procedures, Part 4: Information for Specification Writers - Test Summaries.
IEC 721-2-6	Classification of Environmental Conditions, Part 2: Environmental Conditions Appearing in Nature - Earthquake Vibration and Shock.
IEC 721-3-1	Classification of Environmental Conditions, Part 3; Classification of Groups of Environmental Parameters and Their Severities - Storage.
IEC 721-3-2	Classification of Environmental Conditions, Part 3; Classification of Groups of Environmental Parameters and Their Severities - Transportation.
IEC 721-3-3	Classification of Environmental Conditions, Part 3; Classification of Groups of Environmental Parameters and Their Severities - Stationary Use at Weatherprotected Locations.
IEC 721-3-4	Classification of Environmental Conditions, Part 3; Classification of Groups of Environmental Parameters and Their Severities - Stationary Use at Non-Weatherprotected Locations.
IEC 721-3-5	Classification of Environmental Conditions, Part 3; Classification of Groups of Environmental Parameters and Their Severities - Ground Vehicle Installations.

IEC 721-3-6	Classification of Environmental Conditions, Part 3; Classification of Groups of Environmental Parameters and Their Severities - Ship Environment.
IEC 721-3-7	Classification of Environmental Conditions, Part 3; Classification of Groups of Environmental Parameters and Their Severities - Portable and Non-stationary Use.
IEC 950	Safety of Information Technology Equipment Including Electrical Business Equipment.

(Application 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)

IEEE C57.114	Seismic Guide for Power Transformers and Reactors.
IEEE C62.47	Guide on Electrostatic Discharge (ESD): Characterization of the ESD Environment.
IEEE 100	Standard Dictionary of Electrical and Electronics Terms.
IEEE 141	Recommended Practice for Electric Power Distribution for Industrial Plants.
IEEE 383	IEEE Standard for Type Test of Class IE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.
IEEE 519	Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
IEEE 693	Recommended Practices for Seismic Design of Substations.

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum).

(Application for copies should be addressed to the National Electrical Manufacturers Association, 2101 L Street, N.W., Washington, DC 20037.)

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.)

SOCIETY OF AUTOMOTIVE ENGINEERS, INC. (SAE)

SAE J 1211	Recommended Environmental Practices for Electronic Equipment Design, Recommended Practice.
SAE J 1455	Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design (Heavy-Duty Trucks), Recommended Practice.

(Application for copies should be addressed to the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096-0001.)

UNDERWRITERS LABORATORIES, INC. (UL)

UL 50	UL Standard for Safety, Enclosures for Electrical Equipment.
UL 698	UL Standard for Safety, Industrial Control Equipment for Use in Hazardous (Classified) Locations.
ANSI/UL 1203	UL Standard for Safety, Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations.
UL 1950	UL Standard for Safety of Information Technology Equipment, Including Electrical Business Equipment.

(Application for copies should be addressed to the Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.)

(Non-government standards and other publications are normally available from the organization that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.4 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, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS.

3.1 Definitions of acronyms. The acronyms used herein are defined as follows:

AC	- alternating current
C	- Celsius
C^4I	- Command, control, communications, computers, and intelligence
CLIPS	- classified information processing system
COTS	- commercial off-the-shelf
dB	- decibel
DC	- direct current
DODISS	- Department of Defense Index of Specifications and Standards
EMC	- electromagnetic compatibility
EMCON	- emission control
EMI	- electromagnetic interference
EMP	- electromagnetic pulse
ESD	- electrostatic discharge
FCC	- Federal Communications Commission
g	- acceleration of gravity
HM&E	- hull, mechanical, and electrical
HVAC	- heating, ventilation, and air conditioning
Hz	- Hertz
IC	- integrated circuit
I/O	- input/output
kHz	- kilohertz
MTBF	- mean-time-between-failures
MTTR	- mean-time-to-repair
NDI	- nondevelopmental item
OASPL	- overall sound pressure level
OSA	- open systems architecture
rms	- root-mean-square
RF	- radio frequency
SEM	- standard electronic module
SPS	- standard power supply
TREE	- transient radiation effects on electronics
UPS	- uninterruptable power supply
V	- volt
Vrms	- volts root-mean-square
VDC	- volts direct current

3.2 Definitions of terms. The definitions specified in ANSI/IEEE 100 and 3.2.1 through 3.2.5.1 apply.

3.2.1 Assembly. A number of parts or subassemblies, or any combination thereof, joined together to perform a specific function and capable of disassembly (examples: power shovel-front, fan assembly, audio frequency amplifier).

3.2.2 Battleshort. A function which disables equipment protection and personnel safety interlocks in order to keep the equipment on-line during high readiness states.

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

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

3.2.5 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 cataloged item.

3.2.6 Component (space). An assembly or any combination of parts, subassemblies and assemblies mounted together, normally capable of independent operation in a variety of situations.

3.2.7 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.

3.2.8 Corrosion. A specific type of deterioration resulting in damage or impairment of metals or metallic parts as the result of attack by moisture, air, acid, alkali, chemicals, or electrochemical action.

3.2.9 Electromagnetic interference (EMI). An 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.

3.2.10 Electromagnetic pulse (EMP). A transient high-intensity electromagnetic field. EMP is commonly associated with nuclear explosions in or near the Earth’s atmosphere; however, electromagnetic pulses can arise from other sources, such as lightning.

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

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

3.2.13 Enclaving. A synergistic zoning of the combat system; hull mechanical and electrical (HM&E) systems; and damage control systems into regions which, if necessary, can function independently to provide a subset of the ship mission capabilities.

3.2.14 Faults (battleshort). Definition is dependent upon the application/ equipment type, see ANSI/IEEE 100.

3.2.15 Fully hardened. The most stringent performance criterion for a requirement (see 3.2.27). Fully hardened equipment may be COTS, ruggedized, or militarized equipment. Fully hardened is not synonymous with fully militarized.

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

3.2.17 Greenwater loading. Mechanical loading due to wave slap. Greenwater loading applies to exterior or unsheltered equipment on ships or craft. Mobile equipment which may by placed on vehicles that are carried topside or in landing craft should be considered susceptable to greenwater loading.

3.2.18 Group. A collection of units, assemblies, or subassemblies which is not capable of performing a complete operational function. A group may be a subdivision of a set or may be designed to be added to or used in conjunction with a set to extend the function or the utility of the set. (example: antenna group)

3.2.19 Hardware levels of assembly (space). Item levels from the simplest division to the more complex are part, subassembly, component, subsystem, space vehicle, and system.

3.2.20 Hardware levels of assembly (ship, mobile, and land). Item levels from the simplest division to the more complex are part, subassembly, assembly, unit, group, set, subsystem, system.

3.2.21 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.

3.2.22 Launch system. A composite of equipment, skills, and techniques capable of launching and boosting the space vehicle into orbit. The launch system includes the space vehicle, the launch vehicle, and related facilities, equipment, material, software, procedures, services, and personnel required for their operation.

3.2.23 Launch vehicle, expendable. A composite of the booster initial stages, injection stages, space vehicle adapter, and fairing having the capability of a single launching and injection of a space vehicle or vehicles into orbit.

3.2.24 Launch vehicle, recoverable. A composite of booster stages, injection stages, and a space vehicle carrier having the capability to carry a space vehicle to a parking orbit. Elements of the launch vehicle may be recovered for use and may return to earth with or without the space vehicle.

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

3.2.26 Militarized. Items which are designed and manufactured to meet military requirements.

3.2.27 Minimal acceptance. The least strict performance criterion for a requirement.

3.2.28 Mission critical. quipment that contributes significantly to the safety, maneuverability, and continued mission capability of the platform. Mission critical equipment should be identified as such by the program manager, as directed by the sponsor.

3.2.29 Multipacting. The resonant flow of secondary electrons in a vacuum between two surfaces separated by a distance such that the electron transit time is an odd integral multiple of one half the period of the alternating voltage impressed on the surfaces.

3.2.30 NDI. Nondevelopmental Item. An item which does not require further development. NDI can be COTS, ruggedized, or militarized. NDI may include any of the items specified 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 Government, a state or local Government, or a foreign Government with which the United States has a mutual defense cooperation agreement.

c. Item described in a and b above that requires only minor modification to conform to the contracting agency requirements.

d. Item currently being produced that does not conform to requirements specified in a through c above solely because the item is not yet in use, or not yet available in the commercial marketplace.

3.2.31 Open systems architecture (OSA). A system that implements sufficient open specifications, services, and supporting formats to enable properly engineered components to be utilized across a wide range of systems and minimal changes, to interoperate with other components on local and remote systems, and to interact with users in a style that facilitates portability. An open system is characterized by the following:

a. Well defined, widely used, non-propietary interfaces.

b. Use of standards which are developed/adopted by industrially recognized standards bodies.

c. Definition of all aspects of system interfaces to facilitate new or additional systems capabilities for a wide range of applications.

d. Explicit provision for expansion or upgrading through the incorporation of additional or higher performance elements with minimal impact on the system.

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

3.2.33 Part. One piece, or two or more pieces joined together, which are not normally subject to disassembly without destruction of designed use. (examples: outer front wheel bearing, electron tube, resistor, screw, gear, capacitor, transformer)

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

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

3.2.36 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 milliseconds to 15 milliseconds.

3.2.37 Qualification tests (space). Formal contractual demonstrations that the design, manufacturing, and assembly have resulted in hardware and computer programs conforming to specification requirements.

3.2.38 Ruggedized. COTS equipment that has been modified to function reliably in harsh environments such as extremes of temperature, shock and vibration, humidity, or radiation.

3.2.39 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 (see 3.2.16). Service requirements are specified in Sections 4 and 5.

3.2.40 Set. A unit or units and necessary assemblies, subassemblies and parts connected together or used in association to perform an operational function. (examples: radio receiving set, sound measuring set, radar homing set) Also used to denote a collection of related items. (examples: tool set, drawing set, set of tires)

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

3.2.42 Space vehicle. A complete, integrated set of subsystems and components capable of supporting an operational role in space. A space vehicle may be an orbiting vehicle, a major portion of an orbiting vehicle, or a payload which performs its mission while attached to a recoverable launch vehicle. The airborne support equipment which is peculiar to programs utilizing a recoverable launch vehicle should be considered part of the space vehicle being carried by the launch vehicle.

3.2.43 Subassembly. Two or more parts which form a portion of an assembly or a unit replaceable as a whole, but having a part or parts which are individually replaceable. (examples: gun mount stand, window recoil mechanism, floating piston, telephone dial, mounting board with mounted parts, power shovel dipper stick)

3.2.44 Subsystem. A combination of sets, groups, and so forth, which performs an operational function within a system and is a major subdivision of the system. (examples: data processing subsystem, guidance subsystem)

3.2.45 System. A composite of equipment, skills, and techniques capable of performing or supporting an operational role, or both. A complete system includes all equipment, related facilities, material, software, services, and personnel required for its operation and support to the degree that the system can be considered a self-sufficient unit in its intended operational environment. A combination of two or more sets, which may be physically separated when in operation, and such other assemblies, subassemblies, and parts necessary to perform an operational function or functions. (examples: electronic system, fire control system, computer, and gun mount)

3.2.46 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.

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

3.2.48 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 alter or permanently alter the operating characteristics/state of the semiconductor device.

3.2.49 Unit. This replaces the term component. An assembly or any combination of parts, subassemblies and assemblies mounted together, normally capable of independent operation in a variety of situations. (examples: hydraulic jack, electric motor, electronic power supply, internal combustion engine, electric generator, radio receiver)

3.2.50 Unsheltered. Installations that are not protected from the external environment.

3.2.51 Warmup time. The time period required to reach specified operational performance capability from a nonoperational condition and environment.

4. GENERAL REQUIREMENTS.

4.1. Policy guidance. The specifier should tailor performance criteria to conform to the applications and operating conditions for which the equipment is intended to be used (see 4.1.3 and 6.1). NAVSO P-6071 provides guidance for the program manager 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.

4.1.2 Acquisition preference. The order of preference for acquisition should be NDI (which includes COTS, ruggedized NDI, and militarized NDI) (see 3.2.30), ruggedized items requiring additional development, and militarized items requiring additional development. Guidelines for NDI are provided in SD-2.

4.1.3 Tailoring of requirements. Specification requirements should be driven by the equipment application rather than equipment capability. Requirements should be tailored to reflect the projected operating conditions for the equipment specified in the end item specification, based on field and measured data, rather than subjective opinion (see 1.1.1). Two factors are of significant importance in military and space environments that are not common in the commercial environment. They are; survivability and combat system integration. The platform should be designed to carry out its mission in extreme conditions, which may include exposure to shock, fire and thermal extremes. The specifier must also understand the constraints and limitations of supporting systems, which will operate under the same conditions. Finally, the specifier must accommodate the direction of future system design, including integration with other systems.

4.1.3.1 Tailoring ship requirements. Table II provides guidance for tailoring ship requirements. Equipment procured for a common system should be acquired to the same guidelines and classification. As applicable, mission critical equipment should be fully hardened (see 4.2.1). Equipment which is exposed to weather and other external conditions should be fully hardened for those conditions (see 3.2.41 and 3.2.50). Table II does not include general requirements (see Section 4), nuclear effects (see 5.1.2.10), conditions when fully hardened and minimal acceptance criteria are the same (see 5.1.2.2, 5.1.2.17, and 5.1.3), or size and weight (see 5.1.3.8). Requirements should be tailored based upon the intended application of the equipment.

TABLE II. Ship tailoring matrix.

Requirement	Paragraph	Minimal acceptance		Fully hardened
Conditions apparent throughout the ship			← TAILOR →	
Auxiliary support services	5.1.1	Nonmission critical		Mission critical
Ship motion and attitude	5.1.2.12			
Shock	5.1.2.13			
DC magnetic field	5.1.2.1			
Temperature	5.1.2.15			
Humidity	5.1.2.6			
External effects			← TAILOR →	
Greenwater loading	5.1.2.4			
Dust and sand	5.1.2.3	Sheltered		Unsheltered
Gun muzzle	5.1.2.5			
Hydrostatic pressure	5.1.2.7			
Missile exhaust	5.1.2.9			
Icing	5.1.2.8			
Wind	5.1.2.18			
Salt fog	5.1.2.11			
Solar radiation	5.1.2.14			
Underwater explosion	5.1.2.16			

4.1.3.2 Tailoring of space requirements. Table III provides guidance for tailoring space requirements. Equipment procured for a common system should be acquired to the same guidelines and classification. As applicable, mission critical equipment should be fully hardened (see 4.2.1). Probability of mission success (see 4.13), and environmental level (see 5.2.2) should be based on the system classification in accordance with Table III.

TABLE III. Space 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

4.1.3.3 Tailoring mobile requirements. Table IV provides guidance for tailoring mobile requirements. Equipment procured for a common system should be acquired to the same guidelines and classification. As applicable, mission critical equipment should be fully hardened (see 4.2.1). Equipment which is exposed to weather and other external conditions should be fully hardened for those conditions. Table IV does not include general requirements (see Section 4), chemical and biological warfare (see 5.3.2.1), nuclear effects (see 5.3.2.2), electromagnetic compatibility (EMC) (see 5.3.1.10 and 5.3.1.11), fungus (see 5.3.2.7), or size and weight (see 5.3.2.8). Requirements should be tailored based on the application of the equipment.

TABLE IV. Mobile tailoring matrix.

Requirement	Paragraph	Minimal acceptance	Fully hardened
Conditions apparent throughout the vehicle		← TAILOR →	
Temperature	5.3.1.1	Nonmission critical	Mission critical
Humidity	5.3.1.2		
Salt Fog	5.3.1.3		
Dust and sand	5.3.1.5		
Altitude	5.3.1.6		
Vibration[1]	5.3.1.7		
Shock[1]	5.3.1.8		
Direct current power	5.3.1.9		
Solar radiation	5.3.2.3		
External effects		← TAILOR →	
Immersion and splash	5.3.1.4		
Wind	5.3.2.4	Interior	Exterior
Icing	5.3.2.5		
Rain	5.3.2.6		

[1] Fully hardened for off-road operations (including nonmission critical equipment)

4.1.3.3.1 Mobile portable equipment. Requirements for portable equipment should be tailored to the projected mission of the equipment. Conditions exterior to the vehicle may be encountered during nonoperational conditions, such as transport and handling. Operational conditions may vary, depending upon the end-use of the equipment. IEC 721-3-7 provides guidelines for the specification of environmental conditions for portable and nonstationary applications.

4.1.3.4 Tailoring of land-based requirements. Table V provides guidance for tailoring land-based requirements. Equipment procured for a common system should be acquired to the same guidelines and classification. As applicable, mission critical equipment should be fully hardened (see 4.2.1). Equipment which is exposed to weather and other external conditions should be fully hardened for those conditions. Table V does not include general requirements (see Section 4), chemical and biological warfare (see 5.4.2.7), nuclear effects (see 5.4.2.8), EMC (see 5.4.2.2 and 5.4.2.3), airborne noise (see 5.4.2.15), fungus (see 5.4.2.16), or size and weight (see 5.4.3). Requirements should be tailored based on the application of the equipment.

TABLE V. Land-based tailoring matrix.

Requirement	Paragraph	Minimal acceptance	Fully hardened
Conditions apparent throughout facility		← TAILOR →	
Alternating current power	5.4.1.1	Nonmission critical	Mission critical
Altitude	5.4.2.1		
Humidity	5.4.2.5		
Shock and vibration	5.4.2.14		
Temperature	5.4.2.13		
External effects		← TAILOR →	
Dust and sand	5.4.2.4		
Icing	5.4.2.6	Sheltered	Unsheltered
Salt fog	5.4.2.9		
Solar radiation	5.4.2.10		
Wind	5.4.2.11		
Rain	5.4.2.12		

4.1.3.5 Unique applications. Requirements for unique applications which apply to a small fraction of units or have a small probability of occurrence should 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 should be considered such as modification of individual units and the development of field kits/add-ons.

4.1.3.6 Commonality. When similar functions are performed by different equipment, consideration should be given to incorporating all required capabilities into one piece of hardware. The resulting end item specification should be nonproprietary such that a qualified manufacturer may provide the equipment.

4.1.4 General application. The specifier should tailor the requirements of this document based on the application of the equipment (see 4.1.3), and should encourage contractors to submit cost effective tailoring recommendations.

4.1.5 Computer resources. Equipment should have intracomputer and intercomputer interfaces which support an OSA. Equipment should have the capability to accept upgrades in computer technology and should be capable of interfacing with all system architectures envisioned during service life.

4.1.5.1 Data buses. The preferred method for data transfer between units should be by a common data bus. The use of an industry accepted standard data bus format is encouraged.

4.1.5.2 Fiber optics. The preferred method for data transmission between system elements which are not on a common data bus should be fiber optics.

4.1.5.3 Distributive processing. Reliance on central computer systems for operation and control of the combat system should be avoided.

4.2. Mission critical requirements (ship). All mission critical equipment should be in accordance with 4.2.1 through 4.2.4.

4.2.1 Mission critical equipment. Fully hardened requirements should be specified for mission critical equipment to the extent applicable. Mission critical equipment should be identified as such by the program manager, as directed by the sponsor.

4.2.2 Survivability. Survivability should be a major criterion for all mission critical equipment. Survivability criteria include the ability to withstand battle damage, to maintain maximum readiness during an engagement, and to permit rapid repairs following casualties. Survivability criteria also include system and system interface considerations, for example, the availability of data communication circuits and auxiliary support services routed through damaged spaces.

4.2.2.1 Battleshort. Interlock bypass circuits should be provided to override personnel safety and maintenance interlocks. Interlocks provided for protection against catastrophic faults should not be bypassed. Interlock bypass circuits should be such that loss of power does not disable the battleshort mode. Visual indication should be provided when the equipment is in the battleshort mode. When in the battleshort mode, an audible alarm should be provided to indicate when personnel hazards exist.

4.2.2.2 Smart loadshed. Equipment rated 5 kilovoltamperes or more should be provided with a means for being placed in a low power mode when loadshed has been activated.

4.2.2.3 Redundancy and enclaving. Redundancy and enclaving criteria should be determined from the operating requirements.

4.2.2.4 Soft kills. Even though the combatant mission priority may be simultaneous engagement of multiple threats and other tactical offensive capabilities, the specifier should 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.

4.2.2.5 Withdrawal and repair. A high 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 (ship). Power interface should be as specified in 4.2.3.1 through 4.2.3.3 (see 5.1.1.1).

4.2.3.1 Momentary power interruptions. Mission critical equipment should remain fully operational through momentary power interruptions of 150 milliseconds or less. The intent of this requirement is to coordinate ride-through of shipboard systems and equipment.

4.2.3.2 Nondomestic power. Equipment should be suitable for operation from nondomestic 50 Hz power sources. The intent of this requirement is to provide for cold-iron status and emergency repairs of mission critical equipment while the ship is docked in a foreign port.

4.2.3.3 Circuit breaker protection. The circuit breaker protection for the equipment, and the interface to the electrical power system, should be coordinated to ensure that the circuit breaker closest to the cause of an overcurrent or fault current condition will be the first to trip (see A.5.1.5.5). The intent of this requirement is to prevent inadvertent shut down of adjacent equipment connected to a common source.

4.2.4 Flammability. Fire spread is a major cause for loss of mission capability in casualty situations. Equipment should be in accordance with 4.12.2.

4.3. Equipment control (space). Requirements for mass and power should be as specified in 4.3.1 and 4.3.2.

4.3.1 Mass. Equipment mass should be controlled throughout the acquisition process for the preservation of performance margins, and as a control of other mass properties such as the equipment center of gravity. Weight and center of gravity should be measured at the component and at each higher level of assembly.

4.3.2 Power management. Equipment power consumption should be controlled throughout the acquisition process for the preservation of performance margins. Power consumption should be measured at the component and at each higher level of assembly.

4.4. TEMPEST. TEMPEST requirements should be specified for Navy CLIPS.

4.5. Interchangeability. Interchangeability should support an OSA (see 4.1.5). When appropriate, hardware from different sources of supply may be designated as interchangeable.

4.6. Human factors engineering (space). Human engineering design criteria for equipment installed in manned space vehicles, or intended for on-orbit maintenance/ recovery, should be tailored from NASA-STD-3000.

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

4.8. ESD. Equipment should tolerate an ESD in accordance with ANSI/IEEE C62.47. Assemblies which may be accessed during installation, maintenance or repair actions should tolerate an ESD in accordance with ANSI/IEEE C62.47; or the equipment and assemblies should be marked in accordance with EIA RS-471. Equipment and assemblies should be tested in accordance with ANSI/IEEE C63.16.

4.9. Corrosion. Equipment should be resistant to corrosion. Equipment should be tested in accordance with ASTM G 31, ASTM G 52, ASTM G 7, and ASTM G 50, as applicable. Paint systems should be tested in accordance with ASTM B 117 and ASTM D 1654, except that the test duration should be 21 days. Paint systems should show no blistering or adhesive failure.

4.10. Protective enclosures. Requirements for protective enclosures for use in hazardous locations, and for protection against specified environmental conditions, should be tailored in accordance with NEMA 250, UL 50, UL 698, and ANSI/UL 1203. The internal clearance and the equipment mounting holes of racks and panels should be in accordance with EIA 310. The use of NDI (English) panels on metric racks in accordance with EIA 310 may require modification of hole spacing on panels.

4.11. Packaging and handling. Specific packaging requirements are incorporated into the contract documents; equipment should be packaged in accordance with ASTM D 3951. When conditions which require special packaging arise, the requirements should be conveyed to the contracting officer for incorporation into the contract documents. Testing of equipment and equipment packaging for handling and transportation should be in accordance with ASTM D 4169. Additional guidance for tailoring of requirements for storage and transportation is provided in IEC 721-3-1 and IEC 721-3-2.

4.11.1 Altitude (nonoperating). Equipment should be suitable for transit in an unpressurized aircraft cargo bay at an altitude of 4.6 kilometers. Altitude tests should be tailored in accordance with IEC 68-2-13 or MIL-STD-810, Method 500.

4.11.2 Temperature (nonoperating). Equipment should withstand a nonoperating temperature range of -40°C to +70°C.

4.12. Safety. Equipment should be in accordance with all applicable Federal regulations. Equipment should be such that systems (including personnel, other equipment, interfaces and ordnance) will not be exposed to safety hazards during the installation, operation, maintenance, repair, or replacement of equipment or parts thereof. Equipment should be such that systems will not be exposed to safety hazards should the equipment fail during the installation, operation, maintenance, repair, or replacement of the equipment or parts thereof. Equipment should be tested in accordance with IEC 950, UL 1950, or equivalent test procedure.
When preparing electronic equipment specifications, the documents cited below must be used.

4.12.1 Prohibited materials. Equipment should not contain toxic or hazardous substances in accordance with 29 CFR 1910, Subpart H and Subpart Z, FED-STD-313, 40 CFR Chapter I, Subchapter J, and SD-14 (see ?). The use of ozone-depleting chemicals in accordance with SD-14 and 40 CFR Chapter I, Subchapter C should require the approval of the contracting activity. Unless otherwise specified, the materials specified in Table VI should not be used. Special care should be taken when selecting materials to be installed in a controled submarine atmosphere.

TABLE VI. Prohibited materials.

Carcinogens
Glass fibers (exposed), see 4.12.1.1
Lithium and lithium compounds, except batteries approved for the intended service conditions
Magnesium or magnesium alloys
Polyvinyl chloride (PVC), except when used for part leads
Radioactive commodities
Zinc or zinc alloys

4.12.1.1 Glass fibers. Glass fiber materials should not be used as the outside surface or covering on cables, wire, piping, cases, or other items where the glass fiber materials may cause irritation to personnel.

4.12.2 Flammability. Equipment should not be flammable, that is, equipment should not contribute to combustion loading (see 4.2.4). When ignited, equipment should not show sustained combustion in absence of an outside heat source. Equipment should be self extinguishing. Equipment should not produce carcinogens, toxic or hazardous substances when burning or smoldering (see 4.12.1).
Fire retardance should not be achieved by use of nonpermanent additives.

Cable flammability should be tested in accordance with the vertical tray flame test of IEEE 383. Other parts and materials should be tested in accordance with ASTM D 568, ASTM D 635, or ASTM D 1000.

4.12.3 Radiation hazards. Equipment should be in accordance with ANSI/IEEE C95.1, ANSI C95.2, ANSI Z136.1, 29 CFR 1910, and 21 CFR 1040, as applicable. Exempt military lasers and support equipment should be in accordance with MIL-STD-1425.

4.12.3.1 Ionizing radiation. Equipment should be in accordance with the provisions of 29 CFR 1910, Subpart G, and should be such that personnel will not be exposed to radiation levels in excess of 0.002 rem in one hour, 0.1 rem in seven consecutive days, 0.125 rem in a calendar quarter, or 0.50 rem in a year.

4.12.4 Thermal hazards. Under conditions of maximum intended load and an ambient temperature of 25°C, the operating temperature of control panels and operating controls should not exceed 50°C. Other exposed parts subject to contact by operating personnel should not exceed 65°C.

4.12.5 Electrical hazards. Equipment should be configured so that personnel will not be exposed to voltages in excess of 30 volts rms (Vrms) or 60 volts direct current (VDC). Test points should not exceed 30 Vrms or 60 VDC. High voltage circuits and devices internal to equipment should discharge to 30 volts (V) or less within two seconds after power removal.

4.12.5.1 Electrical installation (land). Equipment should comply with the provisions of NFPA 70.

4.12.5.2 Leakage current. Equipment leakage current should not exceed 5 milliamperes. Leakage current tests should be in accordance with APPENDIX B, IEC 950, or UL 1950.

4.12.5.3 Safety ground. All accessible surfaces of equipment should be at ground potential. Equipment power cable assemblies should be provided with a safety ground conductor. A safety ground conductor should be included with the power cable assembly and connector of equipment drawers, and should be such that disconnecting of the safety ground from the drawer will result in disconnecting of the power assembly. Drawers, panels, and doors should be grounded at all times and in all positions. The DC resistance from the equipment to ground potential should not exceed 100 milliohms. Safety ground conductors should be the same size or larger than the power conductors.

4.12.5.4 Electrical power. Equipment should be provided with means to disconnect all sources of power from the equipment. The disconnect means should be such that accidental contact by personnel will not place the equipment in operation.

4.12.5.5 Overcurrent/fault protection. Equipment should be provided with means for electrical overload/fault protection, such as fuses or circuit breakers.

4.12.5.6 Electrical connectors. Connectors should be configured so that they cannot be plugged into the wrong receptacle. In all cases, port connections should be clearly marked as to their appropriate use. Connectors should be designed so that exposed pin contacts are 30 V or less.

4.12.6 Mechanical hazards. Equipment should be fabricated such that personnel will not be exposed to moving mechanical parts such as gears, fans, and belts.

4.12.6.1 Drawers and rack-mounted components. Equipment should be provided with means to prevent accidental pulling out of drawers and rack-mounted components.

4.12.6.2 Doors and hinged covers. Equipment should be designed so that doors and hinged covers can be latched in an open position.

4.12.6.3 Cathode ray tubes. Provisions should be incorporated to protect personnel from injury due to implosion of cathode ray tubes.

4.12.6.4 Connectors. Connectors should be such that the connectors cannot be plugged into the wrong receptacle.

4.12.6.5 Switches. Switches should be provided for disconnecting mechanical drive units for maintenance purposes.

4.12.7 Handling. Equipment weighing in excess of 68 kilograms should be provided with lifting eyes, with a minimum of 100 millimeters of space around each eye.

4.12.8 Noise hazards. Equipment should comply with 29 CFR 1910, Subpart G.

4.12.9 Marking. Equipment should be marked when safety hazards are present during the installation, operation, maintenance, repair, or replacement of equipment or parts thereof. Guards and barriers should be marked when the guards and barriers protect personnel from safety hazards. Hazardous material and hazardous material containers should be marked in accordance with 29 CFR 1910, Subpart Z. Parts containing hazardous material should be marked with the appropriate hazard warning. For equipment weighing in excess of 15 kilograms (30 pounds), the equipment weight should be marked on the external surface of the equipment. Safety markings should be in accordance with ANSI/NEMA Z535.1, ANSI/NEMA Z535.2, ANSI/NEMA Z535.3, ANSI/NEMA Z535.4, and ANSI N2.1, as applicable. Additional safety marking requirements are specified in Federal regulations. Safety markings should be such that the safety markings will be legible for twice the normal life expectancy of the equipment to which the safety markings are affixed.

4.13. Reliability. To provide for the availability of equipment, equipment MTBF should be specified for equipment. Reliability requirements should be tailored to the acquisition. Analysis, field experience, or test should be required as evidence of achievement of reliability.

4.14. Maintainability. To provide rapid repairs, an equipment MTTR should be specified. Maintainability requirements should be tailored for the acquisition based on the operational requirements, such as requirements for prelaunch and postlaunch activities for space equipment.

4.15. Environmental stress screening. Environmental stress screening should be developed and performed for equipment in accordance with Tri-Service Technical Brief 002-93-08 or IES Publication, Environmental Stress Screening Guidelines for Assemblies. Environmental stress screening requirements should be tailored to the needs of the acquisition.

5. DETAILED GUIDELINES

5.1 Ship equipment. Naval ships and the shipboard environment pose unique requirements on the design of electronic equipment. Equipment should meet the minimal acceptance limits for all ship environmental conditions to which the equipment will be subjected; mission critical equipment should be fully hardened so that the equipment will operate under the full range of applicable environmental conditions. Environmental tests may be combined when cost effective and approved by the contracting activity. The program manager should tailor requirements to the application of the equipment in a cost effective manner (see 4.1.3); for example, the greenwater loading requirement should not be specified for equipment installed in a controlled environment. The contracting activity should coordinate requirements with ship acqusition managers to ensure that specification requirements satisfy the ship's complete operational envelope.

5.1.1 Auxiliary support services. Equipment should be compatible with the auxiliary support services as specified in 5.1.1.1 through 5.1.1.6.1.

5.1.1.1 AC power. Equipment should be suitable for operation in accordance with 440 Vrms, Type I power as specified in MIL-STD-1399, Section 300 (see 4.2.3). Equipment should be tested in accordance with MIL-STD-1399, Section 300.

5.1.1.1.1 Fully hardened. Equipment should be suitable for operation under Type I power in accordance with MIL-STD-1399, Section 300. The preferred equipment service is 440 Vrms, 60 Hz, 3-phase. Equipment should 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 should remain operational for momentary power interruptions of 150 milliseconds, and should restart within 1 second following a power interruption of 5 minutes or less.

5.1.1.1.2 Minimal acceptance. Equipment should be suitable for operation under Type I power in accordance with MIL-STD-1399, Section 300. The preferred equipment service is 440 Vrms, 60 Hz, 3-phase. Equipment should 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 should 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 electrical power system is significantly different from commercial standards. For example, fault current of public utilities will typically be limited to 65,000 amperes rms at 13,000 Vrms, while surface ship fault current is limited to 100,000 amperes rms at 450 Vrms (with two of three generators paralleled). COTS equipment can be ruggedized to be powered from the ship electrical service. The primary considerations for ruggedization are specified as follows:

a. MIL-STD-1399, Section 300, specifies a harmonic current limit of 3 percent of the fundamental for equipment rated 1 kilovoltampere or more. The ship electrical system has a lower reactance/resistance ratio than the commercial applications, and harmonic currents have a higher impact on voltage distortion. To conform to the harmonic current limits of MIL-STD-1399, Section 300, a low-harmonic distortion transformer/rectifier circuit or unity power-factor power supply may be applied. The output of these devices are DC, rather than AC. For circuits requiring AC input, a power conditioner or UPS that has unity power-factor characteristics may be applied.

b. The voltage variations specified in MIL-STD-1399, Section 300, are more severe than those of the commercial environment. The line voltage may be 155 Vrms (220 V peak) for 2 minutes for 115 Vrms equipment, which may be sufficient to damage COTS equipment. Voltage spikes are 1000 V for 115 Vrms equipment, when COTS equipment is typically rated for 600 V. Voltage arrestors should be applied to protect against voltage spikes; voltage arrestors that conduct at less than 220 V 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 overvoltage protection applied to remove the equipment from the line under such conditions.

c. The line and return leads on the 115 Vrms, 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. An alternative for 115 Vrms equipment 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.

d. All equipment permanently installed in office or engineering spaces and energized more than 50 percent of the working day, such as copiers, personal computers and peripherals, soda machines, and automatic teller machines, should not to be connected to the ship isolated receptacle circuits. Equipment of this type should be connected to a separate dedicated, hard-wired circuit supplied by the lighting distribution system. Convenience outlet services rated 15 amperes are fire hazards when overloaded, such as when several workstations are colocated.

e. 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. Other approaches to achieving rapid restart vary, depending upon the type of equipment being used and sequential operations required for startup.

f. 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.

5.1.1.2 Submarine DC power. Equipment should 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 should remain fully operational for the conditions specified for user voltage tolerance and transient voltage in accordance with MIL-STD-1399, Section 390.

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

5.1.1.3 Seawater. This requirement should apply to open ship cooling systems which use seawater. Equipment should be suitable for the conditions specified in MIL-STD-1399, Section 105.

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

5.1.1.4 Cooling water. Closed ship cooling systems which use fresh water should be suitable for the conditions specified in DOD-STD-1399, Section 532.

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

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

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

5.1.1.6 Dry air. This guidance is applicable to equipment requiring high quality (nonconductive) 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 should be suitable for the conditions specified in MIL-STD-1399, Section 102.

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

5.1.2 Environmental conditions. Environmental conditions should be as specified in 5.1.2.1 through 5.1.2.18.2. Separate requirements should be provided for shipment, installation, and operation. All equipment should be suitable for the environmental conditions when the equipment will be installed and used. Specification requirements for environmental conditions under which the equipment is to be fully operational should be tailored to the application and use of the equipment (see 4.1.3), and from the environmental conditions specified in 5.1.2.1 through 5.1.2.18.2. IEC 721-3-6 provides guidelines for specification of environmental conditions for ship applications, but does not address weapons effects, such as high impact shock (see 5.1.2.13). The equipment should not require alignment or adjustment when fully operational. Some IEC and ASTM tests are similar to the MIL-STD-810 tests, and the IEC standards noted herein are accepted alternatives to the MIL-STD-810 methods. Other industry consensus standards may be approved for specific acquisitions. IEC 68-4 provides summary information for the IEC 68-2-xx series of environmental test standards. COTS and ruggedized equipment which have been design-qualified to 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 DC magnetic field environment. Requirements for DC magnetic fields should be as specified in 5.1.2.1.1 and 5.1.2.1.2.

5.1.2.1.1 Fully hardened. Equipment should be suitable for operation in a DC magnetic field of 20 Oersteds.

5.1.2.1.2 Minimal acceptance. Requirements for equipment used on ships which contain degaussing or mine neutralization equipment should be tailored based on measured ship data. The primary concern of DC magnetic fields is the distortion caused on displays using cathode ray tube technology. Ship measurements have shown that magnetic fields may vary from 2.0 Oersteds (160 amperes per meter) to 20 Oersteds (1600 amperes per meter). As a tailored requirement, it is recommended that equipment be required to operate satisfactorily in an environment of 10 Oersteds (800 amperes per meter), and that shielding be employed if necessary.

5.1.2.2 Electromagnetic susceptibility. Electromagnetic susceptibility requirements should 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 should be tailored in accordance with MIL-STD-462.

5.1.2.3 Dust and sand. Requirements for dust and sand should be as specified in 5.1.2.3.1 and 5.1.2.3.2.

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

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

5.1.2.4 Greenwater loading. Requirements for greenwater loading should be as specified in 5.1.2.4.1 and 5.1.2.4.2.

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

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

5.1.2.5 Gun muzzle. Requirements for gun muzzle effects should be as specified in 5.1.2.5.1 and 5.1.2.5.2.

5.1.2.5.1 Fully hardened. Equipment should be in accordance with the interface requirements in accordance with MIL-STD-1399, Section 072.2.

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

5.1.2.6 Humidity. Requirements for humidity should be as specified in 5.1.2.6.1 and 5.1.2.6.2. Equipment should be suitable for exposure in an uncontrolled environment for 8 hours (see 5.1.2.15).

5.1.2.6.1 Fully hardened. Equipment should maintain specified performance when subjected to 100 percent relative humidity. Humidity tests should be tailored in accordance with IEC 68-2-30 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 68-2-30 should be changed to "25°C to 55°C". Equipment not subjected to testing in accordance with IEC 68-2-30 or MIL-STD-810 should withstand 95 percent relative humidity, and humidity tests should be tailored in accordance with IEC 68-2-3, except the test period should be 21 days.

5.1.2.6.2 Minimal acceptance. Equipment should 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.

5.1.2.7 Hydrostatic pressure. Requirements for hydrostatic pressure should be as specified in 5.1.2.7.1 and 5.1.2.7.2.

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

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

5.1.2.8 Icing. Requirements for icing should be as specified in 5.1.2.8.1 and 5.1.2.8.2.

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

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

5.1.2.9 Missile exhaust. Requirements for missile exhaust effects should be as specified in 5.1.2.9.1 and 5.1.2.9.2.

5.1.2.9.1 Fully hardened. The equipment should be in accordance with the interface requirements of MIL-STD-1399, Section 072.1.

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

5.1.2.10 Nuclear hardening. Requirements for nuclear hardening should be as specified in 5.1.2.10.1 and 5.1.2.10.2.

5.1.2.10.1 Fully hardened. Levels of nuclear survivability should be tailored from NAVSEA INST C3401.1. Requirements for air blast, thermal radiation, and free field EMP should be tailored from NSWC TR 87-192 for exposed equipment and exposed cable; modified to limit conducted current levels to 10 amperes on cables that penetrate the ship hull. Requirements for air blast induced shock, TREE, and conducted EMP should be tailored from NSWC TR 87-192 for all equipment. EMP tests should be tailored in accordance with MIL-STD-461 (see 5.1.2.2).

5.1.2.10.2 Minimal acceptance. The specifier should determine the requirement for nuclear hardening, and the degree required for nuclear hardening. Installation in a sheltered, controlled environment does not protect the equipment from all effects of a nuclear event.

5.1.2.10.3 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 as follows:

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 , equipment may be shock mounted.

c. EMP: Appropriate electromagnetic shielding and grounding should 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 should 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 hull is relatively transparent to the TREE conditions. Radiation detection, power interruption and dump may be applied. With this approach, a radiation detection integrated circuit (IC) provides a signal for power supplies to momentarily turn off, and high voltage circuits and capacitors to be crowbarred (discharged to ground). (A radiation detection IC is under development and will be available as a SEM module.) Using this approach, momentary part latch-ups will not result in a sustained fault of parts 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 should be selected which are insensitive to TREE.

5.1.2.11 Salt fog. Requirements for salt fog should be as specified in 5.1.2.10.1 and 5.1.2.10.2.

5.1.2.11.1 Fully hardened. Equipment should withstand salt fog. Salt fog tests should be tailored in accordance with MIL-STD-810, Method 509. As an alternative, salt fog tests should be tailored in accordance with IEC 68-2-11, except that the exposure should be specified as 48 hours.

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

5.1.2.12 Ship motion and attitude. Requirements for ship motion and attitude should be as specified in 5.1.2.12.1 through 5.1.2.12.2.

5.1.2.12.1 Fully hardened. Equipment should be fully operational for the ship motion and attitude conditions in accordance with DOD-STD-1399, Section 301. Equipment should be tested in accordance with 5.1.2.12.1.1.

5.1.2.12.1.1 Ship motion and attitude testing. Equipment should be energized and fully operating during the test. The equipment should be inclined at the rate of 5 cycles per minute to 7 cycles per minute in one phase, to angles of 45 degrees on both sides of the vertical for surface ships, and to 60 degrees on both of the vertical for submarines, for a period of not less than 30 minutes. For equipment whose operation is not degraded when drawer slides are extended, tests should be performed with the drawer slides extended. The test should be repeated with the equipment reoriented 90 degrees to the plane in which the equipment was originally tested. The equipment should then be operated with the inclination adjusted to an angle of 15 degrees for a sufficient period to ensure that the continuous operation can be maintained. The equipment should then be rotated through the vertical to 15 degrees in the opposite direction and the test for continuous operation repeated.

5.1.2.12.2 Minimal acceptance. Ship 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 prespecified limit.

5.1.2.13 Shock. Equipment used aboard ship is subjected to shock as a result of weapons effects (see 5.1.2.10.3). Mission critical equipment should operate before, during, and after shock conditions as result from high impact shock testing.

5.1.2.13.1 Tailoring guidance. A shock spectrum and transient duration should be defined which represent the extreme design conditions to be encountered.

5.1.2.13.2 Shock grades. To determine the testing requirements for combat shock, equipment should be classified into grades, and pass/fail criteria specified for each of the shock tests. Equipment grades classification and pass/fail criteria should be in accordance with the following:

a. Grade A items are items which are mission critical. Grade A items should be fully operational before, during, and after the shock event. Momentary malfunctions of Grade A items should be considered acceptable only if the momentary malfunction is automatically self correcting, and if the momentary malfunction has no detrimental effect on the capability of the Grade A item.

b. Grade B items are items which are not Grade A, but which could become a hazard to personnel, to Grade A items, or to the ship as a whole as a result of exposure to shock. Grade B items, and parts thereof, should not come adrift or become a safety hazard before, during, or after the shock event.

c. Grade C items are items which are not Grade A items or Grade B items, such as items normally stowed for combat in a non-tactical compartment or space. Grade C items should not require shock testing.

5.1.2.13.3 Fully hardened. Equipment should be classified as Grade A and should be tested in accordance with MIL-S-901. As an alternate, equipment weighing less than 113 kilograms should be tested in accordance with ANSI S2.15. ANSI S2.15 should be tailored to require hammer drop heights of 0.30 meters, 0.91 meters, and 1.52 meters in each of three mutually perpendicular axes of the item being tested.

5.1.2.13.4 Minimal acceptance. Grade C items should not require shock testing. Test equipment does not require shock testing, however, test equipment should require Grade A stowage. All other equipment should be classified as Grade B and should be tested in accordance with MIL-S-901. As an alternate, equipment weighing less than 113 kilograms should be tested in accordance with ANSI S2.15. ANSI S2.15 should be tailored to require hammer drop heights of 0.30 meters, 0.91 meters, and 1.52 meters in each of three mutually perpendicular axes of the item being tested.

5.1.2.13.5 Ruggedization techniques. To conform to the high impact shock conditions, the following should be considered:

a. Enclosures and drawer mounts should be strengthened.

b. Expansion cards in electronic equipment racks should be secured in place.

c. Parts that are vertically mounted on a printed circuit board may not tolerate shock and vibration.

d. Parts 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.

5.1.2.13.5.1 Shock mounts. During equipment design, shock is treated as a spectral function. Shock mounts may be employed to attenuate shock at equipment and part resonant frequencies. Equipment motion and sway should be considered. A shock mount applied to attenuate shock may be resonant at vibration frequencies. Vibration (see 5.1.2.17) is a steady-state condition as opposed to ship shock which is a transient condition. The selection of shock mounts should include consideration of high impact shock testing, ship shock trials, and vibration testing in accordance with 5.1.2.17.

5.1.2.13.5.2 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 should ensure that the total system, as installed, conforms to the high impact shock requirements.

5.1.2.14 Solar radiation. Requirements for solar radiation should be as specified in 5.1.2.14.1 and 5.1.2.14.2.

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

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

5.1.2.15 Temperature. Requirements for temperature should be as specified in 5.1.2.15.1 and 5.1.2.15.2. Temperature tests should be tailored in accordance with MIL-STD-810, Method 501, and MIL-STD-810, Method 502. Safety criteria should be as specified in 4.12.4. The specified criteria for equipment installed in controlled spaces should include consideration of failure of the environmental control system for 8 hours, that is, equipment should be suitable for exposure in an uncontrolled environment for 8 hours (see 5.1.2.6).

5.1.2.15.1 Fully hardened. Equipment temperature requirements should be tailored from Table VII.

TABLE VII. Temperature limits.

Environment	Fully hardened	Minimal acceptance
Uncontrolled	-25°C to +65°C	-25°C to +50°C
Controlled	0°C to +50°C	10°C to +50°C

5.1.2.15.2 Minimal acceptance. Equipment temperature requirements should be tailored from Table VII. Equipment should not be damaged when ambient conditions are outside nominal operating limits.

5.1.2.16 Underwater explosion. Requirements for underwater explosion should be as specified in 5.1.2.16.1 and 5.1.2.16.2.

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

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

5.1.2.17 Vibration. Equipment should be tested in accordance with the provisions of IEC 68-2-6 or the Type I requirements of MIL-STD-167-1. Equipment should be operating when tested. Tests conducted in accordance with IEC 68-2-6 should be tailored as specified in 5.1.2.17.1. Vibration tests should be tailored to the application platform.

5.1.2.17.1 Vibration testing. A vibration response investigation should be performed. Equipment should be subjected to endurance testing at fixed frequencies based upon the critical frequencies determined from the vibration response investigation. When the vibration response investigation does not identify critical frequencies, tests should be conducted at the maximum vibration frequency. The test duration at each frequency should be 2 hours. The vibration frequency range and amplitude should be as specified in Table VIII.

TABLE VIII. Vibration frequency range and amplitude.

Frequency range	Vibration amplitude	
	Mast-mounted equipment	All other equipment
4 Hz to 10 Hz	2.54 mm	0.76 mm
11 Hz to 15 Hz	0.76 mm	0.76 mm
16 Hz to 25 Hz	0.51 mm	0.51 mm
26 Hz to 33 Hz	0.25 mm	0.25 mm
34 Hz to 40 Hz	Not applicable	0.13 mm
41 Hz to 50 Hz	Not applicable	0.076 mm

5.1.2.18 Wind effects. Requirements for wind effects should be as specified in 5.1.2.18.1 and 5.1.2.18.2.

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

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

5.1.3 Operational constraints. Equipment should be in accordance with the operational constraints as specified in 5.1.3.1 through 5.1.3.8. Requirements specified are applicable to fully hardened and minimal acceptance.

5.1.3.1 Airborne noise. Submarine noise requirements should be tailored to the submarine specification generated by the ship acquisition manager. Equipment generated sound pressure levels should not exceed 54 db A-weighted scale and the limits specified in Table IX. Equipment sound pressure levels should be measured in accordance with 29 CFR 1910, Subpart G.

TABLE IX. Equipment sound levels.

Octave band center frequency (Hz)	Sound pressure level (dB: Re 20 micropascals)
31.5	66
63	63
125	60
250	57
500	54
1000	51
2000	48
4000	45
8000	42

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

5.1.3.3 AC power. The equipment should 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 should be suitable for operation in each operating mode with one power input line grounded.

5.1.3.4 Submarine DC power. The equipment should 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 should be tailored in accordance with MIL-STD-461 (see 5.1.2.2). Electromagnetic emissions tests should be tailored in accordance with MIL-STD-462. Radar equipment should 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, and modified to conform to the requirements of the shipboard installation, through application of EMI filters and shielding.

5.1.3.5.1 EMCON. Acoustic, electromagnetic, and optical emitters, such as radars and communication systems, should have provisions for EMCON. When EMCON is in effect, equipment should 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 should be in accordance with DOD-STD-2143.

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

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

5.1.3.9 Mounting hardware. Equipment should be suitable for installation using the fastener hardware (studs, bolts, screws, nuts and washers) specified in MIL-S-1222.

5.2 Space equipment. The constraints inherent in space vehicles and space environment pose unique requirements on the design of electronic equipment. All equipment should 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 should be fully hardened in such a manner that the equipment will operate under the full range of applicable environment conditions. Guidance for equipment to be designed as fully hardened is provided in 4.1.3.2. The program manager should tailor requirements to the application of the equipment (see 4.1.3) in a cost effective manner.

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

5.2.1.1 Warmup time. Equipment warmup times should be minimized.

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

5.2.1.3 Electrical overload protection (manned space vehicles). Overload protection should 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 should be of the manual reset or remote reset type.

5.2.2 Environmental requirements. Equipment should be suitable for environmental conditions that exceed the maximum levels predicted during service life, including mildly corrosive conditions to which equipment may be exposed while unprotected during manufacture or handling. Environmental conditions should be predicted in accordance with MIL-STD-1540. Equipment should be tested in accordance with MIL-STD-1540. These requirements should be tailored to reflect the installation and use of the equipment (see 4.1.3).

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

5.2.2.1.1 Temperature. Temperatures under launch conditions should be predicted and tested in accordance with MIL-STD-1540. Predicted temperatures should include a thermal uncertainty margin in accordance with MIL-STD-1540.

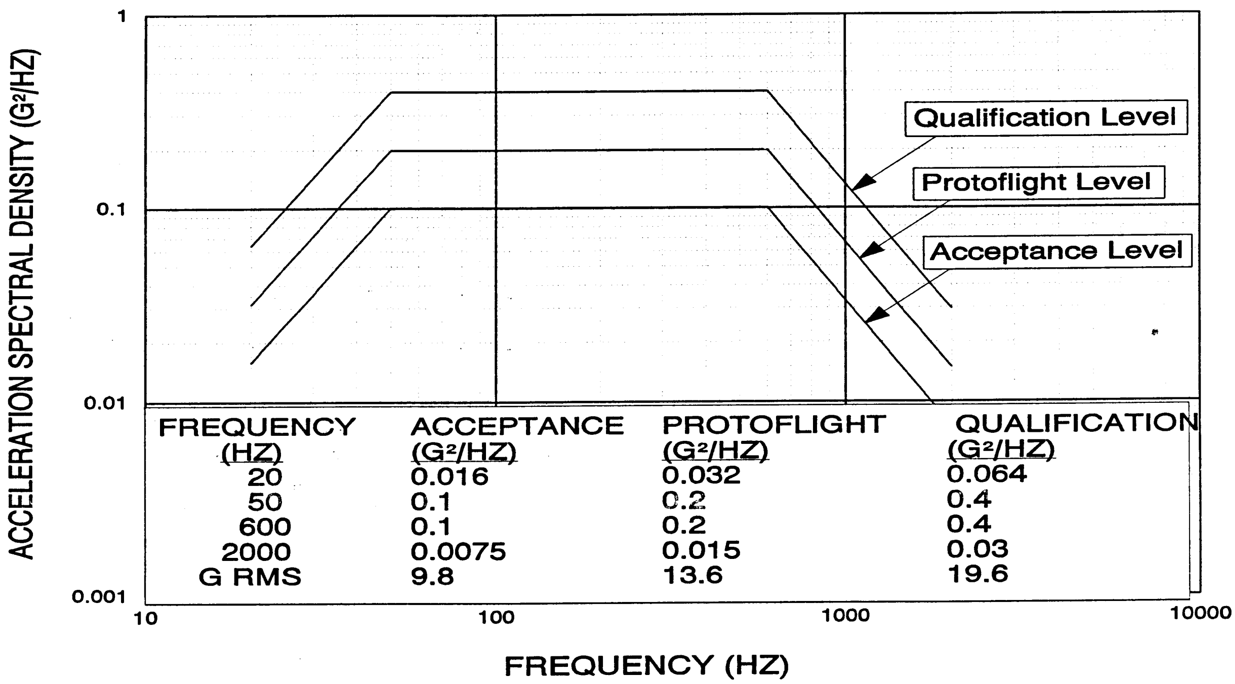
5.2.2.1.1.1 Fully hardened. Equipment should be suitable for operation between 10°C above the maximum predicted temperature and 10°C below the minimum predicted temperature. As a minimum temperature range, equipment should be suitable for operation between -35°C to 70°C.

5.2.2.1.1.2 Minimal acceptance. Equipment should be suitable for operation between maximum and minimum predicted temperatures. As a minimum temperature range, equipment should be suitable for operation between -25°C to 60°C.

5.2.2.1.2 Vibration. Vibration under launch conditions should be predicted and tested in accordance with MIL-STD-1540. Vibration should 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 3 minutes, along each of the three orthogonal axes.

5.2.2.1.2.1 Fully hardened. Equipment should be suitable for an environmental condition that is 6 dB above the maximum predicted vibration level, and should be not less than 12 g rms.

5.2.2.1.2.2 Minimal acceptance. Equipment should be suitable for an environmental condition at the maximum predicted vibration level, and should be not less than 9 g rms. Typical random vibration levels experienced during launch are shown on Figure 2. Figure 2 is provided for information only, and should be tailored to specific launch vehicles.



FREQUENCY (HZ)	ACCEPTANCE (G^2/HZ)	PROTOFLIGHT (G^2/HZ)	QUALIFICATION (G^2/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 2. Typical random vibration during launch.

5.2.2.1.3 Acoustic noise. Acoustic noise under launch conditions should be predicted and tested in accordance with MIL-STD-1540.

5.2.2.1.3.1 Fully hardened. Equipment should be suitable for an environmental condition that is 6 dB above the maximum predicted acoustic level, and should be not less than 144 dB.

5.2.2.1.3.2 Minimal acceptance. Equipment should be suitable for an environmental condition that is at the maximum predicted acoustic level, to be no less than 141 dB. Typical acoustic noise levels experienced during launch are shown on Figure 3 and Table X. Figure 3 and Table X are provided for information only, and should be tailored to specific launch vehicles.

5.2.2.1.4 Sinusoidal vibration. Sinusoidal vibration under launch conditions should be predicted and tested in accordance with MIL-STD-1540.

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

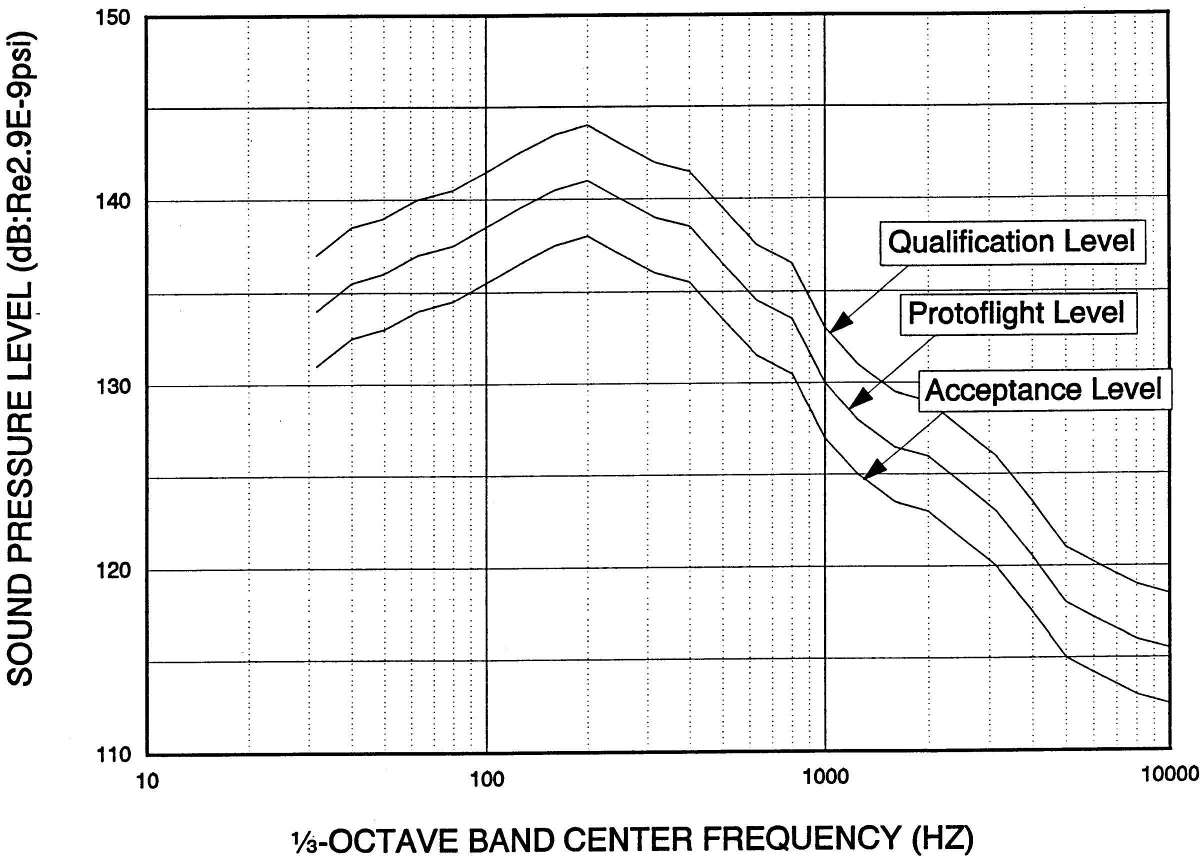


FIGURE 3. Acoustic loading environment for typical launch vehicle.

TABLE X. Acoustic loading environment for typical launch vehicle.

1/3-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

5.2.2.1.4.2 Minimal acceptance. Equipment should be suitable for an environmental condition that is at maximum predicted sinusoidal vibration level. Typical sinusoidal vibration levels experienced during launch are provided in Table XI. Table XI is provided for information only, and should be tailored to specific launch vehicles.

5.2.2.1.5 Shock. Shock levels under launch conditions should be predicted and tested in accordance with MIL-STD-1540.

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

TABLE XI. Typical sinusoidal vibration during launch.

Frequency (Hz)	Level
5 - 17	1.3 centimeters, double amplitude
17 - 22	7.0 g peak
22 - 400	5.0 g peak
400 - 2000	7.5 g peak

5.2.2.1.5.2 Minimal acceptance. Equipment should be suitable for an environmental condition that is at the maximum predicted shock level. Typical levels of mechanical shock experienced during launch are 30 g, half-sine, 8 milliseconds in each of the principal equipment axes. Typical levels of pyroshock experienced during launch are shown on Figure 4. These levels of pyroshock are provided for information only, and should 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. The shock response spectrum is determined at frequency intervals of one-sixth octave or less over a frequency range of 100 Hz to 10 kHz. When sufficient data are available, the maximum predicted environment may be derived using parametric statistical methods. The data should be tested to show a satisfactory fit to the assumed underlying distribution. The maximum predicted environment should be the environment that is 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 should be applied to account for the variability of the environment.

5.2.2.1.6 Acceleration. The cross-axis acceleration should include the acceleration due to rotation. Acceleration levels under launch conditions should be predicted and tested in accordance with MIL-STD-1540.

5.2.2.1.6.1 Fully hardened. Equipment should 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.

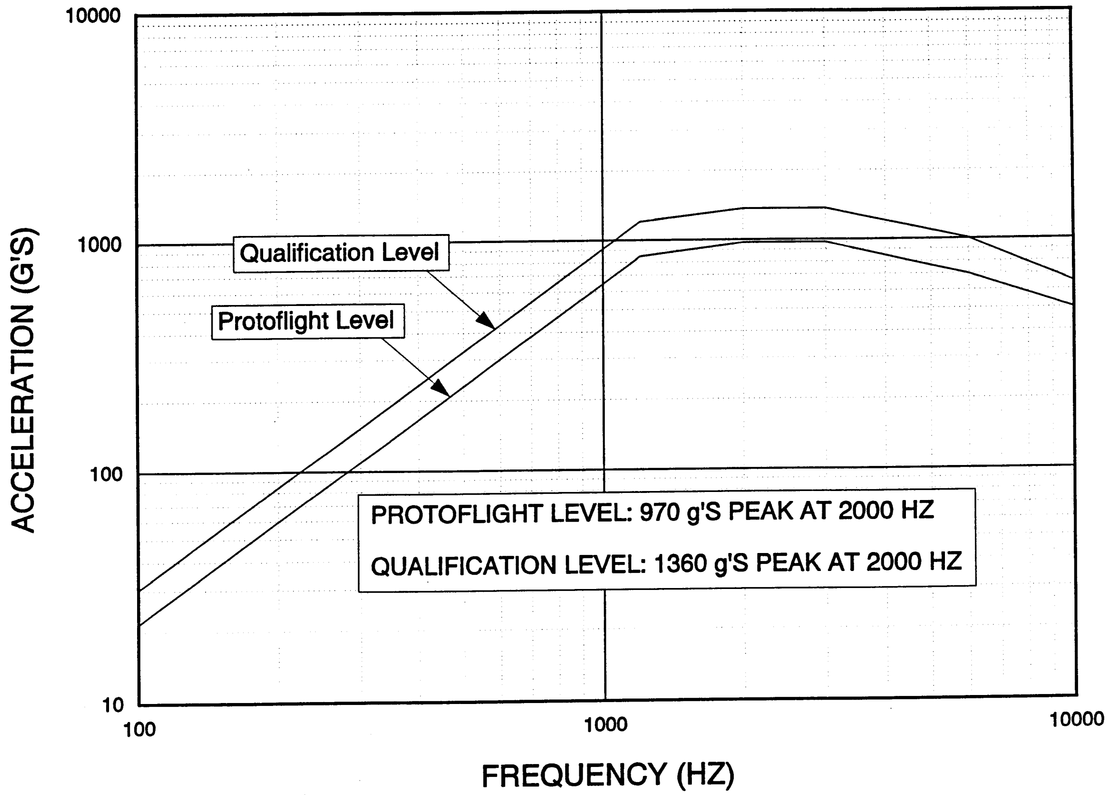


FIGURE 4. Pyroshock environment for typical launch vehicle.

5.2.2.1.6.2 Minimal acceptance. Equipment should be suitable for an environmental condition that is at the maximum predicted acceleration level. 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 should be tailored to specific launch vehicles.

5.2.2.1.7 Atmospheric pressure. Equipment should be suitable for a change in ambient pressure from sea level to 0.13 millipascals in 3 minutes. Equipment should be suitable for a sustained exposure to an ambient pressure between sea level and 0.13 millipascals.

5.2.2.1.8 Humidity and salt fog. Humidity and salt fog requirements should be as specified in 5.2.2.1.8.1 and 5.2.2.1.8.2.

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

5.2.2.1.8.2 Minimal acceptance. Equipment should 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 Applications Volume.

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

5.2.2.2.1 Atmospheric pressure. Equipment should be suitable for sustained exposure to a minimum ambient pressure of 0.13 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 should be based upon a thermal analysis of the particular space vehicle under planned operating conditions. This analysis should 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 should 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 not less than -35°C to 70°C. Equipment should 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 should be suitable for an environmental condition that is between the minimum and maximum predicted temperatures. When practical, components should be suitable for operation over a temperature range of -25°C to 60°C. Equipment should 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 should 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 should be suitable for environmental conditions that are at the maximum predicted radiation level, for the service life of the equipment.

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

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

5.2.2.5 EMC. Equipment and subsystems installed aboard spacecraft and launch vehicles, including associated ground support equipment, should be in accordance with MIL-STD-461 when tested in accordance with MIL-STD-462. Conformance to system level requirements should be verified in accordance with MIL-STD-1541.

5.2.2.6 Grounding, bonding, and shielding. Grounding, bonding, and shielding should be in accordance with MIL-STD-464 (see 4.12.5.3).

5.2.2.7 Corona and RF electrical breakdown prevention. High voltage circuits should 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, should be avoided to minimize high voltage field stress. When the frequency-distance product is greater than 0.7 megahertz-m, multipacting should be a design consideration, and a through c should be considered:

a. The use of encapsulation should be considered to raise the voltage required to start electrons resonating.

b. The area should be vented to allow gas generated by multipacting to escape and thereby reduce corona.

c. The use of an electrical or magnetic bias should be considered to sweep away ions.

5.2.2.8 Explosion-proofing. As applicable, equipment should be made explosion-proof. To prevent generating a possible ignition source, the temperature of any part exposed to the atmosphere should be not greater than 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, should be considered explosion-proof.

5.3 Mobile equipment. The constraints inherent in mobile applications pose unique requirements on the design of electronic equipment. All equipment should be in accordance with the minimal acceptance limits for all conditions to which the equipment will be subjected; mission critical equipment should be fully hardened such that the equipment will operate under the full range of applicable environment conditions. The program manager should tailor requirements to the application of the equipment (see 4.1.3) in a cost effective manner. Further tailoring guidance is provided in MIL-STD-210 and IEC 721-3-5.

5.3.1 Automotive baseline specifications. SAE J 1211 provides recommended environmental practices for front engine, rear wheel drive coupe, sedans, and hard top vehicles with reciprocating gasoline engines. SAE J 1455 provides recommended environmental practices for diesel powered trucks in Classes 6, 7, and 8. The requirements specified in 5.3.1.1 through 5.3.1.11.1 are based on SAE J 1211, SAE J 1455 and MIL-STD-810, and should be tailored to the specific vehicle and application.

5.3.1.1 Temperature. Equipment should be suitable for the temperature conditions specified in SAE J 1211 in its intended location. Temperature tests should be tailored in accordance with SAE J 1211, SAE J 1455, or MIL-STD-810, Method 501, Method 502, and Method 503.

5.3.1.1.1 Fully hardened. Equipment should remain fully operational for the full range of temperature conditions specified in SAE J 1211 or SAE J 1455, except that the lower temperature extreme should be tailored to be -50°C.

5.3.1.1.2 Minimal acceptance. Equipment should remain fully operational for temperature conditions of -25°C to +60°C. When operating outside these limits, equipment may shut down or go into a standby mode, but should not be damaged.

5.3.1.2 Humidity. Humidity tests should be tailored in accordance with SAE J 1211, SAE J 1455, IEC 68-2-30, or MIL-STD-810, Method 507, except that the temperature range in IEC 68-2-30 should be tailored to be 25 °C to 55°C.

5.3.1.2.1 Fully hardened. Equipment should remain fully operational for 100 percent relative humidity.

5.3.1.2.2 Minimal acceptance. Equipment should remain fully operational for 95 percent relative humidity. When subjected to 100 percent relative humidity equipment may shut down or go into a standby mode, but should not be damaged.

5.3.1.3 Salt fog. Salt fog tests should be tailored in accordance with MIL-STD-810, Method 509, IEC 68-2-11, or the salt atmosphere test of SAE J 1211 or SAE J 1455, except that the exposure should be tailored to be 48 hours.

5.3.1.3.1 Fully hardened and minimal acceptance. Equipment should remain fully operational for salt fog conditions.

5.3.1.4 Immersion and splash. Immersion and splash requirements should be as specified in 5.3.1.4.1 and 5.3.1.4.2.

5.3.1.4.1 Fully hardened. Immersion and splash tests should be tailored in accordance with SAE J 1211 or SAE J 1455.

5.3.1.4.2 Minimal acceptance. Generally, equipment installed in the interior of the vehicle are not subjected to excessive immersion and splash conditions.

5.3.1.5 Dust and sand. Dust and sand tests should be as specified in 5.3.1.5.1.

5.3.1.5.1 Fully hardened and minimal acceptance. Equipment should withstand the dust and sand tests in accordance with SAE J 1211, SAE J 1455 or MIL-STD-810, Method 510.

5.3.1.6 Altitude (operating). Altitude tests should be selected from SAE J 1211, SAE J 1455, MIL-STD-810, Method 500, or IEC 68-2-13.

5.3.1.6.1 Fully hardened. Equipment should remain fully operational to a maximum altitude of 4.6 kilometers.

5.3.1.6.2 Minimal acceptance. Equipment should remain fully operational to a maximum altitude of 3.7 kilometers.

5.3.1.7 Vibration. Vibration tests should be as specified in 5.3.1.7.1 and 5.3.1.7.2.

5.3.1.7.1 Fully hardened. Equipment should remain fully operational following vibration tests selected from SAE J 1211, SAE J 1455, or MIL-STD-810, Method 514, Category 8.

5.3.1.7.2 Minimal acceptance. Equipment should remain fully operational following vibration tests selected from with SAE J 1211, SAE J 1455, or MIL-STD-810, Method 514, Category 8. When operating outside these limits, equipment may shut down or go into a standby mode, but should not be damaged.

5.3.1.8 Shock. Shock tests should be as specified in 5.3.1.8.1.

5.3.1.8.1 Fully hardened and minimal acceptance. Equipment should remain fully operational during and after operational shock conditions. Equipment should not become a safety hazard when subjected to crash shock conditions. It should be noted that SAE J 1211 and SAE J 1455 do not provide test procedures for operational shock conditions. Shock tests should be tailored in accordance with MIL-STD-810, Method 516, Procedure I and Procedure V.

5.3.1.9 DC power. As applicable, equipment should be suitable for the operating conditions specified for 12 VDC or 24 VDC power in accordance with SAE J 1211, SAE J 1455, or MIL-STD-1275. Other system voltages may be specified by the contracting activity. Equipment should be protected for reverse polarity connections, as may be encountered when batteries are being replaced.

5.3.1.9.1 Fully hardened. Equipment should be fully operational for steady state and transient voltage conditions. Equipment should operate through momentary power interruptions of 150 milliseconds.

5.3.1.9.2 Minimal acceptance. Equipment should be fully operational for steady state voltage conditions. When operating outside these limits, equipment may shut down or go into a standby mode, but not be damaged.

5.3.1.10 Electromagnetic susceptibility. Equipment susceptibility requirements should be in accordance with SAE J 1211, SAE J 1455, and MIL-STD-461, as applicable. Tailoring guidance for electromagnetic susceptibility is provided in MIL-STD-461. The equipment should be tested in accordance with MIL-STD-462.

5.3.1.11 Electromagnetic emissions. Equipment radiated and conducted emissions requirements should be in accordance with MIL-STD-461 (see 5.3.1.10). The equipment should be tested in accordance with MIL-STD-462. Radar equipment should conform to the requirements of the NTIA Manual and MIL-STD-469.

5.3.1.11.1 EMCON. Acoustic, electromagnetic, and optical emitters, such as radars and communication systems, should have provisions for EMCON. When EMCON is in effect, equipment should not emit electromagnetic energy of an electrical field strength greater than 9.0 millivolts per meter when measured at a separation distance of 1.0 meter from the equipment.

5.3.2 Additional requirements. Additional requirements should be as specified in 5.3.2.1 through 5.3.2.8.

5.3.2.1 Chemical and biological warfare. Requirements should be tailored to the mission needs.

5.3.2.2 Nuclear hardening. Requirements for nuclear hardening should be as specified in 5.3.2.2.1 and 5.3.2.2.2.

5.3.2.2.1 Fully hardened. Levels of nuclear survivability should be tailored from NAVSEA INST C3401.1. Requirements for air blast, thermal radiation, and free field EMP should be tailored from NSWC TR 87-192 for exposed equipment and exposed cable; modified to limit conducted current levels to 10 amperes on exposed cables. Requirements for air blast induced shock, TREE, and conducted EMP should be tailored from NSWC TR 87-192 for all equipment. EMP tests should be tailored in accordance with MIL-STD-461 (see 5.3.1.10).

5.3.2.2.2 Minimal acceptance. It is the responsibility of the specifier to determine if the equipment requires nuclear hardening, and the degree of nuclear hardening. Installation in a sheltered, controlled environment does not protect the equipment from all effects of a nuclear event.

5.3.2.3 Solar radiation. Solar radiation requirements should be as specified in 5.3.2.3.1 and 5.3.2.4.2.

5.3.2.3.1 Fully hardened. Exposed equipment should not be damaged and should maintain specified performance when exposed to the sun in its installed configuration. Solar radiation tests should be tailored in accordance with MIL-STD-810, Method 505.

5.3.2.3.2 Minimal acceptance. This requirement is not applicable to equipment that is not exposed to the sun in its installed configuration.

5.3.2.4 Wind effects. Wind effects requirements should be as specified in 5.3.2.4.1 and 5.3.2.4.2.

5.3.2.4.1 Fully hardened. Exposed equipment, or portions thereof, should operate within performance limits in winds having a relative velocity of 140 kilometers/hour (75 knots) with gusts up to 250 kilometers/hour (130 knots), and should withstand, without damage, winds having a relative velocity as great as 185 kilometers/hour (100 knots) with gusts up to 325 kilometers/hour (175 knots).

5.3.2.4.2 Minimal acceptance. Generally, equipment installed in the interior of mobile vehicles are not subjected to excessive wind conditions.

5.3.2.5 Icing. Icing requirements should be as specified in 5.3.2.5.1 and 5.3.2.5.2.

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

5.3.2.5.2 Minimal acceptance. Generally, equipment installed in the interior of mobile vehicles are not subjected to excessive icing conditions.

5.3.2.6 Rain. Rain requirements should be as specified in 5.3.2.6.1 and 5.3.2.6.2.

5.3.2.6.1 Fully hardened. Rain tests should be tailored in accordance with MIL-STD-810, Method 506, Procedure I for equipment subjected to blowing rain, Procedure II for equipment subjected to drip conditions, and Procedure III for watertight equipment.

5.3.2.6.2 Minimal acceptance. Generally, equipment installed in the interior of mobile vehicles is not subjected to excessive rain conditions.

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

5.3.2.8 Size and weight. The size and weight of the equipment should be constrained in accordance with the end item specification. Size limits may be achieved by use of separable units. Equipment design should maintain the center of gravity as low as practical.

5.4 Land-based equipment. The constraints inherent in land-based applications pose unique requirements on the design of electronic equipment. Detailed criteria that establish the boundaries of the requirements applicable to land-based platforms are specified in 5.4.1 through 5.4.3. All equipment should be in accordance with the minimal acceptance limits for all conditions to which the equipment will be subjected; mission critical equipment should be fully hardened such that the equipment will operate under the full range of applicable environment conditions. The program manager should tailor requirements to the application of the equipment (see 4.1.3) in a cost effective manner. Further tailoring guidance is provided in MIL-STD-210, IEC 721-3-3, and IEC 721-3-4.

5.4.1 Auxiliary support services. The equipment should be suitable for the auxiliary support services to which the equipment are connected as specified in 5.4.1.1 through 5.4.1.2.

5.4.1.1 AC power. The electrical power to equipment is a systems consideration, and should be coordinated with the facilities specification. Equipment should be suitable for line voltage conditions in accordance with ANSI C84.1. Further tailoring guidance is provided in IEEE 141. Equipment current harmonic content should be in accordance with IEEE 519. Equipment should tolerate voltage transients in accordance with ANSI C62.41/IEEE 587.

5.4.1.1.1 Fully hardened. Equipment should be suitable for line voltage variations of +6 percent, -13 percent. Equipment should operate through transient voltage conditions in accordance with ANSI C62.41/IEEE 587. Equipment should operate through momentary power interruptions of 150 milliseconds.

5.4.1.1.2 Minimal acceptance. Equipment should be suitable for line voltage variations of +5 percent, -10 percent. Equipment may shut down or go into a standby mode when operating outside these limits.

5.4.1.1.3 Nondomestic AC power. Specifications for electrical power in other countries, such as 50 Hz electrical power in European countries, vary and should be tailored accordingly.

5.4.1.2 DC power, cooling water, compressed air, dry air. Normally, these services are not provided to equipment. When provided, these services are typically unique to the facility, and requirements should be tailored.

5.4.2 Environmental conditions. Guidelines for environmental conditions are provided in 5.4.2.1 through 5.4.3. Separate requirements should be provided for shipment, installation, and operation. All equipment should be suitable for the environmental conditions under which the equipment will be installed. Environmental conditions under which the equipment is to be fully operational should be tailored to the application and use of the equipment. The equipment should not require alignment or adjustment when fully operational.

5.4.2.1 Altitude (operating). Altitude tests should be tailored from MIL-STD-810, Method 500, or IEC 68-2-13.

5.4.2.1.1 Fully hardened. Equipment should remain fully operational for an altitude of 4.6 kilometers.

5.4.2.1.2 Minimal acceptance. Equipment should remain fully operational for an altitude of 1 kilometer. Applications at elevations higher than 1 kilometer, such as Denver, Colorado, should be tailored to the projected environment.

5.4.2.2 Electromagnetic susceptibility. Equipment susceptibility requirements should be in accordance with MIL-STD-461. Tailoring guidance for electromagnetic susceptibility is provided in MIL-STD-461. Tests should be in accordance with MIL-STD-462.

5.4.2.3 Electromagnetic emissions. Equipment radiated and conducted emissions requirements should be in accordance with MIL-STD-461 (see 5.4.2.2). Tests should be in accordance with MIL-STD-462. Radar equipment should also conform to the requirements of the NTIA Manual and MIL-STD-469.

5.4.2.3.1 EMCON. Acoustic, electromagnetic, and optical emitters, such as radars and communication systems, should have provisions for EMCON. When EMCON is in effect, equipment should not emit electromagnetic energy of an electrical field strength greater than 9.0 millivolt per meter when measured at a separation distance of 1.0 meter from the equipment.

5.4.2.4 Dust and sand. Dust and sand tests should be tailored from MIL-STD-810, Method 510.

5.4.2.4.1 Fully hardened. Equipment should withstand dust and sand in accordance with MIL-STD-810, Method 510.

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

5.4.2.5 Humidity. Humidity tests should be tailored in accordance with IEC 68-2-30 or MIL-STD-810, Method 507, except that the temperature range should be specified as "25 °C to 55°C." Equipment not subjected to testing in accordance with IEC 68-2-30 or MIL-STD-810 should withstand 95 percent relative humidity, and humidity tests should be tailored in accordance with IEC 68-2-3, except that the equipment should be tested for 21 days.

5.4.2.5.1 Fully hardened. Equipment in a noncontrolled environment should remain fully operational for 5 percent to 95 percent relative humidity. Requirements for equipment operation under 100 percent relative humidity, including condensation due to temperature changes, should be tailored to application of the equipment.

5.4.2.5.2 Minimal acceptance. Equipment should remain fully operational for 20 percent to 70 percent relative humidity. When subjected to humidity conditions outside these limits, equipment may shut down or go into a standby mode, but should not be damaged.

5.4.2.6 Icing. Icing requirements should be as specified in 5.4.2.6.1 and 5.4.2.6.2.

5.4.2.6.1 Fully hardened. Exposed equipment should withstand an icing load of 20 kilograms per square meter. Icing tests should be tailored from MIL-STD-810, Method 521.

5.4.2.6.2 Minimal acceptance. Generally, requirements for icing are not applicable. Requirements for equipment operation under icing loads should be specified only for installations determined by the specifier to be subject to icing.

5.4.2.7 Chemical and biological warfare. Requirements should be tailored to the mission needs.

5.4.2.8 Nuclear hardening. Requirements for nuclear hardening should be as specified in 5.4.2.8.1 and 5.4.2.8.2.

5.4.2.8.1 Fully hardened. Levels of nuclear survivability should be tailored from NAVSEA INST C3401.1. Requirements for air blast, thermal radiation, and free-field EMP should be tailored from NSWC TR 87-192 for exposed equipment and exposed cable, except that the limit of conducted current levels should be 10 amperes on exposed cables. Requirements for air blast induced shock, TREE, and conducted EMP should be tailored from NSWC TR 87-192 for all equipment. EMP tests should be tailored in accordance with MIL-STD-461 (see 5.4.2.2).

5.4.2.8.2 Minimal acceptance. The specifier should determine if the equipment requires nuclear hardening, and, if so, the degree of nuclear hardening. Installation in a sheltered, controlled environment does not protect the equipment from all effects of a nuclear event.

5.4.2.9 Salt fog. Salt fog requirements should be as specified in 5.4.2.9.1 and 5.4.2.9.2.

5.4.2.9.1 Fully hardened. Equipment should withstand salt fog. Salt fog tests should be tailored in accordance with MIL-STD-810, Method 509. As an alternative, salt fog tests should be tailored in accordance with IEC 68-2-11, except that the exposure should be 48 hours.

5.4.2.9.2 Minimal acceptance. Generally, requirements for salt fog effects are not applicable. Requirements for equipment operation under salt fog effects should be specified only for installations determined by the specifier to be subjected to salt fog effects.

5.4.2.10 Solar radiation. Solar radiation requirements should be as specified in 5.4.2.10.1 and 5.4.2.10.2.

5.4.2.10.1 Fully hardened. Exposed equipment should not be damaged and should maintain specified performance when exposed to the sun in its installed configuration. Solar radiation tests should be tailored from MIL-STD-810, Method 505.

5.4.2.10.2 Minimal acceptance. Generally, requirements for solar radiation are not applicable for equipment installed in sheltered locations. Requirements for equipment operation under solar radiation should be specified only for installations determined by the specifier to be subject to solar radiation.

5.4.2.11 Wind effects. Wind effects requirements should be as specified in 5.4.2.11.1 and 5.4.2.11.2.

5.4.2.11.1 Fully hardened. Exposed equipment, or portions thereof, should operate within performance limits in winds having a relative velocity of 140 kilometers/hour (75 knots) with gusts up to 250 kilometers/hour (130 knots), and should withstand, without damage, winds having a relative velocity as great as 185 kilometers/hour (100 knots) with gusts up to 325 kilometers/hour (175 knots).

5.4.2.11.2 Minimal acceptance. Generally, equipment installed in a controlled environment are not subjected to excessive wind conditions.

5.4.2.12 Rain. Rain requirements should be as specified in 5.4.2.12.1 and 5.4.2.12.2.

5.4.2.12.1 Fully hardened. Rain tests should be tailored in accordance with MIL-STD-810, Method 506, Procedure I for equipment subjected to blowing rain, Procedure II for equipment subjected to drip conditions, and Procedure III for watertight equipment.

5.4.2.12.2 Minimal acceptance. Generally, equipment installed in a controlled environment are not subjected to excessive rain conditions.

5.4.2.13 Temperature. Temperature tests should be tailored in accordance with MIL-STD-810, Method 501 and MIL-STD-810, Method 502. Safety criteria should be as specified in 4.12.4. The temperature ranges specified in Table XII include the effects of solar radiation (see 5.4.2.10) external to equipment.

5.4.2.13.1 Fully hardened. Equipment should remain fully operational for the temperature range specified in Table XII for the applicable area.

5.4.2.13.2 Minimal acceptance. Equipment should remain fully operational for a temperature range of 0°C to +40°C. Equipment may shut down or go into a standby mode, but should not be damaged, when subjected to the temperature range specified in Table XII for the applicable area.

5.4.2.14 Shock and vibration. Equipment shock and vibration considerations include seismic and weapon effects. Requirements for weapon effects should be tailored to the application of the equipment. Requirements for seismic conditions should be as specified in 5.4.2.14.1 and 5.4.2.14.2.

5.4.2.14.1 Fully hardened. Equipment should remain fully operational for Zone 4 seismic conditions in accordance with IEEE 693 or IEC 721-2-6.

5.4.2.14.2 Minimal acceptance. Equipment should remain fully operational for Zone 1 seismic conditions in accordance with IEEE 693 or IEC 721-2-6. Tailoring guidance on seismic conditions is provided in IEEE 693, IEEE C57.114, and IEC 721-2-6.

5.4.2.15 Airborne noise. Requirements should be tailored to the facility in which the equipment is being installed. Equipment generated sound pressure levels should not exceed 54 db A-weighted scale and the limits specified in Table XIII. Equipment sound pressure levels should be measured in accordance with 29 CFR 1910, Subpart G. Airborne noise tests for susceptibility to aircraft or rocket-generated noise should be tailored in accordance with MIL-STD-810, Method 515.

TABLE XII. Temperature limits.

	Area	Temperature range
Noncontrolled environment	Areas where a minimum daily temperature of -25°C or less has been encountered for 30 or more days a year, or where the average temperature for the month of January is -5°C or less.	-55°C to +50°C
	Hot areas where a) high moisture and humidity present problems, or b) low moisture and humidity, and blowing dust or sand, present problems.	0°C to +70°C
	All other areas	-40°C to +50°C
Controlled environment	All areas	0°C to 50°C

TABLE XIII. Equipment sound levels.

Octave band center frequency (Hz)	Sound pressure level (dB: Re 20 micropascals)
31.5	66
63	63
125	60
250	57
500	54
1000	51
2000	48
4000	45
8000	42

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

5.4.3 Size and weight. Requirements should be tailored to the facility in which the equipment is being installed. Particular attention should be paid to foundation strength and handling requirements. Size limits may be achieved by use of separable units. Equipment design should maintain the center of gravity as low as practical.

6. NOTES.

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

6.1 Intended use. This document is intended to be used by the specifier to assist in the preparation of end item specifications for COTS, ruggedized, and militarized equipment for ship (including submarines), space, mobile, and land applications.

6.2 Applications. Guidance for the preparation of requirements for airborne applications is promulgated in MIL-HDBK-5400.

6.3 Changes for previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

6.4 Subject term (key word) listing.

Commercial
Commercial off-the-shelf
COTS
Electronic
Militarized
Nondevelopmental Item
NDI
Performance specification
Ruggedized
Tailoring

APPENDIX A

Equipment Design Guidance

A.1 GENERAL.

A.1.1 Scope. This APPENDIX provides design guidance for militarized equipment which is fabricated to a detail specification only. It is inappropriate for acquisition of COTS or ruggedized equipment and equipment acquired using a performance specification. This APPENDIX is being provided solely for specialized acquisitions requiring detailed specifications, maintenance of existing detailed specifications which must be retained for archival purposes. Its use is discouraged for new acquisitions. This APPENDIX is not a mandatory part of the document. The information contained herein is for guidance only. The text has been prepared so that applicable sections may be excerpted and inserted directly into end-item specifications as appropriate.

The use of the word "shall" in the remainder of this appendix is solely to facilitate the excerpting of the guide form provisions of this appendix for insertion into end-item detail specifications.

A.2 APPLICABLE DOCUMENTS.

A.2.1. General. The documents listed below are not necessarily all of the documents referenced herein, but are the ones that are needed in order to fully understand the information provided by this appendix to the handbook.

A.2.2. Government documents.

A.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents 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

A-A-50454	Lamp, Incandescent, G-6, Bayonet, Candelabra, Double Contact.
A-A-50552	Fittings for Cable, Power, Electrical and Conduit, Metal Flexible.
A-A-50588	Lamp, Incandescent, T-3¼, Miniature, Bayonet Single Contact.

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-B-639	Brass, Naval: Flat Products (Plate, Bar, Sheet, and Strip).
QQ-B-654	Brazing Alloys, Silver.
QQ-C-320	Chromium Plating (Electrodeposited).
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-S-365	Silver Plating, Electrodeposited: General Requirements for.
TT-C-490	Cleaning Methods for Ferrous Surfaces and Pretreatments for Organic Coatings.
TT-P-645	Primer, Paint, Zinc-Molybdate, Alkyd Type.
TT-P-664	Primer Coating, Alkyd, Corrosion-Inhibiting, Lead and Chromate Free, VOC-Compliant.
WW-T-700	Tube, Aluminum Alloy, Drawn, Seamless, 5052 General Specification for.
WW-T-700/2	Tube, Aluminum, Alloy, Drawn, Seamless, 3003.
WW-T-700/4	Tube, Aluminum Alloy, Drawn, Seamless.
WW-T-700/6	Tube, Aluminum Alloy, Drawn, Seamless, 6061.

DEPARTMENT OF DEFENSE

MIL-C-17	Cables, Radio Frequency, Flexible and Semirigid, General Specification for.

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MIL-T-27	Transformers and Inductors (Audio, Power, and High-Power Pulse), General Specification for.
MIL-S-61	Shunts, 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-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-L-3661	Lampholders, Indicator Lights, Indicator Light Housings, and Indicator Light Lenses, General Specification for.
MIL-L-6363	Lamps, Incandescent, Aircraft Service, General Specification for.
MIL-G-3787	Glass, Laminated, Flat; (Except Aircraft).
MIL-L-3890	Lines, Radio Frequency Transmission (Coaxial, Air Dielectric), General Specification for.
MIL-S-4040	Solenoid, Electrical, General Specification for.
MIL-C-5015	Connectors, Electrical, Circular Threaded, AN Type, General Specification for.
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-PRF-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-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	Switches, Thermostatic.
MIL-F-14072	Finishes for Ground Based 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-DTL-15090	Enamel, Equipment, Light-Gray (Formula No. 111).
MIL-G-15624	Gasket Material, Rubber, 50 Durometer Hardness (Maximum).
MIL-C-15726	Copper-Nickel Alloy, Sheet, Plate, Strip, Bar, Rod and Wire.
MIL-S-15743	Switches, Rotary, Enclosed.
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, Epoxy.
MIL-F-17111	Fluid, Power Transmission.
MIL-B-17931	Bearings, Ball, Annular, for Quiet Operation.
MIL-N-18307	Nomenclature and Identification for Aeronautical Systems Including Joint Electronics Type Designated Systems and Associated Support Systems.
MIL-S-18396	Switches, Meter and Control, Naval Shipboard.
MIL-H-19457	Hydraulic Fluid, Fire-Resistant, Non-Neurotoxic.
MIL-S-19622	Stuffing Tubes, Nylon; and Packing Assemblies; General Specification for.
MIL-A-21180	Aluminum-Alloy Castings, High Strength.
MIL-C-22520	Crimping Tools, Terminal Hand or Power Actuated, Wire Termination, and Tool Kits, General Specification for.
MIL-DTL-22529	Grommet, Plastic.

MIL-C-22931	Cables, Radio Frequency, Semirigid, Coaxial, Semi-Air-Dielectric, General Specification for.
MIL-B-23071	Blowers, Miniature, for Cooling Electronic Equipment, General Specification for.
MIL-P-23377	Primer Coatings: Epoxy, High-Solids.
MIL-PRF-23586	Sealing Compound (with Accelerator), Silicone Rubber, Electrical.
MIL-C-23806	Cable, Radio Frequency, Coaxial, Semirigid, Foam Dielectric, General Specification for.
MIL-M-24041	Molding and Potting Compound, Chemically Cured, Polyurethane.
MIL-C-24231	Connectors, Plugs, Receptacles, Adapters, Hull Inserts, and Hull Insert Plugs, Pressure-Proof, General Specification for.
MIL-C-24308	Connectors, Electric, Rectangular, Nonenvironmental, Miniature Polarized Shell, Rack and Panel, General Specification for.
MIL-P-24441	Paint, Epoxy-Polyamide, General Specification for.
MIL-P-24441/20	Paint, Epoxy-Polyamide, Green Primer, Formula 150, Type III.
MIL-P-24441/22	Paint, Epoxy-Polyamide, White, Formula 152, Type III.
MIL-P-24441/25	Paint, Epoxy-Polyamide, Dark Gray, RO6, Formula 155, Type III.
MIL-E-24635	Enamel, Silicone Alkyd Copolymer (Metric).
MIL-C-24640	Cable, Electrical, Lightweight for Shipboard Use, General Specification for.
MIL-C-24643	Cable and Cords, 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-C-26482	Connectors, 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-M-28787	Modules, Standard Electronic, General Specification for.
MIL-C-28790	Circulators, Radio Frequency, General Specification for.
MIL-PRF-28800	Test Equipment for Use With Electrical and Electronic Equipment, General Specification for.
MIL-D-28803	Display, Optoelectronic, Readouts, Backlighted, Segmented, General Specification for.
MIL-C-28840	Connectors, Electrical, Circular Threaded, High Density, High Shock Shipboard, Class D, General Specification for.
MIL-C-38999	Connector, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded, and Breech Coupling), Environment Resistant, Removable Crimp and Hermetic Solder Contacts, General Specification for.
MIL-C-39012	Connectors, Coaxial, Radiofrequency; General Specification for.
MIL-M-45202	Magnesium Alloys, Anodic Treatment of.
MIL-G-45204	Gold Plating, Electrodeposited.
MIL-I-46058	Insulating Compound, Electrical (for Coating Printed Circuit Assemblies).
MIL-R-46085	Rhodium Plating, Electrodeposited.
MIL-C-49055	Cables, Electrical, (Flexible, Flat, Unshielded), (Round Conductor), General Specification for.
MIL-PRF-53095	Hose Assemblies, Rubber, Synthetic, Liquid Petrolium Fuels, Dispensing, Low Temperature.
MIL-P-55110	Printed Wiring-Board, Rigid, General Specification for.
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-P-83461	Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Improved Performance at 275°F (135°C).
MIL-T-83721	Transformers, Variable, Power, General Specification for.
MIL-C-83723	Connector, Electrical, (Circular, Environment Resistant), Receptacles and Plugs, General Specification for.
MIL-S-83731	Switches, Toggle, Unsealed and Sealed Toggle, General Specification for.
MIL-C-83733	Connector, Plug and Receptacle, Electrical Miniature, Rectangular Type, Rack to Panel, Environment Resisting, 200°C Total Continuous Operating Temperature, High Reliability, General Specification for.
MIL-D-85285	Coating: Polyurethane, High Solids.
MIL-D-87157	Displays, Diode, Light Emitting, Solid State, General Specification for.
MS33540	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-595	Colors Used in Government Procurement.

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MIL-STD-108	Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment.
MIL-STD-196	Joint Electronics Type Designation System.
MIL-STD-198	Capacitors, Selection and Use Of.
MIL-STD-199	Resisters, Selection and Use Of.
MIL-STD-683	Crystal Units (Quartz), Crystal Holders (Enclosures) and Oscillators, Selection Of.
MIL-STD-701	List of Standard Semiconductor Devices.
MIL-STD-710	Synchros, 60 and 400 HZ, Selection and Application of.
MIL-STD-889	Dissimilar Metals.

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MIL-STD-1132	Switches and Associated Hardware, Selection and Use of.
MIL-STD-1246	Product Cleanliness Levels and Contamination Control Program.
MIL-STD-1279	Meters, Electrical Indicating, Selection and Use of.
MIL-STD-1286	Transformers, Inductors, and Coils, Selection and Use of.
MIL-STD-1310	Standard Practice for Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety.
MIL-STD-1346	Relays, Selection and Application Of.
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, Electronic Systems Parameters.
MIL-STD-1399, Section 702	Interface Standard for Shipboard Systems, Synchro Data Transmission.
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment, and Facilities.
MIL-STD-1515	Fastener Systems for Aerospace Applications.
MIL-STD-1540	Test Requirements for Launch, Upper Stage and Space Vehicles.
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).
MIL-STD-1837	Miscellaneous Electrical and Electronic Components, Selection Guide.
MIL-STD-1839	Calibration and Measurement Requirements, Standard Practice for.
MIL-STD-2003-3	Electric Plant Installation Standard Methods for Surface Ship and Submarines (Penetrations).

MIL-STD-2038	Requirements for Employing Standard Power Supplies.
MIL-STD-2115	Audio Devices and Components, Selection and Use of.

HANDBOOKS

DEPARTMENT OF DEFENSE

MIL-HDBK-5	Metallic Materials and Elements for Aerospace Vehicle Structures.
MIL-HDBK-225	Synchros Description and Operation.
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).
MIL-HDBK-454	General Guidelines for Electronic Equipment.
MIL-HDBK-700	Plastics.
MIL-HDBK-722	Glass.
MIL-HDBK-965	Acquisition Practices for Parts Management.
MIL-HDBK-1250	Corrosion Prevention and Deterioration Control in Electronic Components and Assemblies.
MIL-HDBK-2165	Testability Handbook for Systems and Equipments.

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

A.2.2.2 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.

APPENDIX A

PUBLICATIONS

ASSISTANT SECRETARY OF THE NAVY (ASN)

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)

(Unless otherwise indicated, copies of documents are available to Government agencies from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094. Copies of documents are available to non-Government agencies from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22151.)

JOINT CHIEFS OF STAFF (JCS)

TAAF	The Test, Analyze, and Fix (TAAF) Process; A Technical Brief for TAAF Implementation

(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.)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

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
40M38277	Connectors, Electrical, Circular, Miniature, High Density, Environment Resisting, Specification for
40M38298	Connectors, Electrical, Special Miniature Circular, Environment Resisting, 200°C, Specification for
40M39569	Connectors, Electrical, Miniature Circular, Environment Resisting, Specification for

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NASA Reference Publication 1061	Outgassing Data for Space Vehicles
NASA Technical Paper 2361	Design Guidelines for Assessing and Controlling Charging Effects

(Application for copies should be addressed to the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 1911-5094.)

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

S9086-VD-STM-101/ CH-631 V1	Naval Ships' Technical Manual, Chapter 631, Volume 1, Preservation of Ships in Service - General (Stock No. 0901-LP-631-0030)
S9086-VD-STM-101/CH-631 V2	Naval Ships' Technical Manual, Chapter 631, Volume 2, Preservation of Ships in Service - Surface Preparation and Painting (Stock No. 0901-LP-631-0040)
S9086-VD-STM-101/CH-631 V3	Naval Ships' Technical Manual, Chapter 631, Volume 3, Preservation of Ships in Service - Surface Ship/Submarine Applications (Stock No. 0901-LP-631-0050)
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 Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094. Copies of documents are available to non-Government agencies from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22151.)

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 Enhanced, Trip Free, Series Trip, Three Pole (0.2 to 30 Amperes)

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

A.2.3. Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents 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 INSTITUTE OF AERONAUTICS AND ASTRONAUTICS (AIAA)

AIAA R100	Parts Management.

(Application for copies should be addressed to the American Institute of Aeronautics and Astronautics, 1801 Alexander Bell Drive (Third Floor), Reston, VA 20191.)

APPENDIX A

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware. (AASHTO No. M232)
ASTM A 494	Standard Specification for Castings, Nickel and Nickel Alloy.
ASTM A 967	Standard Specification for Chemical Passevation Treatments for Stainless Steel Parts.
ASTM B 16	Standard Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines.
ASTM B 21	Standard Specification for Naval Brass Rod, Bar and Shapes.
ASTM B 26	Standard Specification for Aluminum-Alloy Sand Castings.
ASTM B 36	Standard Specification for Brass Plate and Sheet, Strip and Rolled Bar.
ASTM B 69	Standard Specification for Rolled Zinc.
ASTM B 80	Standard Specification for Magnesium-Alloy Sand Castings.
ASTM B 85	Standard Specification for Aluminum Alloy Die Castings.
ASTM B 108	Standard Specification for Aluminum-Alloy Permanent Mold Castings
ASTM B 117	Standard Practice for Operating Salt Spray (Fog) Apparatus.
ASTM B 121	Standard Specification for Leaded Brass, Plate, Sheet, Strip and Rolled Bar.
ASTM B 122	Standard Specification for Copper-Nickel-Tin Alloy, Copper-Nickel-Zinc Alloy (Nickel Silver), and Copper-Nickel Alloy Plate, Sheet, Strip, and Rolled Bar.
ASTM B 124	Standard Specification for Copper and Copper-Alloy Forging Rod, Bar, and Shapes.
ASTM B 133	Standard Specification for Copper Rod, Bar and Shapes.
ASTM B 138	Standard Specification for Manganese Bronze Rod, Bar, and Shapes.
ASTM B 139	Standard Specification for Phosphor Bronze Rod, Bar, and Shapes.
ASTM B 151	Standard Specification for Copper-Nickel-Zinc Alloy (Nickel Silver) and Copper-Nickel Rod and Bar.

ASTM B 194	Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar.
ASTM B 196	Standard Specification for Copper-Beryllium Alloy Rod and Bar.
ASTM B 197	Standard Specification for Copper-Beryllium Alloy Wire.
ASTM B 206	Standard Specification for Copper-Nickel-Zinc Alloy (Nickel Silver) Wire and Copper-Nickel Alloy Wire.
ASTM B 221	Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
ASTM B 241	Standard Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube.
ASTM B 272	Standard Specification for Copper Flat Products with Finished (Rolled or Drawn) Edges (Flat Wire and Strip).
ASTM B 308	Standard Specification for Aluminum Alloy 6061-T6 Standard Structural Profiles.
ASTM B 369	Standard Specification for Copper-Nickel Alloy Castings.
ASTM B 545	Standard Specification for Electrodeposited Coatings of Tin.
ASTM B 607	Standard Specification for Autocatalytic Nicel Boron Coatings for Engineering Use.
ASTM B 633	Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
ASTM B 656	Standard Guide for Autocatalytic (Electrodless) Nickel-Phosphorus Deposition on Metals for Engineering Use.
ASTM B 733	Standard Specification for Autocatalytic Nickel-Phosphorus Coatings on Metals.
ASTM D-1000	Standard Test Method for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications.
ASTM D 1868	Standard Test Method for Detection and Measurement of Partial Discharge (Corona) Pulses in Evaluation of Insulation Systems.
ASTM E 595	Standard Test Method for Total Mass Loss and Collected Volatile Condensable Material From Outgassing in a Vacuum Environment.
ASTM E 1417	Standard Practice for Liquid Penetrant Examination.

ASTM F 104	Standard Classification System for Nonmetallic Gasket Materials.
ASTM F 1166	Standard Practice for Human Engineering Design for Marine Systems, Equipment and Facilities

(Application for copies should be addressed to the American Society for Testing and Materials, 100 Bar Harbor Drive, W. Conshohocken, PA 19428-2959.)

THE AMERICAN WELDING SOCIETY (AWS)

AWS-C3.4	Torch Brazing

(Application for copies should be addressed to the American Welding Society, 550 NW LeJeune Road, Miami, FL 33126.)

THE INSTITUTE FOR INTERCONNECTING AND PACKAGING ELECTRONIC CIRCUITS (IPC)

IPC D 275	Design Standard for Rigid Printed Boards and Rigid Printed Board Assemblies.
IPC D 330	Documents, Design Guide.
IPC L 125	Specification for Plastic Substrates, Clad or Unclad for High Speed/High Frequency Interconnections.
IPC HF 318	Microwave End Product Board Inspection and Test.
IPC RB 276	Qualification and Performance Specification for Rigid Printed Boards.

(Application for copies should be addressed to the Institute for Interconnecting and Packaging Electronic Circuits, 2215 Sanders Road, Suite 200 South, Northbrook, IL 60062.)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA NW 1000	Magnet Wire.

(Application for copies should be addressed to the National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1847, Roslyn, VA 22209.)

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.)

SOCIETY OF AUTOMOTIVE ENGINEERS, INC. (SAE)

SAE AMS 2404	Plating, Electrodless Nickel.
SAE AMS 2405	Electrodless Nickel Plating, Low Phosphorus.
SAE AMS 2433	Plating Nickel-Thallium-Boron or Nickel- Boron Electrodless Deposition.
SAE ARP 1199	Selection, Application, and Inspection of Electric Overcurrent Protective Devices.

(Application for copies should be addressed to the Society of Automitive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.)

UNDERWRITERS LABORATORIES, INC. (UL)

UL 1012	UL Standard for Safety Power Units Other Than Class 2

(Application for copies should be addressed to the Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

A.3 DEFINITIONS.

A.3.1 Definitions of acronyms. The acronyms used herein are defined as follows:

BIT	- built-in test
CSCI	- computer software configuration item
GFB	- Government furnished baseline
NPT	- national taper pipe (thread)
PTTI	- precise time and time interval
SBS	- standard battery system
SES	- standard enclosure system
SHARP	- standard hardware acquisition reliability program
TAAF	- test, analyze, and fix

A.3.2 Computer software configuration item (CSCI). An aggregation of software that satisfies an end use function and is designated by the Government for separate configuration management. CSCIs are selected based on tradeoffs among software function, size, host or target computers, developer, support concept, plans for reuse, criticality, interface considerations, need to be separately documented and controlled, and other factors.

A.3.3 Power density. Power divided by unit volume, including cooling fins and EMI filters.

A.3.4 Harmful corrosion. Corrosion which may interfere with the performance of the equipment or its associated parts.

A.3.5 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.

A.4 GENERAL REQUIREMENTS.

A.4.1 Standard hardware (ship). When possible and cost effective over the equipment life cycle, militarized equipment shall use SES (see 5.2.3), SPS (see A.5.1.11), SBS (see A.5.1.12), and SEM (see A.5.3.6.1) hardware from the SHARP.

A.4.2 Maintainabilty. Maintainability requirements shall be as specified in A.4.2.1. through A.4.2.3.3.

A.4.2.1 Accessibility. Consideration shall be given to equipment accessibility by maintenance personnel in the equipment's installed configuration.

A.4.2.2 Special tools. The use of special tools shall require the approval of the contracting 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 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).

A.4.2.3 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. To the extent that the technical guidance of MIL-HDBK-2165 is applicable to the end-item specification, testability technical requirements should be tailored from MIL-HDBK-2165. Levels of fault detection and fault isolation shall be specified for all items, including NDI.

A.4.2.3.1 Test equipment and BIT devices. Test equipment and BIT of militarized equipment shall be in accordance with MIL-PRF-28800. Test equipment calibration shall be in accordance with MIL-STD-1839.

A.4.2.3.2 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.

A.4.2.3.3 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.

A.4.3 Human factors engineering. Ruggedized and militarized equipment for ship applications shall be in accordance with ASTM F 1166. Ruggedized and militarized equipment for space, mobile, and land applications shall be in accordance with MIL-STD-1472. Equipment shall be suitable for operation and maintenance by a person within the 5th to 95th percentile range of the anthropometric data in accordance with ASTM F 1166 or MIL-STD-1472. ASTM F 1166 or MIL-STD-1472 shall be part of the selection criteria for determining the suitability and applicability of NDI.

A.4.4 Marking requirements. Marking of militarized equipment and items thereof shall be as specified in A.4.4.1 through A.4.4.7. Identification plates shall be in accordance with MIL-P-15024 and MIL-P-15024/5. Marking and labeling of radioactive commodities, their packages and shipping containers shall be in accordance with 29 CFR 1910, Subpart G.

A.4.4.1 Mounting and location. When possible, 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.

A.4.4.2 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 parts shall be defined and marked in accordance with MIL-STD-1686.

A.4.4.3 Lubrication points. Lubrication points shall be marked as LUBRICATION POINT.

A.4.4.4 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.

A.4.4.5 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

A.4.4.6 Electrical power source plates. Information plates conforming to 29 CFR 1910, Subpart J and Figure 5 shall be provided on each unit of the equipment that is powered from multiple electrical power sources. This requirement shall not apply to nonmaintainable satellites.

A.4.4.7 Power supplies. Power supplies shall be marked in accordance with UL 1012.

A.4.5 Corrosion. Militarized equipment subject to corrosion shall have corrosion prevention and deterioration control. The guidelines of MIL-HDBK-1250 should be followed.

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 5. Electrical power source information plate.

A.4.6 Parts derating. For new designs, parts shall be derated in accordance with TE000-AB-GTP-010, except that MIL-STD-1547 shall be used for Air Force applications.

A.4.7 Sneak circuit analysis. For new designs, sneak circuit analysis shall be performed for Navy mission or safety critical circuitry and software in accordance with NAVSO P-3634.

A.4.8 Fiber optics. Requirements for fiber optic systems shall be developed from MIL-HDBK-454, Guideline 76.

A.5 DETAILED REQUIREMENTS (SHIP).

A.5.1 Electrical design and construction. Electrical design and construction of militarized equipment shall be as specified in A.5.1.1 through A.5.5.2. The specifier of ruggedized equipment shall review these requirements for design features that may be tailored for the application of the equipment.

A.5.1.1 Grounding. Equipment shall be grounded in accordance with MIL-STD-1310 (see 4.12.5.3).

A.5.1.2 Equipment controls. Equipment controls shall be such that incorrect operation or sequencing shall not cause damage to equipment.

A.5.1.3 Electrical power. The equipment shall operate from electrical power sources as specified in A.5.1.3.1 and A.5.1.3.2.

A.5.1.3.1 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 XIV. Input power connectors shall be as specified in the end item specification (see 5.3.6).

TABLE XIV. Conductor designations.[1]

Equipment power supply	Conductor assignment	Connector designation	Conductor color
Single-phase	115/440 Vrms	A	White
	115/440 Vrms	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

[1/] Ship electrical distribution systems are delta-connected; this precludes 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.

A.5.1.3.2 Color code. The color code for conductors shall be maintained from the input power connections to all parts having the same voltage and frequency as the input power.

A.5.1.4 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.

A.5.1.5 Electrical equipment protection. Electrical equipment shall employ electrical protection as specified in A.5.1.5.1 through A.5.1.5.5.1.

A.5.1.5.1 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 Vrms or 30 VDC, as specified in 4.12.5. 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 5.1.2.13).

A.5.1.5.2 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 specified in Table XV for 1 minute at 60 Hz.

TABLE XV. 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

A.5.1.5.3 Insulation resistance. Insulation resistance of the equipment shall be not less than 10 megohms at specified environmental service conditions, measured at 500 VDC. Each circuit shall be measured against all other circuits, with all other circuits connected to the chassis.

A.5.1.5.4 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.

A.5.1.5.5 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 4.2.3.3). 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 ship equipment shall be in accordance with DESC Drawings 87060, 87061, or 87062, and shall be mounted in the horizontal orientation.

5.1.5.5.1 Fuses and circuit breakers. XXXFuseholders 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 spare 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.

A.5.1.6 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.

A.5.1.7 Equipment capacitance and EMI filters. When EMI filters are required, line-to-line filters are preferred to line-to-ground filters (see 4.12.5.2). 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.

A.5.1.8 Equipment electrical performance. Equipment electrical performance characteristics shall be as specified in A.5.1.8.1 through A.5.1.8.2.1.

A.5.1.8.1 Grounded input power. Under casualty conditions, and even during the day-to-day ship operations, one of the three-phase line voltages may short to ground. The ship 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 power source is not connected WYE. If the equipment is connected WYE, a significant voltage may exist between the neutral connection and the ship 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.

A.5.1.8.2 Failure tolerance. The equipment shall be designed such that failure of a part 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 should 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.

A.5.1.8.2.1 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.

A.5.1.9 Switching transients. The change in load current of equipment that uses 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 amperes should not exceed 100 amperes 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.

A.5.1.10 Internal wiring practices. Internal wiring practices shall be in accordance with MIL-T-152, MIL-V-173, MIL-I-631, MIL-T-713, MIL-I-3158, MIL-I-3190, MIL-T-7928, MIL-I-22076, MIL-I-23053, MIL-S-23190, MIL-T-43435, MIL-STD-108 and MIL-STD-1130. Guidance in the user application of the foregoing is contained in MIL-HDBK-454, Guideline 69.

A.5.1.11 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. Other power supplies shall be as specified in A.5.1.11.1 through A.5.1.11.5. Guidance for power supply design and manufacturing is provided in NAVMAT P-4855-1 (NAVSO P-3641).

A.5.1.11.1 Power density. An output power density exceeding 0.4 watts per cubic centimeter shall require the approval of the contracting activity.

A.5.1.11.2 Power supply interface. Power supplies shall be tested with the end item equipment, or shall be tested as a unit by simulating the I/O 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.

A.5.1.11.3 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.

A.5.1.11.4 Open and short circuit. Power supplies shall not be damaged by any load between an open circuit and a short circuit.

A.5.1.11.5 Power supply EMI design guidance. Design guidance for conforming with EMI requirements is provided in NAVMAT P-4855-1 (NAVSO P-3641) and MIL-HDBK-241.

A.5.1.12 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 A.5.1.12.1 through A.5.1.12.4.

A.5.1.12.1 Battery selection. Navy primary and secondary batteries shall be in accordance with NAVSO P-3676. Batteries should be selected in accordance with the guidance of MIL-HDBK-454, Requirement 27, or SHARP TP-001. Rechargeable batteries shall be valve regulated/starved electrolyte type. Unless it is demonstrated that no other alternative is practical, lithium batteries should not be used. The strength of the compartment containing lithium cells should 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 NSWC Crane Division TM S9310-AQ-SAF-010.

A.5.1.12.2 Battery compartment. Battery compartments shall be separate from equipment electronic circuits and shall be located for ease of battery replacement. The compartment should 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.

A.5.1.12.3 Battery charging. Charging circuits shall fail low voltage only, and should be temperature compensated. As determined by the battery type selected, charging circuits shall have two modes, for normal (bulk) charging of discharged batteries, for float (trickle) charging of charged batteries.

A.5.1.12.4 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).

A.5.1.13 Electronic signal interfaces. The interface requirements for electronic signals which send and receive data shall be as specified in 4.1.5 and as specified in A.5.1.13.1 through A.5.1.13.4. The interface requirements shall apply to both external equipment interfaces and internal equipment interfaces such as computer bus backplanes.

A.5.1.13.1 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.

A.5.1.13.2 PTTI. When specified in the end item specification, the equipment shall be compatible with the requirements of DOD-STD-1399, Section 441.

A.5.1.13.3 Synchro data. The equipment shall be in accordance with the guidance provided in MIL-HDBK-225. Synchro capacitors shall be rated at 600 VDC for 60 Hz synchros. 400 Hz power will be provided for ship avionics use only. Synchro capacitors shall be rated 1000 VDC for 400 Hz synchros.

A.5.1.13.4 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.

A.5.1.14 Digital form of documentation. Printed wiring board description in digital (numerical) form shall be in accordance with IPC D 330.

A.5.2 Mechanical design and construction. The mechanical design and construction of militarized equipment shall be as specified in A.5.2.1 through A.5.2.11.3. The specifier of ruggedized equipment should review these requirements for design features that may be required for the application of the equipment.

A.5.2.1 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.

A.5.2.1 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) should be installed in cable entrance holes to provide protection during shipment or handling prior to equipment installation.

A.5.2.1 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.

A.5.2.2 Rotating parts. 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.

A.5.2.2.1 Balancing. Rotatable and rotating parts, except locking adjustment controls, shall be statically and dynamically balanced and supported to prevent damage or unintentional movement. If weights are necessary for balancing, the weights shall be securely mounted to prevent movement or loss.

A.5.2.3 Enclosures. 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.

A.5.2.4 Equipment mounting. The method of equipment mounting shall be as specified in Table XVI, and A.5.2.4.1 through A.5.2.4.6.

TABLE XVI. Equipment mounting.

Equipment mounting method	Order of preference	Maximum weight (kilograms)
Horizontal	1	No limit
Panel	2	As specified in EIA RS 310
Vertical	3	89
Overhead	4	23

A.5.2.4.1 Horizontal mounting. Equipment shall have mounting features which permit through bolts to be installed perpendicular to the mounting surface. When necessary for stable horizontal mounting, additional features shall provide for installing sway braces to the upper rear of the equipment when necessary for stable horizontal mounting.

A.5.2.4.2 Overhead mounting. Equipment shall incorporate mounting features located to suspend the equipment and to transmit the load to the overhead structure.

A.5.2.4.3 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.

A.5.2.4.4 Sliding drawer mounting. Equipment shall include provisions to prevent accidental derailing and detachment or pulling off slides of equipment mounted on drawer slides.

A.5.2.4.5 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.

A.5.2.4.6 Resilient mounts. 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 will conform to specified shock performance at the end of its design life.

A.5.2.5 Handling. The equipment shall incorporate the design features for efficient handling in accordance with ASTM F 1166.

A.5.2.6 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 specified 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-PRF-8516, MIL-I-16923, MIL-PRF-23586, MIL-M-24041, and MIL-I-81550.

A.5.2.7 Pockets, wells, and traps. When the equipment is in normal position, pockets, wells, and traps in which water or condensate could collect shall be avoided.

A.5.2.7.1 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.

A.5.2.8 Mounting hardware. Mounting hardware shall be in accordance with MIL-S-1222, and shall have a minimum strength equivalent to SAE Grade 5 carbon and alloy steel. When possible, mounting hardware shall be course thread (UNC).

A.5.2.8.1 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.

A.5.2.8.2 Locknuts. Locknuts are the preferred method for conforming to ship vibration requirements. Non-captive lock washers shall not be used.

A.5.2.9 Mounting of electric receptacles. When practical and 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.

A.5.2.9.1 Location. External connections (excluding test connections) shall not be located on the front of the equipment.

A.5.2.9.1.1 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 degree grounding of the cable shield. Terminal boards or stuffing tubes (see 5.2.1) 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.

A.5.2.9.1.2 Terminal board accessibility. Access to terminal boards and test points shall not be dependent upon removal of cable entrance plates and cables.

A.5.2.10 Sealed equipment. In sealed equipment or assemblies such as waveguides, the use of desiccants or other methods, such as gas purging, is permitted.

A.5.2.10.1 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.

A.5.2.11 Thermal design and construction. Thermal design shall be in accordance with the guidance of MIL-HDBK-251, 4.12.4, and A.5.2.11.1 through A.5.2.11.3. Equipment shall be tested as specified in 5.1.2.15.

A.5.2.11.1 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 selection of the cooling method shall include consideration of available cooling systems, density, space, weight, and structureborne noise caused by fans and pumps.

A.5.2.11.2 Inlet/outlet location. The inlet air port shall be located not less than 300 millimeters from the floor. Exhaust air should be directed away from operating personnel.

A.5.2.11.3 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.

A.5.3 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 in A.5.3.1 through A.5.3.7.2.2. When possible (see A.4.1), standard hardware shall be used. The specifier of ruggedized equipment shall review the requirements for design features that may be required for the application of the equipment.

A.5.3.1 Obsolescence or nonavailability. The contractor design and method of part selection shall minimize the impact of parts obsolescence or nonavailability, as specified in the end item specification or contract.

A.5.3.2 Parts management. The parts to be incorporated in the equipment shall be managed in accordance with AIAA R100 to the extent specified in the end item specification. Further guidance is provided in MIL-HDBK-965.

A.5.3.3 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 ASTM F 1166.

A.5.3.4 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. The goal is a robust design which accommodates the complete range of service conditions, is maintainable from readily available parts, and does not require frequent recalibration or adjustment.

A.5.3.5 Used or damaged parts. Used or damaged parts or materials shall not be used.

A.5.3.6 Parts, general requirements. Parts shall be as specified in Table XVII, and as specified in A.5.3.6.1 through A.5.3.6.16. The use of other parts shall require the approval of the contracting activity, and should have a demonstrated parts defect rate of a maximum of 100 parts per million.

TABLE XVII. Parts.

Item	Requirement
Bearings	Should follow the guidance of MIL-HDBK-454, Guideline 6. Bearings for use in noise critical applications shall be in accordance with MIL-B-17931.
Cable, coaxial	Shall be in accordance with MIL-C-17, MIL-L-3890, MIL-C-22931, or MIL-C-23806.
Cable, flat	Shall be in accordance with MIL-C-49055 for cables with round conductors.
Cable, interconnecting	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. Selection guidance is provided in MIL-HDBK-454, Guideline 71.
Cable, multiconductor (internal)	Selection guidance is provided in MIL-HDBK-454, Guideline 66.
Circulators	Shall be in accordance with MIL-C-28790.
Clamp, cable entrance	Shall be in accordance with A-A-5052.
Connectors	See A.5.3.6.7. 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-K-3926, MIL-K-25049, MIL-D-28728. Selection guidance is provided in MIL-HDBK-454, Guideline 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	Hex bolts should be in accordance with MIL-S-1222, and lock washers should not be used. Guidance is provided in MIL-HDBK-454, Guideline 12.

TABLE XVII. Parts. - continued

Item	Requirement
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-DTL-22529.
Gyroscopes, rate integrating	Shall be in accordance with MIL-G-81168.
Indicator lights	Shall be in accordance with the color coding requirements of ASTM F 1166. Guidance is provided in MIL-HDBK-454, Guideline 50.
Meters, electrical indicating	Shall be selected and applied in accordance with MIL-STD-1279. Meters shall not be the electrochemical type.
Motors, dynamotors, and rotating devices	Shall show the direction of rotation. Guidance is provided in MIL-HDBK-454, Guideline 46.
Readouts	Shall be in accordance with MIL-D-28803, or MIL-D-87157, Quality level A or B.
Relays	Should conform to the guidance of MIL-HDBK-454, Guideline 57.
Servo devices	Should conform to the guidance of MIL-HDBK-454, Guideline 56.
Shunts	Shall be in accordance with MIL-S-61 or MIL-I-1361, as applicable.
Sockets and accessories	Should conform to the guidance of MIL-HDBK-454, Guideline 60.
Solenoids	Shall be in accordance with MIL-S-4040.
Springs	Should conform to the guidance of MIL-HDBK-454, Guideline 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	Should conform to the guidance of MIL-HDBK-454, Guideline 19.

TABLE XVII. Parts. - continued

Item	Requirement
Vibrator power supply	Shall not be used.
Waveguides and related devices	Should conform to the guidance of MIL-HDBK-454, Guideline 53.
Wire internal, hook-up	Should conform to the guidance of MIL-HDBK-454, Guideline 20.
Wire magnet	Shall be in accordance with NEMA NW-1000.

A.5.3.6.1 Electronic parts. SEM shall be used when possible and cost effective over the equipment life cycle. SEM shall be in accordance with MIL-M-28787 and the guidance in MIL-HDBK-246. To prevent large numbers of SEM A and SEM B modules, SEM D and larger modules should be used. Other electronic parts shall be selected from MIL-STD-683, MIL-STD-701 (semiconductors), MIL-STD-1286, MIL-STD-1833, and the GFB. Guidance on the GFB is provided in MIL-HDBK-965. General guidance is provided in MIL-HDBK-454, Guideline, 64 for microelectronic devices. The order of preference for electronic part selection shall be in accordance with Table XVIII.

TABLE XVIII. 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

A.5.3.6.2 Printed circuits. Printed circuits and printed circuit wiring boards shall be in accordance with IPC D 275, and MIL-PRF-55110. Requirements for printed circuits shall also conform to the guidance of MIL-HDBK-454, Guideline 17. Thick film ceramic boards with leadless components shall be in accordance with NAVSO P-3651.

A.5.3.6.3 Wire and cable. Aluminum wire and cable shall not be used.

A.5.3.6.4 Air filters. Air filters shall be in accordance with MIL-F-16552. Filters shall be removable for cleaning without disassembly of the equipment.

A.5.3.6.5 Convenience power receptacles. Convenience power receptacles shall not be provided.

A.5.3.6.6 Capacitors. Capacitors shall be in accordance with MIL-STD-198, and as specified in A.5.3.6.6.1 through A.5.3.6.6.3.

A.5.3.6.6.1 Electrolytic capacitors. Electrolytic (aluminum foil) capacitors shall not be used in AC applications.

A.5.3.6.6.2 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.

A.5.3.6.6.3 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.

A.5.3.6.7 Connectors. Connectors should conform to the guidance of MIL-HDBK-454, Guideline 10. Connectors shall be as specified in A.5.3.6.7.1 through A,5,3,6,7,7.

A.5.3.6.7.1 Connector type. Connectors shall be of the type that will not disconnect or become loose 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.

A.5.3.6.7.2 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.

A.5.3.6.7.3 Connector contacts, energized. Connector plug or receptacle contacts which remain energized after unmating shall be inaccessible to personnel.

A.5.3.6.7.4 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.

A.5.3.6.7.5 Connector keying. Multicontact connectors, including printed circuit assembly connections, shall be keyed, polarized, or of a contact configuration to prevent improper connection, positioning or mating.

A.5.3.6.7.6 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 XVII 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).

A.5.3.6.7.7 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.

A.5.3.6.8 Gaskets. Gaskets on exposed equipment shall provide grounding along the perimeter of the gasket for EMP protection. Gaskets shall be in accordance with A.5.3.6.8.1 and A.5.3.6.8.2.

A.5.3.6.8.1 Flat gaskets. The use of flat gaskets shall be held to a minimum and should be used only between smooth regular surfaces. Flat gaskets shall be in accordance with MIL-G-15624. Consideration should be given to the required degree of enclosure and the accessibility. Gaskets which are not penetrated by mounting screws are preferred.

A.5.3.6.8.2 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-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 should be a minimum of 3 millimeters.

A.5.3.6.9 Glass. Glass shall be used in accordance with MIL-HDBK-722, and shall be in accordance with MIL-G-3787, Class 1, Type I.

A.5.3.6.9.1 Securing glass windows. When operating controls are arranged in such a manner 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.

A.5.3.6.10 Dials and pointer 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 graduation. The pointer shall not cover the graduations to which the pointer refers but shall extend only to the nearer edge of the graduations.

A.5.3.6.11 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.

A.5.3.6.12 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 light sources.

A.5.3.6.12.1 Design for dark adapted areas. Equipment designed for use in dark adapted areas shall use either clear lamps with red filters and stencil type material having transmission characteristics as shown on Figure 6 or red light emitting diodes having the same spectral characteristics. There should be no bright reflective surface visible to the equipment operator.

A.5.3.6.12.2 Illuminated panels. Integrally illuminated panels should be in accordance with MIL-P-7788.

A.5.3.6.12.3 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 windings of a transformer, and the lighting circuit shall be equipped with a control device to vary light intensity from maximum value to the minimum discernible intensity when either 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.

A.5.3.6.12.4 Lamp/display test feature. A lamp/display test feature shall be provided. Incandescent lamps shall be replaceable from the front panel.

A.5.3.6.12.5 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 6. The transmission cut-off should be 590 nanometers with a peak of 700 nanometers.

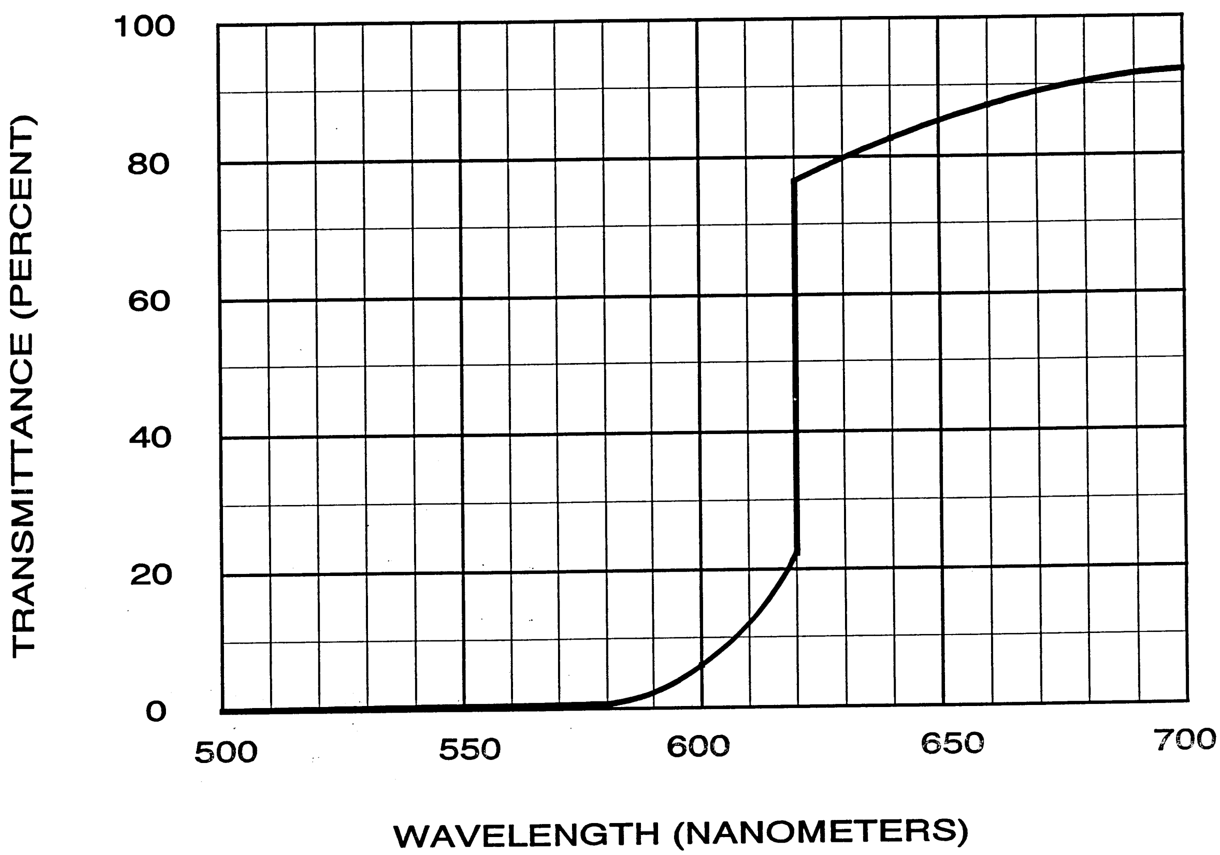

FIGURE 6. Curve of light transmission of red material.

A.5.3.6.13 Terminal lugs. Terminal lugs for fitting to ships cables shall not be utilized.

A.5.3.6.14 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.

A.5.3.6.15 Transformers, inductors and coils. Selection of transformers, inductors, and coils shall be in accordance with MIL-STD-1286.

A.5.3.6.15.1 Variable transformers. Variable transformers shall be in accordance with MIL-T-83721.

A.5.3.6.15.2 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, Class T, Class U, or Class V.

b. MIL-T-27, Grade 4 transformers and inductors shall not be potted or liquid filled.

c. Items that are selected from other sources shall have a minimum operating temperature of 130°C or greater.

A.5.3.6.16 Tuning dial mechanisms. Tuning dial mechanisms should conform to the guidance of MIL-HDBK-454, Guideline 42. Markings shall conform to the style of MS 33558.

A.5.3.7 Materials. Materials shall be in accordance with Table XIX, and as specified in 5.3.6.7.1 through A.5.3.6.7.7.

A.5.3.7.1 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 not less than 10 percent elongation. This may be achieved with properly fabricated alloys of the ALMAG family.

A.5.3.7.2 Metals and alloys. Metals and alloys shall be corrosion-resistant or shall be given a corrosion-resisting treatment or coating.

A.5.3.7.2.1 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.

A.5.3.7.2.2 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 into the aluminum.

TABLE XIX. Materials.

Item	Requirement
Aluminum alloy bars, rods,and shapes	Shall be in accordance with ASTM B 221, ASTM B 241 ASTM B 308, QQ-A-225, QQ-A-225/2, QQ-A-225/7, or QQ-A-225/8.
Aluminum alloy castings	Shall be in accordance with ASTM B 85; ASTM B 108; 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 materials	Should conform to the guidance of MIL-HDBK-454, Guideline 26.
Beryllium-beryllium compound	Shall be identified as containing beryllium (by labeling, and so forth). The 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 ASTM B 133 or ASTM B 272.
Copper-beryllium alloy	Shall be in accordance with ASTM B 194, ASTM B 196, or ASTM B 197.
Copper-nickel alloy	Shall be in accordance with MIL-C-15726 or ASTM B 369.
Copper-nickel-zinc alloy	Shall be in accordance with ASTM B 122, ASTM B 151, or ASTM B 206.

TABLE XIX. Materials. - continued

Item	Requirement
Desiccants	Shall be in accordance with MIL-D-3464.
Item	Requirement
Fungus-inert	Should conform to the guidance of MIL-HDBK-454, Guideline 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	Should conform to the guidance of MIL-HDBK-454, Guideline 11.
Lubricants	Should conform to the guidance MIL-HDBK-454, Guideline 43.
Nickel-copper alloy	Shall be in accordance with QQ-N-281, QQ-N-286, ASTM A 494, or MIL-C-24723.
Plastic	Shall be selected from MIL-HDBK-700. Shall be coated with varnish conforming to MIL-V-173, if porous. Shall not be used for viewing windows.
Silver brazing alloys	Shall be in accordance with QQ-B-654.

A.5.4 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 A.5.4.1 through A.5.4.7. 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 requirements for design features that may be required for the application of the equipment.

A.5.4.1 Aluminum and aluminum alloy pretreatment. Aluminum and aluminum alloy pretreatment shall be as specified in a through 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 as specified in A.5.4.4.

A.5.4.2 Ferrous metal pretreatment. Ferrous metal pretreatment shall be as specified in a and b:

a. Cleaning. After all machining, welding, and brazing operations have been 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 Type III of TT-C-490.

A.5.4.3 Protected equipment. Protected equipment shall be finished as specified in A.5.4.3.1 and A.5.4.3.2.

A.5.4.3.1 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.

A.5.4.3.2 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 not less than 0.025 millimeters, dry film thickness. Enamel for ship 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.

A.5.4.4 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-24441/20 (0.075 millimeters to 0.100 millimeters dry film thickness).

b. Second coat: Epoxy-polyamide top coat in accordance with MIL-P-24441/25 or MIL-P-24441/22 (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.

A.5.4.5 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 A.5.4.5.1 and A.5.4.5.2.

A.5.4.5.1 Primer. Primer in accordance with MIL-P-23377 shall be applied with a dry film thickness of 0.015 millimeters to 0.025 millimeters.

A.5.4.5.2 Topcoat. Two coats of urethane enamel in accordance with MIL-PRF-85285 shall be applied. Each coat shall have a minimum thickness of not less than 0.025 millimeters.

A.5.4.6 Colors. Colors for the painting of equipment shall be selected in accordance with FED-STD-595.

A.5.4.7 Paint systems. When alternative paint schemes are 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 when possible; the use of lead- and chromate-containing coatings shall be avoided when an approved alternative exists. Consideration shall be given to the ability to perform field maintenance on paint systems.

A.5.5 Processes. The specifier of ruggedized equipment shall review the requirements for design features that may be required for the application of the equipment. Processes shall be as specified in Table XX and as specified in A.5.5.1 and A.5.5.2.

A.5.5.1 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.

TABLE XX. Processes.

	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 CWS-C3.4.
Castings	Shall be in conform to the guidance of MIL-HDBK-454, Guideline 21. Zinc alloy and magnesium alloy castings should 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 deposition shall be in accordance with ASTM B 607, ASTM B 656, ASTM B 733, SAE AMS 2404, SAE AMS 2405, and SAE AMS 2433.
Passivation	Shall be in accordance with ASTM A 967.
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.
Tin plating	Shall be in accordance with ASTM B 545.
Aliphatic urethane plating	Shall be in accordance with MIL-PRF-85285.
Welds, resistance	Shall be in accordance with MIL-PRF-53095.
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 ASTM B 69 (Wrought zinc alloys)

A.5.5.2 Welding. Welding shall be in accordance with 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 nondestructive test using either radiographic or ultrasonic procedures.

A.6 DETAILED REQUIREMENTS (SPACE).

A.6.1 Equipment design. Equipment design shall be as specified in A.6.1.2 through A.6.1.10.

A.6.1.1 Maintainability. Unless otherwise specified, space vehicles and payloads shall be such that scheduled maintenance or servicing shall not be required while deployed. Provisions shall be considered for recovering deployed equipment for repairs. The equipment shall incorporate test and telemetry points to allow verification of functional performance. 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.

A.6.1.2 Limited life items. Limited life items such as batteries, fillers, and other consumables shall be identified.

A.6.1.3 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.

A.6.1.4 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.

A.6.1.5 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.

A.6.1.6 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 contracting 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.

A.6.1.7 Pressure subsystems. Pressure subsystems shall be tested in accordance with MIL-STD-1540, NHB 1700.7, and SAMTO HB S-100 (KHB 1700.7).

A.6.1.8 Failure modes and effects. Required performance and reliability shall be ensured based on 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.

A.6.1.9 Single point failures. When 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 document 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 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.

A.6.1.10 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.

A.6.2 Electrical design and construction. Electrical design and construction shall be as specified in A.6.2.1 through A.6.2.9.14.

A.6.2.1 Electronic parts, materials, and processes. Electronic parts, materials, and processes shall be in accordance with MIL-STD-1547.

A.6.2.2 External wire harnesses and cable assemblies. External wire harnesses and cable assemblies shall be protected from damage arising from environmental exposure including temperature, electromagnetic radiation, and mechanical damage.

A.6.2.3 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.

A.6.2.4 Welds (electrical interconnections). Electrical interconnection resistance welds shall be in accordance with MIL-PRF-53095, except when 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.

A.6.2.5 Potted modules. Potted modules are not preferred for new designs.

A.6.2.6 Electric motors. Electric motors shall be in accordance with MIL-A-83577.

A.6.2.7 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 A.6.6.2.

A.6.2.8 Enclosures. Enclosures shall not impede on the proper deployment of any antenna system (see 6.3.4) 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 in such a manner 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.

A.6.2.9 Connector selection. 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 in A.6.2.9.1 through A.6.2.9.14.

A.6.2.9.1 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.

A.6.2.9.2 Existing wiring harness connectors. When required to connect to existing wiring harness connectors, MIL-C-26482, series II; MIL-C-81703; or 40M38298 or 40M39569 connectors shall be used.

A.6.2.9.3 Coaxial connectors. Coaxial connectors shall be in accordance with MIL-C-39012.

A.6.2.9.4 Connector shells. Connector shells shall have a conductive finish. Cadmium plating shall not be used.

A.6.2.9.5 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.

A.6.2.9.6 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.

A.6.2.9.7 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.

A.6.2.9.8 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.

A.6.2.9.9 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.

A.6.2.9.10 Circuit isolation. When wires from isolated circuits use the same connector, the pin assignments and layout shall maintain isolation between the wires.

A.6.2.9.11 Twisted wire contacts. Contacts for twisted wires shall be adjacent.

A.6.2.9.12 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.

A.6.2.9.13 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.

A.6.2.9.14 Connector savers. Connector savers shall be provided and used during ground operations for connector applications subject to frequent connect/ disconnect operations, such as connectors used during testing.

A.6.2.10 Fasteners and locking. Fastening systems shall be in accordance with MIL-STD-1515.

A.6.2.11 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.

A.6.2.12 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. When practical, self-locking devices which depend upon an interference fit between metallic threads shall be avoided 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 MS33540. 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.

A.6.2.13 Controls. Adjustment, alignment, or calibration controls shall not be provided external to the enclosures.

A.6.2.14 Electroexplosive devices. Electrical current margins of all electroexplosive device circuits shall be demonstrated. The tests 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.

A.6.2.15 Printed wiring boards. Rigid printed wiring boards shall be in accordance with IPC RB 276. Microwave printed boards shall be inspected and tested in accordance with IPC HF 318.

A.6.2.16 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.

A.6.2.17 Mounting and installation of parts. Mounting and installation of parts shall be in accordance with MIL-STD-1547, and as specified in A.6.2.17.1 through A.6.2.17.4. 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.

A.6.2.17.1 Sleeving. Fragile parts shall be fitted with sleeving or a buffer coat to prevent damage.

A.6.2.17.2 Hermetic seals. 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.

A.6.2.17.3 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 alternative to redundant wiring is step soldering of the terminal to the printed wiring board to preclude solder reflow during subsequent soldering operations.

A.6.2.17.4 Power device mounting. Metallurgical connection to the case is preferred to compression connections. Metal power packages requiring electrical connection to the case shall be mounted with stressed hardware appropriately torqued to ensure electrical contact during expansion and contraction of the printed wiring board during thermal excursion.

A.6.2.18 Soldering. 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.

A.6.2.19 Conformal coating. Printed wiring board shall be conformally coated. Conformal coating shall be in accordance with a through e:

a. The selection of conformal coatings shall include consideration of outgassing that may cause contamination of optical and thermal control surfaces.

b. A technique for 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. For any of the cited coated assembly anomalies the maximum number of reworks which can be performed without approval of the contracting 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.

A.6.3 Waveguides, antennas, and RF devices. Waveguides, antennas, and RF devices shall be as specified in A.6.3.1 through A.6.3.4.

A.6.3.1 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 ASTM E 1417. 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) with a Rockwell B hardness between 45.0 and 80.0. Unless the aluminum or magnesium waveguide is silver-plated or both are plated with a common metal, aluminum or magnesium waveguides and coin silver waveguides shall not be in contact. 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.

A.6.3.2 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 ± 0.50 degrees with internal waveguide surfaces. For smaller waveguides, the face of the flange shall make an angle of 90 degrees ± 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 the 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.

A.6.3.3 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 not 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.

A.6.3.4 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.

A.6.4 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, prelaunch checkout, and on-orbit test measurements as applicable.

A.6.4.1 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 in such a manner 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.

A.6.4.2 Test points and test parameters. The test equipment shall ensure 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. When practical, test points shall be provided as telemetry points on connector contacts or pins. Test points shall be short-circuit protected. The test parameters shall be selected to provide assurance of satisfactory equipment performance and to isolate faults should faults occur. The parameter test limits shall be established in such a manner 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.

A.6.5 Materials and process controls. Manufacturing procedures and process controls shall be documented to identify the procedures and specifications by which all processes, operations, inspections, and tests shall 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. 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. The manufacturing process and control documents shall be such 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.

A.6.6 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. When practical, the materials listed in MIL-HDBK-5 shall be used.

A.6.6.1 Prohibited materials. Mercury, compounds containing mercury, zinc parts, zinc plating, cadmium parts, and cadmium-plated parts shall not be used, except when 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 4.12.1) may be permitted 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. Nonrecyclable 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.

A.6.6.2 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. Further guidance (see 6.8.2) is provided in NASA Reference Publication 1061. The outgassing properties of parts, materials, and components whose outgassing properties are not known shall be determined in accordance with ASTM E 595.

A.6.6.3 Fungus-inert material. Equipment shall not support fungal growth. Fungus tests shall be in accordance with MIL-STD-810, Method 508. When practical, fungus-inert materials shall be used.

A.6.6.4 Adhesives. Adhesives shall be selected based on their strength with respect to specifically-prepared surfaces of the materials with which the adhesives will 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.

A.6.6.5 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. Further guidance is provided in NASA Technical Paper 2361. 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 ensure that excessive atomic oxygen degradation does not occur during the service life of the application.

A.6.6.6 Castings. Aluminum alloy castings shall be in accordance with MIL-A-21180. Magnesium alloy castings shall be in accordance with ASTM B 80. 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.

A.6.6.7 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. 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.

A.6.6.8 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.

A.6.6.9 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.

A.6.6.10 Honeycomb sandwich structures. Honeycomb sandwich structures shall be designed to permit venting of air or other volatiles from within the honeycomb core.

A.6.6.11 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.

A.6.6.12 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 ASTM B 607, ASTM B 656, ASTM B 733, SAE AMS 2404, SAE AMS 2405, and SAE AMS 2433. 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 not less than 1.3 micrometers.

A.6.7 Processes. Processes shall be as specified in A.6.7.1 through A.6.7.5.

A.6.7.1 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, in such a manner as to provide strong contrast with the color of the surface upon which the fasteners and assembly screws 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 the fasteners and assembly screws are used.

A.6.7.2 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.

A.6.7.3 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 magnesium alloys shall be painted after finishing.

A.6.7.4 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.

A.6.7.5 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. If practical, grounded semiconductive surface coatings or other forms of charge leakage paths shall be provided. Surface resistivity shall be as specified in 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.

A.6.8 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.

A.6.8.1 Cleanliness. Product particulate cleanliness shall be in accordance with MIL-STD-1246, Level 500. External surfaces shall be visibly clean.

A.6.8.2 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 A.6.8.2) prior to installation in the payload or space vehicle.

A.6.8.3 Mechanical templates. When practical, a common interface drill template shall be used to ensure correct mechanical mating, particularly for interfaces external to the equipment.

A.6.9 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 shall allow for contingency growth and unpredicted demands on resources.

A.6.9.1 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.

A.6.9.1.2 Computer instruction performance rate. Each processing unit shall perform instructions at a rate which is a minimum of 200 percent of that required to perform specified functions.

A.6.9.1.3 Data channel capacity. When operating with the application computer programs, the maximum input data rate capability and the maximum output data rate capability shall be a minimum of 200 percent of that required to perform specified functions.

A.6.9.1.4 Main storage (primary memory). The capacity of the main storage (primary memory) in each computer shall be a minimum of 150 percent of the basic capacity required to perform specified functions.

A.6.9.1.5 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.

A.6.9.2 Operating systems used in computers. When practical, the operating system for each computer shall support an OSA with a demonstrated record of reliable performance. 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 vendor-maintained operating systems shall require approval by the contracting officer prior to implementation.

A.6.9.2.1 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.

A.6.9.2.2 On-orbit reprogramming. Consideration shall be given to providing the means for on-orbit reprogramming of computer resources.

APPENDIX B

Leakage Current Tests

B.1 GENERAL.

B.1 1 Scope. This Appendix provides test methods for measuring leakage current. This Appendix is not a mandatory part of this document. The information contained herein is for guidance only. The text has been prepared so that applicable sections may be excerpted and inserted directly into equipment specifications when leakage tests are required.

The use of the word "shall" in the remainder of this Appendix is solely to facilitate the excerpting of the guide form provivisions of this appendix for insertion into equipment detail specifications.

B.2 APPLICABLE DOCUMENTS.

This section is not applicable to this Appendix.

B.3 DEFINITIONS.

This section is not applicable to this Appendix.

B.4 GENERAL REQUIREMENTS. The tests and procedures presented below have been prepared so that they may be excerpted and inserted directly into end-item specifications as appropriate.

B.4.1 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.

B.4.2 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 7 if connected to single-phase power, as shown on Figure 8 if connected to 3-phase power, or as shown on Figure 9 if connected to DC power.

B.4.3 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 milliamperes of leakage current, the voltage drop across the 1500 ohm resistor in parallel with the 0.15 microfarad capacitor will be 7.5 VDC at DC, 7.5 Vrms at 60 Hz, and 6.53 Vrms 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.

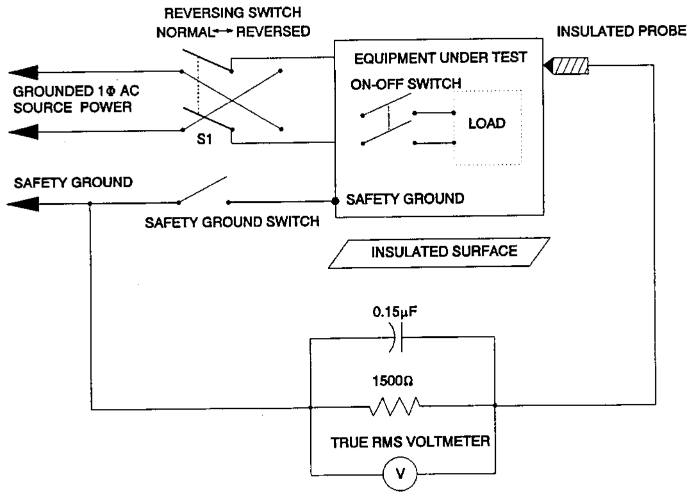

FIGURE 7. Single-phase test diagram for leakage current measurement.

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: 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.

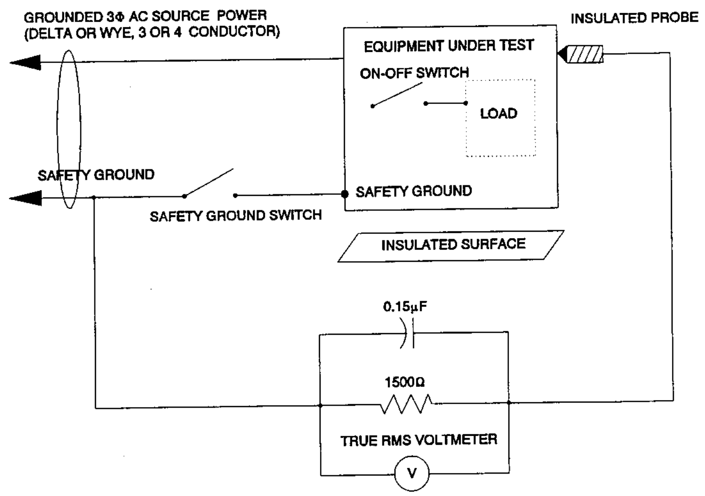

FIGURE 8. Three-phase test diagram for leakage current measurement.

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 Steps 3 through 6 for each mode of operation.
8. Source power OFF. Disconnect equipment. Sign record sheet.

NOTES:
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.

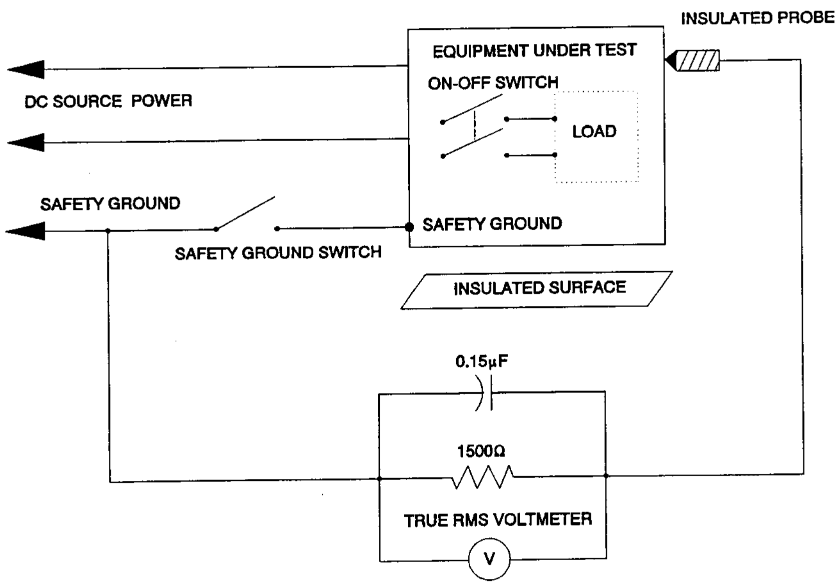

FIGURE 9. DC test diagram for leakage current measurement.

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.

NOTE: 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.

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3. DOCUMENT TITLE **ELECTRONIC EQUIPMENT SPECIFICATIONS, PREPARATION OF**

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

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