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**MIL-HDBK-11991
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DEPARTMENT OF DEFENSE HANDBOOK

DESIGN OF ELECTRICAL ELECTRONIC AND ELECTRO-MECHANICAL EQUIPMENT GUIDED MISSILE AND ASSOCIATED WEAPON SYSTEMS



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FOREWORD

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

2. Beneficial comments (recommmendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, US Army Missile Command, ATTN: AMSMI-RD-SE-TD-ST, Redstone Arsenal, AL 35898-5270, by using the self addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

3. This military standard was prepared to supersede MIL-E-11991. It establishes the general requirements for standardized design of electrical, electronic, and electromechanical equipment for use in missile systems and associated weapon systems.

MIL-STD-11991

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1. SCOPE

1.1 Scope. The purpose of this standard is to standardize requirements for the design of electronic, electrical, and electromechanical equipment common to guided missile and associated weapons systems.

1.2 Applicability. This standard does not address detailed fabrication, test or performance requirements for designed equipment, as these requirements are addressed in the detailed specifications for equipment.

1.3 Application guidance. This standard is intended to cover all classes and types of electronic, electrical, and electromechanical equipment and all applicable phases of service test, preproduction and production specified in detailed equipment specifications.

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2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

FEDERAL

A-A-50057	Rope, Fibrous, Tent-Lay
A-A-51144	Anodes, Copper
C-F-206	Felt Sheet: Cloth, Felt, Wool, Pressed
J-W-1177	Wire, Magnet, Electrical
O-F-506	Flux, Soldering; Paste and Liquid
T-R-605	Rope, Manila and Sisal
NN-P-530	Plywood, Flat Panel
QQ-A-591	Aluminum Alloy Die Castings
QQ-A-596	Aluminum Alloy Permanent and Semipermanent Mold Casting
QQ-A-601	Aluminum Alloy Sand Casting
QQ-A-1876	Aluminum Foil
QQ-B-613	Brass, Leaded and Nonleaded: Flat Products (Plate, Bar, Sheet and Strip)
QQ-B-626	Brass, Leaded and Nonleaded: Rod, Shapes, Forgings, and Flat Products with Finished Edges (Bar and Strip)
QQ-C-390	Copper Alloy Castings (Including Cast Bar)
QQ-C-450	Copper-Aluminum Alloy (Aluminum Bronze) Plate, Sheet, Strip, and Bar (Copper Alloy Numbers 606, 610, 613, 614 and 630)
QQ-C-502	Copper Rods and Shapes; and Flat Products with Finished Edges (Flat Wire, Strips and Bars)
QQ-C-571	Copper, Phosphor (Alloying Additive)
QQ-C-576	Copper Flat Products with Slit, Slit and Edge-Rolled, Sheared, Sawed, or Machined Edges (Plate, Bar, Sheet, and Strip)
QQ-C-585	Copper-Nickel-Zinc Alloy Plate, Sheet, Strip, and Bar (Copper Alloy Numbers 735, 745, 752, 762, 766 and 770)

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QQ-C-586	Copper-Nickel-Zinc Alloy; Rod, Shapes and Flat Products with Finished Edges (Flat Wire, Strip and Bar)
QQ-C-591	Copper-Silicon, Copper-Zinc-Silicon, and Copper-Nickel Silicon Alloys: Rod, Wire, Shapes, Forgings and Flat Products (Flat Wire, Strip, Sheet, Bar and Plate)
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-288	Nickel-Copper Alloy and Nickel-Copper-Silicon Alloy Castings
QQ-N-290	Nickel Plating (Electrodeposited)
QQ-S-571	Solder: Tin Alloy, Tin-Lead Alloy, and Lead Alloy
QQ-S-763	Steel Bars, Wire, Shapes, and Forgings, Corrosion Resisting
TT-P-320	Pigment, Aluminum: Powder and Paste, For Paint
TT-S-1732	Sealing Compound; Pipe Joint and Thread, Lead Free, General Purpose
ZZ-R-765	Rubber, Silicone

MILITARY

MIL-E-1	Electron Tubes, General Specification For
MIL-I-10	Insulating Compound, Electrical, Ceramic, Class L
MIL-M-14	Molding Plastics and Molded Plastic Parts, Thermosetting
MIL-W-80	Window, Observation, Acrylic Base, Anti-electrostatic, Transparent (For Indicating Instrument)
MIL-T-152	Treatment, Moisture and Fungus-Resistant, of Communications, Electronic and Associated Electrical Equipment
MIL-V-173	Varnish, Moisture-and Fungus-Resistant, (For Treatment of Communications, Electronics, and Associated Equipment)
MIL-G-174	Glass Optical
MIL-C-675	Coating of Glass Optical Elements (Anti-Reflection)

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MIL-T-713	Twine, Fibrous: Impregnated, Lacing and Tying
MIL-P-997	Plastic Material, Laminated, Thermosetting, Electrical Insulation: Sheets, Glass Cloth, Silicone Resin
DOD-D-1000	Drawings, Engineering and Associated Lists
MIL-F-2312	Felt, Hair or Wool: Mildew Resistant and Moisture Resistant, Treatment For
MIL-R-3065	Rubber, Fabricated Products
MIL-R-3080	Resistors, Current-Regulating (Ballast Tubes)
MIL-V-3144	Vials, Level
MIL-G-3787	Glass, Laminated, Flat; (Except Aircraft)
MIL-C-3883	Cord, Electrical, Shielded (Audio Frequency)
MIL-L-3890	Line, Radio Frequency Transmission (Coaxial, Air Dielectric), General Specification for
MIL-L-3891	Luminescent Material and Equipment (Nonradioactive)
MIL-W-5044	Walkway Compound, Nonslip and Walkway Matting, Nonslip
MIL-W-5050	Walkway, Coating and Matting, Nonslip, Aircraft, Application of
MIL-P-5315	Packing, Preformed, Hydrocarbon Fuel Resistant
MIL-P-5516	Packing Preformed, Petroleum Hydraulic Fluid Resistant, 160 Deg. F
MIL-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-E-6051	Electromagnetic Compatibility Requirements, System
MIL-C-6183	Cork and Rubber Composition Sheet; for Aromatic Fuel and Oil Resistant Gaskets
MIL-R-6855	Rubber, Synthetic Sheets, Strips, Molded and Extruded Shapes, General Specification for
MIL-W-8160	Wiring, Guided Missile, Installation of, General Specification For
MIL-A-8625	Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-F-9329	Filters, Light Photographic, General Specification for
MIL-C-10578	Corrosion Removing and Metal Conditioning Compound (Phosphoric Acid Base)
MIL-R-11050	Rectifier, Metallic, Selenium
MIL-F-12784	Flux, Soldering (Stearine Compound IC-3)
MIL-M-13508	Mirror, Front Surface Aluminized: For Optical Elements

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MIL-O-13830	Optical Components For Fire Control Instruments: General Specification Governing The Manufacture, Assembly, and Inspection of
MIL-F-14072	Finishes for Ground Electronic Equipment
MIL-R-14224	Rectifiers, Metallic, Selenium (High Temperature)
MIL-F-14256	Flux, Soldering, Liquid (Rosin Base)
MIL-B-16540	Bronze, Phosphor, Castings
MIL-W-18142	Wood Preservative Solutions, Oil-Soluble, Ship and Boat Use
MIL-S-19500	Semiconductor Devices, General Specification for
MIL-G-20098	Gypsum, Calcined
MIL-A-21180	Aluminum-Alloy Castings, High Strength
MIL-C-22750	Coating, Epoxy-Polyamide, VOC Compliant
MIL-S-23190	Straps, Clamps and Mounting Hardware, Plastic and Metal for Cable Harness Tying and Support
MIL-P-25732	Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Limited Service at 275° F (132° C)
MIL-G-25871	Glass, Laminated, Aircraft Glazing
MIL-T-28800	Test Equipment for Use with Electrical and Electronic Equipment, General Specification For
MIL-M-38510	Microcircuits, General Specification For
MIL-C-39006/9	Capacitors, Fixed, Electrolytic (Nonsolid Electrolyte), Tantalum (Polarized, Sintered Slug), 85°C (Voltage Derated to 125°C), Established Reliability, Style CLR 65
MIL-C-39006/22	Capacitors, Fixed, Electrolytic (Nonsolid Electrolyte), Tantalum (Polarized, Sintered Slug), 85°C (Voltage Derated to 125°C), Established Reliability, Style CLR 79
MIL-C-39018	Capacitors, Fixed Electrolytic (Aluminum Oxide) Established Reliability and Non-established Reliability, General Specification For
MIL-T-43435	Tape, Lacing and Tying
MIL-C-45224	Cable and Harness Assemblies, Electrical Missile System; General Specification for
MIL-E-45782	Electrical Wiring, Procedures for
MIL-C-46168	Coating, Aliphatic Polyurethane, Chemical Agent Resistant
DOD-F-49291	Fiber, Optical, (Metric) General Specification for
MIL-P-55110	Printed Wiring Boards, General Specification for
MIL-R-55342	Resistors, Fixed, Film, Chip, Established Reliability, General Specification for
MIL-C-55365	Capacitors, Chip, Fixed, Tantalum, Established Reliability, General Specification For

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MIL-C-55681	Capacitors, Chip, Multiple Layer, Fixed, Unencapsulated, Ceramic Dielectric, Established Reliability, General Specification For
MIL-G-81704	Glass, Aircraft Instrument, Lighting Wedge and Cover
MIL-C-83446	Coils, Radio Frequency, Chip, Fixed or Variable, General Specification For
MIL-S-83519	Shield Termination, Solder Style, Insulated, Heat-Shrinkable, Environment Resistant, for Cables having Tin or Silver Plated Shields (Class I)

STANDARDS

FEDERAL

FED-STD-406	Plastics: Methods of Testing
FED-STD-595	Colors

MILITARY

DOD-STD-35	Automated Engineering Document Preparation System, Basic
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-171	Finishing of Metal and Wood Surfaces
MIL-STD-186	Protective Finishing for Army Missile Weapon Systems
MIL-STD-188-111	Interoperability and Performance Standards for Fiber Optics Communications Systems
MIL-STD-194	System for Painting and Finishing Fire-Control Material
MIL-STD-252	Classification of Visual and Mechanical Defects for Equipment, Electronic, Wired, and Other Devices
MIL-STD-403	Preparation for and Installation of Rivets and Screws, Rocket and Missile Structures
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-470	Maintainability Program for Systems and Equipment
MIL-STD-490	Specification Practices
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production
MIL-STD-810	Environmental Test Methods and Engineering Guidelines

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MIL-STD-882	System Safety Program Requirements
MIL-STD-883	Test Methods and Procedures for Microelectronics
MIL-STD-965	Parts Control Program
MIL-STD-1131	Storage Shelf Life and Reforming Procedures for Aluminum Electrolytic Fixed Capacitors
MIL-STD-1189	Standard Department of Defense Bar Code Symbology
MIL-STD-1250	Corrosion Prevention and Deterioration Control in Electronic Components and Assemblies
MIL-STD-1316	Fuze Design, Safety Criteria for
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MIL-STD-1512	Electroexplosive Subsystems, Electrically Initiated, Design Requirements and Test Methods
MIL-STD-1568	Materials and Processes for Corrosion Prevention and Control in Aerospace Weapon Systems
MIL-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices), Metric
MIL-STD-1836	Standardization and Control Program for Parts, Materials and Processes Used in Intercontinental Ballistic Missile Weapon Systems
MIL-STD-1863	Interface Designs and Dimensions for Fiber Optics Interconnection Devices
DOD-STD-1866	Soldering Process, General (Non-Electrical)
MIL-STD-2000	Standard Requirements for Soldered Electrical and Electronic Assemblies

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

2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

DEPARTMENT OF THE AIR FORCE

AFSC Pamphlet 800-27 - Parts Derating Guide

(Application for copies should be addressed to: Department of the Air Force, Headquarters, AFSC, Andrews AFB, Washington, DC 20334-5000.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

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AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 124	-	Standard Specification for Copper and Copper-Alloy Forging Rod, Bar, and Shapes
ASTM B 150	-	Standard Specification for Aluminum Bronze Rod, Bar, and Shapes
ASTM B 166	-	Standard Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, and N06690), Rod, Bar and Wire
ASTM B 168	-	Standard Specification for Nickel-Chromium-Iron Alloys (UNS N06600 and N06690), Plate, Sheet and Strip
ASTM B 169	-	Standard Specification for Aluminum Bronze, Plate, Sheet, Strip and Rolled Bar
ASTM B 196	-	Standard Specification for Copper Beryllium Alloy Rod and Bar [Metric]
ASTM B 283	-	Standard Specification for Copper and Copper-Alloy Die Forgings (Hot Pressed)
ASTM C 1036	-	Standard Specification for Flat Glass
ASTM D 1055	-	Standard Specification for Flexible Cellular Materials - Latex Foam
ASTM D 1056	-	Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM D 1565	-	Standard Specification for Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (Open-Cell Foam)
ASTM D 1667	-	Standard Specification for Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (Closed-Cell Foam)
ASTM D 3574	-	Standard Methods of Testing Flexible Cellular Materials - Slab, Bonded, and Molded Urethane Foams

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

(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.)

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

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3. DEFINITIONS

3.1 Effective voltage. Effective voltage is obtained by dividing the ac voltage by 1.414.

3.2 Equipment failure. An equipment failure is the cessation of the ability to meet minimum performance requirements of the equipment specifications. Further, equipment failure shall imply that the minimum specified performance cannot be restored through permissible adjustment of operator controls.

3.3 Critical materials. Those materials vital to national defense, the main source of which is within the continental limits of the United States, which may not be produced in quality and quantity sufficient to meet requirements.

3.4 Strategic materials. Those materials vital to national security because available production will not be sufficient in quality or quantity to meet requirements in time of national emergency.

3.5 Casting defects. Casting defects are defects that would cause a casting to fail, keeping a part or assembly from functioning as intended.

3.6 Piece part qualification. The entire process by which products are obtained from manufacturers, examined and tested, and then identified on a list of qualified products, is known as qualification. Testing of product compliance with specification requirements in advance of, and independent of any specific procurement action, is known as qualification testing. To establish a Qualified Products List (QPL), a specification must exist which requires qualification and sets forth the qualification examinations and tests, and also criteria for qualification retention.

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4. GENERAL REQUIREMENTS

4.1 Applicability. The requirements of this standard and documents referenced herein shall not relieve the contractor of the responsibility for complying with all equipment performance and other requirements set forth in the detail equipment specifications or contract for the particular equipment being furnished on contract (see 6.4).

4.1.1 Qualification. The equipment furnished under this standard shall be qualified in accordance with qualification requirements specified in the individual equipment and part detail specification.

4.1.1.1 Purpose of qualification. Since many specifications are based on performance requirements, the possible variations in design and quality, and the nature of the requirements and tests for certain products are such that it is impractical to procure products solely on acceptance tests without unduly delaying delivery. To assure continuous availability of products in such cases, qualification of specific products is required prior to the opening of bids on an award.

4.1.1.2 System qualification. The system or equipment qualification shall meet all of the requirements specified in the individual detail equipment specifications (see 6.4).

4.1.2 Environmental conditions. The equipment shall withstand any specified combination of environmental conditions herein without mechanical or electrical damage or degradation which will result in performance below the minimum specified by the procuring activity.

4.1.3 Qualification of materials. The production design shall be based on the use of qualified materials, consistent with the severity of the known or predicted applications. In order to provide acceptable reliability within economic feasibility, use of approved techniques such as printed circuits, miniature parts, modular and micromodular concepts and encapsulation will be considered justifiable. Maximum use shall be made of reclaimed/recycled materials to the extent possible without jeopardizing the intended use of the part or equipment.

4.1.4 Responsibility for procuring and installing parts and materials. The responsibility for procuring and installing parts and materials shall rest with the contractor, subject to the requirements specified herein.

4.1.5 Qualified standard parts, materials, and processes. Qualified standard parts (see 5.1.3), materials, and processes covered by standard documents shall be used. Where standard documents are not specified herein, selection shall be made in the following order:

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- a. Military specifications and standards and non-Government documents listed in the DODISS.
- b. Documents promulgated by national and international non-Government organizations, not adopted by the Department of Defense.
- c. Program-peculiar specifications (MIL-STD-490) and other government documents that meet contract requirements for existing data.
- d. *Company standards when allowed by contract (DOD-D-1000).*

4.1.6 Choice of standard parts and materials. As specified herein or by the procuring activity, beginning with the design phase and continuing through completion of procurement, only part types, materials, and processes qualified to military specifications, standards, and DOD-adopted industry standards will be considered acceptable items.

4.1.7 Nonstandard parts. Nonstandard parts shall be processed in accordance with MIL-STD-965 as specified in the procurement contract.

4.1.7.1 Military exception (ME) specifications. When a part or material covered by a current military specification or DOD-adopted industry standard will not meet system requirements and when specified in the contract, the procedures and requirements of DOD-STD-35, standardized military drawing (SMD), or DESC drawing shall be used to document the part or material (see 5.1.3.36 for microcircuits, semiconductor devices, and electron tubes).

4.1.7.2 Nuclear radiation environment. When equipment is required to operate in or survive a nuclear environment, use parts and materials that are radiation hard. Select and procure parts, materials, and processes per MIL-STD-1836.

4.1.8 Critical and strategic material. The use of critical and strategic material shall be held to a minimum consistent with the performance requirements of the equipment.

4.1.9 Derating of electronic parts and materials. Unless otherwise specified by the procuring activity, derating of electrical, electronic and electromechanical parts and materials shall be in accordance with AFSC Pamphlet 800-27.

4.1.10 Worse-case analysis. Unless otherwise specified by the procuring activity, a worse-case analysis shall be performed on each electrical, electronic or electromechanical piece part within the system prior to design completion.

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5. DETAILED REQUIREMENTS

5.1 Materials, parts and processes.5.1.1 Materials.

5.1.1.1 Flammable materials. The control of flammable materials shall be in accordance with Requirement 3 of MIL-STD-454. Such materials shall not be used without approval of the procuring activity.

5.1.1.2 Aluminum antiseize compound. Aluminum antiseize compound in accordance with TT-S-1732 shall be used in all threaded aluminum alloy assemblies.

5.1.1.3 Electrical tape. Fabric or textile pressure sensitive (adhesive or friction) tape shall not be used, except as specified herein. Moisture absorbing tape may be used for mechanical purposes or when included in hermetically sealed assemblies as approved by the procuring activity.

5.1.1.4 Fungus-inert materials. Materials shall be fungus-inert in compliance with Requirement 43 of MIL-STD-454.

5.1.1.5 Lubricants. All lubricants shall be in accordance with Requirement 43 of MIL-STD-454.

5.1.1.6 Adhesives. Adhesives shall be in accordance with Requirement 23 of MIL-STD-454.

5.1.1.7 Encapsulation. Unless otherwise specified by the procuring activity, encapsulation shall be accomplished in accordance with Requirement 47 of MIL-STD-454.

5.1.1.8 Fabric base materials. All fibrous materials shall be in accordance with Requirement 44 of MIL-STD-454. No cotton or linen-base materials shall be used except for mechanical applications. Such parts shall be vacuum impregnated with a varnish in accordance with MIL-V-173 and dried after machining operations are completed (see 5.1.1.8.7).

5.1.1.8.1 Fabric and thread. Fabric and thread shall conform to the following:

- a. Color. The color of fabric and thread shall be No. 34087 in accordance with FED-STD-595. For treated materials this requirement shall be met after treatment.
- b. Shrinkage. Fabric and thread shall be preshrunk or allowance shall be made for shrinkage in order to provide for satisfactory fit of the finished article after the article is immersed in water and then dried.

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5.1.1.8.2 Felt. Wool felt shall be in accordance with C-F-206 and shall be given Type III treatment in accordance with MIL-F-2312. Hair felt shall conform to MIL-F-2312 and shall be mildew-proofed as specified therein.

5.1.1.8.3 Webbing. Webbing shall be in accordance with Requirement 44 of MIL-STD-454.

5.1.1.8.4 Thread. Thread shall be in accordance with Requirement 44 of MIL-STD-454.

5.1.1.8.5 Lacing twine, tape, and straps. Lacing twine, tape and straps for cable harnesses and other applications shall conform to MIL-T-713, Type P (waxed), MIL-T-43435, and MIL-S-23190, respectively.

5.1.1.8.6 Rope. Rope shall be in accordance with T-R-605 or A-A-50057. For severe outdoor use polyamide rope shall be used, subject to the approval of the procuring activity.

5.1.1.8.7 Cotton and linen. Cotton or linen shall not be used in the form of fabric or tape except as follows:

- a. In construction of rotating electrical machinery where no other tape of sufficient mechanical strength is available.
- b. On coils or parts such as inductors, transformers, and relays where the coil is subsequently completely encapsulated and covered against moisture and fungus.

5.1.1.9 Metals. The use and selection of metals shall be in accordance with the CPC requirements of paragraph 4.1.9. Unless otherwise specified in the detailed specification for the individual equipment, applicable metal usage shall be as specified herein.

5.1.1.9.1 Aluminum alloys.

5.1.1.9.1.1 Aluminum alloy structural parts. Aluminum alloys shall meet or exceed American Society for Testing and Materials (ASTM) standards. Aluminum alloy castings shall conform to QQ-A-591, QQ-A-596 or QQ-A-601 (alloy 43 temper F, alloy 356, or alloy 195). Aluminum alloy castings for high strength and high quality applications shall conform to MIL-A-21180. Structural parts that do not need to be grounded or electrically bonded shall be anodized in accordance with MIL-A-8625 or upon procuring activity approval be coated with a chemical film in accordance with MIL-C-5541.

5.1.1.9.1.2 Aluminum alloy electrical parts. Aluminum alloy parts or assemblies used for electrical parts shall be constructed from corrosion resisting material and shall not be anodized. A chemical conversion coating in accordance with MIL-C-5541 shall be used.

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5.1.1.9.1.3 Aluminum foil. Aluminum foil shall conform to QQ-A-1876.

5.1.1.9.1.4 Aluminum pigment for paint. Aluminum pigment, powder or paste for paint shall conform to TT-P-320.

5.1.1.9.2 Brass. Brass parts and assemblies shall conform to QQ-B-613 or QQ-B-626, whichever is applicable.

5.1.1.9.3 Bronze. Bronze parts and assemblies shall conform to QQ-C-390, QQ-C-450, ASTM B 124, ASTM B 150, ASTM B 169, or ASTM B 283, whichever is applicable.

5.1.1.9.4 Copper. Copper parts and assemblies, except copper wire, shall conform to A-A-51144, QQ-C-502, QQ-C-571, QQ-C-576, QQ-C-585, QQ-C-586, QQ-C-591, QQ-N-288, or ASTM B 196, whichever is applicable.

5.1.1.9.5 Nickel alloys. Nickel alloy parts and assemblies shall conform to QQ-N-281, QQ-N-286, QQ-N-290, ASTM B 166, or ASTM B 168, whichever is applicable.

5.1.1.9.6 Ferrous alloys. Ferrous alloys shall be used in accordance with Requirement 15 of MIL-STD-454. Iron and steel alloys shall be finished in accordance with MIL-STD-171 and MIL-STD-186, except that parts shall be electroplated when functioning necessary or when paint films are subject to removal in service.

5.1.1.9.7 Other metals and alloys. As necessary, other metals and alloys shall be finished in accordance with MIL-STD-171 and MIL-STD-186 to meet the corrosion resistance requirements of the detail specification (see 6.4).

5.1.1.9.8 Finishes for metals. Unless otherwise specified in the detail specification, finishes for parts and assemblies shall conform to requirements specified in MIL-STD-171, MIL-STD-186, MIL-STD-194 or MIL-F-14072, whichever is applicable. Bright finishes shall not be used on external parts. MIL-C-46168 polyurethane paint shall be used as the top coat for exterior surfaces. MIL-C-22750 epoxy paint shall be used for the top coat for interior applications.

5.1.1.9.9 Solder. Solder, tin alloys, tin-lead alloy, and lead alloy shall conform to QQ-S-571 (see 5.1.1.21).

5.1.1.10 Paint finishes. Paint finishes shall be in accordance with MIL-STD-171 and MIL-STD-194. The colors of paints shall be in accordance with FED-STD-595. Consideration shall be given to human factors, camouflage, and standardization in the specification of paint colors in accordance with applicable requirements in MIL-STD-1472.

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5.1.1.11 Special finishes. Special finishes, or modifications of the finishes specified herein, for parts and assemblies exposed to high temperature, erosion, rocket blast, severe corrosion, special mechanical or electrical applications shall be as specified by the procuring activity.

5.1.1.12 Castings. Castings shall be in accordance with Requirement 21 of MIL-STD-454.

5.1.1.13 Rubber. Rubber materials, except cellular rubber types, used for the absorption of noise, shock or vibration, or for applications where resiliency is required, shall be in accordance with MIL-R-3065. The type, class, and grade (including suffixes) of rubber materials shall be chosen in accordance with requirements of the applications.

5.1.1.13.1 Synthetic rubber. A general purpose synthetic rubber conforming to MIL-R-6855 shall be used where resistance to oil and fuel is required. A high silicone conforming to ZZ-R-765 shall be used where resistance to high and low temperature is required.

5.1.1.13.2 Cellular rubber. Cellular rubber used for the absorption of noise, shock and vibration, or where resiliency is required, shall be in accordance with ASTM D 1055, ASTM D 1056, ASTM D 1565, ASTM D 1667, or ASTM D 3574. The type, class, and grade (including suffixes of cellular rubber) shall be chosen in accordance with application requirements.

5.1.1.13.3 Plastics. Plastic materials that are determined to be "burning" when subjected to FED-STD-406, Methods 2021, 2022, and 2023, shall be considered flammable and shall not be used.

5.1.1.13.3.1 Anti-electrostatic plastic materials. Anti-electrostatic plastic materials for dials and other transparent/translucent anti-electrostatic applications shall conform to MIL-W-80.

5.1.1.13.3.2 Plastic materials for high-frequency applications. Where frequencies higher than 100 kHz or circuit Q higher than 25 are involved or associated with circuits, the plastic materials shall conform to MIL-M-14.

5.1.1.13.3.3 Laminated thermosetting plastics. A silicone resin glass-cloth material conforming to MIL-P-997 shall be used where thermosetting plastic sheets are used for maintaining insulation of greater than one megohm or where temperatures of greater than 43 degrees Centigrade are encountered.

5.1.1.14 Ceramic material. Ceramic material, except where used as the dielectric in capacitors, shall conform to MIL-I-10; however, prior approval for the use of glass-bonded mica shall be obtained from the procuring activity. Ceramic material not used for electrical purposes may be glazed or unglazed and need not be treated. Ceramics used for electrical purposes shall be glazed. The surface of glazed ceramics shall be smooth, uniform, and free from porosity. Ceramics shall be treated in accordance with directions furnished by the manufacturer of the material where glazing is impractical; such treatments must be approved by the procuring activity.

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5.1.1.15 Glass. Glass shall be shatterproof in accordance with MIL-G-3787, Grade A, Class I, unless otherwise approved by the procuring activity. Glass used for the protection of instruments, meters, cathode ray tube faces, and for viewing dials and indicators, shall be in accordance with MIL-G-81704. Glare-proof glass shall be used when equipment to be viewed will be illuminated from an outside source.

5.1.1.15.1 Glass insulators and glass-bonded mica insulation. Glass insulators and glass-bonded mica insulation shall be in accordance with Requirement 11 of MIL-STD-454. Prior approval for the use of glass-bonded mica insulation shall be obtained from the procuring activity.

5.1.1.15.2 Glass fiber. Glass fiber materials shall not be used as the outer covering on cables, wires or other components where they may cause skin irritation to operating or maintenance personnel.

5.1.1.15.3 Optical glass and optical components. Optical glass used in the fabrication of optical components shall comply with MIL-G-174 or MIL-O-13830. Glass mirrors shall conform to MIL-M-13508 and optical filters shall be selected in accordance with MIL-F-9329.

5.1.1.15.4 Nonoptical glass. Nonoptical glass products shall conform to MIL-G-25871 or ASTM C 1036.

5.1.1.16 Insulating materials, electrical. Electrical insulating materials shall be in accordance with Requirement 11 of MIL-STD-454.

5.1.1.16.1 Arc-resistant material. Arc-resistant material used for insulation of electrical power circuits shall be in accordance with Requirement 26 of MIL-STD-454.

5.1.1.16.2 Electrical breakdown prevention. Electrical breakdown prevention shall conform to Requirement 45 of MIL-STD-454.

5.1.1.17 Nonslip coating. Platforms, steps, walkways, and other common working surfaces shall have a nonslip surface coating applied. Such coatings, as well as their methods of application, shall comply with MIL-W-5044 or MIL-W-5050. The coatings selected shall be subject to approval of the procuring activity.

5.1.1.18 Cork. Cork shall be treated with a fungus-resistant agent containing water reducible zinc naphthenate.

5.1.1.19 Wood. Unless otherwise specified, wood shall not be used except in approved component parts. When specified, solid wood shall be free from any defects that would adversely effect use of parts made of wood.

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5.1.1.19.1 Plywood. Plywood shall be Group A - (CS-35) Hardwood plywood or Group B - (PS-1) Softwood plywood, construction and industrial, in accordance with NN-P-530. Plywood shall be treated with Type A preservative for moisture and fungus resistance for interior or exterior usage, whichever is applicable, in accordance with MIL-W-18142.

5.1.1.20 Electrical wire.

5.1.1.20.1 Hookup wire. Hookup wire shall be in accordance with Requirement 20 of MIL-STD-454.

5.1.1.20.2 Magnet wire. Magnet wire shall conform to J-W-1177.

5.1.1.20.3 Wiring and cabling. Unless otherwise specified in the detail specification, wiring and cabling shall be in accordance with MIL-W-8160, MIL-E-45782, MIL-C-45224 and Requirement 69 of MIL-STD-454, as applicable.

5.1.1.20.4 Electrical connections. Crimped and wire wrapped electrical connections shall be made in accordance with Requirement 69 of MIL-STD-454.

5.1.1.21 Flux for nonelectrical joints. Flux used for the joining of parts to make a nonelectrical connection in the process of soldering shall conform to O-F-506, QQ-S-571, MIL-F-12784, or MIL-F-14256 as applicable.

5.1.2 Processes.

5.1.2.1 Soldering.

5.1.2.1.1 Soldering electrical and electronic connections. Soldering to make electrical and electronic connections to terminals, wires, cables, connectors, printed wiring boards and like parts shall conform to MIL-STD-2000. Only Types R and RMA soldering flux shall be used in manual soldering.

5.1.2.1.2 Nonelectrical joints. Mechanical soldering of nonelectrical (structural) joints shall conform to DOD-STD-1866. In no case shall DOD-STD-1866 be used for soldering electrical and electronic connections.

5.1.2.1.3 Solder splice joints. Solder splice joints shall be made in accordance with MIL-S-83519.

5.1.2.2 Brazing. Brazing of steels, copper, copper alloys, nickel alloys, aluminum, and aluminum alloys shall be in accordance with Requirement 59 of MIL-STD-454.

5.1.2.3 Welding. Welding shall be in accordance with Requirement 13 of MIL-STD-454.

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5.1.2.3.1 Cleaning after welding. Welded assemblies shall be cleaned to remove rust, scale, oxidation products, and excess flux by sandblasting, wire brushing, or other suitable means. Prior to painting, steel parts that have been arc welded or acetylene welded shall, in addition, be subjected to vat passivation or phosphoric acid etch in accordance with MIL-C-10578. Acid used for cleaning shall be completely neutralized and removed.

5.1.2.3.2 Welding process. Preheating shall be employed where distortion is likely to result from welding. Welds shall have thorough penetration and good fusion and shall be free from scabs, blisters, abnormal pock marks, and other harmful defects. Where undesirable internal stresses are likely to result from welding, welded items shall be stress-relieved. Inert-gas shielded arc welding shall be used, when practical, for welding of aluminum magnesium or stainless steel.

5.1.2.3.3 Resistance welds for electrical interconnections. Resistance welds for electrical interconnections shall be in accordance with Requirement 24 of MIL-STD-454.

5.1.2.4 Electrostatic discharge control. Electrostatic discharge control shall be in accordance with MIL-STD-1686.

5.1.2.5 Environmental stress screening. A cost effective environmental stress screening program shall be established during the development phase of the product and implemented into the production process. This shall include temperature cycling and random vibration at the component assembly and system level. This program shall allow for detection and correction of all latent defects in the product prior to customer acceptance.

5.1.2.6 Glass coating. All optical or nonoptical glass requiring anti-reflective coatings shall be treated in accordance with MIL-C-675.

5.1.3 Parts. Unless otherwise specified herein, parts for guided missile and associated tactical equipment shall be selected from a military Qualified Products List (QPL) as first priority and be of the military specification established reliability (ER) types to the maximum extent possible.

5.1.3.1 Bearings. Bearings shall be in accordance with Requirement 6 of MIL-STD-454.

5.1.3.2 Capacitors. Capacitors shall conform to Requirement 2 of MIL-STD-454. For missile and associated tactical mission essential equipment, capacitors shall be, as a minimum, established reliability (ER) failure rate level "P" for exponential or level "B" for weibul. When a capacitor used is not covered by a military specification (see 4.1.7) and a new specification or drawing is prepared, the nearest appropriate military specification for the type of capacitor shall be used as a guide and the product assurance requirements shall be specified to assure a minimum life failure rate level of 0.1% per 1,000 hours.

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5.1.3.2.1 Electrolytic capacitor warning. Where electrolytic capacitors, conforming to MIL-C-39018 or MIL-C-39006/9 or equivalent are used, either as specified herein or as approved by the procuring activity, a caution plate shall be affixed to the equipment. The caution plate shall be so conspicuously displayed as to insure that it will be seen prior to energizing the equipment. The warning plate shall be worded as follows: "WARNING ELECTROLYTIC CAPACITORS USED IN (insert name and location of chassis or equipment where capacitor is used). IF EQUIPMENT HAS BEEN STORED OR INOPERATIVE FOR A PERIOD LONGER THAN 12 MONTHS, THE CAPACITORS SHALL BE CHECKED OR REPLACED." For information on shelf life and reforming aluminum electrolytic capacitors, see MIL-STD-1131.

5.1.3.2.2 Wet electrolytic capacitors. Wet slug tantalum and aluminum electrolytic capacitors (MIL-C-39006/9 and MIL-C-39018) shall not be used without prior approval of the procuring activity. Tantalum case wet slug capacitors complying with MIL-C-39006/22 are authorized for use without prior approval of the procuring activity.

5.1.3.3 Electrical connectors. Electrical connectors shall be in accordance with Requirement 10 of MIL-STD-454.

5.1.3.4 Controls. All controls shall be in accordance with Requirement 28 of MIL-STD-454.

5.1.3.4.1 Flexible tuning shafts. Flexible tuning shafts shall be in accordance with Requirement 42 of MIL-STD-454.

5.1.3.5 Crystal units. Quartz crystal units shall be in accordance with Requirement 38 of MIL-STD-454.

5.1.3.6 Dynamotors. Dynamotors shall be in accordance with Requirement 46 of MIL-STD-454.

5.1.3.7 Circuit breakers. Circuit breakers shall be in accordance with Requirement 37 of MIL-STD-454.

5.1.3.8 Fuses and fuse holders. Fuses and fuse holders shall be in accordance with Requirement 39 of MIL-STD-454.

5.1.3.9 Gaskets. Rubber gaskets, intended to prevent leakage of petroleum products, glycol, alcohol and water, shall be made from material complying with MIL-C-6183, or MIL-R-3065. O-ring gaskets shall be in accordance with MIL-P-5315, MIL-P-5516, or MIL-P-25732.

5.1.3.10 Gears. All gears shall be in accordance with Requirement 48 of MIL-STD-454 and the detail equipment specification.

5.1.3.10.1 Heavy-duty gears. Spur, worm, and bevel gears for heavy duty drives shall be of Class FS-416 corrosion-resisting steel conforming to QQ-S-763, or of bronze conforming to MIL-B-16540.

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5.1.3.11 Telephone jacks. Telephone jacks shall be in accordance with Requirement 10 of MIL-STD-454.

5.1.3.12 Telephone plugs. Telephone plugs shall be in accordance with Requirement 10 of MIL-STD-454.

5.1.3.13 Lampholders and indicator lights. Lampholders and indicator lights shall be as specified in Requirement 50 of MIL-STD-454.

5.1.3.14 Level vials. Level vials shall conform to MIL-V-3144 and shall be centrally positioned in their holes and fastened with gypsum cement conforming to MIL-G-20098.

5.1.3.15 Electrical-indicating meters and accessories. Electrical-indicating meters and accessories shall be in conformance with Requirement 51 of MIL-STD-454.

5.1.3.15.1 Electrical-indicating meters, ruggedized. Unless otherwise specified, electrical-indicating meters shall be ruggedized sealed meters.

5.1.3.15.2 Ammeter shunts. Ammeter shunts shall be in accordance with Requirement 40 of MIL-STD-454.

5.1.3.15.3 Iron and direct current fields. Meters shall be so mounted that large masses of iron and direct current fields will not affect their operation. Iron vane type meters shall be mounted so that transformers or choke coils carrying current will not affect their operation.

5.1.3.15.4 Shielding. External thermocouple radio frequency meters, especially those carrying currents above one ampere, and the leads thereto, shall be shielded as necessary to protect the thermocouples from currents caused by stray radio frequency fields. For meters operating at high radio frequency voltage above ground, shielding shall also be provided against stray capacity currents through the meter to the panel of the equipment.

5.1.3.15.5 Scales, dials, and pointers. Unless otherwise specified in the detail specification, scales, dials, and pointers shall conform to requirements specified in MIL-STD-1472.

5.1.3.16 Electromechanical counters. Numbers shall snap into place with an upward movement of the counter drum indicating a numerical increase. The height-to-width ratio of numeral shall preferably be one-to-one. When the last digits have no operational and maintenance value, they shall be read from left to right. Large horizontal spaces between number drums, when more than three digits are displayed, shall be avoided. Mounting shall be as close to the panel surface as possible to provide maximum viewing angle and minimum shadow effects from ambient lighting.

5.1.3.17 Motors. Motors shall be in accordance with Requirement 46 of MIL-STD-454.

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5.1.3.18 Printed wiring assemblies. The attachment of parts and component mounting shall be in accordance with MIL-STD-2000. Printed circuit assemblies or printed wiring assemblies shall conform to MIL-P-55110. When documentation is prepared, MIL-STD-2000 shall be specified on the top drawing. Printed circuit boards or printed wiring boards shall be designed to allow for automatic insertion of components where packaging density or system configuration permits. The printed wiring board materials, processes and the methods used to mount leadless chip carriers on printed wiring boards shall be approved by the procuring activity.

5.1.3.19 Selenium rectifiers. Selenium rectifiers of the open-construction type shall conform to MIL-R-11050 or MIL-R-14224, whichever is applicable. Selenium rectifiers shall not be used in new design without prior approval of the procuring activity.

5.1.3.20 Relays. Relays shall be of the hermetically sealed type and shall conform to Requirement 57 of MIL-STD-454. Relays which are not of the solid state high reliability or established reliability types shall not be used without prior approval of the procuring activity.

5.1.3.21 Resistors and thermistors. Resistors and thermistors shall conform to Requirement 33 of MIL-STD-454. For missile and associated tactical mission essential equipment, resistors shall be, as a minimum, established reliability (ER) failure rate level "P". When a resistor used is not covered by a military specification (see 4.1.7) and a new specification or drawing is prepared, the nearest appropriate military specification for the type of resistor shall be used as a guide and the product assurance requirements shall be specified to assure a minimum life failure rate level of 0.1% per 1,000 hours. Variable resistors shall not be used in new design without prior approval of the procuring activity.

5.1.3.22 Rivets and riveting. Rivets shall not be used to mount parts which may require removal for maintenance of the equipment. Rivets, when used, shall conform to requirements specified in the detail specification. Riveting shall be accomplished in accordance with requirements specified in MIL-STD-403.

5.1.3.23 Shock and vibration isolators. Shock and vibration isolators shall not be used unless it is impractical to design and construct the equipment to meet the shock and vibration requirements specified in the detail equipment specification (see 6.4).

5.1.3.23.1 Design of isolators. The isolators may be of resilient material or metallic type and may employ viscous damping. The design of the isolators shall be such that failure of the resilient material will not set the supported component free.

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5.1.3.23.2 Resilient materials for isolators. The resilient material used in isolators shall be ozone resistant and capable of giving the required performance when exposed to any temperature within the range specified herein under the environmental conditions.

5.1.3.23.3 Installation of isolators. All isolators shall be readily replaceable without a major disassembly of the equipment. All electrical connections between a resilient supported component and its foundation shall be flexible. Sufficient clearance shall be provided between parts to preclude the possibility of a cushioned part striking any other part.

5.1.3.23.4 Electrical bypass of shock mounts. All shock mounted assemblies shall be electrically bypassed by a flexible bonding strap of copper at least one inch wide by 1/16 inch thick, except in such cases where a strap of this size would impair the action of the shock mount. Deviations from this requirement are subject to the approval of the procuring activity.

5.1.3.24 Springs. Springs shall be in accordance with Requirement 41 of MIL-STD-454.

5.1.3.25 Switches. Switches shall be in accordance with Requirement 58 of MIL-STD-454.

5.1.3.26 Access interlock switches. Access interlock switches shall be designed and constructed to conform to Requirement 1 of MIL-STD-454.

5.1.3.27 Servomotors, synchros, resolvers, and tachometer generators. Servomotors, synchros, resolvers, and tachometer generators shall be in accordance with Requirement 56 of MIL-STD-454.

5.1.3.28 Terminals. Terminals, boards and strips shall be in accordance with Requirement 19 of MIL-STD-454.

5.1.3.29 Transformers, inductors, and coils. Transformers, inductors and coils shall be in accordance with Requirement 14 of MIL-STD-454.

5.1.3.30 Transmission lines. Transmission lines and fittings shall be in accordance with Requirement 53 of MIL-STD-454.

5.1.3.31 Radio frequency cables. Radio frequency cables shall be in accordance with Requirement 65 of MIL-STD-454. Unless otherwise specified, cables for use in general purpose applications shall have a nominal impedance of 50 to 93 ohms.

5.1.3.32 Multiconductor cables.

5.1.3.32.1 Interconnection cables. External cables used for interconnecting fire control instruments, generator units, weapons in anti-aircraft and guided missile systems shall conform to Requirement 71 of MIL-STD-454.

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5.1.3.32.2 Internal multiconductor cables. Multiconductor cables used in electronic equipment shall be in accordance with Requirement 66 of MIL-STD-454.

5.1.3.33 Radio frequency connectors. Radio frequency connectors shall be in accordance with Requirement 10 of MIL-STD-454.

5.1.3.34 Waveguides and fittings. Waveguides and fittings shall conform to Requirement 53 of MIL-STD-454.

5.1.3.34.1 Absorbers. Absorbers shall conform to requirements specified in the detail specification of the individual equipment (see 6.4).

5.1.3.35 Directional couplers. Directional couplers shall be in accordance with Requirement 53 of MIL-STD-454.

5.1.3.36 Microcircuits, semiconductor devices and electron tubes.

5.1.3.36.1 Microcircuits. All microcircuits including customs and hybrids shall conform to Requirement 64 of MIL-STD-454. When a nonstandard microcircuit device is approved for use, and a DOD-STD-35, SMD, or DESC drawing is not available, a new drawing shall be prepared in accordance with the requirements of MIL-M-38510, Appendix F or Appendix G, as appropriate. The nearest MIL-M-38510 specification sheet shall be used as drawing preparation guide. The microcircuit group assignment of MIL-M-38510, Appendix E will be used to select the nearest applicable MIL-M-38510 specification sheet. The specification or drawing shall contain the screening, quality conformance inspection, and qualification inspection (first article test) as specified in MIL-STD-883, Methods 5004, 5005, 5008, and 5010, for Class B, and as specified in Appendix G of MIL-M-38510, as applicable to the particular part. Custom complex monolithic devices shall be subjected to the tests in MIL-STD-883, Method 5006, prior to drawing approval. Nonstandard parts in compliance with paragraph 1.2.1 of MIL-STD-883 are exempted from the first article test requirement. The microcircuits shall be procured to a percent defective allowed (PDA) of five percent, except that hybrids shall meet a PDA of ten percent, based on the post burn-in electrical measurement failures, as specified in MIL-STD-883. The specification for a nonstandard microcircuit may take exception to the MIL-M-38510 certification and country of manufacture requirements. First article test and retention of first article test shall be substituted for the qualification and retention of qualification requirements of MIL-M-38510. Only hermetically-sealed devices shall be used. The use of hybrids or custom devices shall be held to a minimum.

5.1.3.36.1.1 Hybrid microcircuits. A parts list shall be generated for each hybrid microcircuit listing each unique element and the quantity of each contained within the package. Each unique element shall be traceable to the drawing. Each unique element shall comply with the specification for that part type. Adhesives used inside hybrid microcircuits shall comply with MIL-STD-883, Method 5011.

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5.1.3.36.1.2 Discrete semiconductor and integrated circuit chips. The order of precedence in selecting discrete chips for use in hybrid or multichip microcircuits shall be as follows:

a. Chips from wafers manufactured on a government certified line and electrically probed to the same criteria used for processing dice to be fabricated as Qualified Product Listing devices.

b. Chips from wafers 100 percent electrically probed to the requirements used for the vendor's MIL-STD-883, Class B microcircuits.

c. Chips procured to a detail specification approved by the procuring activity.

5.1.3.36.1.3 Leadless chip carriers (LCC). Leadless chip carriers shall conform to the requirements of MIL-M-38510, including the package configurations of Appendix C.

5.1.3.36.1.4 Ceramic capacitor chips. Ceramic capacitor chips shall meet requirements of MIL-C-55681.

5.1.3.36.1.5 Tantalum capacitor chips. Tantalum capacitor chips shall meet in the requirements of MIL-C-55365.

5.1.3.36.1.6 Resistor chips. Chip resistors shall meet the requirements of MIL-R-55342.

5.1.3.36.1.7 Coil chips. Chip coils shall meet the requirements of MIL-C-83446.

5.1.3.36.1.8 Sealing requirements for custom or hybrid microcircuits. Hybrid microcircuits using eutectic bonding shall be vacuum baked at $150^{\circ} \pm 2^{\circ} \text{C}$ for 4 hours minimum immediately prior to sealing, and microcircuits using organic adhesives shall be vacuum baked at $150^{\circ} \text{C} \pm 2^{\circ} \text{C}$ for 16 hours minimum. The transfer from vacuum bake to dry nitrogen seal box shall be direct with no exposure to the ambient air. The dry nitrogen seal box shall have a moisture level less than 100 PPM. If a combination of prebake plus vacuum bake yields a hybrid microcircuit with less than 1,000 PPM water vapor content when tested in accordance with MIL-STD-883 Method 1018, the amount of vacuum bake required may be reduced.

5.1.3.36.2 Semiconductor devices. Semiconductor devices, including light-emitting diodes, shall comply with Requirement 30 of MIL-STD-454. All semiconductor devices shall be JANTX, JANTXV or JANS types. All nonstandard (non-JAN) semiconductors shall comply with MIL-S-19500 for JANTX devices except requirements associated with placement of a part on the qualified part list (QPL) are deleted. Only hermetically-sealed semiconductors shall be used. When a required device is not covered by MIL-S-19500 and a new drawing is prepared (see 4.1.7), the nearest appropriate MIL-S-19500 specification sheet shall be used as a guide.

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5.1.3.36.3 Electron tubes. Electron tubes shall be in accordance with Requirement 29 of MIL-STD-454.

5.1.3.36.4 Equipment using electron tubes, semiconductors and microcircuits. Equipment using electron tubes semiconductors, microcircuits or any combination of these devices shall be furnished with a complete set of devices installed or mounted in its operating socket or permanently affixed operating position. These devices shall be the ones used in testing the equipment and each device shall remain as previously mounted or affixed.

5.1.3.36.5 Electron tube, semiconductor and microcircuit selection. The equipment shall be so designed that it will conform to all requirements without special tube, semiconductor or microcircuit selection.

5.1.3.36.6 Current regulating devices. Current regulating devices of the nonelectron type shall conform to MIL-R-3080.

5.1.3.36.7 Electron tube, semiconductor and microcircuit complement report. The complement of electron tube, semiconductor devices, and microcircuits used in the equipment design shall be reported in accordance with the requirements of the procuring activity (see 6.3).

5.1.3.36.8 Sockets, tube shields, parts and tube clamps. Sockets, tube shields, parts, and tube clamps shall be in accordance with Requirement 60 of MIL-STD-454.

5.1.3.36.9 Filament and heater connections. Electron tube heaters or filaments shall be so connected that the removal of any one tube does not change the filament voltage of any other tube more than 20 percent.

5.1.3.37 Fastener hardware. Fastener hardware shall be in accordance with Requirement 12 of MIL-STD-454.

5.1.3.37.1 Color of fastening and assembly screws. External fastening and assembly screws which are loosened, removed, or otherwise manipulated in normal process of installing and servicing shall be of a color providing a strong contrast with the background surface or of a type which makes them easily distinguishable from any other screws, unless equipment requires camouflaging for concealment.

5.1.3.38 Low-capacitance cable. Low-capacitance electrical cable shall be Type WS conforming to MIL-C-3883.

5.1.3.38.1 Cable derating. Power cable shall be derated for the operating ambient temperature in excess of 30° C which is the usual ambient on which cable manufacturers rate the current-carrying capacity of cables. The American Wire Gage of the copper conductor shall be chosen to provide the required current-carrying capacity at the elevated ambient temperature. The correction factors shall be those recommended by the cable manufacturer.

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5.1.3.39 Tuning dial mechanisms. Tuning dial mechanisms shall be in accordance with Requirement 42 of MIL-STD-454.

5.1.3.40 Readouts. Readouts for indicating alphanumeric or symbolic information shall be in accordance with Requirement 68 of MIL-STD-454.

5.1.3.41 Electrical filters. Electrical filters shall be in accordance with Requirement 70 of MIL-STD-454.

5.1.3.42 Batteries. Batteries shall be in accordance with Requirement 27 of MIL-STD-454.

5.1.3.43 Standard electronic modules. Standard electronic modules shall be in accordance with Requirement 73 of MIL-STD-454.

5.1.3.44 Fiber optics. Optical fibers to be used for signal transmission shall comply with MIL-F-49291. Fiber optic systems and subsystems designs shall be in accordance with the criteria specified in MIL-STD-188/111. Standard interface designs, dimensions, and termination types for fiber optic connectors shall be as specified in MIL-STD-1863.

5.2 Maintainability.

5.2.1 Design criteria. Physical design for maintainability shall be in accordance with Requirement 103, MIL-STD-2084, except those portions of the third and fourth sentences of paragraph 4.1 pertaining to weights of WRA's shall be disregarded. Weight limitations shall be governed by MIL-STD-1472.

5.2.2 Built-in-test (BIT). Criteria for design and application of built-in-test (BIT) shall be in accordance with Requirement 104, MIL-STD-2084.

5.2.3 Reliability and maintainability. Reliability and maintainability shall be specified in MIL-STD-785 and MIL-STD-470. Quantitative reliability and maintainability requirements shall be specified in the contract and the end item system requirement specification.

5.2.4 Operation and maintenance.

5.2.4.1 Ease of operation. Unless otherwise specified in the detail specification, operating controls shall conform to Requirement 28 of MIL-STD-454.

5.2.4.2 Ease of adjustment and maintenance. The equipment shall be so constructed that all parts, terminals and wiring (other than encapsulated or hermetically sealed modules) are accessible for circuit checking, adjustment, maintenance, and repair with a minimum of disturbance to other parts and with a minimum number and variety of tools. Adjustments required shall be the minimum consistent with required performance. If sequential adjustments are

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required, the adjustments shall be marked with a symbol to designate the order of adjustments. Harmonizing or mop-up of adjustments (where, for example, after "A", "B", and "C" are all adjusted, "A" must be readjusted) shall be avoided unless the equipment is greatly simplified by having such adjustments. All adjustments shall contain the following features:

- a. Under nominal service conditions, optimum adjustment shall fall within the center fifty percent of the adjustment range.
- b. Under any probable combination of service conditions, optimum adjustment shall fall within the center eighty percent of the adjustment range.
- c. Under any known combination of service conditions, optimum adjustment shall fall within the center ninety percent of the adjustment range.
- d. All adjustments shall contain a simple reliable locking device, which does not change adjustment settings. The preferred type of locking device shall be one which is manually operated.

5.2.4.3 Interchangeability. Interchangeability shall be in accordance with paragraph 5.2.1 and Requirements 7 and 12 of MIL-STD-454.

5.2.4.4 Chassis protection. When a chassis, module, or subassembly is removed from its normal rack position or housing, it shall be possible to place the chassis, module, or subassembly on any side, except front and rear, on a smooth surface without causing damage to any of its components. It shall be possible to operate the chassis, module, or subassembly when removed from its housing by using extender cables which shall be not greater than two feet in length. Chassis shall be of rugged construction for protection against rough handling as experienced in field operations.

5.2.4.5 Closed loop circuits. Closed loop circuits shall be so designed that external test equipment can be inserted for routine maintenance and diagnostic purposes.

5.2.4.6 Power supplies. All low voltage regulated power supplies shall have easily removable regulator subassemblies. Wherever possible, power supplies shall be capable of the following:

- a. Continuous twenty percent overload under normal operating conditions, where normal current is taken as the maximum current at nominal input voltages, with favorable conditions of adjustments, and part(s) or component tolerances.
- b. Continuous twenty percent overload at ten percent less than the nominal source voltage and five percent less than the source frequency.

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5.2.5 Human engineering. Unless otherwise specified in the detail specification, human engineering shall be in accordance with applicable provisions of MIL-STD-1472.

5.2.6 Safety and protective devices. Safety and protective devices for personnel shall be in accordance with Requirement 1 of MIL-STD-454. Safety and protective devices for equipment shall be in accordance with MIL-STD-882.

5.2.6.1 Explosion proofing (explosion-proof and dust ignition-proof). Equipment that will be exposed to an explosive concentration of gases, vapors, or dust shall be made explosive-proof or dust ignition-proof, as applicable during normal and abnormal operations. (Abnormal operations include rupture of containers or failure of ventilation systems.) Equipment which produces arcing or sparking in normal operations shall be totally enclosed or effectively isolated from solid explosives even though flammable gases, vapors, or dust, may not be present in the atmosphere of the specific gas, vapor, or dust involved, shall be tested to assure safe performance in the hazardous atmosphere. The agency responsible for the design of the equipment shall specify the test method to be used after approval by the procuring activity (see 6.3). The explosion-proof or dust ignition-proof requirements of this paragraph are not applicable to missile electronic test equipment or missiles with liquid propulsion or liquid power systems unless so designated by the procuring activity.

5.2.6.2 Electroexplosives. The design of electroexplosive subsystems and fuzes shall be in accordance with MIL-STD-1512 and MIL-STD-1316, respectively.

5.2.7 Electrical overload protection. Electrical overload protection for electrical and electronic equipment shall be in accordance with the applicable class of Requirements 8 of MIL-STD-454.

5.2.7.1 Corona prevention. Corona discharge shall be in accordance with Requirement 45 of MIL-STD-454.

5.2.7.2 Time delay devices. Time delay devices of a type approved by the procuring activity shall be incorporated where necessary for the protection of the equipment.

5.2.8 Interference suppression. Interference suppression shall be in accordance with Requirement 61 of MIL-STD-454.

5.2.8.1 Anti-jamming. The electronic systems or equipment shall be designed for maximum protection against possible interfering signals due to enemy jamming, inadvertent radio interference, and atmospherics, as prescribed by the procuring agency.

5.2.8.2 Electromagnetic interference control. Electromagnetic interference control shall be in accordance with Requirement 61 of MIL-STD-454.

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5.2.8.3 Electromagnetic environmental control. Electromagnetic environment control shall be compatible with the systems requirement in MIL-E-6051.

5.2.9 Run-time indicators. Run-time indicators shall be installed in each piece of equipment that has a mean-time-between-failure (MTBF) requirement or as required by the detail equipment specifications (see 6.4).

5.2.10 Removable covers. Front panels or removable cover plates shall employ captive type screws or similar devices for retention. The captive fasteners shall employ slotted heads or knurled and slotted heads and shall be designed to be capable of definitive individual loosening prior to movement of the part to which they are captive. Design and construction shall be such as to provide for their self-alignment with their retaining nuts, blocks, or inserts without sticking and without damage to their threads. A chain shall be used on removable covers for which no convenient location for depositing the cover is expected to be available during maintenance. Captive fasteners shall be painted or otherwise marked in a conspicuous manner to effect high visual contrast with the removable cover unless equipment requires camouflaging for concealment. Access covers and panels shall be interlocked in accordance with Requirement 1 of MIL-STD-454.

5.2.11 Cooling. Adequate means shall be employed to maintain parts within their maximum permissible operating temperature under all operating conditions. Exhaust fans and blowers shall be designed for operation from the applicable ac power supply if possible (see 5.2.16).

5.2.12 Moisture pockets. Control of moisture pockets shall be in accordance with Requirements 31 of MIL-STD-454.

5.2.13 Test equipment. New test equipment shall be designed in accordance with MIL-T-28800.

5.2.13.1 External test equipment. The equipment shall be designed to provide for connections for such test equipment as may be required for its installation, maintenance, calibration and repair. The equipment shall be designed in such a manner as to permit the use of test equipment generally available to the Armed Services to accomplish all necessary tests.

5.2.13.2 Test points. Criteria for design and application of test points shall be in accordance with 5.2.2.

5.2.13.3 Built-in test (BIT) equipment. The BIT equipment shall be incorporated to the fullest practicable extent to permit monitoring of performance on a go/no-go basis. Techniques shall be included for assessment of overall performance of the entire equipment. The BIT equipment shall enable rapid assessment of performance by semi-skilled personnel. Checking techniques which provide information regarding anticipated failure shall be

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incorporated to the fullest extent possible. The BIT equipment shall enable test and evaluation of all modules and plug-in components except electron tubes and transistors. Modules aligned while operating with inputs from BIT equipment shall not require realignment when installed in their proper position within the operating equipment.

5.2.13.4 Accuracy. When test instruments are built into equipment, they shall be required to maintain their accuracy under all electrical, mechanical and other environmental conditions to which the equipment may be subjected.

5.2.13.5 Accessibility (test points and terminals). Access to test points and terminals of each article of equipment for required circuit checking shall be in accordance with Requirement 36 of MIL-STD-454.

5.2.14 Tools.

5.2.14.1 Standard tools. Requirements as to type and quantity of standard tools for use with the equipment shall be kept to a minimum.

5.2.14.2 Special tools. Special tools shall be in accordance with Requirement 63 of MIL-STD-454.

5.2.15 Tropicalization. Tropicalization for protection against moisture and fungus shall be accomplished by conforming to MIL-T-152 and requirements specified in the detail specification for the equipment. The detail specification shall specify either Type I or II treatments and identify the parts or assemblies that require treatment (see 6.4).

5.2.16 Electrical power source. Electrical power sources shall be in accordance with Requirement 25 of MIL-STD-454.

5.2.17 Thermal design. Thermal design shall conform to Requirement 52 of MIL-STD-454 (see 5.2.II).

5.2.18 Enclosures. Enclosures for electric and electronic equipment shall be in accordance with Requirement 55 of MIL-STD-454.

5.2.19 Hydraulics. The design and installation of hydraulic systems shall be in accordance with Requirement 49 of MIL-STD-454 or as specified in the detail specification (see 6.4).

5.2.20 Grounding, bonding, and shielding. Unless otherwise specified by the procuring activity, ground, bonding, and shielding shall be in accordance with Requirement 74 of MIL-STD-454.

5.2.20.1 Single point grounding. To minimize degradation of performance and safety caused by circulating ground currents, each missile system shall use a single point grounding system in which the various ground planes (power, signal, earth, etc.) are electrically connected at only one point.

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5.2.21 Substitutability. Unless otherwise specified by the procuring activity, substitutability of parts shall be in accordance with Requirement 72 of MIL-STD-454.

5.3 Environmental.

5.3.1 Corrosion prevention and control (CPC). Unless otherwise specified by the procuring activity, corrosion prevention and control shall be in accordance with MIL-STD-186, MIL-STD-1568, and MIL-STD-1250.

5.3.1.1 CPC design prohibitions. The following design practices are not acceptable:

- a. Crevices susceptible to moisture collection.
- b. Unsealed fasteners.
- c. Galvanic metal couples with over 100 mV potential difference.
- d. Printed circuit assemblies without conformal coating.
- e. Moisture tight designs without proper seals.
- f. Unprotected bearings.
- g. Untested adhesively bonded designs (stress and humidity tests).
- h. Metallic construction if nonmetallic is acceptable.
- i. Hardware requiring field maintenance for corrosion control.

5.3.1.2 CPC materials prohibitions. The following materials are not acceptable:

- a. Aluminum alloys 2024-T3 or T4; use T8 or 5000/6000 series.
- b. Aluminum alloys 7075-T6; use 7075-T73, 7175-T7, or 7050 series.
- c. Magnesium.
- d. Precipitation hardened steels in H900, H950, or H1100 tempers.
- e. Graphite lubricants.
- f. PVC and PVF plastics.
- g. Corrosive type RTV (yields acetic acid during cure).
- h. Rubber that is susceptible to ozone damage.
- i. Teflon insulated, silver plated wire (red plague).
- j. Class 3 conversion coating on aluminum.
- k. Type I cadmium plating.
- l. Gold plated electrical contacts without nickel undercoating.
- m. Silver plated electrical contacts.
- n. Potting and foam material that are reversion prone.
- o. Bare corrodible metal surface.
- p. Materials that are not inherently moisture and fungus resistant.
- q. Nickel plated aluminum constructions.

5.3.2 Protection against electrolytic corrosion. Where it is necessary for any combination of dissimilar metals to be assembled, they shall be selected and protected in accordance with Requirement 16 of MIL-STD-454, MIL-STD-171, MIL-STD-186 and MIL-STD-1250, as applicable.

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5.3.3 Altitude. Unless otherwise specified in the detail specification, the equipment shall be capable of withstanding, without discernible damage to the equipment, the applicable test specified in MIL-STD-810, Method 500, Low Pressure.

5.3.3.1 Pressurization. Whenever pressurization of the electronic equipment is required by the detailed specification, the following provisions shall be met:

- a. The case shall have sufficient strength to withstand the applicable pressure differences. A means shall be provided for determining the effectiveness of the seal. This may consist of a suitable fitting to permit use of an air pump for increasing the pressure approximately 5 pounds per square inch above sea level pressure.
- b. The case shall be of a type that will permit ready opening and clearing for access to the equipment for repair and maintenance. The equipment shall be completely operable after removal from the case, and alignment shall be unaffected by replacement in the case.
- c. When possible and advantageous, external points shall be provided for checks without removing equipment from the case.
- d. Sealing instructions shall be placed on one side of the case.
- e. Pressurized equipment shall be capable of withstanding pressures developed under external operating conditions, after initial pressurization on the ground, so no arcing, or loss of power due to corona, occurs at more than 5 pounds per square inch gage (psig) at -20° C to 50° C.
- f. Unless specified or permitted in the detail specification, pressure shall be maintained without the need for a pressurization pump.

5.3.4 Temperature. Unless otherwise specified in the detail specification, the equipment shall be capable of operating under and withstanding, without discernible damage to the equipment, the applicable test specified in MIL-STD-810, Method 501, High Temperature, and Method 502, Low Temperature.

5.3.5 Relative humidity. Unless otherwise specified in the detail specification, the equipment shall be capable of operating under and withstanding, without discernible damage to the equipment, the applicable test specified in MIL-STD-810, Method 507, Humidity.

5.3.6 Dust and sand. Unless otherwise specified in the detail specification, the equipment shall be capable of operating under and withstanding, without discernible damage to the equipment, the applicable test specified in MIL-STD-810, Method 510, Dust.

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5.3.7 Salt-laden air. Unless otherwise specified in the detail specification, the equipment shall be capable of operating under and withstanding, without discernible damage to the equipment, the applicable test specified in MIL-STD-810, Method 509, Salt Fog.

5.3.8 Rainfall. Unless otherwise specified in the detail specification, the equipment shall be capable of operating under and withstanding, without discernible damage to the equipment, the applicable test specified in MIL-STD-810, Method 506, Rain.

5.3.9 Wind and ice load. Unless otherwise specified in the detail specification, the equipment shall be capable of operating under and withstanding, without discernible damage to the equipment, the applicable test specified in MIL-STD-810, Method 521, Icing/Freezing Rain.

5.3.10 Insects and rodents. The equipment shall be adequately protected to assure positive prevention of any damage that can be caused by insects and rodents.

5.3.11 Fungus. The equipment shall not be damaged nor shall its performance be impaired when subjected to the fungus supporting tests specified in MIL-STD-810, Method 508, Fungus.

5.3.12 Mechanical.

5.3.12.1 Vibration. Unless otherwise specified in the detail specification, the equipment shall be capable of operating under and withstanding, without discernible damage to the equipment, the applicable test specified in MIL-STD-810, Method 514, Vibration.

5.3.12.2 Acceleration. When otherwise specified in the detail specification, the equipment shall be capable of operating under and withstanding, without discernible damage to the equipment, the applicable test specified in MIL-STD-810, Method 513, Acceleration.

5.3.12.3 Shock. Unless otherwise specified in the detail specification, the equipment shall be capable of operating under and withstanding, without discernible damage to the equipment, the applicable test specified in MIL-STD-810, Method 516, Shock.

5.3.13 Orientation. When the equipment is to be operated on sandy, muddy, or frozen terrain, it shall be capable of being leveled on slopes up to 10 degrees when required to accomplish the specified operation.

5.4 Marking.

5.4.1 Identification. Unless otherwise specified in the detail specification, equipment, assemblies, and parts shall be marked for identification in accordance with Requirement 67 of MIL-STD-454.

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5.4.1.1 Hookup wire identification. Hookup wire identification shall be in accordance with Requirement 20 of MIL-STD-454.

5.4.1.2 Bar codes. Marking of bar code symbology shall be in accordance with MIL-STD-1189. Bar codes shall be applied to all classified, warranted or serialized items. Bar code marking data shall include contract number, part number, CAGE code, and serial or lot number. Other marking data, as required by contract or order, may be included in the bar code.

5.4.2 Marking for shipment. Unless otherwise specified in the detail specification of the equipment, marking for shipment shall conform to MIL-STD-129.

5.4.3 Nomenclature. Nomenclature shall be in accordance with Requirement 34 of MIL-STD-454 and as specified in the contract.

5.4.3.1 Mounting of labels and nameplates. Labels and nameplates shall be securely and permanently mounted by adhesives, screws or rivets (whichever is applicable) that will not stain the labels under specified environmental conditions. They shall be mounted so they are not obstructed from view by units or parts.

5.4.4 Reference designations. Reference designations shall be in accordance with Requirement 67 of MIL-STD-454.

5.4.5 Battery circuits. Components designed to operate from internal batteries shall be marked with the following 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.

5.4.6 Luminescent marking. Luminescent marking shall conform to MIL-L-3891.

5.5 Workmanship. Workmanship shall be in accordance with Requirement 9 of MIL-STD-454. Visual and mechanical defects shall be in accordance with MIL-STD-252.

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6. NOTES

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

6.1 Intended use. This standard is intended for use in standardizing requirements for electronic, electrical and electromechanical equipment that are common to guided missile and associated weapon systems.

6.2 Issue of DODISS. When this standard is used in acquisition, the applicable issue of the DODISS must be cited in the solicitation (see 2.1.1, and 2.2).

6.3 Consideration of data requirements. The following data requirements should be considered when this standard is applied on a contract. The applicable Data Item Description (DID's) should be reviewed in conjunction with the specific acquisition to ensure that only essential data are requested/provided and that the DID's are tailored to reflect the requirements of the specific acquisition. To ensure correct contractual application of the data requirements, a Contract Data Requirements List (DD Form 1423) must be prepared to obtain the data, except where DOD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423.

<u>Reference Paragraph</u>	<u>DID Number</u>	<u>DID Title</u>	<u>Suggested Tailoring</u>
5.1.3.36.7	DI-T-2072	Reports, Test	
5.2.6.1	DI-MISC-80731	Contractor Test Plans/ Procedures	

The above DID's were those cleared as of the date of this standard. The current issue of DOD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSOL), must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.

6.4 Detail equipment specifications. Since this standard covers only the general requirements for materials, parts, processes, design and construction, detail equipment specifications, drawings, contracts or orders should specify the actual requirements from the multiple choices or exceptions available herein.

6.5 CAUTION. Certain chemicals have been identified in the Occupational Safety and Health Act (OSHA) as cancer-producing substances (carcinogens). Before using any materials which might contain these chemicals, they should be evaluated in accordance with the Code of Federal Regulations, Title 29, Chapter XVII, Part 1910, Subpart Z.

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6.6 Subject term (keyword) listing.

Alloys, metal
Cables, electrical
Cables, radio frequency
Chassis protection
Circuit breakers
Connectors, electrical
Counters, electromechanical
Crystal units
Directional couplers
Dynamotors
Electromagnetic interference control
Electromechanical equipment, design of
Electron tubes
Electronic equipment, design of
Electrostatic discharge control
Guided missile systems, design of
Inductors
Insulating materials, electrical
Isolators, shock and vibration
Meters, electrical
Microcircuits
Module, electronic
Printed wiring assemblies
Resolvers
Semiconductor devices
Servo motors
Synchros
Tachometer generators
Time delay devices
Transformers
Transmission lines
Vibrators
Waveguide
Wire, electrical

6.7 Metrickation. Wherever inch/pound dimensions are used in this document, metric equivalents in accordance with FED-STD-376 shall be acceptable.

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3. DOCUMENT TITLE ELECTRICAL, ELECTRONIC, AND ELECTRO-MECHANICAL EQUIPMENT, GUIDED MISSILE AND ASSOCIATED WEAPON SYSTEMS, GENERAL STANDARD FOR THE DESIGN OF			
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