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STANDARD GENERAL REQUIREMENTS FOR ELECTRONIC EQUIPMENT

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DEPARTMENT OF DEFENSE

Washington DC 20360

Standard General Requirements for Electronic Equipment

MIL-STD-454N

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

*2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to Defense Electronics Supply Center, ATTN: DESC-EPE, Dayton, OH 45444-5270, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

*FOREWORD

This standard is the technical baseline for the design and construction of electronic equipment for the Department of Defense. It captures in one document, under suitable subject headings, fundamental design requirements for eleven general electronic specifications. The opportunity to focus on a single document, afforded to contractors, results in substantial savings to the Government. This standard was prepared and is semiannually updated through the cooperative efforts of Government and industry. The following Government documents are intimately associated with this standard:

MIL-I-983	Interior Communication Equipment, Naval Shipboard, Basic Design Requirements for (Not for New Design)
MIL-E-4158	Electronic Equipment, Ground, General Specification for
MIL-E-5400	Electronic Equipment, Aerospace, General Specification for
MIL-E-8189	Electronic Equipment, Missiles, Boosters and Allied Vehicles, General Specification for (Not for New Design)
DOD-E-8983	Electronic Equipment, Aerospace, Extended Space Environment, General Specification for
MIL-P-11268	Parts, Materials, and Processes Used in Electronic Equipment
MIL-E-11991	Electronic, Electrical and Electromechanical Equipment, Guided Missile and Associated Weapon Systems, General Specification for
MIL-F-18870	Fire Control Equipment, Naval Shipboard, General Specification for
MIL-T-21200	Test Equipment for Use with Electronic and Electrical Equipment, General Specification for (Not for New Design)
MIL-T-28800	Test Equipment for Use with Electrical and Electronic Equipment, General Specification for

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STANDARD GENERAL REQUIREMENTS FOR ELECTRONIC EQUIPMENT

1. SCOPE

1.1 Requirements applicable to electronic equipment. This standard covers the common requirements to be used in military specifications for electronic equipment.

1.2 Revision of requirements. Revisions of individual requirements are indicated by a date below the requirement number located at the bottom of the page. A note, #Supersedes Requirement (no.) (date)", is placed in the lower corner of each revised page, opposite the requirement number and date. When the basic document is revised, those requirements not affected by change retain their existing date.

*1.2.1 Redating. Although individual requirements are reviewed and updated or validated at least once every twelve months, requirements are not redated unless technical changes are made.

*1.3. Method of reference. This standard shall not be invoked on a blanket basis. Rather each requirement contained herein shall be referenced in the individual specification by specifying this standard and the requirement number.

1.4 Interrelationship of requirements. Each requirement is intended to cover some discipline in the design of equipment, such as a procedure, a process or the selection and application of parts and materials. Many of these disciplines, however, cannot retain a clear-cut separation or isolation from others so that when requirements of MIL-STD-454 are referenced in a specification some requirements will undoubtedly have a direct interrelationship with other requirements. This interrelationship should be taken into consideration when invoking or using these requirements.

2. APPLICABLE DOCUMENTS

2.1 Individual Requirements. See paragraph 2 of each individual requirement for a listing of applicable documents contained therein, including those for guidance only. Documents referenced in the individual requirements apply to the extent specified therein.

2.1.1 Applicable issues. Unless otherwise specified, the applicable issues shall be those listed in that issue of the Department of Defense Index of Specifications and Standards (DODISS) specified in the solicitation. The applicable issue of nongovernment documents shall be the issue specified.

2.1.2 Copies. Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.

*2.1.3 Industry addresses. Addresses for obtaining documents referenced herein but not obtainable from the Government are as follows:

AGMA American Gear Manufacturers Association
1500 King Street
Suite 201
Arlington VA 22314

AMS Society of Automotive Engineers (SAE)
400 Commonwealth Drive
Warrendale PA 15096

ANSI American National Standards Institute
11 West 42nd Street
New York NY 10036

ASM American Society for Metals
Metals Park OH 44073

ASTM American Society for Testing and Materials
1916 Race Street
Philadelphia PA 19103

AWS American Welding Society
550 N W LeJeune Road
PO Box 351040
Miami FL 33135

EIA Electronic Industries Association
2001 Pennsylvania Ave, NW
Washington DC 20006

IEEE Institute of Electrical and Electronics Engineers
IEEE Service Center
445 Hoes Lane PO Box 1331
Piscataway, NJ 08855-1331

IPC Institute for Interconnecting and Packaging Electronic Circuits
7380 North Lincoln Avenue
Lincolnwood IL 60646-1776

NAS National Standards Association
1200 Quince Orchard Boulevard
Gaithersburg MD 20878

NFPA National Fire Protection Association
Battery March Park
Quincy MA 02269

UL Underwriters Laboratories, Incorporated
333 Pfingsten
Road Northbrook IL 60062-2096

3. DEFINITIONS

3.1 As used in this standard, the word "airborne" denotes those applications peculiar to aircraft and missile or other systems designed for operation primarily within the earth's atmosphere; "space" denotes application peculiar to spacecraft and systems designed for operation near or beyond the upper reaches of the earth's atmosphere; and "aerospace" includes both airborne and space applications.

3.2 Other terms are defined in the individual Requirements.

4. GENERAL REQUIREMENTS

4.1 Application. The Requirements contained herein are intended to provide uniform requirements applicable to electronic equipment, unless otherwise specified in the Requirement, and shall be incorporated by reference in general equipment specifications. Other documents may reference Requirements when applicable.

4.2 Use of selection and application standards. When a selection and application standard is invoked in a Requirement, the devices or parts selected shall conform to the applicable military specifications referenced in the standard.

5. DETAIL REQUIREMENTS

5.1 Individual Requirements for electronic equipment follow.

6. NOTES

6.1 The margins of this standard are marked with asterisks to indicate where changes (additions, modifications, corrections, deletions) from the previous issue were made. This is done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these

notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

6.2 Subject term (key word) listing.

Cable selection	Nomenclature
Corona protection	Parts selection
Encapsulation	Printed wiring
Fasteners	Safety
Flammability	Soldering
Fungus protection	Substitutability of parts
Interchangeability of parts	Thermal design
Marking	Waveguides
Materials selection	Wire selection
Microelectronics	Workmanship

Custodians:
Army - ER
Navy - AS
Air Force - 11

Review activities:
Army - AR, AV, CR, ME, MI, PT, TE
Navy - EC, SH, OS
Air Force - 17, 19, 85, 99

Other:
DLA - ES
FAA

Preparing activity:
Air Force - 10

Agent:
DLA - ES

Project GDRQ-0119

REQUIREMENT 1

SAFETY DESIGN CRITERIA - PERSONNEL HAZARDS

1. Purpose. This requirement establishes safety design criteria and provides guidelines for personnel protection.

2. Documents applicable to Requirement 1:

MIL-B-5087	Bonding, Electrical, and Lightning Protection, for Aerospace Systems
MIL-STD-1310	Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety Shielding
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MIL-HDBK-600	Guidelines for Identification, Markings, Labeling, Storage, and Transportation of Radioactive Commodities
ANSI C95.1-1982	Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 KHz to 100 GHz
ANSI C95.2-1982	Radio Frequency Radiation Hazard Warning Symbol
ANSI N2.1-1969	Radiation Symbol
ANSI Z35.1-1972	Accident Prevention Signs, Specification for
ANSI Z35.2-1968	Accident Prevention Tags, Specification for
ANSI Z35.4-1973	Specification for Informational Signs Complementary to ANSI Z35.1, Accident Prevention Signs
ANSI Z53.1-1979	Marking Physical Hazards, Safety Color Code for
NFPA 70-1990	National Electrical Code
10 CFR 20	Code of Federal Regulations, Title 10, Chapter I, Part 20
21 CFR 1000-1050	Code of Federal Regulations, Title 21, Chapter I, Parts 1000-1050
29 CFR 1910	Code of Federal Regulations, Title 29, Chapter XVII, Part 1910

3. Definitions

3.1 Chassis, electrical equipment. The chassis is a structural item fabricated in such manner as to facilitate assemblage and interconnection of electrical or electronic items for the specific purpose of providing a basis for electrical or electronic circuits. It normally has drilled or stamped holes to accommodate the items but may include only the items necessary for its own mounting and support.

3.2 Frame. The frame is any construction system fitted and united together, designed for mounting or supporting electrical or electronic parts or units.

3.3 Fail-safe. The design feature of a part, unit or equipment which allows the item to fail only into a non-hazardous mode.

3.4 Interlock. An interlock is an automatic switch which eliminates all power from the equipment when an access door, cover or plate is removed.

3.4.1 Bypassable interlock. A bypassable interlock is an automatic switch with a manually operated electrical bypass device to allow equipment maintenance operations on energized equipment.

3.5 Battleshort. A switch used to bypass normal interlocks in mission critical equipment (i.e., equipment which must not be shut down or the mission function will fail) during battle conditions.

4. Requirements

4.1 Fail-safe. The design and development of all military electronic equipment shall provide fail-safe features for safety of personnel during the installation, operation, maintenance, and repair or interchanging of a complete equipment assembly or component parts thereof.

4.2 Bonding in hazardous areas. Electronic equipment to be installed in areas where explosive or fire hazards exist shall be bonded in accordance with MIL-B-5087 for aerospace systems, MIL-STD-1310 for shipboard systems, and NFPA 70, Chapter 5, for ground systems, or as otherwise specified in the detail equipment specification.

4.3 Temperature. At an ambient temperature of 25°C, the operating temperature of control panels and operating controls shall not exceed 49°C. Other exposed parts subject to contact by operating personnel shall not exceed 60°C.

4.4 Electrical. The design shall incorporate methods to protect personnel from inadvertent contact with voltages capable of producing shock hazards.

4.4.1 Power. Means shall be provided so that power may be cut off while installing, replacing, or interchanging a complete equipment, assembly, or part thereof. Interface with electrical power sources shall be in accordance with the applicable regulations or requirements. If a main power switch is provided, it shall be clearly labeled as such and shall cut off all power to the complete equipment.

4.4.2 Ground. The design and construction of equipment, excluding self-powered equipment, shall insure that all external parts, surfaces, and shields, exclusive of antenna and transmission line terminals, are at ground potential at all times during normal operation. The design shall include consideration of ground currents and voltage limits (possible arcing) established on a basis of hazardous location. Antenna and transmission line terminals shall be at ground potential, except for radio frequency (rf) energy on their external surfaces.

4.4.2.1 Self-powered equipment. Self-powered equipment shall have all external surfaces at the same potential.

4.4.2.2 Grounding methods. Plugs for use with metal cased portable tools and equipment shall have provisions for automatically grounding the metal frame or case of tools and equipment when the plug is mated with receptacle, and the grounding pin shall make first, break last. Ground connections to shields, hinges, and other mechanical parts shall not be used to complete electrical circuits. Any external or interconnecting cable, where a ground is part of the circuit, shall carry a ground wire in the cable terminated at both ends in the same manner as the other conductors. In no case, except with coaxial cables, shall the shield be depended upon for a current-carrying ground connection. Static and safety grounds shall not be used to complete electrical circuits. A point on the electrically conductive chassis or equipment frame shall serve as the common tie point for static and safety grounding. The path from the tie point to ground shall:

a. Be continuous and permanent,

b. Have ample carrying capacity to conduct safely any fault currents that may be imposed upon it,

c. Have impedance sufficiently low to limit the potential above ground and to facilitate the operation of the over current devices in the circuits, and

d. Have sufficient mechanical strength of the material to minimize possibility of ground disconnection.

4.4.2.3 Hinged or slide-mounted panels and doors. Hinges or slides shall not be used for grounding paths. Panels and doors containing meters, switches, test points, etc, shall be attached or hinged in such a manner as to insure that they are at the same ground potential as the equipment in which they are mounted, whether in a closed or open position. A ground shall be considered satisfactory if the electrical connection between the door or panel and the system tie point exhibits a resistance of 0.1 ohm or less and has sufficient ampacity to insure the reliable and immediate tripping of equipment over-current protection devices.

4.4.2.4 Shielding. Except where a conflict with single-point shield grounding requirements would be created, shielding on wire or cable shall be grounded to the chassis or frame. The shielding shall be secured to prevent it from contacting exposed current-carrying parts or grounding to the chassis or frame at any point other than the ground termination. The shielding shall end at a sufficient distance from exposed conductors to prevent shorting or arcing between the conductor and the shielding.

4.4.3 Accidental contact. The design shall incorporate methods to protect personnel from accidental contact with voltages in excess of 30 volts rms or dc during normal operation of a complete equipment.

4.4.3.1 Guards and barriers. All contacts, terminals and like devices having voltages between 70 and 500 volts rms or dc with respect to ground shall be guarded from accidental contact by personnel if such points are exposed to contact during direct support or operator maintenance. Guards or barriers may be provided with test probe holes where maintenance testing is required.

4.4.3.2 High voltage guarding. Assemblies operating at potentials in excess of 500 volts shall be completely enclosed from the remainder of the assembly and equipped with nonbypassable interlocks.

4.4.3.3 Voltage measurement. When the operation or maintenance of equipment employing potentials in excess of 300 volts peak could require that these voltages be measured, the equipment shall be provided with test points so that these voltages can be measured at a relatively low potential level. In no case shall the potential exceed 300 volts peak relative to ground. Test points with voltages above 30 volts shall have the conducting material recessed a distance no less than the diameter of the probe hole and a minimum of 1.5 mm. If a voltage divider is used, the voltage divider resistance between the test point and ground shall consist of at least two resistors of equal value in parallel.

4.4.3.4 Guarding of rf voltages. Transmitter output terminals, antennas and other devices that carry sufficient rf voltage to burn or injure personnel shall be protected from accidental contact in the same manner as for ac voltages in the 70 to 500 volt range.

4.4.3.5 Main power switch. The power input side of the main power switch and the incoming power line connections shall be given physical protection against accidental contact.

4.4.4 Protective devices

4.4.4.1 Interlocks. When a unit is provided with access doors, covers or plates, these access points shall be interlocked as follows:

a. No interlocks are required when all potentials in excess of 70 volts are completely protected with guards or barriers to prevent accidental contact under all conditions of operation or any level of maintenance.

b. Bypassable interlocks are required when voltages between 70 and 500 volts are exposed as the result of an access door, cover, or plate being opened. Note that these internal voltages are allowed to be unguarded only if they are not exposed during direct support or operator maintenance. The bypass device shall be of such design that closing the associated door, cover or plate will automatically open the bypass device and leave the interlock in position to function normally. Visual means shall be provided to indicate when the interlock is bypassed.

c. Nonbypassable interlocks are required when any voltage in excess of 500 volts is exposed as a result of an access door, cover or plate being opened.

4.4.4.2 Battle short indicator. When a battle short switch is required by the individual equipment specification, a readily visible indicator light shall be provided to indicate when the battle short switch is ON.

4.4.4.3 Safety switches. Safety switches which will deactivate associated mechanical drive units shall be provided for the purpose of disconnecting these units without disconnecting other parts of the equipment. Such remotely located units and assemblies shall have provision for nonoverrideable safety switches to allow independent disconnection in the associated equipment.

4.4.5 Discharging devices

4.4.5.1 Automatic discharge devices. High voltage circuits and capacitors shall be provided with discharging devices unless they discharge to 30 volts or less within two seconds after power removal. The particular discharging device that is chosen shall insure that the capacitor or high voltage circuit is discharged to 30 volts or less within two seconds. These protective devices shall be positive acting, highly reliable, and shall actuate automatically either by mechanical release or by electrical solenoid when the door or cover is opened. When resistive bleeder networks are used to discharge capacitors, the bleeder network shall consist of at least two equal valued resistors in parallel.

4.4.5.2 Shorting rods. Shorting rods shall be provided with all transmitting equipment where voltages are in excess of 70 volts rms or dc. Where size permits, shorting rods shall be stored within the transmitting equipment, permanently attached, and readily accessible to maintenance personnel. The permanently attached rod shall be connected through a flexible stranded copper wire (covered with a transparent sleeving) to the stud provided at the transmitter main frame. Where size does not permit internal storage of the shorting rod, a grounding stud shall be provided to permit attachment of a portable shorting rod. The connection to the stud shall be such that accidental loosening or high resistance to the ground is prevented.

4.4.6 Connectors. Connectors used in multiple electric circuits shall be selected to preclude mismating. Where design considerations require plug and receptacles of similar configuration in close proximity, the mating plugs and receptacles shall be suitably coded or marked to clearly indicate the mating connectors. Plugs and receptacles shall not be of similar configuration if the major unit contains explosive items. The design of the connector shall be such that the operator is not exposed to electrical shock or burns when normal disconnect methods are used. Exposed pin contacts shall not be energized (hot) after being disconnected from the socket contacts.

4.5 Radiation. The design of all equipment for which a federal standard exists under 21 CFR 1000 - 1050, on the Radiation Control for Health and Safety Act of 1968, shall conform to the appropriate federal standard.

4.5.1 Microwave and rf radiation. All electronic equipment or electrical devices capable of emitting microwave or rf radiation between 300 KHz and 100 GHz shall be so designed, fabricated, shielded and operated as to avoid overexposure of personnel. In areas where unintended radiation levels exist, equipment design and installation in any unrestricted area accessible to personnel shall meet the requirements of ANSI C95.1. Shields, covers, doors, etc, which when opened or removed will allow microwave and rf radiation to exceed the above, shall be provided with nonbypassable interlocks.

4.5.2 X radiation. All electronic or electrical devices capable of producing X radiation shall be so designed, fabricated, shielded and operated as to keep personnel exposure as low as reasonably achievable. For equipment and installation design, shielding requirements shall be maintained at all times which limit radiation levels to not greater than 2 milliroentgens (mr) in any one hour and 100 mr in any 7 consecutive days at the operator position or within 5cm from the equipment (whichever is closer) in any unrestricted area accessible to personnel. In addition, these levels shall be reduced whenever necessary to ensure that exposed personnel never receive an absorbed dose to the whole body or any critical organ in excess of 125 millirem per calendar quarter or 500 millirem per year. Other exposure shall be based on application criteria and limits as required by Nuclear Regulatory Commission Rules and Regulations, 10 CFR 20; OSHA Regulations, 29 CFR 1910.96; and FDA Regulation, 21 CFR, Chapter I, Subchapter J, Radiological Health. Equipment which, when shields, covers, doors, etc, are removed, will allow X radiation to exceed 2.0 mr per hour shall be provided with nonbypassable interlocks.

4.5.3 Laser radiation. Laser equipment and system design, installation, and operational and maintenance procedures shall conform to 21 CFR 1040. If Title 21 cannot be met because of operational requirements, an exemption shall be requested from the procuring activity and applicable military laser safety regulations shall be used as a design requirement.

4.6 Mechanical. The design of the equipment shall provide personnel maximum access and safety while installing, operating, and maintaining the equipment. Equipment design shall include provisions to prevent accidental pulling out of drawers or rack mounted equipment components. Suitable protection shall be provided to prevent contact with moving mechanical parts such as gears, fans, and belts when the equipment is complete and operating. Sharp projections on cabinets, doors, and similar parts shall be avoided. Doors or hinged covers shall be rounded at the corners and provided with stops to hold them open.

4.6.1 Mechanical interconnection. The design shall provide positive means to prevent the inadvertent reversing or mismating of fittings; couplings; fuel, oil, hydraulic, and pneumatic lines; and mechanical linkage. When prevention of mismating by design consideration is not feasible, coding or marking shall be employed when approved by the procuring activity. Coding and marking will not be approved as a substitute for proper design or items involving explosive, emergency, or safety critical systems.

4.6.2 Power switch location. Equipment power switches shall be so selected and located that accidental contact by personnel will not place equipment in operation.

4.6.3 Cathode ray tubes. Provision shall be incorporated to protect personnel from injury due to implosion of cathode ray tubes.

4.7 Equipment safety markings. Danger, caution, etc, signs, labels and markings shall be used to warn of specific hazards such as voltage, current, thermal, or physical. The signs, labels, and markings shall be as permanent as the normal life expectancy of the equipment on which they are affixed. Guards, barriers, and access doors, covers or plates shall be marked to indicate the hazard which may be be present upon removal of such devices. When possible, marking shall be located such that it is not removed when the barrier or access door is removed. Additionally, hazards internal to a unit shall be marked adjacent to hazards if they are significantly different from those of surrounding items. Such a case would be a high voltage terminal in a group of low voltage devices.

a. Physical hazards shall be marked with color codes in accordance with ANSI Z53.1 where applicable to electronic equipment.

b. For potentials between 70 and 500 volts, warning signs or labels shall be in accordance with ANSI Z35.1, Class II, and ANSI Z35.4, and shall read, as a minimum, "*Caution* - (Insert maximum voltage applicable) *Volts.*"

c. For potentials in excess of 500 volts, warning signs or labels shall be in accordance with ANSI Z35.1, Class I and ANSI Z35.4, and shall read, as a minimum, "*Danger - High Voltage* - (Insert maximum voltage applicable) *Volts.*"

d. Microwave or rf radiation warning signs shall be in accordance with ANSI Z35.1 and ANSI C95.2. Labels shall be provided on all radiation shields to warn personnel of the radiation hazards involved upon removal thereof. Any item which can emit radiation levels in excess of those specified in paragraph 4.5.1 shall be labeled. Minimum safe clearance distances shall be clearly marked. Warning signs shall be posted in all areas having electronic equipment designed to operate between 300 KHz and 100 GHz with intended electromagnetic radiation levels exceeding those in paragraph 4.5.1.

e. (1) Laser labels shall be in accordance with 21 CFR 1040.

(2) Military exempt laser labels: A permanent label shall be affixed on all military laser systems that have been certified exempt from 21 CFR 1040 (Performance Standards for Light-Emitting Products), which reads:

CAUTION

This electronic product has been exempted from FDA radiation safety performance standards, prescribed in the Code of Federal Regulations, Title 21, Chapter I, Subchapter J, pursuant to Exemption No. 76 EL-01 DOD issued on 26 July 1976. This product should not be used without adequate protective devices or procedures.

f. Shields which protect personnel from X radiation shall be labeled in accordance with 10 CFR 20.

g. Coding for accident prevention tags shall be in accordance with ANSI Z35.2.

h. The marking or labeling of commodities containing radioactive materials shall be in accordance with 10 CFR 20.

i. Ionizing radiation hazard symbols shall be in accordance with ANSI N2.1.

4.8 Hazardous and restricted materials

4.8.1 Gases or fumes. The materials, as installed in the equipment and under service conditions specified in the equipment specification, shall not liberate gases which combine with the atmosphere to form an acid or corrosive alkali, nor shall they liberate toxic or corrosive fumes which

would be detrimental to the performance of the equipment or health of personnel. The materials also shall not liberate gases which will produce an explosive atmosphere.

4.8.2 Mercury. Materials and parts containing mercury shall not be used unless use of mercury is specifically required or approved by the procuring activity.

4.8.3 Radioactive materials. Use of radioactive materials shall conform to Nuclear Regulatory Commission regulations and shall require approval of the procuring activity. Radium shall not be used to achieve self-luminosity.

4.8.4 Glass fibers. Glass fiber materials shall not be used as the outer surface or covering on cables, wire or other items where they may cause skin irritation to operating personnel. This does not preclude the use of military specification wire and cable. When maintenance procedures require access to glass fibers, such as insulation, a proper caution note shall be provided.

5. Information for guidance only

5.1 Human engineering. Human engineering factors affecting safety should be considered when establishing general or detailed design criteria. Rigorous detailed operational or maintenance procedures are not acceptable substitutes for an inherently safe design. Hazard and safety requirements of MIL-STD-1472 should be used as a guide.

5.2 Electrical. Proper instructions in accident prevention and first-aid procedures should be given to all persons engaged in electrical work to fully inform them of the hazards involved.

5.2.1 Shock hazards. Current rather than voltage is the most important variable in establishing the criterion for shock intensity. Three factors that determine the severity of electrical shock are: (1) quantity of current flowing through the body; (2) path of current through the body; and (3) duration of time that the current flows through the body. The voltage necessary to produce the fatal current is dependent upon the resistance of the body, contact conditions, and the path through the body. See table 1-I. Sufficient current passing through any part of the body will cause severe burns and hemorrhages. However, relatively small currents can be lethal if the path includes a vital part of the body, such as the heart or lungs. Electrical burns are usually of two types, those produced by heat of the arc which occurs when the body touches a high-voltage circuit, and those caused by passage of electrical current through the skin and tissue. While current

is the primary factor which determines shock severity, protection requirements are based upon the voltage involved to simplify their application. In cases where the maximum current which can flow from a point is less than the values shown in table 1-I for reflex action, protection requirements may be relaxed.

TABLE 1-I. Probable effects of shock.

Current Values (Milliamperes)		Effects
AC 25 Hz to 400 Hz	DC	
0-1	0-4	Perception
1-4	4-15	Surprise
4-21	15-80	Reflex action
21-40	80-160	Muscular inhibition
40-100	160-300	Respiratory block
Over 100	Over 300	Usually fatal

5.2.2 Insulation of controls. All control shafts and bushings thereof should be grounded whenever practicable. Alternatively, the control knobs or levers and all attachment screws that can be contacted during use should be electrically insulated from the shaft.

5.2.3 Grounding to chassis. Ground connection to an electrically conductive chassis or frame should be mechanically secured by soldering to a spotwelded terminal lug or to a portion of the chassis or frame that has been formed into a soldering lug, or by use of a terminal on the ground wire and then securing the terminal by a screw, nut, and lockwasher. The screw should fit in a tapped hole in the chassis or frame or it should be held in a through-hole by a nut. When the chassis or frame is made of steel, the metal around the screw hole should be plated or tinned to provide a corrosion resistant connection. When aluminum alloys are used, the metal around the grounding screw or bolt hole may be covered with a corrosion resistant surface film only if the resistance through the film is not more than 0.002 ohm. Hardware used for mounting of meters, switches, test points, etc, should be grounded, whenever possible.

5.2.4 Accidental contact. Suitable protective measures are defined in table 1-II.

5.2.4.1 High current protection. Power sources capable of supplying high current can be hazardous regardless of the voltage at which they operate because of the arcing and heat generated if an accidental short circuit occurs. All power buses supplying 25 amperes or over should be protected against accidental short circuiting by tools, jewelry or removable conductive assemblies. This may be accomplished by one or more of the following:

a. Use of guards and barriers,

b. Sufficient space separation to prevent short circuits,

c. Caution - warning signs.

5.2.4.2 Interlocks. Various equipment designs require different approaches to the use of interlocks. Interlock use does not modify any other requirements of this standard and must be consistent with equipment or system specifications. Equipment sub-assemblies operating in excess of 500 volts should be considered guarded from accidental contact only if they are completely enclosed from the remainder of the equipment and are separately protected by nonbypassable interlocks. (An example of an equipment where such compartmentalization is desirable is a display unit which utilizes a high voltage power supply for a cathode ray tube.) Modularized or sealed high voltage assemblies which are opened only at depot level are exempt from interlocking requirements when approved by the procuring activity.

5.2.4.3 Permanent terminations. Terminations such as soldered connections to transformers, connectors, splices, etc, which are normally permanent and not used during routine maintenance testing, may be protected by permanent insulation such as shrink sleeving, tubing, insulating shields, etc, provided the material is rated for the potential exposed voltage.

5.3 Mechanical. Design of rack-mounted equipment should maintain the center of gravity as low as possible to minimize tipping over.

5.4 Marking. MIL-HDBK-600 references known electronic items which require marking and may be used as a guide.

5.5 Materials. 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 29 CFR 1910.

TABLE 1-II. Suitable protective measures. 1/

Voltage range	Type of protection 2/								
				Marking		Interlocks		Discharge devices	
	None 3/	Guards and barriers (4.4.3.1)	Enclosures (4.4.3.2 4.4.4.1)	Caution (4.7b)	Danger (4.7c)	Bypassable (4.4.4.1b)	Non- 4/ bypassable (4.4.4.1c)	Automatic (4.4.5.1)	Shorting Rods (4.4.5.2)
0 - 30 Volts	X								
> 30 - 70 Volts	X							X	
> 70 - 500 Volts		X		X		X		X	X
>500 Volts			X		X		X	X	X

1/ Table is for reference only. See applicable paragraph for requirements.

2/ Confine the application of headings to voltage ranges indicated. More than one option may be available on design requirements.

3/ Although no specific requirements exist for servicing 0-70 volts, designs should be reviewed for possible hazards in accordance with table 1-I.

4/ Designs may use nonbypassable interlock applications below 500 volts, but the intent here is to imply complete enclosure.

REQUIREMENT 2

CAPACITORS

1. Purpose. This requirement establishes criteria for the selection and application of capacitors.

2. Documents applicable to Requirement 2:

MIL-C-39006/22 Capacitors, Fixed, Electrolytic (Nonsolid Electrolyte), Tantalum, (Polarized, Sintered Slug), 85 C (Voltage Derated to 125 C), Established Reliability, Style CLR79

MIL-C-39006/25 Capacitors, Fixed, Electrolytic (Nonsolid Electrolyte), Tantalum, (Polarized, Sintered Slug) (Extended Range), 85 C (Voltage Derated to 125 C), Established Reliability, Style CLR81

MIL-STD-198 Capacitors, Selection and Use of

3. Definitions. Not applicable.

4. Requirements

4.1 Selection. Capacitors shall be selected and applied in accordance with MILSTD-198.

4.2 Fixed, tantalum electrolytic. For Naval Air Systems Command, the use of wet slug tantalum capacitors (except tantalum cased units in accordance with MIL-C39006/22 and MIL-C-39006/25) requires the approval of the procuring activity, and silver cased tantalum capacitors shall not be used.

5. Information for guidance only. Not applicable.

REQUIREMENT 3

FLAMMABILITY

1. Purpose. This requirement establishes criteria for the selection and application of materials with respect to flammability.

2. Documents applicable to Requirement 3:

MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
ASTM D568-77	Rate of Burning and/or Extent and Time of Burning of Flexible Plastics in a Vertical Position, Test Method for
ASTM D635-81	Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position, Test Method for
ASTM D1000-82	Pressure-Sensitive Adhesive Coated Tapes Used for Electrical Insulation, Methods of Testing
UL 94-80	Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

3. Definition. Flammability is a complex characteristic which combines ease of ignition, surface flammability, heat contribution, smoke production, fire gasses, and fire endurance. Flammability is a function of chemical composition, physical configuration, temperature, availability of oxygen, and retardants or additives.

4. Requirements. Materials used in military equipment shall, in the end item configuration, be noncombustible or fire retardant in the most hazardous conditions of atmosphere, pressure, and temperature to be expected in the application. Fire retardant additives may be used provided they do not adversely affect the specified performance requirements of the basic materials. Fire retardance shall not be achieved by use of nonpermanent additives to the basic material.

5. Information for guidance only. The test used to determine the flammability of material should be the test specified in the material specification. Since some materials may change state or characteristics relative to flammability during application, tests may be performed on the end item materials mixed/blended/saturated/impregnated/layered and processed to simulate the final configuration in the end equipment usage.

5.1 If the specification does not have such a test, testing should be in accordance with ASTM D568, ASTM D635, ASTM D1000, or MIL-STD-202, Method 111, as applicable.

5.2 Materials not covered by the above tests should be tested in accordance with a procedure approved by the procuring activity. UL 94 is a useful guide to develop test methods and offers a comparative scale to define degree of flammability.

REQUIREMENT 4

FUNGUS-INERT MATERIALS

1. Purpose. This requirement identifies those materials which are acceptable nonnutrients of fungus and establishes conditions under which fungus nutrient materials are acceptable.

2. Documents applicable to Requirement 4:

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, Electronic, and Associated Equipment)
MIL-STD-810	Environmental Test Methods and Engineering Guidelines
29 CFR 1910	Code of Federal Regulations, Title 29, Chapter XVII, Part 1910

3. Definitions

3.1 Fungus-inert material. A material which, in all modified states and grades, is not a nutrient to fungi.

3.2 Fungicide. A substance that destroys or inhibits the growth of fungi.

4. Requirements

4.1 Preferred materials. Fungus-inert materials listed in Group I of table 4-I are preferred for use. These materials need not be tested for fungus resistance prior to use. The appearance of a particular material in table 4-I does not constitute approval for its use except from the viewpoint of the resistance of the material to fungi.

4.2 Acceptable materials. Those materials listed in Group II of table 4-I may be used, provided it has been demonstrated that they meet the requirements of paragraph 4.4. When materials are compounded with a permanently effective fungicide in order to meet the fungus test requirement, there shall be no loss of the original electronic or physical properties required by the basic material specification. Fungicides containing mercury shall not be used.

4.3 Hermetically sealed applications. Fungus nutrient materials may be used untreated within hermetically sealed enclosures.

4.4 Fungus testing. Group II materials shall be subjected to the fungus test specified in MIL-STD-810, Method 508, for a period of 28 days. Certification by a qualified laboratory or by the material producer, based

on test data on record that the material meets Grade 0 or Grade 1 requirements of table 508-I, Method 508, MIL-STD-810, is sufficient evidence of acceptability.

TABLE 4-I. Fungi susceptibility of materials.

Group I - Fungus-inert materials (Fungus-inert in all modified states and grades)	
Acrylics 1/	Polyamide
Acrylonitrile-styrene	Polycarbonate
Acrylonitrile-vinyl-chloride copolymer	Polyester-glass fiber laminates
Asbestos	Polyethylene, high density (above 0.940)
Ceramics	Polyethylene terephthalate
Chlorinated polyester	Polyimide
Fluorinated ethylenepropylene copolymer (FEP)	Polymonochlorotrifluoroethylene
Glass	Polypropylene
Metals	Polystyrene
Mica	Polysulfone
Plastic laminates:	Polytetrafluoroethylene
Silicone-glass fiber	Polyvinylidene chloride
Phenolic-nylon fiber	Silicone resin
Diallyl phthalate	Siloxane-polyolefin polymer
Polyacrylonitrile	Siloxane polystyrene
Group II - Fungus nutrient materials (May require treatment to attain fungus resistance)	
ABS (acrylonitrile-butadiene-styrene)	Polyethylene, low and medium density (0.940 and below)
Acetal resins	Polymethyl methacrylate
Cellulose acetate	Polyurethane (the ester types are particularly susceptible)
Cellulose acetate butyrate	Polyricinoleates
Epoxy-glass fiber laminates	Polyvinyl chloride
Epoxy-resin	Polyvinyl chloride-acetate
Lubricants	Polyvinyl fluoride
Melamine-formaldehyde	Rubbers, natural and synthetic
Organic polysulphides	Urea-formaldehyde
Phenol-formaldehyde	
Polydichlorostyrene	

1/ Literature shows that under certain conditions polyamides may be attacked by selective micro-organisms. However, for military applications, they are considered Group I.

5. Information for guidance only

5.1 Process-related materials. Processing materials to be tested for fungus resistance in accordance with paragraph 4.4, such as paint, ink, coatings, adhesives, lubricants, viscous damping fluids, silicone grease, etc, should be prepared in the form of 50 mm squares or circles no more than 1.6 mm thick for testing. Liquid or paste materials should be prepared by impregnating to saturation a sterile sample of glass fabric.

5.2 Parts treatment. When treatment of parts is required to form fungus-resistant materials, a moisture and fungus proofing (MFP) varnish conforming to MIL-V-173 may be applied in accordance with MIL-T-152 after the part is cleaned. The MFP varnish should not be applied to any part where the treatment will interfere with performance.

5.3 Carcinogens. 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 29 CFR 1910. Consideration of the toxicity of a substance should be given prior to material selection.

REQUIREMENT 5

SOLDERING

1. Purpose. This requirement establishes the basis for soldering of electrical and electronic equipment.

2. Document applicable to Requirement 5:

MIL-STD-2000	Standard Requirements for Soldered Electrical and Electronic Assemblies
DOD-STD-1866	Soldering Process, General (Non-Electrical) (Metric)

3. Definitions. Not applicable.

4. Requirements

4.1 General. Electrical and Electronic equipment shall be assembled, soldered, and cleaned in accordance with the requirements of MIL-STD-2000.

4.2 Structural Soldering. Non-Electrical soldered connections shall be in accordance with the requirements of DOD-STD-1866.

4.3 Workmanship. Workmanship of soldered assemblies shall be in accordance with MIL-STD-2000 or DOD-STD-1866 as appropriate.

Information for guidance only.

5.1 Application. MIL-STD-2000 expresses the minimum requirements appropriate to the manufacture of electrical and electronic equipment. It may be necessary to supplement the requirements of MIL-STD-2000 in order to achieve higher reliability requirements associated with critical equipment applications (space, nuclear ordnance, command/control, etc.).

REQUIREMENT 6

BEARINGS

1. Purpose. This requirement establishes criteria for the selection and application of bearings.

2. Documents applicable to Requirement 6:

FF-B-171	Bearings, Ball, Annular (General Purpose)
FF-B-185	Bearings, Roller, Cylindrical; and Bearings, Roller, Self-Aligning
FF-B-187	Bearing, Roller, Tapered
FF-B-195	Bearings, Sleeve, (Bronze, Plain or Flanged)
MIL-B-3990	Bearing, Roller, Needle, Airframe, Anti-Friction, Inch
MIL-B-5687	Bearing, Sleeve, Washers, Thrust, Sintered, Metal Powder Oil Impregnated, General Specification for
MIL-B-8942	Bearings, Plain, TFE Lined, Self-Aligning
MIL-B-8943	Bearings, Journal-Plain and Flanged, TFE Lined
MIL-B-8948	Bearing, Plain Rod End, TFE Lined, Self-Aligning
MIL-B-13506	Bearing, Sleeve (Steel Backed)
MIL-B-17380	Bearing, Roller, Thrust
MIL-B-81744	Barrier Coating Solution, Lubricant Migration Deterring
MIL-B-81793	Bearing, Ball, Annular, for Instruments and Precision Rotating Components
MIL-B-81934	Bearing, Sleeve, Plain and Flanged, Self-Lubricating
MIL-B-81936	Bearing, Plain, Self-Aligning (BeCu, CRES Race)
MIL-STD-1334	Process for Barrier Coating of Anti-Friction Bearings

3. Definitions. Not applicable.

4. Requirements

4.1 Selection and application. Bearings best suited to meet the physical, functional, environmental and service life requirements of the application shall be selected from those conforming to one or more of the specifications listed below. Replacement of the bearing shall be possible without use of special tools unless such provisions would adversely affect the proper functioning or service life of the bearing.

FF-B-171	MIL-B-5687	MIL-B-17380
FF-B-185	MIL-B-8942	MIL-B-81793
FF-B-187	MIL-B-8943	MIL-B-81934
FF-B-195	MIL-B-8948	MIL-B-81936
MIL-B-3990	MIL-B-13506	

4.2 Lubricant. Adequate lubricant shall be provided either within the bearing or externally in the form of oil reservoirs or grease relubrication facilities except as noted in 4.3. Where lubricant replenishment is required, precaution shall be taken to prevent purged or lost lubricant from entering and adversely affecting the operation of the electronic equipment. Where bearings coated with preservative are installed in closed housings, the preservatives shall be compatible with the lubricant used in the assembly.

4.3 Unlubricated bearings. Unlubricated bearings or bushings may be used only in applications where the presence of a lubricant would be undesirable or detrimental and the functional, environmental and service life requirements can be met in this condition.

4.4 Barrier coating. Bearings requiring a barrier coating shall be coated in accordance with MIL-STD-1334. Barrier coating material shall conform to MIL-B-81744.

4.5 Seals and shields. All rolling element bearings shall be adequately protected by seals or shields on the bearing or installed in housings which provide adequate shielding to prevent foreign matter from entering the bearing.

4.6 Electrical grounding. Ball and roller bearings used for rotating an electrically energized equipment shall be electrically shunted to avoid current flow through the bearings.

4.7. Alignment. Bearings shall be located to ensure proper shaft alignment and support.

5. Information for guidance only

5.1 Self-lubricating bearings. Permanently lubricated bearings or bushings of plastic, metallic-plastic combinations, or all metallic materials with or without dry film lubricants may be used provided wear products produced during operation will not cause or contribute to failure of the electronic equipment or bearings.

5.2 Unlubricated bearings. For selection of low friction, long life, unlubricated bearings refer to MIL-B-8942, MIL-B-8943, and MIL-B-8948.

REQUIREMENT 7

INTERCHANGEABILITY

1. Purpose. This requirement establishes design criteria to assure the interchangeability of parts, subassemblies, and assemblies.

2. Documents applicable to Requirement 7:

MIL-STD-280	Definitions of Items Levels, Item Exchangeability, Models, and Related Terms
MIL-STD-1547	Electronic Parts, Materials, and Processes for Space and Launch Vehicles

3. Definitions.

3.1 Assembly, interchangeable item, part, subassembly and substitute item. The terms assembly, interchangeable item, part, subassembly and substitute item are defined in MIL-STD-280.

3.2 Standard parts. For Air Force space and launch vehicles, standard parts are as described in MIL-STD-1547. For all other equipments, standard parts are defined in the applicable general specification or contract.

4. Requirements

4.1 Design tolerances. Design tolerances shall permit parts, subassemblies and assemblies to be used in their parent assemblies without regard to the source of supply or manufacturer. Parts, subassemblies and and assemblies having the full range of dimensions and characteristics permitted by the specification governing the part, subassembly or assembly shall be usable as replacement items without selection and without from the specified performance requirements of the parent items.

4.2 Parts and materials. When permission is granted to use a nonstandard part or material because the existing standard part or material is not available, the equipment shall be so designed that the nonstandard part or material and the standard part or material are interchangeable. When the specification for the part or material contains substitutability or supersession information, the design shall permit the substitute or superseding parts or materials to be used interchangeably.

5. Information for guidance only. Not applicable.

REQUIREMENT 8

ELECTRICAL OVERLOAD PROTECTION

1. Purpose. This requirement establishes the criteria and philosophy for electrical overload protection.

2. Documents applicable to Requirement 8:

MIL-STD-280	Definitions of Item Levels, Item Exchangeability, Models, and Related Terms
MIL-STD-1539	Electrical Power, Direct Current, Space Vehicle Design Requirements
NFPA 70-1990	National Electrical Code

3. Definitions

3.1 Class 1 equipment: Ground and shipboard, including test and checkout ground equipment

3.2 Class 2 equipment: Manned aerospace equipment

3.3 Class 3 equipment: Unmanned aerospace equipment

4. Requirements. The requirements specified herein shall apply only to equipment and systems as defined in MIL-STD-280 for class 1 and class 2 equipment and MIL-STD-1539 for class 3 equipment.

4.1 Protection for class 1 equipment

4.1.1 Current overload protection. Current overload protection shall be provided for primary circuits. Devices such as fuses, circuit breakers, time delays, cutouts, or solid-state current-interruption devices shall be used to open a circuit whenever an overload condition occurs. No overcurrent protective device shall be connected in series with any conductor which is grounded at the power source unless the device simultaneously opens all load conductors in the circuit and no pole operates independently, or as otherwise allowed by the National Electrical Code, NFPA 70. Protective devices for wired-in equipment shall be connected to the load side of the equipment power switch (main circuit power disconnect). For portable equipment a separable connector or the attachment plug and receptable shall serve as the main circuit power disconnect and the protective device may be on either the line side or the load side of the equipment on-off switch.

4.1.2 Fuses. Where fuses are used, at least one extra fuse of each type and rating used shall be supplied and attached to the applicable units of the equipment. Panel-mounted fuse posts shall be such as to permit renewal of fuses without use of tools.

4.1.3 Circuit breakers. Circuit breakers shall give a visual indication when tripped. Holding the switching device closed on an overload shall not prevent tripping of the breaker. Multi-pole circuit breakers shall be used

for three-phase equipment and shall disconnect all phases if an overload occurs in any one phase. Circuit breakers shall not be used as switches unless such breakers have been specifically designed and tested for that type service.

4.2 Protection for class 2 equipment

4.2.1 Current overload protection. Current overload protection for the equipment shall be provided by fuses or circuit breakers. Circuit breakers shall not be used as switches unless such breakers have been specifically designed and tested for that type service.

4.2.2 Spare fuses. When fuses are used, a minimum of one spare fuse for each size and rating but a quantity of not less than 10 percent of the total shall be incorporated in the equipment and shall be contained in the same compartment.

4.3 Protection for class 3 equipment. Electrical overload protection shall not be provided in individual boxes or systems receiving power.

5. Information for guidance only

5.1 Location. Overload protection for the equipment should be provided therein. For class 1 and class 2 equipment, all protective devices employed in the equipment should be in a readily accessible, safe location.

5.2 Resettable circuit protectors. Circuit breakers or other resettable devices should be used to protect critical circuits, or where predictable overloads or surges occur because of peculiar equipment functions or operator effects which are unavoidable.

REQUIREMENT 9

WORKMANSHIP

1. Purpose. This requirement establishes the acceptable workmanship criteria for electronic equipment. This requirement will define those workmanship requirements not normally covered in subsidiary specifications or drawings.

2. Documents applicable to Requirement 9: Not applicable.

3. Definitions. Not applicable.

4. Requirements

4.1 Cleaning. After fabrication, parts and assembled equipment shall be cleaned of smudges; loose, spattered, or excess solder; weld metal; metal chips and mold release agents; or any other foreign material which might detract from the intended operation, function, or appearance of the equipment.

4.2 Threaded parts or devices. Screws, nuts and bolts shall show no evidence of cross threading, mutilation, or detrimental or hazardous burrs, and shall be firmly secured.

4.3 Bearing assemblies. Bearing assemblies shall be free of rust, discoloration, and imperfections of ground, honed, or lapped surfaces. Contacting surfaces shall be free of tool marks, gouge marks, nicks, or other surface-type defects. There shall be no detrimental interference, binding, or galling.

4.4 Wiring. Wires and cables shall be positioned or protected to avoid contact with rough or irregular surfaces and sharp edges and to avoid damage to conductors or adjacent parts.

4.5 Shielding. Shielding on wires and cables shall be secured in a manner that will prevent it from contacting or shorting exposed current-carrying parts. The ends of the shielding or braid shall be secured to prevent fraying.

5. Information for guidance only

5.1 Containment. The harness and cable form containment means should be neat in appearance, uniformly applied, and positioned to retain critical form factors and breakout locations. The containment means (lacing, ties, tiedown straps, etc) should not cause the wire or cable insulation to deform so that performance characteristics are adversely affected.

5.2 Insulation. There should be no evidence of burns, abrading, or pinch marks in the insulation that could cause short circuits or leakage.

5.3 Clearance. The clearance between wires or cables and heat generating parts should be sufficient to minimize deterioration of the wires or cables.

REQUIREMENT 10

ELECTRICAL CONNECTORS

1. Purpose. This requirement establishes criteria for the selection and application of electrical connectors.

*2. Documents applicable to Requirement 10 :

MIL-J-641	Jack, Telephone, General Specification for
MIL-P-642	Plug, Telephone, and Accessory Screws, General Specification for
MIL-C-10544	Connector, Plug and Receptacle (Electrical, Audio, Waterproof, Ten Contact, Polarized)
MIL-C-12520	Connector, Plug and Receptacle (Electrical, Waterproof), and Accessories, General Specification for
MIL-C-29600	Connector, Electrical, Circular, Miniature, Composite, High Density, Quick Coupling, Environment Resistant, Removable Crimp Contacts
MIL-C-38999	Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded, and Breech Coupling) Environment Resistant, Removable Crimp and Hermetic Solder contacts, General Specifications for
MIL-C-55116	Connectors, Miniature, Audio, Five-Pin and Six-Pin
MIL-C-55181	Connectors, Plug and Receptacle, Intermediate Power (Electrical) (Waterproof) Type MW, General Specification for
MIL-A-55339	Adapters, Connector, Coaxial, Radio Frequency (Between Series and Within Series)
MIL-C-83503	Connectors, Electrical, Flat Cable, and/or Printed Wiring Board, Nonenvironmental, General Specification for
MIL-STD-1353	Electrical Connectors, Plug-In Sockets and Associated Hardware, Selection and Use of
MIL-STD-1646	Servicing Tools for Electric Contacts and Connections, Selection and Use of
MIL-STD-2120	Connectors, Electromagnetic Interference (EMI) Filter Contact
EIA-297-A	Cable Connectors for Audio Facilities for Radio Broadcasting

3. Definitions. Not applicable.

4. Requirements

4.1 Selection. Selection and use of electrical connectors shall be in accordance with MIL-STD-1353 and as specified herein. Intended use information contained in the individual connector specifications shall be considered prior to making connector selections. Contact crimp, installing

and removal tools shall be in accordance with MIL-STD-1646 or as specified in the individual connector specifications. However, contractors may use tooling as recommended by the contact or tooling manufacturer provided that the finished crimp meets all of the performance requirements of the contact and connector specification. The variety of these tools required within a system shall be kept to a minimum. Maintenance instructions and other data supplied by the contractor shall list the military standard tools and contacts.

4.2 Audio frequency and communication connectors, special purpose. Connectors conforming to MIL-C-10544 or MIL-C-55116 shall be used in audio frequency applications, such as head sets and chest sets, excluding pilots' helmets. For low level, three wire and audio input circuits in fixed plant nontactical sound equipment, connectors conforming to EIA-297-A shall be used.

4.3 Connectors with thermocouple contacts. All connectors used in conjunction with thermocouples shall have their contact materials identified by one of the following methods:

a. Nameplate securely attached to each connector half or mounted on the panel-mounted receptacles.

b. Insulation sleeving or other markers designed for attachment around wire bundles. Markers shall be attached adjacent to the plug. Contact materials shall be identified with abbreviations in accordance with table 10-I.

TABLE 10-I. Abbreviations for thermocouple materials.

Chromel	CR	Cobalt	CO
Alumel	AL	Tungsten	
Iron	FE	Rhenium	W RE
Constantan	CN	Tungsten	W
Copper	CU	Iridium	IR
Platinum	PT	Rhodium	RH
Platinum		Iridium	
Rhodium	PT RH	Rhodium	IR RH
Rhenium	RE	Molybdenum	MO
		Gold	AU

4.4 Heavy duty connectors

4.4.1 Power connectors (40-200 amperes). All power connectors for any ground application shall conform to Section 102 of MIL-STD-1353 and shall be used with heavy duty jacketed cable as specified on the insert standards.

*4.4.2 General purpose and shipboard. Connectors for general purpose heavy duty applications and shipboard power applications shall conform to Section 102 of MIL-STD-1353. Connectors used for external applications shall be pressurized and waterproof in the mated and unmated condition in accordance with the requirements of Classes C or L. Connectors used internally (within a protective enclosure such as a shelter) may be in accordance with Class R provided waterproofing or pressurization is not a requirement for the application.

4.4.3 Right angle power and control (Army only). In application where right angle bend is required, center lock screw multicontact connectors shall conform to MIL-C-12520 or MIL-C-55181, as applicable.

4.5 General utility connectors. Polarized connectors are the preferred styles and shall be used where automatic grounding must be provided to insure safety to equipment and personnel. Connectors for general utility power applications shall conform to Section 106 of MIL-STD-1353.

4.6 Plugs and jacks (telephone type). Telephone type jacks and plugs shall conform to MIL-J-641 and MIL-P-642.

4.7 Test jacks. Test jacks shall conform to Section 105 of MIL-STD-1353. Jacks or receptacles for use as rf test points shall be selected in accordance with paragraph 4.8.

4.8 Rf connectors. Rf connectors shall conform to Section 200 of MIL-STD-1353. Adapters used with rf connectors shall conform to MIL-A-55339.

4.9 Connectors for printed wiring. Printed circuit connectors shall conform to Section 104 of MIL-STD-1353.

4.10 Connector wiring. Multiple conductors may terminate in a contact provided the sum of the cross sectional areas of the conductors does not exceed the maximum cross sectional area for which the contact is rated. Not more than one wire shall be routed through any hole in the grommet of an environmentally sealed connector.

4.11 Extra contacts. The following requirements are applicable to all articles of equipment, except those in which it is unlikely that additional circuits will be required.

4.11.1 Quantity and location. Unused connector contacts or contact positions for external circuits shall be provided for future use, and shall be located on the periphery (outer contacts) of the connector. The minimum quantity shall be as specified below:

Total number of used contacts in connector	Unused contacts or contact positions required (min)
1 thru 3	1 (optional)
4 thru 25	2
26 thru 100	4
101 or over	6

4.11.2 An extra connector shall not be used to meet this requirement without the approval of the procuring activity.

4.11.3 Size and rating of extra contacts. The size and rating of extra contacts shall be compatible with other contacts within the connectors.

4.11.4 Crimp contact connectors. When crimp contact environmentally sealed connectors are used, all contact positions shall be filled with contacts.

4.11.5 Sealing plugs. Sealing plugs shall be inserted in the grommet holes of unused contacts in environmentally sealed connectors.

4.11.6 Potted connectors. For potted connectors, each unused contact shall have a maximum gauge wire of 150 mm minimum length attached and identified

with the contact designation for future use. For connectors external to the unit, the wire end shall be suitably capped to prevent moisture from entering the connector.

4.12 Protective measures. All unmated connectors shall be protected with metal or plastic caps or otherwise suitably protected during maintenance, storage and shipment. Protective caps specified by military specifications or military standards and designed for mating with specific connectors shall be used. Unmated connectors which may contain electrically "hot" circuits while in environmentally hazardous areas shall be covered with moistureproof and vaporproof caps. Connectors on enclosed cabinet mounted equipment need not be provided with protective caps unless an environmental hazard exists.

4.13 Connectors for round conductor flat cable. Connectors for use with flexible round conductor flat cable shall conform to MIL-C-83503.

4.14 Fireproof connectors. Fireproof and firewall connectors shall be class K and shall conform to Section 101 of MIL-STD-1353. Where it is necessary to maintain electrical continuity for a limited time under continuous flame, both the receptacle and mating plug shall be class K. If flame integrity only is necessary without the need for electrical continuity, a class K receptacle shall be used, but the mating plug may be of any type and class. In all cases, the plug and receptacle shall be environment resisting.

4.15 Filter pin connectors. Electrical connectors incorporating filter pins shall be considered for use only when conventional electrical filters are not acceptable. When used, filter pin connectors shall conform to MIL-STD-2120.

*4.16 Composite Connectors. Miniature composite environment resisting connectors shall conform to MIL-C-29600 or MIL-C-38999.

5. Information for guidance only. Not applicable.

REQUIREMENT 11

INSULATING MATERIALS, ELECTRICAL

1. Purpose. This requirement establishes criteria for the selection and application of electrical insulating materials. Insulating materials used for encapsulation and embedment (potting) and for conformal coating are excluded from this requirement.

2. Documents applicable to Requirement 11:

L-P-516	Plastic Sheet and Plastic Rod, Thermosetting, Cast
HH-I-553	Insulation Tape, Electrical (Rubber, Natural and Synthetic)
MIL-I-10	Insulating Compound, Electrical, Ceramic, Class L
MIL-M-14	Molding Plastics and Molded Plastic Parts, Thermosetting
MIL-P-79	Plastic Rods and Tubes, Thermosetting, Laminated
MIL-I-631	Insulation, Electrical, Synthetic-Resin Composition, Nonrigid
MIL-P-997	Plastic Material, Laminated, Thermosetting, Electrical Insulation, Sheets, Glass Cloth, Silicone Resin
MIL-I-3158	Insulation Tape, Electrical, Glass-Fiber (Resin-Filled), and Cord, Fibrous-Glass
MIL-I-3190	Insulation Sleeving, Electrical, Flexible, Coated, General Specification for
MIL-I-3825	Insulation Tape, Electrical, Self-Fusing: For Use in Electronics, Communications, and Allied Equipment
MIL-I-7444	Insulation Sleeving, Electrical, Flexible
MIL-T-13020	Tape, Rubber, Unvulcanized, Splicing and Molding (Tapes TL-317/U and TL-318/U)
MIL-P-15037	Plastic Sheet, Laminated, Thermosetting, Glass-Cloth, Melamine-Resin
MIL-P-15047	Plastic Sheets, Laminated, Thermosetting, Nylon Fabric Base, Phenolic-resin
MIL-I-15126	Insulation Tape, Electrical, Pressure Sensitive Adhesive and Pressure Sensitive Thermosetting Adhesive
MIL-I-17205	Insulation Cloth and Tape, Electrical, Glass Fiber, Varnished
MIL-P-18177	Plastic Sheet, Laminated, Thermosetting, Glass Fiber Base, Epoxy-Resin
MIL-I-18746	Insulation Tape, Nonadhering, Glass Fabric, Polytetrafluoroethylene Coated
MIL-P-19161	Plastic Sheet, Laminated, Glass Cloth Polytetrafluoroethylene Resin
MIL-I-19166	Insulation Tape, Electrical, High-Temperature, Glass Fiber, Pressure Sensitive

MIL-I-22076	Insulation Tubing, Electrical, Nonrigid, Vinyl, Very Low Temperature Grade
MIL-I-22129	Insulation Tubing, Electrical, Polytetrafluoroethylene Resin, Nonrigid
MIL-I-23053	Insulation Sleeving, Electrical, Heat-Shrinkable, General Specification for
MIL-I-23264	Insulators, Ceramic, Electrical and Electronic, General Specification for
MIL-I-23594	Insulation Tape, Electrical; High Temperature Polytetrafluoroethylene, Pressure-Sensitive
MIL-I-24092	Insulating Varnish, Electrical, Impregnating, Solvent Containing
MIL-I-24204	Insulation, Electrical, High Temperature, Bonded, Synthetic Fiber Paper
MIL-I-24391	Insulation Tape, Electrical, Plastic, Pressure Sensitive
MIL-I-46852	Insulation Tape, Electrical, Self-Adhering, Unsupported Silicone Rubber
MIL-I-49456	Insulation Sheet, Electrical, Silicone Rubber, Thermally Conductive, Fiberglass Reinforced
MIL-I-81765	Insulating Components, Molded, Electrical, Heat Shrinkable, General Specification for
MIL-I-85080	Insulation Sleeving, Electrical, Shrinkable Without Heat, General Specification for
AMS 3638E	Plastic tubing, Electrical Insulation, Irradiated Polyolefin, Pigmented, Semi-rigid, Heat-Shrinkable 2 to 1 Shrink Ratio
AMS 3653D	Tubing, Electrical Insulation, Standard Wall, Extruded Polytetrafluoroethylene (PTFE)
AMS 3654B	Tubing, Electrical Insulation, Light Wall, Extruded Polytetrafluoroethylene (PTFE)
AMS 3655A	Tubing, Electrical Insulation, Thin Wall, Extruded Polytetrafluoroethylene (PTFE)
ASTM D3295-81	PTFE Tubing, Specification for
29 CFR 1910	Code of Federal Regulations, Title 29, Chapter XVII, Part 1910

3. Definitions. Not applicable.

4. Requirements

4.1 Ceramics. Ceramic compounds shall conform to MIL-I-10. Ceramic insulators shall conform to MIL-I-23264.

4.2 Electrical tape. Tape shall be selected from the types included in MIL-I-3158, MIL-I-3825, MIL-T-13020, MIL-I-15126, MIL-I-17205, MIL-I-18746, MIL-I-19166, MIL-I-23594, MIL-I-24391, and MIL-I-46852.

4.3 Sleeving and tubing. Sleeving and tubing shall conform to MIL-I-631, MIL-I-3190, MIL-I-7444, MIL-I-22076, MIL-I-22129, MIL-I-23053, MIL-I-85080, AMS 3638, AMS 3653, AMS 3654, AMS 3655, or ASTM D3295. MIL-I-631 shall also apply to film, film tape, sheet and sheet tape forms of insulation.

4.4 Plastic, thermosetting, cast. When used for electrical insulation, parts fabricated from cast thermosetting plastic materials shall be in accordance with L-P-516.

4.5 Plastic, thermosetting, laminated. Materials selected shall conform to MIL-P-79, MIL-P-997, MIL-P-15037, MIL-P-15047, MIL-P-18177, MIL-P-19161, or MIL-I-24204. The preferred base is glass cloth. Electrical insulators fabricated from laminated thermosetting-plastic sheets, plates, rods and tubes (except transparent plastics) shall be treated after all machining and punching operations with a suitable moisture barrier unless the plastic has a moisture absorption of 1.0 percent or less or is used in a hermetically sealed container.

4.6 Plastic, thermosetting, molded. Materials used to mold electrical insulators shall conform to MIL-M-14. Molded parts which undergo subsequent machining shall be vacuum impregnated with a suitable moisture barrier material and dried after all surface-breaking operations have been completed. Cotton and linen shall not be used as filler material in any electrical insulator. Materials having moisture absorption of 1.0 percent or less, and those used in hermetically sealed containers, need not be impregnated.

4.7 Varnish, insulating. Insulating varnish shall conform to MIL-I-24092.

4.8 Heat shrinkable insulators. For applications requiring heat shrinkable insulators other than sleeving, such as strain relief boots or enclosure feed throughs, the material shall conform to MIL-I-81765.

4.9 Thermally conductive insulators. Applications which require a thermally conductive insulator between heat generating parts and their heat sinks shall use a material in accordance with MIL-I-49456 if silicone grease is not suitable.

*4.10 Polyvinyl chloride. Polyvinyl chloride insulating materials shall not be used in aerospace applications. Their use in other applications requires procuring activity approval.

5. Information for guidance only

*5.1 Selection criteria. Insulating materials should be selected based upon meeting or exceeding application requirements, such as:

a. Temperature endurance
b. Moisture absorption and penetration
c. Fungus resistance
d. Dielectric strength
e. Dielectric constant
f. Mechanical strength
g. Dissipation factor
h. Ozone resistance
i. Flammability

5.2 Carcinogens. 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 29 CFR 1910. Consideration of the toxicity of a substance should be given prior to material selection.

REQUIREMENT 12

FASTENER HARDWARE

1. Purpose. This requirement establishes criteria for the selection and application of fastener hardware.

2. Documents applicable to Requirement 12:

FF-B-575	Bolts, Hexagon and Square
FF-N-836	Nut, Square, Hexagon, Cap, Slotted, Castle Knurled, Welding and Single Ball Seat
FF-R-556	Rivet, Solid, Small; Rivet, Split, Small; Rivet Tubular, Small; Flat Washer (Burr); and Cap, Rivet, General Purpose
FF-S-85	Screw, Cap, Slotted and Hexagon-Head
FF-S-86	Screw, Cap, Socket-Head
FF-S-92	Screw, Machine; Slotted, Cross Recessed or Hexagon Head
FF-S-200	Setscrews; Hexagon Socket and Spline Socket, Headless
FF-S-210	Setscrews, Square Head and Slotted Headless
FF-W-84	Washers, Lock (Spring)
FF-W-92	Washer, Metal, Flat (Plain)
FF-W-100	Washer, Lock (Tooth)
TT-S-1732	Sealing Compound, Pipe Joint and Thread, Lead Free, General Purpose
FED-STD-H28	Screw-Thread Standards for Federal Services
MIL-S-1222	Studs, Bolts, Hex Cap Screws, Socket Head Cap Screws and Nuts
MIL-F-5591	Fasteners, Panel; Nonstructural
MIL-R-5674	Rivets, Structural, Aluminum Alloy, Titanium Columbium Alloy, General Specification for
MIL-B-6812	Bolts, Aircraft
MIL-S-7742	Screw Threads, Standard, Optimum Selected Series; General Specification for
MIL-B-7838	Bolt, Internal Wrenching, 160 KSI FTU
MIL-R-7885	Rivets; Blind, Structural, Pull-Stem and Chemically Expanded
MIL-R-8814	Rivets, Blind, Nonstructural Type
MIL-B-8831	Bolt, Tensile, Steel, 180 KSI FTU, 450°F, External Wrenching, Flanged Head
MIL-S-8879	Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification for
MIL-F-18240	Fastener, Externally Threaded 250°F, Self-Locking, Element for
MIL-T-22361	Thread Compound, Antiseize, Zinc Dust-petrolatum
MIL-S-22473	Sealing, Locking and Retaining Compounds: (Single-Component)
MIL-R-22978	Fastener, Rotary, Quick-Operating, High Strength
MIL-R-24243	Rivet, Blind, Nonstructural, Retained Mandrel, Open-end, Domed Head, Aluminum Alloy, Carbon Steel

MIL-N-25027	Nut, Self-Locking 250°F, 450°F, and 800°F
MIL-R-27384	Rivet, Blind, Drive Type
MIL-S-46163	Sealing, Lubricating, and Wicking Compounds: Thread Locking, Anaerobic, Single Component
MS33522	Rivets, Blind, Structural, Mechanically Locked and Friction Retainer Spindle, (Reliability and Maintainability, Design and Construction Requirements for)
MS33540	Safety Wiring, and Cotter Pinning, General Practices for
MS33557	Nonstructural Rivets for Blind Attachment, Limitations for Design and Usage
NAS498	Bolts, Shear, 95 KSI FSU
NAS547	Fastener, Rotary, Quick-Operating, High Strength
NAS1686	Rivet, Blind, Aluminum Sleeve, Mechanically Locked, Spindle, Bulbed
NAS1687	Rivet, Blind, Monel and Inconel Sleeve, Mechanically Locked Spindle, Bulbed

3. Definitions. Not applicable.

4. Requirements

4.1 Threaded fasteners and related parts

4.1.1 Screw threads. Screw thread selection shall be based on the using applications in accordance with the following.

a. Screw threads shall be in accordance with FED-STD-H28 in applications where the threaded fasteners are required to mate with or mount threaded commercial equipment or devices.

b. Screw threads shall be in accordance with MIL-S-8879 for applications requiring high strength or high fatigue life. (Caution shall be exercised where a MIL-S-8879 UNJ external thread fastener is used due to its incompatibility with the commonly used UNC, UNF or UNEF threaded nut or tapped hole.)

c. Screw thread sizes and series for general usage shall be selected in accordance with MIL-S-7742.

4.1.2 Screws. Screws shall conform to the specifications listed below.

a. Machine screws shall conform to FF-S-92.

b. Cap screws shall conform to FF-S-85 or FF-S-86.

c. Setscrews shall conform to FF-S-200 or FF-S-210.

d. Self-locking screws shall conform to MIL-F-18240. Fiber inserts shall not be used as the locking device.

4.1.3 Bolts. Bolts shall conform to the specifications listed below.

a. Hex bolts shall conform to FF-B-575.

b. Bolt studs shall conform to MIL-S-1222.

c. Aircraft bolts shall conform to MIL-B-6812.

d. Internal wrenching bolts shall conform to MIL-B-7838.

e. High tensile strength bolts shall conform to MIL-B-8831.

f. Shear bolts shall conform to NAS498.

4.1.4 Nuts. Nuts shall conform to the specifications listed below.

a. General purpose nuts shall conform to FF-N-836.

b. High temperature nuts shall conform to MIL-S-1222.

c. Self-locking nuts shall conform to MIL-N-25027.

4.1.4.1 Sheet spring nuts. Sheet spring nuts shall not be used without specific approval of the procuring agency.

4.1.5 Safety wiring and cotter pins. Application of safety wiring and cotter pins shall conform to MS33540.

4.1.6 Quarter turn fasteners. Quarter turn fasteners shall conform to MIL-F-5591.

4.1.7 Rotary quick operating high strength fasteners. Rotary quick operating high strength fasteners shall conform to MIL-F-22978 or NAS547.

4.1.8. Lockwashers. Lockwashers shall conform to the specifications listed below.

a. Spring lockwashers shall conform to FF-W-84.

b. Tooth lockwashers shall conform to FF-W-100.

4.1.9 Flat washers. Flat washers shall conform to FF-W-92.

4.1.10 Thread-locking and retaining compounds. Thread-locking and retaining compounds shall conform to MIL-S-22473 or MIL-S-46163.

4.1.11 Antiseize compounds. Antiseize compounds shall conform to MIL-T-22361 or TT-S-1732.

4.2 Rivets

4.2.1 Nonstructural rivets. Nonstructural rivets shall conform to the following.

a. Small solid, split, tubular and general purpose rivets shall conform to FF-R-556.

b. Nonstructural blind rivets shall conform to MIL-R-8814.

c. Blind, nonstructural, retained mandrel type rivets shall conform to MIL-R-24243.

4.2.2 Structural rivets. Structural rivets shall conform to the following:

a. Aluminum and aluminum alloy rivets shall conform to MIL-R-5674.

b. Structural, blind, pull-stem rivets shall conform to MIL-R-7885, NAS1686 or NAS 1687.

c. Blind, drive type rivets shall conform to MIL-R-27384.

5. Information for guidance only

5.1 Threaded fasteners

5.1.1 Fastening of soft materials to soft materials. The mounting or assembly of parts made of soft materials to soft materials should be accomplished by one of the following methods:

a. A through-screw or bolt secured by a self-locking nut or plain nut with a lockwasher.

b. A through-screw or bolt secured by a plain nut with a thread locking compound applied to the threads of the screw or bolt and nut.

c. A screw or bolt in a threaded device such as a threaded bushing; a staked, clinched or pressed-in nut; or a threaded insert. The bushing, nut,

or insert shall be secured to, or should be installed in, the parent structure in accordance with the applicable procedures. The engaged length of threaded inserts in the parent material should be at least 1.5 times the nominal diameter of the internal thread. Where the material thickness is insufficient to accommodate a 1.5 times thread diameter insert, a shorter insert may be used in applications where maximum strength is not of primary importance; or a solid threaded bushing (which provides equal strength with less length because of the greater outside diameter of the bushing) should be used. When the screw or bolt is to be installed in an aluminum alloy part, the aluminum alloy part should be provided with threaded inserts of corrosion resistant steel or other suitable materials. When the screw or bolt is to be installed in a plastic material part, the plastic part should be provided with threaded inserts. If lockwashers or self-locking threaded inserts are not used, a thread-locking compound in accordance with 4.1.10 should be applied to the threads of the screw or bolt.

d. A screw or bolt in a tapped hole, with a thread-locking compound in accordance with 4.1.10 applied to the threads of the screw or bolt.

e. A stud in a tapped hole. Self-locking nuts should be avoided on stud-mounted components, unless the stud material is compatible with the strength and material of the nut used.

5.1.2 Fastening of hard materials to soft materials. In addition to the methods outlined in 5.1.1, a screw or bolt with a lockwasher may be used in a threaded bushing, staked, clinched or pressed-in nut, threaded insert or tapped hole.

5.1.3 Fastening of soft materials to hard materials. In addition to the methods outlined in 5.1.1, a self-locking screw or bolt may be used in a hole tapped into the hard material. Self-locking screws or bolts with nonmetallic

locking devices should not be used where the specified service conditions or processing, such as baking of paints or soldering, might deteriorate the locking device.

5.1.4 Fastening of hard materials to hard materials. Any of the methods outlined in 5.1.1 through 5.1.3 may be used.

5.1.5 Fastening of brittle materials. Brittle castings or parts made of ceramic or other brittle materials should be properly cushioned when necessary to prevent breakage. Washers or gaskets of suitable material and compressibility should be used between the facing surfaces of the brittle part and other brittle or metal parts, when practicable, to prevent breakage or damage to the protected parts during assembly or from severe shock, vibration or temperature changes encountered under the specified service

conditions. Lead washers should not be used. Parts that are secured with threaded devices and pliable washers should not use lockwashers as the locking device, and other appropriate locking devices should be considered.

5.1.6 Fastening with aluminum alloy or magnesium fasteners. The use of threaded fasteners made of aluminum alloy or magnesium to mate with threaded parts of aluminum alloy or magnesium should be avoided wherever possible. Where such is required, an antiseize compound in accordance with 4.1.11 should be used to prevent seizing of the threads.

5.1.7 Flat washers. Flat washers should be used for the following applications:

a. Between screw heads and soft materials, unless a washer head screw, or similar type that provides a bearing surface equivalent to the bearing surface of the appropriate flat washer, is being used.

b. Between a nut or lockwasher and a soft material.

c. Where lockwashers are used for securing a soft material, a flat washer should be provided to prevent marring or chipping of the material or the applied protective coating, except in areas where an electrical ground is required.

d. Except where it conflicts with electromagnetic interference considerations, a flat washer should be used between an organically finished material and lock-washers, bolt and screw heads, or nuts.

*5.1.8. Thread engagement. The length of the screws and bolts installed with nuts should be such that the exposed portion is a minimum lenght equivalent to 1.5 thread pitches plus the chamber. Maximum length should be limited by the nearest larger standard screw length. For highly stressed applications, screws or bolts should have a minimum thread engagement of 1.5 times their nominal diameter in tapped parts other than nuts. In normal applications, screws or bolts should have a minimum engagement length equal to their nominal diameter in tapped parts other than nuts. When the assembly is not frequently disassembled and where maximum strength is not required, less thread engagement may be used.

5.2 Rivets. Rivets should be used in preference to other hardware for securing parts not requiring removal. Wherever the thickness of metal which accepts the heads of flush rivets is less than the height of the rivet heads, the material should be dimpled rather than countersunk. The distance from the center of rivet holes to the edges of the material in which the rivets are placed shall not be less than 1.5 times the rivet diameter. Design and limitations of rivets should be in accordance with MS33522 and MS33557.

Rivets for joining magnesium parts should be composition 5056 anodized aluminum alloy or an aluminum alloy having equal galvanic compatibility with the magnesium being used.

5.3 Other fastening methods

5.3.1 Set screws. One set screw may be used on a flatted shaft. Two set screws at 90° to 120° displacement should be used when the shaft is not flatted. Cone-point set screws should not be used, except when the opposing metal has been properly countersunk to receive the cone-point.

5.3.2 Access devices. Fasteners for use with access devices should be readily removable for replacement purposes without damaging the attached panel or access door.

5.3.2.1 Nonstructural applications. Quarter-turn fasteners should be used only to retain nonstructural access to devices where quick access is required.

5.3.2.2 Structural applications. Rotary, quick-operating, high strength panel fasteners should be used to retain structural access devices where quick access is required.

5.3.2.3 Threaded fasteners. Threaded fasteners used with access devices should be self-aligning, captive type hardware.

5.3.3 Screw threaded device applications

5.3.3.1 Screws or bolts without nuts. Applications requiring the use of screws or bolts without nuts should use one of the following screw locking methods:

a. Lockwashers under the heads of the screws or bolts

b. Self-locking screws

c. Self-locking threaded inserts

d. A locking or retaining compound in accordance with 4.1.10 applied to the threads

e. Safety wire through drilled heads in accordance with 4.1.5.

5.3.3.2 Countersunk head screws. Countersunk head screws, when not secured by other locking means, should be secured by the application of a thread-

locking compound in accordance with 4.1.10. Staking by means of upsetting metal is acceptable for permanent assemblies when other means are impracticable or unsatisfactory for design reasons.

5.3.3.3 Thread-forming, thread-cutting, and drive screws. Thread forming, thread-cutting, and drive screws should not be used except for attaching identification plates.

5.3.3.4 Safety wiring and cotter pins. Safety wiring and cotter pins should not be used on terminals such as screws and threaded studs that are required to function as electrical terminals.

5.3.3.5 Thread-locking and retaining compounds. Thread-locking and retaining compounds should not be used where required electrical conductivity is impaired or failure of the compound would endanger personnel or damage the equipment.

REQUIREMENT 13

STRUCTURAL WELDING

1. Purpose. This requirement establishes criteria for structural welds. Welded electrical connections are excluded from this requirement.

2. Documents applicable to Requirement 13:

MIL-W-6858	Welding, Resistance, Spot and Seam
MIL-W-46132	Welding, Fusion, Electron Beam, Process for
MIL-STD-22	Welded Joint Design
MIL-STD-248	Welding and Brazing Procedure and Performance Qualification
MIL-STD-1261	Arc Welding Procedures for Constructional Steels
MIL-STD-1595	Qualification of Aircraft, Missile, and Aerospace Fusion Welders
MIL-STD-2219	Fusion Welding for Aerospace Applications
MIL-HDBK-5	Metallic Materials and Elements for Aerospace Vehicle Structures
MIL-HDBK-730	Materials Joining
ANSI/AWS A2.4-86	Standard Symbols for Welding, Brazing and Nondestructive Examination
ANSI/AWS A3.0-85	Standard Welding Terms and Definitions, Including Terms for Brazing, Soldering, Thermal Spraying and Thermal Cutting

3. Definitions. Not applicable.

4. Requirements

4.1 Arc and gas welding. Welding by arc and gas methods shall be performed by operators who have passed the applicable certification tests and have a certificate of proficiency in accordance with MIL-STD-248 or MIL-STD-1595. Welding of aluminum, magnesium, and steel alloys shall conform to MIL-STD-2219.

4.2 Resistance welding. Resistance welding of joints shall conform to MIL-W-6858.

5. Information for guidance only

5.1 General. The joint areas of all parts to be welded should be cleaned of contaminants and materials which may be detrimental to obtaining satisfactory welds. Degradatio of material properties in the heat affected zone caused by welding should be considered. Weldments should be stress relieved when induced stress resulting from welding, design configuration, or materials welded may be harmful. See ANSI/AWS 2.4 for welding symbols, ANSI/AWS A3.0

for welding terms and definitions, and MIL-STD-22 for welded joint designs. MIL-HDBK-730 provides guidance in this field of materials joining and its related processes.

5.2 Resistance welding. MIL-HDBK-5 may be used as a guide for spot-to-sheet edge distances and allowable strengths.

5.3 Noncritical applications. In ground equipment applications, welding procedures in accordance with MIL-STD-1261 may be used where, if the weld should fail, it will not compromise personnel or equipment safety or prevent completion of the mission.

5.4 Other methods. Other welding methods, such as the electron beam process of MIL-W-46132, may be used provided approval is obtained from the procuring activity.

REQUIREMENT 14

TRANSFORMERS, INDUCTORS, AND COILS

1. Purpose. This requirement establishes criteria for the selection and application of transformers, inductors, and coils.

2. Documents applicable to Requirement 14:

MIL-T-55631	Transformers, Intermediate Frequency, Radio Frequency and Discriminator, General Specification for
MIL-T-83721	Transformer, Variable, Power, General Specification for
MIL-STD-981	Design, Manufacturing and Quality Standards for Custom Electromagnetic Devices for Space Applications
MIL-STD-1286	Transformers, Inductors, and Coils, Selection and Use of

3. Definitions. Not applicable.

4. Requirements

4.1 Selection. Selection of transformers, inductors, and coils shall be in accordance with MIL-STD-1286 and the following paragraphs.

4.1.1 Intermediate, radio frequency and discriminator transformers. Intermeadiate, radio frequency and discriminator transformers shall conform to Grade 1, 2, or 4 of MIL-T-55631. The use of Grade 3 transformers shall be limited to hermetically sealed or encapsulated assemblies.

4.1.2 Variable transformers. Variable transformers shall conform to MIL-T-83721.

4.1.3 Custom electromagnetic devices for space applications. Custom electromagnetic devices for space applications shall conform to MIL-STD-981.

5. Information for guidance only. Not applicable.

REQUIREMENT 15

METALS, CORROSION RESISTANCE

1. Purpose. This requirement establishes criteria for the selection and treatment of metals as related to their ability to resist corrosion.

2. Documents applicable to Requirement 15:

MIL-STD-889	Dissimilar Metals
MIL-STD-1516	Unified Code for Coatings and Finishes for DOD Materiel

3. Definitions. Not applicable.

4. Requirements. Metals shall be corrosion resistant or shall be coated or metallurgically processed to resist corrosion. Materials and processes for metallic parts shall conform to applicable requirements in MIL-STD-889 and MIL-STD-1516. Coatings shall be selected from MIL-STD-1516.

5. Information for guidance only. The environmental severity to which the equipment will be exposed should be considered in selection of metals. The use of non-corrosion resistant steel alloys, except where specifically required for electronic purposes, should be kept to a minimum.

REQUIREMENT 16

DISSIMILAR METALS

1. Purpose. This requirement establishes criteria for the selection and protection of dissimilar metal combinations and other significant corrosion behavior factors.

2. Document applicable to Requirement 16:

MIL-STD-889 Dissimilar Metals

3. Definitions. Not applicable.

4. Requirements. Selection of metals for use in electronic equipment shall be made in accordance with the requirements of MIL-STD-889.

5. Information for guidance only. Where electronic design requirements preclude the insulation of incompatible metal combinations as identified in MIL-STD-889 from one another, specific attention should be paid to isolating the combination from exterior environments.

REQUIREMENT 17

PRINTED WIRING

1. Purpose. This requirement established criteria for the design and treatment of printed wiring assemblies.

2. Documents applicable to Requirement 17:

MIL-P-46843	Printed Wiring Assemblies
MIL-STD-1861	Electrical and Electronic Assemblies, Boards, Cards, and Associated Hardware, Selection and Use of
ANSI/IPC-D-322	Guidelines for Selecting Printed Wiring Board Sizes Using Standard Panel Sizes

3. Definitions. Not applicable.

4. Requirements

4.1 Rigid printed wiring and printed wiring boards. Rigid printed wiring and printed wiring boards for single-sided, double-sided, and multilayer printed wiring shall conform to MIL-STD-1861. The materials used for single-sided, double-sided, and multilayer printed wiring boards shall conform to MIL-STD-1861.

4.2 Rigid printed wiring assemblies. Rigid printed wiring assemblies consisting of rigid printed wiring boards on which separately manufactured parts have been added shall conform to MIL-STD-1861. For Army missile weapon systems, MIL-P-46843 shall apply only for replacement purposes

4.3 Conformal coating. When conformal coating is required, rigid printing wiring assemblies shall be conformally coated with a coating material which conforms to MIL-STD-1861.

4.4 Flexible and rigid-flex wiring. Flexible and rigid-flex printed wiring shall conform to MIL-STD-1861 and shall be designed in accordance with MIL-STD-1861.

*4.5 Discrete wiring boards. Discrete wiring boards with plated-through holes shall be in accordance with MIL-STD-1861.

4.6 Backplane assemblies, printed wiring. Electrical backplane printed wiring assemblies shall conform to MIL-STD-1861 and shall be designed in accordance with MIL-STD-1861.

5. Information for guidance only

5.1 Printed wiring board size. Guidelines for the selection of printed wiring board sizes are delineated in ANSI/IPC-D-322.

REQUIREMENT 18

DERATING OF ELECTRONIC PARTS AND MATERIALS

1. Purpose. This requirement establishes criteria for derating of electronic parts and materials.

2. Document applicable to Requirement 18:

MIL-STD-1547 Parts, Materials, and Processes for Space and Launch Vehicles, Technical Requirements for

3. Definitions. Not applicable.

4. Requirements

4.1 Derating. In the application of electronic parts and materials, the parts and materials selected shall be used within their electrical ratings and environmental capabilities (e.g., any ambient or hot spot temperatures, voltage, current, or power dissipation). Derating shall be accomplished as necessary to assure the required equipment reliability within the specified operating conditions.

4.2 Derating for launch vehicles and space systems. Electronic parts and materials used in launch vehicles or space systems shall be derated in accordance with the requirements of MIL-STD-1547.

5. Information for guidance only. Not applicable.

REQUIREMENT 19

TERMINATIONS

1. Purpose. This requirement establishes criteria for the selection and application of terminations.

2. Documents applicable to Requirement 19:

MIL-T-7928	Terminals, Lug and Splice, Crimp-Style, Copper
MIL-T-15659	Terminal, Lug, Solder, Copper and Phosphor Bronze
MIL-T-55156	Terminals, Lug, Splices, Conductor; Screw Type, General Specification for
MIL-T-55164	Terminal Boards, Molded, Barrier, Screw Type, and Associated Terminal Board Lugs, General Specification for
MIL-STD-1277	Splices, Terminals, Terminal Boards, Binding Posts, Terminal Junction Systems, Wire Caps; Electrical
MS 27212	Terminal Boards, Assembly, Molded-in Stud, Electric

3. Definitions. Not applicable.

4. Requirements

4.1 Terminals

4.1.1 Lug terminals. Lug terminals shall conform to one of the following specifications, and wherever possible shall be selected from MIL-STD-1277.

MIL-T-7928	Crimp, Insulated and Noninsulated
MIL-T-15659	Solder
MIL-T-55156	Screw

4.1.2 Stud terminals, feed-through terminals, and binding posts. Stud terminals, feed-through terminals and binding posts shall be selected from MIL-STD-1277.

4.1.3 Number of wires per terminal or lug. The number of wires terminated in an individual terminal or lug shall not be greater than three. Multisection turret, bifurcated, or multi-hole lug terminals shall have not more than three wires per section, tong, or hole. In no case shall the total cross sectional area of the terminated wires exceed the cross sectional area capacity of the terminal or lug. If a greater number of wires is required than those specified herein, approval of the procuring activity shall be obtained.

4.2 Terminal boards. Terminal boards shall be selected from MIL-STD-1277.

4.2.1 Number of lugs per terminal. The maximum number of lugs to be connected to any one terminal on a terminal board shall be two for screw-type terminal boards covered by MIL-T-55164 and as specified in the detail specification sheets for stud-type terminal boards. Not more than four lugs shall be connected to any one terminal of a board covered by MS27212. Accessories such as stud connectors, straddle plates, jumpers and terminal board lugs shall be counted as lugs for this purpose.

4.3 Terminal junction systems. Terminal junction systems shall be selected from MIL-STD-1277.

5. Information for guidance only. Crimping of terminal lugs should be so accomplished that the connections will meet the resistance (voltage drop) and tensile strength requirements and tests of MIL-T-7928.

REQUIREMENT 20

WIRE, HOOKUP, INTERNAL

1. Purpose. This requirement establishes criteria for the selection and application of electrical internal hookup wire.

2. Documents applicable to Requirement 20:

QQ-W-343	Wire, Electrical, Copper (Uninsulated)
MIL-W-76	Wire and Cable, Hookup, Electrical, Insulated
MIL-W-5086	Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy
MIL-W-5845	Wire, Electrical, Iron and Constantan, Thermocouple
MIL-W-5846	Wire, Electrical, Chromel and/or Alumel, Thermocouple
MIL-W-5908	Wire, Electrical, Copper and Constantan, Thermocouple
MIL-W-16878	Wire, Electrical, Insulated, General Specification for
MIL-W-19150	Wire, Insulated, Hard Drawn Copper
MIL-W-22759	Wire, Electric, Fluoropolymer-Insulated, Copper or Copper Alloy
MIL-W-81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-Imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy
MIL-W-81381	Wire, Electric, Polyimide Insulated, Copper or Copper Alloy
MIL-W-81822	Wire, Electrical, Solderless Wrap, Insulated and Uninsulated, General Specification for
MIL-STD-681	Identification Coding and Application of Hook-Up and Lead Wire

3. Definitions. Not applicable.

4. Requirements

4.1 Selection. Internal hookup wire shall be selected from the types and classes specified by the documents listed in table 20-I. For solderless wrap applications, wires shall be selected which are in accordance with MIL-W-81822.

4.1.1 MIL-W-76 shall be used for Army applications only.

4.1.2 MIL-W-16878 shall not be used for Air Force or Navy aerospace applications.

*TABLE 20-I. Wire, electrical.

Spec No.	Title	Spec Type or Class	CONSTRUCTION						Max Cond Temp °C	Max rms Volts	Remarks
			1/ Conductor			2/ Insulation					
			Material	Coating	Type	Primary	Primary Cover	Jacket/ Topcoat			
MIL-W-76	Wire and Cable Hook-up, Electrical Insulated	LW	Cu/A or CCW	Sn	S,Str	1	8,10, 13A 3/	8,10,13A 3/	80	300	See Note 4 For US Army
		MW								1000	
		HW								2500	
		HF				2A				1000	
MIL-W-5086	Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy	M5806/1	Cu/A	Sn	Str	1		8	105	600	
		M5086/2						8, 11			
		M5086/4						8	110	3000	
		M5086/5						9A			
		M5086/6	HSA	Ag						600	
		M5086/7	Cu/A	Sn				8	105		
MIL-W-16878	Wire, Electrical, Insulated	M16878/1	Cu/A HSA, CCW	Ag, Sn	S,Str	1	8,10,11	1,8,10,11	105	600	See Note 4
		M16878/2								10000	
		M16878/3								3000	
		M16878/4		Ag		3A		3A,3B,4A, 13B 3/	200	600	
		M16878/5								1000	
		M16878/6								250	
		M16878/7	Cu/A			6	4A,8,10, 11	4A,8,10, 11		600	
		M16878/8								1000	
		M16878/10		Sn		2A	8,10,11		75	600	
		M16878/11	Cu/A, CCW	Ag		4A		4A	200	1000	
		M16878/12								250	
		M16878/13		Ag,Sn						600	
		M16878/14	Cu/A	Sn		2C			125	1000	
		M16878/15								600	
		M16878/16								3000	
		M16878/17									

TABLE 20-I. Wire, electrical. - Continued

Spec No.	Title	Spec Type or Class	CONSTRUCTION						Max Cond Temp °C	Max rms Volts	Remarks
			1/ Conductor			2/ Insulation					
			Material	Coating	Type	Primary	Primary Cover	Jacket/ Topcoat			
		M16878/18		Ag,Sn		1		8	105	1000	
		M16878/19								3000	
		M16878/20								250	
		M16878/21	Cu/A,	Ag		3B			200	600	
		M16878/22	HSA,							1000	
		M16878/23	CCW			3A				250	
		M16878/24				3B		3A,3B,4A,			
		M16878/25		Ni		3A		13B3/	260	600	
		M16878/26				3B					
		M16878/27				3A				1000	
		M16878/28				3B					
		M16878/29								600	
		M16878/30	Cu/A	Sn	Str	6			150		
		M16878/31								1000	
		M16878/32		Ag					200		
		M16878/33	Cu/A, CCW	Sn	S,Str	2A			75	600	
		M16878/34	Cu	Ag	Str	3B			200		
		M16878/35		Ni					260	1000	
MIL-W-19150	Wire, Insulated, Hard Drawn Copper		Cu/H			2A		8			
MIL-W-22759	Wire, Electric, Fluoropolymer Insulated, Copper or Copper Alloy	M22759/9		Ag					200	1000	See Note 4
		M22759/10		Ni		3A			260		
		M22759/11	Cu/A	Ag					200		
		M22759/12		Ni					260		
		M22759/14		Sn		4A		9B	135		
		M22759/15	HSA	Ag						600	
		M22579/16	Cu/A	Sn							

TABLE 20-I. Wire, electrical. - Continued

Spec No.	Title	Spec Type or Class	CONSTRUCTION						Max Cond Temp °C	Max rms Volts	Remarks
			1/ Conductor			2/ Insulation					
			Material	Coating	Type	Primary	Primary Cover	Jacket/ Topcoat			
		M22759/17	HSA	Ag	Str	17			150		
		M22759/18	Cu/A	Sn							
		M22759/19		Ag							
		M22759/21		Ni					260	1000	
		M22759/22	HSA	Ag		3A			200		
		M22759/23		Ni					260		
		M22759/31						7			
		M22759/32	Cu/A	Sn					150		
		M22759/33	HSA	Ag					200	600	
		M22759/34	Cu/A	Sn					150		
		M22759/35	HSA	Ag		21					
		M22759/41	Cu/A	Ni				21	200		
		M22759/42	HSA								
		M22759/43	Cu/A	Ag							
MIL-W-81044	Wire, Electric, Crosslinked Polyalkene, etc. Insulated	M81044/12	Cu/A	Sn	Str	2B		9B	150	600	See application temp limitation on detail spec sheet
		M81044/13	HSA	Ag							

TABLE 20-I. Wire, electrical. - Continued

Spec No.	Title	Spec Type or Class	CONSTRUCTION						Max Cond Temp °C	Max rms Volts	Remarks
			1/ Conductor			2/ Insulation					
			Material	Coating	Type	Primary	Primary Cover	Jacket/ Topcoat			
MIL-W-81381	Wire, Electric, Polyimide Insulated, Copper or Copper Alloy	M81381/7	Cu/A	Ag	Str	19	4B	20	200	600	/11,/12, and /22 have a bright aromatic polyamide braid with clear finisher coatings on 8 AWG and larger
		M81381/8		Ni							
		M81391/9	HSA	Ag							
		M81381/10		Ni							
		M81381/11	Cu/A	Ag							
		M81381/12		Ni							
		M81381/13	HSA	Ag							
		M81381/14		Ni							
		M81381/17	Cu/A	Ag							
		M81381/18		Ni							
		M81381/19	HSA	Ag							
		M81381/20		Ni							
		M81381/21	Cu/A	Sn					150		
		M81381/22									

TABLE 20-I. Wire, electrical. - Continued

NOTES:

1/

Conductor	Code	Description
Material	Cu/A	Copper, annealed
	Cu/H	Copper, hard drawn
	CCW	Copper, covered steel
	HSA	High strength copper alloy
	Al	Aluminum
Coating	Sn	Tin
	Ag	Silver
	Ni	Nickel
Type	S	Solid
	Str	Stranded

2/

Insulation Code	Description
1	Polyvinyl chloride/extruded
2A	Polyethylene/extruded
2B	Polyalkene/cross-linked/extruded
2C	Polyethylene/cross-linked/modified/extruded
3A	Polytetrafluoroethylene/extruded (TFE teflon)
3B	Polytetrafluoroethylene/tape
3C	Polytetrafluoroethylene/mineral filled/extruded
4A	Fluorinated ethylene propylene/extruded (FEP teflon)
4B	Fluorinated ethylene propylene/dispersion
6	Silicone rubber/extruded
7	Polyimide lacquer (Pure ML)
8	Polyamide/extruded (Nylon)
9A	Polyvinylidene fluoride/extruded (Kynar)
9B	Polyvinylidene fluoride/extruded/cross-linked
10	Braid/synthetic yarn/lacquer impregnated
11	Braid/nylon/impregnated
13A	Braid/glass fiber/impregnated
13B	Braid/TFE coated glass fiber/TFE finish
17	ETFE fluoropolymer
19	Fluorocarbon/polyimide tape
20	Modified aromatic polyimide resin
21	Ethylene-tetrafluoroethylene/cross-linked/modified/extruded

3/ When specified on purchase order

4/ Various combinations of primary, primary cover, and jacket insulations, and unshielded, shielded, etc., constructions are available to meet application requirements. See detail wire specification.

4.1.3 MIL-W-22759 wire with only single polytetrafluoroethylene insulation used in Air Force space and missile applications shall require the approval of the procuring activity.

4.1.4 Wires with polyvinyl chloride insulation shall not be used in aerospace applications. Use of these wires in any other application requires prior approval of the procuring activity.

4.1.5 Silver plated copper wire shall not be used in applications involving Army missile systems.

4.2 Identification. Hookup wires in the equipment shall be, insofar as practicable, distinctly coded in color or numbered. Short hookup wire, 150 mm or less between termination points, need not be marked if the path of the short wire can be easily and visually traced. The unmarked wire must be specified on the drawing. Codes, when used, shall be in accordance with MIL-STD-681 or as otherwise agreed upon with the procuring activity. Numbers shall not be used where they would be difficult to read or trace, such as in compact assemblies.

*4.3 Bare wire. Bare hookup wire shall be type H class S, soft or drawn and annealed, and coated, and shall conform to QQ-W-343. Bare hookup wire shall not be used unless insulated wire is impractical because of circuit characteristics or shortness of wire run.

5. Information for guidance only

5.1 Solid or stranded. Stranded wire should be used for conductors and cables which are normally flexed in use and servicing of the equipment, such as cables attached to the movable half of detachable connectors and hanging cables attached to removable or movable doors and shields. Leads 150 mm or less in length may be run as solid wires unless they form interconnections between shock isolation mounted parts and nonshock isolation mounted parts. There are some other instances, such as wire wrapping, where a solid conductor may be required regardless of length.

5.2 Cold flow. Certain insulating materials exhibit a cold flow characteristic. Caution should be used in the selection of these materials in applications requiring restrictive clamping or tying, etc, where this feature may result in exposed or shorted conductors.

5.3 Thermocouple wire. Selection of thermocouple wire shall be in accordance with MIL-W-5845, MIL-W-5846, or MIL-W-5908.

REQUIREMENT 21

CASTINGS

1. Purpose. This requirement establishes criteria for the design, classification, inspection, and repair of castings.

2. Documents applicable to Requirement 21:

MIL-STD-276	Impregnation of Porous Nonferrous Metal Castings
MIL-STD-2175	Castings, Classification and Inspection of

3. Definitions. Not applicable.

4. Requirements

4.1 Die castings. Die castings shall not be used where the casting might be subject to impact. Zinc alloy die castings shall not be used where dimensional changes of the casting could affect use of equipment.

4.2 Porous castings. When required, castings shall be impregnated in accordance with MIL-STD-276.

4.3 Classification and inspection. Castings shall be classified and inspected in accordance with MIL-STD-2175.

4.4 Inserts. Inserts which are intended to be cast in place shall be knurled, grooved, or otherwise prepared to secure satisfactory keying of the insert to the casting. Inserts shall be fabricated from a material which is not adversely affected by exposure to the molten casting alloy. When inserts are located near a casting edge, sufficient edge distance shall be allowed in order to develop the required resistance to insert pull-out, and to avoid cracking of the casting. Casting defects resulting from use of inserts, such as partial alloying, poor bonds, porosity, and cracks shall not be present.

5. Information for guidance only

5.1 Selection and application. In any design utilizing metallic castings, consideration should be given to intended application, the availability of molding and casting alloys, the choice of a suitable casting process (see table 21-I), and the use of ribs and fins.

TABLE 21-I. General comparison of metallic casting processes.

Type of castings	Dimensional accuracy	Ability to reproduce fine detail	Tool cost	Suitability for volume production	Surface smoothness	Suitability for large sized castings
Sand	3	3	1	3	3	1
Die	1	1	3	1	1	3
Investment	1	1	3	2	1	3
Shell mold	2	2	3	1	2	3
Permanent mold	2	2	3	1	2	2
Plaster mold	2	1	1	3	2	3

Legend: 1 = Very good; 2 = good; 3 = fair

5.2 Repair of unmachined castings. Repair of minor discontinuities or defects in unmachined or raw castings should be permitted only when specific approval has been granted by the contractor Material Review Board (MRB), or is specified on the engineering documentation. Weld repair should be limited to class 3 and class 4 castings (class 1 and class 2 repair should require procuring activity approval) and to areas where no severe stress will be encountered. Heat treatable alloys must be fully reheat treated after welding to meet drawing requirements.

5.3 Repair of machined castings. Repair of defects in machined castings should be permitted for class 3 and class 4 castings based on the contractor's MRB decision. Class 1 and class 2 casting repair should require procuring activity approval. Reheat treatment should be required unless engineering analysis during MRB action can demonstrate it is unnecessary.

REQUIREMENT 22

PARTS SELECTION AND CONTROL

1. Purpose. This requirement offers guidance as to parts selection and control which must be considered when preparing contractual documents. IT DOES NOT ESTABLISH REQUIREMENTS AND MUST NOT BE REFERENCED IN CONTRACTUAL DOCUMENTS. Parts selection and control must be directly specified in the contract or the system/equipment specification, as appropriate.

2. Documents applicable to Requirement 22:

MIL-STD-965	Parts Control Program
MIL-STD-1546	Parts, Materials, and Processes Standardization Control and Management Program for Spacecraft and Launch Vehicles

3. Definitions. Not applicable.

4. Requirements. Not applicable.

5. Information for guidance only

5.1 Parts control program. MIL-STD-965 establishes two procedures covering the submission, review, and approval of Program Parts Selection Lists and changes thereto. The objective is to achieve life cycle cost savings and cost avoidances by: (1) assisting equipment or system managers and their contractors in the selection of parts commensurate with contractual requirements, (2) minimizing the variety of parts used in new design, (3) enhancing nterchangeability, reliability, and maintainability of military equipment and supplies, and (4) conserving resources and (5) assuring long term availability of parts. MIL-STD-965 must be tailored when applied; application guidance is offered in the document.

5.2 Parts control program for spacecraft and launch vehicles. (Not applicable to NASA programs) MIL-STD-1546 establishes the criteria and requirements for the preparation and implementation of a Parts, Materials, and Processes Standardization Control and Management Program for use during the design, development, fabrication, and test of spacecraft and launch vehicles. The implementation of this standard is intended to: (1) assure total, integrated, and coordinated management of the selection, application, procurement, control and standardization of parts, materials and processes (PMP), (2) reduce program costs, (3) improve the standardization and reliability of program parts, materials, and processes and (4) assure long term availability of parts.

REQUIREMENT 23

ADHESIVES

1. Purpose. This requirement establishes guidance for the selection and application of adhesives.

2. Documents applicable to Requirement 23:

MMM-A-121	Adhesive, Bonding, Vulcanized Synthetic Rubber to Steel
MMM-A-130	Adhesive, Contact
MMM-A-132	Adhesive, Heat Resistant, Airframe Structural, Metal to Metal
MMM-A-134	Adhesive, Epoxy Resin, Metal to Metal Structural Bonding
MMM-A-138	Adhesive, Metal to Wood, Structural
MMM-A-181	Adhesive, Phenol, Resorcinol, or Melamine Base
MMM-A-189	Adhesive, Synthetic-Rubber, Thermoplastic, General Purpose
MMM-A-1617	Adhesive, Rubber Base, General Purpose
MMM-A-1931	Adhesive, Epoxy, Silver Filled, Conductive
MIL-A-3920	Adhesive, Optical, Thermosetting
MIL-A-5540	Adhesive, Polychloroprene
MIL-A-8576	Adhesive, Acrylic Base, for Acrylic Plastic
MIL-A-22397	Adhesive, Phenol and Resorcinol Resin Base (for Marine Service Use)
MIL-A-24179	Adhesive, Flexible Unicellular-Plastic Thermal Insulation
MIL-A-25463	Adhesive, Film Form, Metallic Structural Sandwich Construction
MIL-A-46050	Adhesive, Cyanoacrylate, Rapid Room-Temperature Curing, Solventless
MIL-A-46146	Adhesive-Sealants, Silicone, RTV, Non-Corrosive (for Use With Sensitive Metals and Equipment)
MIL-A-47089	Adhesive, Metal Filled, Conductive, Electrical and Thermal
MIL-A-47315	Adhesive, Polyurethane
MIL-A-47317	Adhesive, Air Drying, Silicone Rubber
MIL-A-47318	Adhesive, Copolymer Polyurethane
MIL-A-48611	Adhesive System, Epoxy-Elastomeric, for Glass-To-Metal
MIL-A-52194	Adhesive, Epoxy (for Bonding Glass Reinforced Polyester)
MIL-A-81236	Adhesive, Epoxy Resin With Polyamide Curing Agent
MIL-A-81253	Adhesive, Modified Epoxy Resin With Polyamine Curing Agent
MIL-A-83377	Adhesive Bonding (Structural) for Aerospace and Other Systems, Requirements for
MIL-A-87135	Adhesives, Non-Conductive, for Electronics Application
MIL-HDBK-691	Adhesive Bonding
29 CFR 1910	Code of Federal Regulations, Title 29, Chapter XVII, Part 1910

3. Definitions

3.1 Adhesives. Adhesives are substances capable of holding materials together by surface attachment. Adhesive is a general term and includes, among others, cement, glue, mucilage and paste. All of these terms are loosely used interchangeably.

4. Requirements. Not applicable.

5. Information for guidance only

5.1 Design of joint. The joint should be designed to minimize concentrations of stress. The basic stress should be in shear. The weakest design is where the basic stress is in cleavage or peel and non-axial loading in tension produces cleavage.

5.2 Deleterious effects. The user should ascertain that the formulation of the adhesive selected will have no deleterious effects on the bonded assembly or nearby items when the bonded assembly is in storage, transit or use under the environmental conditions for which it was designed. Deleterious effects may be caused by the slow release of trapped solvents which can damage many types of rubber and plastic, or cause other harmful results degrading operation of the equipment.

5.3 Application. Care should be taken to avoid starved joints which are the result of either absorption of adhesive by a porous material, poor application, inadequate coverage, or excessive pressure. Where one or both of the adherends are porous, successive thin coats of adhesive should be applied to completely seal the surface, and each coat should be dry before the next coat is applied. This procedure should be used instead of the application of one thick adhesive coat to the porous surface, except in the case of silicone adhesives. In general, the thicker the adhesive layer, the lower the shear resistance, but the higher the strength to impact and peeling.

5.4 Structural compatibility. Adhesives which are not compatible structurally should be avoided. For example, a brittle adhesive should not be used for glass bonding because excessive shrinkage during setting or curing will load the glass in tension. For assemblies which may be flexed or subject to impact, a brittle adhesive should not be used.

5.5 Carcinogens. 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 carcinogens, they should be evaluated in accordance with 29 CFR 1910. Consideration of the toxicity of a substance should be given prior to material selection.

5.6 Thermoplastic. All thermoplastic adhesives have a tendency to creep under load, especially at elevated temperature, and should not be used in critical structural applications. Many thermoplastic adhesives have limited or poor resistance to certain solvents.

5.7 Materials to be bonded. The materials to be bonded assume critical importance as there are some materials, such as fluorocarbon, polyethylene, and nylon that cannot be bonded satisfactorily without prior treatment, special adhesives, or both.

5.8 Guide for selection and application. The following, although not a complete list, may be used as a guide in selecting adhesives and bonding procedures to meet design requirements in electronic equipment.

MMM-A-121	MMM-A-1617	MIL-A-25463	MIL-A-48611
MMM-A-130	MMM-A-1931	MIL-A-46050	MIL-A-52194
MMM-A-132	MIL-A-3920	MIL-A-46146	MIL-A-81236
MMM-A-134	MIL-A-5540	MIL-A-47089	MIL-A-81253
MMM-A-138	MIL-A-8576	MIL-A-47315	MIL-A-83377
MMM-A-181	MIL-A-22397	MIL-A-47317	MIL-A-87135
MMM-A-189	MIL-A-24179	MIL-A-47318	MIL-HDBK-691

Many of these specifications have no requirements pertaining to electrical properties. Where electrical properties are important, the suitability of the material for the application should be established.

REQUIREMENT 24

WELDS, RESISTANCE, ELECTRICAL INTERCONNECTIONS

1. Purpose. This requirement establishes criteria for resistance welds of electrical and electronic interconnections and part leads. This requirement does not include structural welds.

2. Documents applicable to Requirement 24:

MIL-W-8939 Welding, Resistance, Electronic Circuit Modules

3. Definitions. Not applicable.

4. Requirements. Welds and welding processes shall be in accordance with MIL-W-8939.

5. Information for guidance only

5.1 Contaminants. All surfaces of leads or parts to be welded should be free of contaminants which would adversely affect forming of the welded joint.

5.2 Electrical connections. Except where needed to meet electromagnetic interference or system compatibility requirements, welded electrical connections should not be used where it may be necessary to disconnect, replace, or reconnect a part or module during servicing.

5.3 Excess conductor wire. Excess conductor wire should be trimmed sufficiently close to provide adequate clearance to prevent possible electrical shorting but not so close as to cause damage to the welded joint.

5.4 Strain relief. Each part lead terminating at a connection point should have allowance for strain relief to minimize tensile or shear stress.

REQUIREMENT 25

ELECTRICAL POWER

1. Purpose. This requirement establishes criteria for electrical power.

2. Documents applicable to Requirement 25:

MIL-STD-205	Frequencies for Electric Power
MIL-STD-255	Electric Voltages, Alternating and Direct Current
MIL-STD-704	Aircraft Electric Power Characteristics
MIL-STD-1275	Characteristics of 28 Volt DC Electrical Systems in Military Vehicles
MIL-STD-1399	Interface Standard for Shipboard Systems
MIL-STD-1539	Electrical Power, Direct Current, Space Vehicle Design Requirements

3. Definitions. Not applicable.

4. Requirements

4.1 General. Except as specified below, the electrical power source required for electronic equipment and associated equipment and for portions of systems employing electronic equipment shall be in accordance with MIL-STD-205 and MIL-STD-255.

4.2 Airborne. The electrical power requirements for airborne and associated equipment shall be in accordance with MIL-STD-704.

4.3 Shipboard. The electrical power requirements for shipboard and associated equipment shall be in accordance with Type I or Type II of Section 300 of MIL-STD-1399.

4.4 Space. The electrical power requirements for space equipment shall be in accordance with MIL-STD-1539.

4.5 Ground vehicles. The electrical power requirements for military ground vehicles shall be in accordance with MIL-STD-1275.

5. Information for guidance only. Not applicable.

REQUIREMENT 26

ARC-RESISTANT MATERIALS

1. Purpose. This requirement establishes criteria for the selection and application of arc-resistant materials used for insulation of electrical power circuits.

2. Documents applicable to Requirement 26:

L-P-516	Plastic Sheet and Plastic Rod, Thermosetting, Cast
ZZ-R-765	Rubber, Silicone
MIL-I-10	Insulating Compound, Electrical, Ceramic, Class L
MIL-M-14	Molding Plastics and Molded Plastic Parts, Thermosetting
MIL-P-79	Plastic Rod and Tube, Thermosetting, Laminated
MIL-P-997	Plastic Material, Laminated, Thermosetting, Electrical Insulation, Sheets, Glass Cloth, Silicone Resin
MIL-P-15037	Plastic Sheet, Laminated, Thermosetting, Glass-Cloth, Melamine-Resin
MIL-P-19161	Plastic Sheet, Laminated, Glass Cloth, Polytetrafluoroethylene Resin
MIL-M-24325	Molding Material, Plastic, Epoxy Compounds, Thermosetting
MIL-P-25518	Plastic Material, Silicone Resin, Glass Fiber Base, Low-Pressure Laminated
MIL-P-46112	Plastic Sheet and Strip, Polyimide
FED-STD-406	Plastics: Methods of Testing
ASTM D495-73	Standard Method of Test for High-Voltage, Low-Current Dry Arc Resistance of Solid Electrical Insulation Materials
29 CFR 1910	Code of Federal Regulations, Title 29, Chapter XVII, Part 1910

3. Definitions. Not applicable.

4. Requirements. Materials shall conform to table 26-I. The materials listed have passed the minimum requirements of 115 seconds when subjected to the arc-resistance test of ASTM D495 or Method 4011 of FED-STD-406, and are listed in approximate order of arc resistance.

5. Information for guidance only

5.1 Applications. Materials may be masked, if necessary, during any treatment of the equipment in which they are used which might result in degradation of the arc-resistant properties of the material. For parts which may be exposed to other than high-voltage, low-current arcing, the materials should be evaluated for overall thermal and electrical characteristics. Suitability for the specific application and the potential for satisfactory

performance in elevated humidity, as defined in the detail equipment specification, should also be considered.

5.2 Carcinogens. 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 29 CFR 1910. Consideration of the toxicity of a substance should be given prior to material selection.

TABLE 26-I. Arc-resistant materials.

Materials	Specification	Types
Ceramic	MIL-I-10	All
Plastic(s), thermosetting, Molding	MIL-M-14	CMI-5, GDI-30, GDI-30F, MAG, MAI-30, MAI-60, MAI-100, MAT-30, MDG, MME, MMI-5, MMI-30, MSG MSI-30, SDG, SDG-F, SDI-30
Molding, epoxy compounds	MIL-M-24325	MEE
Laminated rods and tubes	MIL-P-79	GMG
Laminated sheets		
Glass cloth, melamine resin	MIL-P-15037	GME
Glass cloth, polytetra-fluoroethylene resin	MIL-P-19161	GTE
Glass cloth, silicone resin	MIL-P-997	GSG
Low pressure laminate, silicone resin, glass fiber base	MIL-P-25518	All
Sheet and rod, cast	L-P-516	E-2
Sheet and strip, polyimide	MIL-P-46112	All
Silicone rubber	ZZ-R-765	All

REQUIREMENT 27

BATTERIES

1. Purpose. This requirement establishes the criteria for the selection and application of batteries, including installation and marking criteria.

*2. Documents applicable to Requirement 27:

MIL-B-18	Batteries, Non-Rechargeable, Dry
MIL-B-10154	Batteries, Primary, Water-Activated (Dunk Type)
MIL-B-11188	Batteries, Storage, Lead-Acid
DOD-B-15072	Batteries, Storage, Lead-Acid, Portable, General Specification for (Metric)
MIL-B-49030	Batteries, Dry (Alkaline)
MIL-B-49430	Batteries, Non-Rechargeable, Lithium Sulfur Dioxide
MIL-B-49436	Batteries, Rechargeable, Nickel-Cadmium, Sealed
MIL-B-49458	Batteries, Non-Rechargeable, Lithium Manganese Dioxide
MIL-B-49461	Batteries, Non-Rechargeable, Lithium Thionyl Chloride
MIL-B-55118	Batteries, Storage, (Cells), Vented, Nickel-Cadmium
MIL-B-55130	Batteries, Rechargeable, Nickel-Cadmium, Sealed
MIL-B-55252	Batteries, Magnesium, Dry
MIL-B-81757	Batteries and Cells, Storage, Nickel-Cadmium, Aircraft, General Specification for
MIL-B-83769	Batteries, Storage, Lead-Acid, General Specification for
DOD-STD-1578	Nickel-Cadmium Battery Usage Practices for Space Vehicles

Regulation 700-83, Army Materiel Command

3. Definitions. Not applicable.

4. Requirements

4.1 Use. Batteries shall not be used unless approved by the procuring activity.

4.1.1 Army applications. Battery power for Army equipment (development and non-development type) and other-service-developed equipment adopted by the Army shall be selected in accordance with Army Materiel Command Regulation 700-83.

4.1.2 Space applications. Batteries for space applications shall be selected and applied in accordance with DOD-STD-1578.

4.1.3 Lithium batteries. When lithium batteries are to be used in an equipment, direction on their use, transportation, storage, and disposal

should be requested through the procuring activity from the following sources:

For Army: US Army Laboratory Command
Electronics Technology and Devices Laboratory
ATTN: SLCET-P
Ft Monmouth NJ 07703-5302

For Navy: Department of the Navy
Naval Sea Systems Command
ATTN: NAVSEA 652
Washington DC 20362

For Air Force: Sacramento Air Logistics Center
ATTN: MMIEC
McClellan AFB CA 95652

4.2 Rechargeable batteries. Rechargeable batteries shall conform to MIL-B-11188, DOD-B-15072, MIL-B-49436, MIL-B-55118, MIL-B-55130, MIL-B-81757, MIL-B-83769, or DOD-STD-1578.

4.3 Nonrechargeable batteries. Nonrechargeable batteries shall conform to MIL-B-18, MIL-B-10154, MIL-B-49030, MIL-B-49430, MIL-B-49458, MIL-B-49461, or MIL-B-55252.

4.4 Installation marking. Connections, polarity, minimum acceptable voltage for equipment operation, nominal voltage, and type(s) of batteries required shall be marked as applicable in a prominent place on or adjacent to the battery compartment.

4.5 Warning label. Battery-powered equipment, with the exception of equipment requiring permanent battery installation, shall be labeled externally as follows:

WARNING
REMOVE BATTERIES BEFORE
SHIPMENT OR INACTIVE STORAGE
OF 30 DAYS OR MORE

Examples of equipment requiring permanent battery installation are sonobuoys, missiles, and fuses.

5. Information for guidance only. The battery compartment should be provided with devices to firmly secure the batteries. Adequate room should be provided

for battery installation, maintenance, testing, and removal without disassembly of the equipment. The battery compartment should prevent pressure build-up from heat, gases, liquids, or chemicals released during battery operation, charging, deterioration, or rupture, and should also prevent such materials from entering the electronic compartment. When magnesium dry batteries are used, extra precautions should be observed since these batteries give off heat at high rates of discharge (less than 10 hours) and evolve hydrogen.

REQUIREMENT 28

CONTROLS

1. Purpose. This requirement establishes criteria for the selection and application of controls.

2. Documents applicable to Requirement 28:

MIL-K-3926	Knobs, Control (For Use with Electronic, Communications, and Allied Equipment)
MIL-K-25049	Knob, Control, Equipment, Aircraft
MIL-D-28728	Dial, Control, Multiturn Counters, General Specification for

3. Definitions

3.1 Operating control. Operating controls are controls that may be required for use during the normal operation of the equipment.

3.2 Adjustment controls. Adjustment controls are controls that are used for alignment and calibration of the equipment and are not used during normal operation of the equipment.

4. Requirements

4.1 General. All controls shall be marked, indexed, sized, and located so that the control position can be readily identified. Controls shall have fixed guide marks if pre-setting of the controls is required. Controls located adjacent to their associated displays shall be so positioned that operation of the control will not obscure the display. Controls shall be so connected in the circuit that the controlled characteristics (e.g., sensitivity, volume, or voltage) increase with clockwise rotation of the control as seen from the operating position. In general, movement of a control forward, clockwise, to the right, or up, shall turn the equipment on, cause the quantity to increase or cause the equipment to move forward, clockwise, to the right or up.

4.2 Accessibility

4.2.1 Operating controls. Controls necessary for the operation of the equipment shall be readily accessible, and unless otherwise specified shall be located on the front panel of the unit.

4.2.2 Adjustment controls. Adjustment controls that are required for periodic alignment or calibration shall be mounted behind covered openings,

such as access doors, on the surfaces of the equipment accessible when installed. When not adjustable by hand, controls shall be designed to accept a common screwdriver blade tip. Controls which infrequently require adjustment need not be accessible from the operating panel, but shall be readily accessible for servicing when the equipment is opened for maintenance purposes.

4.3 Mechanical characteristics

4.3.1 Stops. Mechanical stops shall be provided for all adjustable controls, except controls designed for unlimited rotation. Where flexible control shafts are employed, or where stops integral to the adjustable control or the mechanism could be damaged by excessive torque, stops shall be provided on the driving end of the shaft.

4.3.2 Locking devices. Control locking devices shall be capable of retaining the controls in any given setting within the range of control. The locking and unlocking action shall be easily and quickly accomplished, and shall not affect the setting of the control. When in the unlocked position, the locking devices shall not interfere with the normal operation of the control. Where vernier controls are used, the locking devices shall operate on both main and vernier controls if necessary to prevent damage.

4.3.3 Nonturn devices. All nonturning controls and bodies or cases of turning controls shall be equipped with a positive device to prevent their turning in the panel or assembly on which they are mounted.

4.3.4 Shafts and couplings. Coupling between or to shafts shall be accomplished by means of metallic or insulated couplings rigidly secured.

4.3.5 Control knobs and handles. Control knobs conforming to MIL-K-3926 or MIL-K-25049 shall be used wherever suitable. For knobs not covered by a military specification, color, tactile information, and flammability requirements shall be in accordance with MIL-K-3926. Control knobs and handles shall have high impact strength and shall be firmly secured to the control shafts by use of setscrews wherever that type of fastener is applicable. Plastic knobs and handles shall have metal inserts for setscrews and shall not warp or crack.

4.3.6 Multiturn counters control dials. Manually operated multiturn counters control dials shall conform to MIL-D-28728.

4.3.7 Stability. All controls shall be so designed that the setting, position, or adjustment of any control shall not be altered when the equipment is subjected to the service conditions specified in the detail equipment specification.

4.3.8 Factory adjustment controls. The design of equipment shall not include "factory" or sealed adjustment controls, unless specifically approved by the detail equipment specification.

5. Information for guidance only

5.1 Arrangement and location. Controls should be arranged to facilitate smooth and rapid operation. All controls which have sequential relations, which are related to a particular function or operation, or which are operated together should be grouped together along with their associated displays. Controls should be conveniently located with respect to associated visual displays. Controls should be of such size and so spaced that the manipulation ofa given control does not interfere with the setting of an adjacent control. Adjustment controls with required test points should be grouped and so marked as to provide for simplicity and ease of maintenance.

5.2 Mechanical operation. Infrequently required controls should be screwdriver adjusted. Play and backlash in controls should be held to a minimum commensurate with intended operational functions and should not cause poor contact or inaccurate setting. Controls should operate freely and smoothly without binding, scraping, or cutting. Controls may be lubricated when lubrication does not interfere with operation and is specified in the detail equipment specification.

5.3 Shafts and couplings. Shafts subject to removal may have their couplings secured by two set screws 90 to 120 degrees apart. Flexible couplings may be used for controls where the use of rigid couplings would interfere with the satisfactory operation or mounting of such controls.

REQUIREMENT 29

ELECTRON TUBES

1. Purpose. This requirement establishes criteria for the selection and application of electron tubes.

2. Document applicable to Requirement 29:

MIL-STD-200 Electron Tubes, Selection and Use of

3. Definitions. Not applicable.

4. Requirements. Electron tubes shall be selected and applied in accordance with MIL-STD-200.

5. Information for guidance only. Not applicable.

REQUIREMENT 30

SEMICONDUCTOR DEVICES

1. Purpose. This requirement establishes criteria for the selection and application of semiconductor devices.

2. Documents Applicable to Requirement 30.

MIL-S-19500	Semiconductor Devices, General Specification for
MIL-STD-701	Lists of Standard Semiconductor Devices
MIL-STD-750	Test Methods for Semiconductor Devices
MIL-STD-1547	Parts, Materials, and Processes for Space and Launch Vehicles, Technical Requirements for

3. Definitions. Not applicable.

4. Requirements.

4.1 Selection and application. Semiconductor devices shall be selected and applied in accordance with MIL-STD-701 and, for Space Division, AFSC (SD), MIL-STD-1547.

4.1.1 Reliability. Discrete semiconductor devices in military systems during full scale development and production shall, as a minimum, conform to MIL-S-19500, product assurance JANTX level. JANS level shall be used for space applications.

4.1.2 Order of Precedence. Unless otherwise specified, the order of precedence shall be as follows:

4.1.2.1 For Packaged Devices:

a. MIL-S-19500 - Qualified semiconductors listed in MIL-STD-701.

b. Other MIL-S-19500 - Other qualified semiconductors subject to procuring activity approvals.

c. Active DESC drawings subject to procuring activity approval.

d. Other semiconductor documents (see 4.1.3) subject to procuring activity approval. All devices shall be screened and tested in accordance with 4.1.3.4.

4.1.2.2 For Dice:

a. MIL-S-19500 JAN C program (See paragraph 1.2.1.2, Appendix H, and detailed specifications).

b. Other semiconductor documents subject to procuring activity approval.

4.1.3 Qualified Devices. When the contract for a design specifies the use of TX equivalent quality level or higher or DESC drawings, and there is a JANTX, JANTXV, or JANS device available, the qualified JANTX, JANTXV, or JANS semiconductor shall be the only device authorized for use.

4.1.3.1 JANS Level. JANS level devices shall be used in space flight, and critical applications for Space Division, AFSC (SD). When JANS level parts, in accordance with MIL-S-19500, are not available or cannot be qualified by the manufacturer, the requirements of MIL-STD-1547 shall apply in accordance with procuring activity direction.

4.1.3.2 JANTX, JANTXV, and JANS Levels. JANTX, JANTXV, or JANS level devices shall be used in Army Missile Command, Army Laboratory Command, Naval Air Systems Command and Air Force applications other than SD space, launch, and reentry equipment. When a qualified JANTX, JANTXV device does not exist and an active DESC drawing device of the required generic chip and package type or case outline does exist, the DESC drawing device shall be the preferred device authorized for that design.

4.1.3.3 JAN Level. JAN level is no longer authorized for new designs. When JAN level does not exist or is not available (for old design), the appropriate substitutions shall be JANTX, JANTXV, or JANS when available. When JANTX, JANTXV, or JANS level devices are not available, JAN level may be used subject to the procuring activity approval provided the devices are screened per JANTX requirements of table II and be tested in accordance with requirements of table III (group A) and table IV (group B) of MIL-S-19500.

4.1.3.4 Other Semiconductors. When MIL-S-19500 qualified devices are not available, other semiconductors may be used subject to procuring activity approval. All devices shall be screened and tested as in 4.1.3.3 above.

4.2 Sealing. All semiconductor devices used in equipment shall be hermetically sealed in glass, metal, metal oxide, ceramic, or a combination of these. Use of plastic (organic or polymeric) encapsulated or sealed devices requires the approval of the procuring activity.

5. Information for guidance only. Semiconductor devices are susceptible to electrostatic discharge damage. Appropriate discharge procedures should be observed prior to handling these parts, and design selections of desired devices should include a consideration of the effectiveness of the input or other protective elements included in the device design.

REQUIREMENT 31

MOISTURE POCKETS

1. Purpose. This requirement establishes criteria for the treatment and drainage of moisture pockets.

2. Documents applicable to Requirement 31. Not applicable.

3. Definitions. Not applicable.

4. Requirements. Where moisture pockets are unavoidable in unsealed equipment, provision shall be made for drainage of such pockets. Desiccants or moisture-absorbent materials shall not be used within moisture pockets.

5. Information for guidance only

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

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

REQUIREMENT 32

TEST PROVISIONS

1. Purpose. This requirement establishes criteria for test provisions.

2. Documents applicable to Requirement 32:

MIL-STD-415	Test Provisions for Electronic Systems and Associated Equipment, Design Criteria for
MIL-STD-2165	Testability Program for Electronic Systems and Equipments

3. Definitions. Not applicable.

4. Requirements

4.1 Built-in test devices. Built-in test devices shall maintain their accuracy under all operating conditions required by the equipment under test. These devices shall be provided with connections or access for their operational checkout or calibration.

4.2 External test points. Protection shall be provided in the test point circuitry to prevent equipment damage caused by the external grounding of test points.

4.3 Failure effect. Unless otherwise specified, provisions for testing shall be so designed that any failure of built-in test devices will not degrade equipment operation or cause equipment shut down.

4.4 Test provisions. Test provisions to provide means for monitoring performance, calibration, and fault isolation shall be in accordance with MIL-STD-415.

5. Information for guidance only

5.1 Testability program. When specified by the procuring activity, a testability program should be implemented in accordance with MIL-STD-2165.

REQUIREMENT 33

RESISTORS

1. Purpose. This requirement establishes criteria for the selection and application of resistors.

2. Documents applicable to Requirement 33:

MIL-T-23648	Thermistor (Thermally Sensitive Resistor), Insulated, General Specification for
MIL-STD-199	Resistors, Selection and Use of

3. Definitions. Not applicable.

4. Requirements

4.1 Selection. Resistors shall be selected and applied in accordance with MIL-STD-199.

4.2 Thermistors. Thermistors shall conform to MIL-T-23648.

5. Information for guidance only. Not applicable.

REQUIREMENT 34

NOMENCLATURE

1. Purpose. This requirement establishes criteria for nomenclature (item name and type designation).

2. Document applicable to Requirement 34:

MIL-STD-196 Joint Electronics Type Designation System

3. Definitions. Not applicable.

4. Requirements. Item names and type designations for electronic equipment shall be established in accordance with MIL-STD-196.

5. Information for guidance only. The assignment of type designations does not constitute approval of equipment or the use of a particular item in a specific set and does not waive any requirements of the contract involved, nor does the approval of the equipment constitute approval of the type designation assignment.

REQUIREMENT 35

RELIABILITY

1. Purpose. This requirement offers guidance as to reliability requirements which must be considered when preparing contractual documents. IT DOES NOT ESTABLISH REQUIREMENTS, AND MUST NOT BE REFERENCED IN CONTRACTUAL DOCUMENTS. Reliability program tasks, quantitative requirements, and verification or demonstration requirements must be directly specified in the contract or the system/equipment specification, as appropriate.

2. Documents applicable to Requirement 35.

MIL-STD-721	Definitions of Terms for Reliability and Maintainability
MIL-STD-756	Reliability Modeling and Prediction
MIL-STD-781	Reliability Design Qualification and Product Acceptance Tests: Exponential Distribution
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production
MIL-STD-1629	Procedures for Performing a Failure Mode, Effects and Criticality Analysis
MIL-HDBK-217	Reliability Prediction of Electronic Equipment

3. Definitions. Not applicable.

4. Requirements. Not applicable.

5. Information for guidance only.

5.1 Reliability program. Reliability engineering and accounting tasks aimed at preventing, detecting, and correcting reliability design deficiencies, weak parts, and workmanship defects and providing reliability related information essential to acquisition, operation, and support management should be included in contract requirements with the objective of establishing and maintaining an efficient reliability program according to life cycle phase. MIL-STD-785 is the overall program document for the area. It is sectionalized into individual task statements and requires extensive tailoring when it is applied. Detailed application guidance as to the nature of the tasks and when they should be imposed is provided. Other reliability documents which may be invoked through MIL-STD-785 or which may be cited directly as a basis for contract requirements include MIL-STD-721, MIL-STD-756, MIL-STD-781, MIL-STD-1629, and MIL-HDBK-217.

5.2 Quantitative requirements. Quantitative reliability requirements and verification or demonstration requirements should be established appropriate to program phase.

REQUIREMENT 36

ACCESSIBILITY

1. Purpose. This requirement establishes criteria for accessibility.

2. Documents applicable to Requirement 36:

MIL-STD-280	Definition of Item Levels, Item Exchangeability, Models, and Related Terms
MIL-STD-721	Definitions of Terms for Reliability and Maintainability
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities

3. Definitions

3.1 Accessibility. Accessibility is as defined in MIL-STD-721.

3.2 Part, subassembly, and assembly. Part, subassembly, and assembly are as defined in MIL-STD-280.

4. Requirements

4.1 Access. Each article of equipment and each major subassembly forming a part thereof shall provide for the necessary access to its interior parts, terminals, and wiring for adjustments, required circuit checking, and the removal and replacement of maintenance parts. Accessibility for testing and replacement does not apply to parts located in nonrepairable subassemblies or assemblies. For routine servicing and maintenance, unsoldering of wires, wire harnesses, parts or subassemblies shall not be required in order to gain access to terminals, soldered connections, mounting screws and the like. Inspection windows shall be provided where necessary. Sizes of openings, maximum reach requirements, and allowable sizes and weights of replaceable assemblies shall conform to limits established in MIL-STD-1472.

4.2 Connections. Connections to parts inside a removable container shall be arranged to permit removal of the container without threading connection leads through the container.

4.3 Parts. Parts which are identified as replaceable parts shall not be mounted by means or rivets, spot welding, or hard curing compounds. No unsoldering or soldering of connections shall be necessary when the front panel or any subchassis is removed for maintenance purposes. Design shall be such that where plug-in modules or assemblies are used, they can be easily inserted in the proper location when correctly oriented without damage to equipment or parts being engaged.

4.4 Enclosures. Accessibility to chassis, assemblies, or parts contained within cabinets, consoles or other enclosures shall be provided from outside the basic equipment through the use of access doors, by mounting such items on withdrawal slides, swinging doors, through cable extenders and cable retractors, provisions for circuit card extenders which will allow part or module operation in the open position, or other arrangements to permit adequate access for properly servicing the equipment. Automatic or manually operated locks shall be provided to lock the chassis in the servicing position. When withdrawal slides are used they shall be of guided sectional construction with tracks and rollers. Complete removal and access for servicing of electronic equipment contained within cabinets, consoles or other enclosures shall be provided from either the front or rear of the equipment. Guide pins or locating pins, or the equivalent, shall be provided for mechanical alignment during mounting. Shipboard equipment shall have complete access for maintenance and servicing from the front of the equipment.

4.5 Bolt-together racks and enclosures. For Navy ship and shore applications, when bolt-together racks are required, fastening shall be provided to bolt adjacent racks together at the top with external brackets and through the bottom of the rack to a base or foundation. Bottom mounting shall be accessible from the front with minimum disassembly of internal parts or subassemblies.

5. Information for guidance only

5.1 Compatibility. Equipment should be designed for optimum accessibility compatible with operating, maintenance, electromagnetic compatibility, and enclosure requirements.

5.2 Parts. If, in order to check or remove a part, it is necessary to displace some other part, the latter part should be so wired and mounted that it can be moved without being disconnected and without causing circuit detuning or instability.

REQUIREMENT 37

CIRCUIT BREAKERS

1. Purpose. This requirement establishes criteria for the selection and application of circuit breakers.

2. Documents applicable to Requirement 37:

MIL-STD-1498 Circuit Breakers, Selection and Use of

3. Definitions. Not applicable.

4. Requirements

4.1 Selection and application. Circuit breakers shall be selected from MIL-STD-1498. Trip-free circuit breakers shall be used. Nontrip-free circuit breakers shall be used only when the application requires overriding of the tripping mechanism for emergency use.

4.2 Manual operation. Circuit breakers shall be capable of being manually operated to the ON and OFF positions. Circuit breakers shall not be used as ON-OFF switches unless such breakers have been specifically designed and tested for that type of service.

4.3 Position identification. Circuit breakers shall have easily identified ON, OFF and TRIPPED positions except that the TRIPPED position may be the same as the OFF position with no differentiation between OFF and TRIPPED being required.

4.4 Orientation. Circuit breakers shall operate when permanently inclined in any direction up to 30 degrees from the normal vertical or normal horizontal position. The trip point of an inclined unit shall not vary more than + 5 percent of the current specified for normal position mounting. Circuit breakers used on flight equipment and portable test equipment shall operate within the limits of the detail specification when the equipment is in any position or rotation about its three principal axes.

5. Information for guidance only. Not applicable.

REQUIREMENT 38

QUARTZ CRYSTALS AND OSCILLATOR UNITS

1. Purpose. This requirement establishes criteria for the selection of quartz crystal units and crystal oscillators.

2. Documents applicable to Requirement 38:

MIL-O-55310	Oscillators, Crystal
MIL-STD-683	Crystal Units, Quartz; and Holders, Crystal

3. Definitions. Not applicable.

4. Requirements

4.1 Quartz crystals. Quartz crystal units shall be selected in accordance with MIL-STD-683.

4.2 Crystal oscillator units. Crystal oscillator units shall conform to MIL-O-55310.

5. Information for guidance only. Not applicable.

REQUIREMENT 39

FUSES AND FUSE HOLDERS

1. Purpose. This requirement establishes criteria for the selection and application of fuses, fuseholders, and associated hardware.

2. Document applicable to Requirement 39:

MIL-STD-1360 Fuses, Fuseholders, and Associated Hardware, Selection and Use of

3. Definitions. Not applicable.

4. Requirements

4.1 Selection and application. Fuses, fuseholders, and associated hardware shall be selected from MIL-STD-1360.

4.2 Extractor post type fuseholders. The load shall be connected to the fuseholder terminal that terminates in the removable cap assembly.

5. Information for guidance only

5.1 Branch circuits. Fusing should be so applied that fuses in branch circuits will open before the fuses in the main circuit.

5.2 Thermal considerations. Fuses are thermally activated devices. In general, time delay fuses are most susceptible to ambient temperature extremes; current limiters the least.

5.3 Load current considerations. Fuse ratings are in terms of RMS, not average, line currents measured using true RMS reading instruments. Direct current lines having a pulsating component should be measured using a true RMS reading instrument.

REQUIREMENT 40

SHUNTS

1. Purpose. This requirement establishes criteria for the selection of external meter shunts.

2. Documents applicable to Requirement 40:

MIL-S-61	Shunt, Instrument, External, 50 millivolt (Lightweight Type)
MIL-I-1361	Instrument Auxiliaries, Electrical Measuring; Shunts, Resistors, and Transformers

3. Definitions. Not applicable.

4. Requirements. External meter shunts shall conform to MIL-S-61 or MIL-I-1361, as applicable.

5. Information for guidance only. Not applicable.

REQUIREMENT 41

SPRINGS

1. Purpose. This requirement establishes criteria for the design, selection, and application of springs.

*2. Documents applicable to Requirement 41:

QQ-S-766	Steel, Stainless and Heat Resisting, Alloys, Plate, Sheet, and Strip
QQ-W-321	Wire, Copper Alloy
MIL-S-7947	Steel, Sheet and Strip (1095) Aircraft Quality
MIL-S-13282	Silver and Silver Alloy
MIL-S-13572	Spring, Helical, Compression and Extension
MIL-C-19311	Copper-Chromium Alloy Forgings, Wrought Rod, Bar and Strip (Copper Alloy Numbers 182, 184 and 185)
MIL-S-46049	Strip, Metal, Carbon Steel, Cold rolled, Hardened and Tempered, Spring Quality
MIL-C-81021	Copper-Beryllium Alloy (Copper Alloy Numbers C17500 and C17510), Strip
ASTM A29/A29M-88	Steel Bars, Carbon and Alloy, Hot Wrought and Cold Finished, General Requirements for
ASTM A228/A228M-83	Steel Wire, Music Spring Quality
ASTM A313-87	Chromium-Nickel Stainless and Heat Resisting Steel Spring Wire
ASTM A682-79	Steel, Strip, High Carbon, Cold Rolled, Spring Quality, General Requirements for
ASTM A684/A684M-86	Steel, Strip, High Carbon, Cold Rolled
ASTM B122-86	Plate, Sheet, Strip and Roller Bar, Copper Nickel Tin Alloy, Copper Nickezinc (Nickel Silver), and Copper Nickel Alloy

ASTM B139/ B139M-90	Bronze, Rod, Bar
ASTM B151/ B151-11.89	Alloy (Nickel Silver) Copper Nickel Zink and Copper Nickel Rod and Bar
ASTM B194-88	Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar
ASTM B196/ B196M-88	Copper-Beryllium Alloy Rod and Bar
ASTM B197/ B197M-89	Copper-Beryllium Alloy Wire
ASTM B206-86A	Copper Nickel Zinc Alloy Wire and Copper Nickel Alloy WIre
ASTM B206M-87	Copper Nickel Zinc Alloy Wire and Copper Nickel Alloy Wire Metric
ASTM B522-80	Gold-Silver-Platinum Electrical Contact Alloy, Specification for

Metals Handbook, Vol I (1978), American Society for Metals

3. Definitions. Not applicable.

4. Requirements

4.1 Helical springs. Helical springs shall conform to MIL-S-13572.

4.2 Electrical contact springs. Electrical contact springs shall use materials selected from table 41-I.

4.3 Carbon steel springs. Carbon steel springs shall be suitably plated or finished to resist corrosion.

5. Information for guidance only

5.1 Corrosion resisting steel. Corrosion resisting steel springs are preferred where electrical conductivity is not a consideration and where they
are adequate for the purpose intended.

5.2 Fatigue limits. Fatigue limits of the springs should not be adversely affected by corrosion, operating temperature, and other environmental

conditions in service. Fatigue limits should be consistent with the maximum specified operating cycles for the respective part or equipment or, if such is not specified, with the maximum duty cycle to be expected during the equipment service life.

5.3 Electrical conductivity. Electrical conductivity of contact springs should not be adversely affected by corrosion, operating temperature and other environmental conditions in service.

5.4 Enclosure. Where practicable, springs should be enclosed in housings or otherwise captivated in order to prevent broken pieces from entering and adversely affecting the equipment.

5.5 Heat treatment. Springs made of materials that achieve their desired properties by heat treatment, such as copper-beryllium alloys, annealed carbon steels, CRES steels, or heat resisting alloys, should be heat treated to the specified temper after forming.

5.6 Grain orientation. Flexure and forming of springs should be designed to occur perpendicular to the grain of the material. Deviation from the perpendicular should not exceed 45 degrees.

5.7 Documents for specifying materials. When the materials listed in tables 41-I, 41-II, and 41-III are used, they should conform to the specifications listed for each material.

*TABLE 41-I. Materials for electrical spring application.

Material	Form	Material Specification
Copper-nickel-zinc alloy	Plate, sheet, strip and rolled bar	ASTM B122
	Rod, shapes and flat products with finished edges (flat wire, strip and bar)	QQ-C-586 ASTM B122 ASTM B151 ASTM B206
Copper-beryllium alloy	Bars and rod	ASTM B196
	Wire	ASTM B197
	Strip	ASTM B194
Copper alloy	Wire, spring	QQ-W-321
Copper-cobalt-beryllium alloy	Strip	MIL-C-81021
Copper-chromium alloy	Bar, rod, and strip	MIL-C-19311
Phosphor bronze	Bar, rod, plate, sheet, strip, and flat wire	ASTM B139
Platinum-iridium alloy	Strip	ASTM B522
Silver-copper alloy	Bar, rod, plate, sheet, strip, and wire	MIL-S-13282
Palladium-copper alloy		Metals Handbook, Vol I

TABLE 41-II. Corrosion resisting steel for springs.

Material	Form	Material Specification
Steel, CRES	Wire Strip	ASTM A313 QQ-S-766

TABLE 41-III. Carbon steel for springs.

Material	Form	Material Specification
Steel, high carbon	Wire, spring, music	ASTM A228
Steel, carbon and alloy (for springs)	Strip, cold rolled untempered spring	ASTM A682 ASTM A684
Steel, carbon and alloy (for springs)	Bars, round, square and flat	ASTM A29
Steel, carbon, strip	Cold rolled, hardened and tempered spring	MIL-S-46049
Steel, carbon (1095)	Sheet and strip A-annealed (condition 1) H-hard temper (condition 3) cold finished	MIL-S-7947

REQUIREMENT 42

TUNING DIAL MECHANISMS

1. Purpose. This requirement establishes criteria for the design of tuning dial mechanisms.

2. Documents applicable to Requirement 42:

MIL-S-3644	Shaft Assembly, Flexible
MS33558	Numerals and Letters, Aircraft Instrument Dial, Standard Form of

3. Definitions. Not applicable.

4. Requirements

4.1 Dial. The division marking and lettering on tuning dials shall be suitably etched or printed with characters of style MS33558. Dial markings shall be legible at a distance of 0.6 meter from any point within a solid angle of 60 degrees defined by a surface of revolution about a line through the center of the dial and perpendicular to the panel. Minimum space between characters shall be one stroke width. The width of the lubber line or pointer tip shall not exceed the width of the graduation marks. Except for digital tuning indicators, for which only one calibration number will be seen, dials shall be marked so that at least two calibration numbers on each band can be seen at any dial setting.

4.2 Balance and friction. Weighted tuning knobs shall be counterbalanced. Friction in tuning dial mechanism shall allow smooth and easy adjustment of the operating knob over the entire operating range of the mechanism, but shall have sufficient resistance or shall incorporate a positive locking device to maintain the setting under all specified service conditions. Friction shall be achieved through dry or elastic resistance rather than by fluid resistance.

4.3 Flexible control shafts. Flexible shaft assemblies conforming to MIL-S-3644 shall be used when a flexible mechanical connection is required between the tuning knob and the tuned device.

5. Information for guidance only

5.1 Tuning ratio. The tuning ratio used should be the optimum which will permit both rapid and precise setting.

REQUIREMENT 43

LUBRICANTS

1. Purposes. This requirement establishes criteria for the selection and application of lubricants.

2. Documents applicable to Requirement 43:

VV-L-800	Lubricating Oil, General Purpose, Preservative (Water-Displacing, Low-Temperature)
VV-P-236	Petrolatum, Technical
MIL-L-2105	Lubricating Oil, Gear, Multi-Purpose
MIL-L-3150	Lubricating Oil, Preservative, Medium
MIL-L-3918	Lubricating Oil, Instrument, Jewel Bearing
MIL-L-6085	Lubricating Oil, Instrument, Aircraft, Low Volatility
MIL-L-6086	Lubricating Oil, Gear, Petroleum Base
MIL-L-15719 and	Lubricating Grease (High-Temperature, Electric Motor, Ball Roller Bearings)
MIL-L-17331	Lubricating Oil, Steam Turbine (Noncorrosive)
MIL-H-17672	Hydraulic Fluid, Petroleum, Inhibited
MIL-L-23398	Lubricant, Solid Film, Air Cured, Corrosion Inhibiting, NATO Code Number S-749
MIL-G-23827	Grease, Aircraft and Instrument, Gear and Actuator Screw
MIL-G-24139	Grease, Multi-Purpose, Quiet Service
DOD-G-24508	Grease, High Performance, Multi-Purpose (Metric)
MIL-L-46010	Lubricant, Cleaner, and Preservative
MIL-G-81322	Grease, Aircraft, General Purpose, Wide Temperature Range

MIL-L-81329 Lubricant, Solid Film, Extreme Environment, NATO Code Number S-1737

29 CFR 1910 Code of Federal Regulations, Title 29, Chapter XVII, Part 1910

3. Definitions. Not applicable.

4. Requirements

4.1 General. Lubricants shall conform to one of the following:

VV-L-800	MIL-L-6086	MIL-G-24139
VV-P-236	MIL-L-15719	DOD-G-24508
MIL-L-2105	MIL-L-17331	MIL-L-46010
MIL-L-3150	MIL-H-17672	MIL-G-81322
MIL-L-3918	MIL-L-23398	MIL-L-81329
MIL-L-6085	MIL-G-23827	

4.2 Silicones. Silicone compounds shall not be used as lubricants.

4.3 Graphite base lubricants. Graphite base lubricants shall not be used.

5. Information for guidance only.

5.1 Variety. The number of different lubricants should be held to a minimum.

5.2 Volatility. Low volatility lubricants should be used where practical.

5.3 Compatibility. The lubricant should be chemically inert with regard to the materials it contacts.

5.4 Carcinogens. 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 29 CFR 1910. Consideration of the toxicity of a substance should be given prior to material selection.

REQUIREMENT 44

FIBROUS MATERIALS, ORGANIC

1. Purpose. This requirement establishes criteria for the selection and application of organic fibrous materials.

2. Documents applicable to Requirement 44:

V-T-276	Thread, Cotton
V-T-285	Thread, Polyester
V-T-291	Thread, Linen
V-T-295	Thread, Nylon
CCC-C-428	Cloth, Duck, Cotton; Fire, Water, Weather, and Mildew Resistant
MIL-W-530	Webbing, Textile, Cotton, General Purpose, Natural or in Colors
MIL-C-572	Cords, Yarns, and Monofilaments, Organic Synthetic Fiber
MIL-T-3530	Thread and Twine, Mildew Resistant or Water Repellant Treated
MIL-W-4088	Webbings, Textile, Woven Nylon
MIL-C-9074	Cloth, Laminated, Sateen, Rubberized
MIL-W-27265	Webbing, Textile, Woven Nylon, Impregnated
29 CFR 1910	Code of Federal Regulations, Title 29, Chapter XVII, Part 1910

3. Definitions. Not applicable.

4. Requirements

4.1 Webbing

4.1.1 Cotton. Cotton webbing shall conform to MIL-W-530, class 4 or 7. Class 7 shall be used when webbing will come in contact with natural or synthetic rubber or class 4 when prolonged contact with the skin may occur.

4.1.2 Nylon. Nylon webbing shall conform to MIL-W-4088 or class R of MIL-W-27265.

4.2 Cotton duck. Cotton duck used for protective enclosures shall conform to type I or type II of CCC-C-428. Medium texture number 4 shall be used for heavy duty service and hard texture number 12 shall be used for services requiring light weight.

4.3 Thread. Thread shall conform to V-T-276, V-T-285, V-T-291, or V-T-295.

4.3.1 Treatment. Cotton and linen thread shall be treated in accordance with MIL-T-3530. Type I, class 2 mildew inhibiting agent shall be used when thread will come in contact with natural or synthetic rubber or type I, class 1 when prolong contact with the skin may occur.

4.4 Sateen. Laminated, two-ply rubberized cotton sateen shall conform to MIL-C-9074. This sateen shall not be used when prolonged contact with the skin may occur.

4.5 Cords, yarn, and monofilaments. Cords, yarns, and monofilaments shall conform to MIL-C-572. Types PVCA, AR, VCR, and CTA shall not be used where they may be exposed to fungus attack.

5. Information for guidance only

5.1 Shrinkage. Fabric and thread should be preshrunk or allowance should be made for shrinkage in order to provide for satisfactory fit of finished items both before and after they are immersed in water and then dried.

5.2 Carcinogens. 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 29 CFR 1910. Consideration of the toxicity of a substance should be given prior to material selection.

REQUIREMENT 45

CORONA AND ELECTRICAL BREAKDOWN PREVENTION

1. Purpose. This requirement establishes criteria for the prevention of corona and electrical breakdown.

2. Documents applicable to Requirement 45:

ASTM D149-87	Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D1868-81	Detection and Measurement of Partial Discharge (Corona) Pulses in Evaluation of Insulation Systems

3. Definitions

3.1 Corona (air). A luminous discharge due to ionization of the air surrounding a conductor caused by a voltage gradient exceeding a certain critical value, called the partial discharge (corona) inception voltage (CIV).

3.2 Partial discharge (corona) inception voltage (CIV). The lowest rms voltage at which continuous partial discharges above some stated magnitude (which may define the limit of permissible background noise) occur as the applied voltage is gradually increased.

3.3 Partial discharge (corona) extinction voltage (CEV). The highest rms voltage at which partial discharges above some stated magnitude no longer occur as the applied voltage is gradually decreased from above the inception voltage.

3.4 Breakdown. A disruptive discharge through insulation, involving a sudden and large increase in current through the insulation because of complete failure under electrostatic stress. Also called puncture.

4. Requirements

4.1 Corona prevention. The CEV shall be at least 150 percent of the peak circuit voltage, corresponding to the maximum specified steady-state rms supply voltage. This requirement applies:

a. When the equipment is terminated with the cabling or other accessory equipment with which it is intended to be used and

b. When the equipment is operated under the specified environmental service conditions and

c. When the equipment is supplied with the specified power source frequencies and voltages including commonly recurring transients.

4.2 Electrical breakdown prevention. The equipment shall be designed and manufactured with electrical clearance spacing, leakage (creepage) distances, and insulation characteristics adequate to prevent electrical breakdown. This requirement applies under all specified environmental service conditions

including service life and using the specified operating voltages (including transients). Liquid dielectrics, gases other than air, or pressurization to prevent electrical breakdown shall not be used unless approved by the procuring activity.

5. Information for guidance only

5.1 Effects of corona. Corona occurring at the interface of an insulator and a metal can damage or reduce the life of an insulating system. In general, inorganic insulating materials are more resistant to the damaging effects of corona than organic insulating materials. Corona also generates electromagnetic interference and liberates ozone, a toxic, oxidant gas.

5.2 Insulation systems. Corona can occur within cavities between an insulating material and a metal surface which are in contact. Therefore, care should be exercised to avoid cavities at such interfaces where high voltages are encountered.

5.3 Metal parts. Sharp edges and points should be avoided on metal parts which are included in high intensity electric fields.

5.4 Corona testing. There are many factors which determine whether or not corona will occur, including temperature, humidity, ambient pressure, test specimen shape, rate of voltage change and the previous history of the applied voltage. Test methods such as ASTM D1868 may be used but the test results lack accuracy and repeatability and require great care due to the personnel hazards involved.

5.5 Electrical breakdown testing. The breakdown voltage of a given insulating material is dependent upon electrode size and shape, insulator thickness, temperature, humidity, rate of voltage application, voltage waveform and voltage frequency. When testing, care must be exercised to assure that the insulating material is evaluated under the actual environmental conditions which apply to the equipment and that the occurrence of corona or localized heating does not mask the true breakdown voltage. A test usable at power frequencies (25 to 800 Hz) is ASTM D149.

REQUIREMENT 46

MOTORS AND ROTARY POWER CONVERTERS

1. Purpose. This requirement establishes criteria for the selection and application of motors and rotary power converters.

*2. Documents applicable to Requirement 46:

MIL-D-24	Dynamotors, General Specification for
MIL-G-3111	Generator, Electric, Direct Current (Naval Shipboard Use)
MIL-G-3124	Generator, Alternating Current, 60 Cycle (Naval Shipboard Use)
MIL-M-4820	Motor-Generator, Skid Mounted, Type MD-4
MIL-M-7969	Motor, Alternating Current, 400 Cycle, 115/200-Volt System, Aircraft, General Specification for
MIL-M-8609	Motors, Direct Current, 28 Volt System, Aircraft, General Specification for
MIL-F-9397	Frequency Converter, Mobile, Type MC-1A
MIL-M-17059	Motor, 60 Cycle, Alternating Current, Fractional Horsepower (Shipboard Use)
MIL-M-17060	Motors, 60 Hertz, Alternating Current, Integral Horsepower (Shipboard Use)
MIL-M-17413	Motors, Direct Current, Integral Horsepower, Naval Shipboard
MIL-M-17556	Motor, Direct Current, Fractional Horsepower, (Shipboard Use)
MIL-M-19097	Motor-Generators, DC to AC, Shipboard Service
MIL-M-19160	Motor-Generator, 60 Hertz AC to 400 Hertz AC, Shipboard Service
MIL-M-19633	Motor-Generator, 60 Cycle AC to 400 Cycle AC (Voltage and Frequency Regulated) Shipboard Service
MIL-B-23071	Blowers, Miniature, for Cooling Electronic Equipment, General Specification for

3. Definitions. Not applicable.

4. Requirements

*4.1 Motors - alternating current. Alternating current motors shall conform to MIL-M-7969, MIL-M-17059 or MIL-M-17060, except that any motor used with a miniature blower for cooling electronic equipment shall be in accordance with MIL-B-23071.

*4.2 Motors - direct current. Direct current motors shall conform to MIL-M-8609, MIL-M-17413 or MIL-M-17556.

*4.3 Motor-generators. Motor-generators shall conform to one of the following:

MIL-M-4820	MIL-M-19160
MIL-M-9397	MIL-M-19633
MIL-M-19097	

4.4 Generators - alternating current. Alternating current generators shall conform to MIL-G-3124.

4.5 Generators - direct current. Direct current generators shall conform to MIL-G-3111.

4.6 Dynamotors. Dynamotors shall conform to MIL-D-24.

5. Information for guidance only. Not applicable.

REQUIREMENT 47

ENCAPSULATION AND EMBEDMENT (POTTING)

1. Purpose. This requirement establishes criteria for encapsulating and embedding (potting) a part or an assembly of discrete parts. Conformal coating of printed circuit assemblies is excluded from this requirement.

2. Documents applicable to Requirement 47:

MIL-S-8516	Sealing Compound, Polysulfide Rubber, Electric Connectors and Electric Systems, Chemically Cured
MIL-I-16923	Insulating Compound, Electrical, Embedding
MIL-S-23586	Sealing Compound, Electrical, Silicone Rubber, Accelerator Required
MIL-M-24041	Molding and Potting Compound, Chemically Cured, Polyurethane (Polyether Based)
MIL-I-81550	Insulating Compound, Electrical, Embedding, Reversion Resistant Silicone
29 CFR 1910	Code of Federal Regulations, Title 29, Chapter XVII, Part 1910

3. Definitions

3.1 Encapsulation. A process for encasing a part or an assembly of discrete parts within a protective material which is generally not over 2.5 mm thick and does not require a mold or container.

3.2 Embedment (potting). A process for encasing a part or an assembly of discrete parts within a protective material which is generally over 2.5 mm thick, varies in thickness, fills the connecting areas within an assembly, and requires a mold or container to confine the material while it is hardening. Potting is an embedding process where the protective material bonds to the mold or container so that it becomes integral with the item.

4. Requirements. Encapsulation and embedment materials shall be of a nonreversion type and shall be selected from the following specifications: MIL-S-8516, MIL-I-16923, MIL-S-23586, MIL-M-24041, and MIL-I-81550. The materials selected shall be capable of filling all voids and air spaces in and around the items being encased. For Air Force applications, approval for use of any material other than transparent silicone in accordance with MIL-I-81550 shall be requested through the procuring activity from the Wright Research and Development Center, ATTN: MLSE, Wright-Patterson AFB OH 45433-6523.

5. Information for guidance only

5.1 Selection. The following points should be considered when selecting an encapsulation or embedment material:

a. Need for precautions due to hazardous characteristics of the material

b. Electrical, mechanical and thermal properties, including tear resistance, resistance to flame, chemicals, moisture, water, humidity, fungus, and temperature extremes

c. Color or transparency

d. Dissipation factor

e. Specific gravity

f. Shrinkage

g. Heat distortion parameters

h. Stresses on parts

i. Durometer hardness

j. Adhesion to substrates (and priming)

k. Temperatures of application and curing

l. Repairability

m. Dielectric constant

n. Volume resistivity

o. Reversion resistance, including hydrolytic stability

p. Viscosity

q. Solvent affects

r. Compatibility with parts or assemblies to which applied.

5.2 Application. The encapsulation or embedment of microelectronic modules and equipment modules should be avoided, except where specifically indicated by the requirements of a particular application. In such instances, the module design should be completely verified for the particular encapsulation

or embedment materials and processes to be employed. Any changes in module design, materials, and processes may require re-evaluation of the modules. In particular, extreme temperature aging and temperature cycling tests should be performed to verify adequacy of the design. Wherever economically feasible, the module to be encapsulated or embedded should be designed as a throw-away unit.

5.3 Carcinogens. 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 29 CFR 1910. Consideration of the toxicity of a substance should be given prior to material selection.

REQUIREMENT 48

GEARS

1. Purpose. This requirement establishes criteria for the selection and application of gears.

2. Documents applicable to Requirement 48:

Index American Gear Manufacturers Association (AGMA)

3. Definitions. Not applicable.

4. Requirement. Gears not operating in a lubricant bath shall be made of corrosion resistant materials. Gears operating in a lubricant bath containing a corrosion inhibiting additive may be made of noncorrosion resistant materials.

5. Information for guidance only

5.1 Designation. Gears should be designated, dimensioned, toleranced and inspected in accordance with the applicable AGMA specifications.

5.2 Planetary or epicyclic gearing. Planetary or epicyclic gearing is preferred to worm gearing.

5.3 Nonmetallic gears. Nonmetallic gears may be used when they meet load, life, and environmental requirements of the applicable specification.

REQUIREMENT 49

HYDRAULICS

1. Purpose. This requirement establishes criteria for the design and installation of a hydraulic system when it functions as an integral part of an electronic system.

2. Documents applicable to Requirement 49:

MIL-H-5440	Hydraulic Systems, Aircraft, Types I and II, Design, Installation, and Data Requirements for
MIL-H-8891	Hydraulic Systems, Manned Flight Vehicles, Type III, Design, Installation, and Data Requirements for
MIL-H-25475	Hydraulic Systems, Missile, Design, Installation, Tests, and Data Requirements, General Requirements for
ANSI B93.1-1964	Fluid Power Cylinders, Dimension Identification Code for
ANSI B93.2-1971	Fluid Power, Glossary of Terms for
ANSI B93.3-1968	Cylinder Bore and Piston Rod Sizes for Fluid Power Cylinders
ANSI B93.4M-1981	Electric Resistance Welded Mandrel Drawn Hydraulic Line Tubing
ANSI B93.5-1979	Use of Fire-Resistant Fluids for Fluid Power Systems, Practices for the
ANSI B93.6-1972	Mounting Flanges and Shafts for Positive Displacement Fluid Power Pumps and Motors, Dimensions and Identification Code for
ANSI B93.7-1968	Mounting Surfaces of Sub-Plate Type Hydraulic Fluid Power Valves, Dimensions for
ANSI B93.8-1968	Bore and Rod Size Combinations and Rod End Configurations for Cataloged Square Head Industrial Fluid Power Cylinders
ANSI B93.9M-1969	Symbols for Marking Electrical Leads and Ports on Fluid Power Valves
ANSI B93.10-1969	Static Pressure Rating Methods of Square Head Fluid Power Cyclinders
ANSI B93.11M-1981	Seamless Low Carbon Steel Hydraulic Line Tubing
ANSI SAE J514f	Hydraulic Tube Fittings
ANSI SAE J518c	Hydraulic Flanged Tube and Hose Connections, 4 Bolt, Split Flanged Type

3. Definitions. Not applicable.

4. Requirements

4.1 Aircraft or manned flight vehicles. The design and installation of hydraulic systems for aircraft or manned flight vehicles shall conform to the applicable type and class or system described in MIL-H-5440 or MIL-H-8891.

4.2 Missiles. The design and installation of hydraulic systems for missiles shall conform to the applicable type and class of system shown in MIL-H-25475.

5. Information for guidance only. The following documents contain additional information on hydraulic design:

ANSI B93.1	ANSI B93.8
ANSI B93.2	ANSI B93.9M
ANSI B93.3	ANSI B93.10
ANSI B93.4M	ANSI B93.11M
ANSI B93.5	ANSI SAE J514
ANSI B93.6	ANSI SAE J518
ANSI B93.7	

REQUIREMENT 50

INDICATOR LIGHTS

1. Purpose. This requirement establishes criteria for selection and application of indicator lights and associated items.

2. Documents applicable to Requirement 50:

MIL-L-3661	Lampholders, Indicator Lights, Indicator-Light Housings, and Indicator-Light Lenses, General Specification for
MIL-L-6363	Lamps, Incandescent, Aircraft Service, General Requirements for
MIL-L-7806	Light, Panel, Plastic Plate Lighting
MIL-L-7961	Lights, Indicators, Press to Test
MIL-L-15098	Lamp, Glow, General Specification for
MIL-S-19500	Semiconductor Devices, General Specification for
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities

3. Definitions. Not applicable.

4. Requirements

4.1 Lights and accessories. Indicator lights, indicator light housings, lampholders, lenses, and lamps shall be selected in accordance with table 50-I.

4.2 Visual display and legend lights. Visual display and legend lights shall comply with the requirements in MIL-STD-1472.

4.3 Light emitting diodes (LED's). LED's when used as indicator lights shall conform to the applicable detail specifications of MIL-S-19500.

5. Information for guidance only. Not applicable.

TABLE 50-I. Indicator lights and associated items.

	MIL-L-3661	MIL-L-7806	MIL-L-7961	MIL-L-6363	MIL-L-15098	MIL-S-19500	W-L-00111	W-L-00116
Indicator lights	X		X			X		
Indicator light housings	X							
Lamp holders	X	X						
Lenses	X							
Incandescent lamps, general purpose				X			X	
Incandescent lamps, severe environment				X				
Neon lamps					X			X
Fluorescent lamps								X

REQUIREMENT 51

METERS, ELECTRICAL INDICATING

1. Purpose. This requirement establishes criteria for the selection and application of electrical meters.

2. Documents applicable to Requirement 51:

MIL-M-7793	Meter, Time Totalizing
MIL-M-16034	Meter, Electrical Indication (Switchboard and Portable Types)
MIL-M-16125	Meters, Electrical, Frequency
MIL-I-81219	Indicator, Elapsed Time, Electrochemical
MIL-STD-1279	Meters, Electrical Indicating, Selection and Use of

3. Definitions. Not applicable.

4. Requirements. Meters shall be selected and applied in accordance with MIL-STD-1279. Meters required other than those listed in MIL-STD-1279 shall conform to one of the following specifications: MIL-M-7793, MIL-M-16034, MIL-M-16125, MIL-I-81219.

5. Information for guidance only. For analog meters, the normal operating value of the quantity to be indicated should be between 1/3 and 3/4 of full scale deflection, wherever practicable.

REQUIREMENT 52

THERMAL DESIGN

1. Purpose. This requirement establishes criteria for thermal design.

2. Documents applicable to Requirement 52:

F-F-300	Filter, Air Conditioning, Viscous-impingement and Dry Types, Cleanable
MIL-F-16552	Filter, Air Environmental Control System, Cleanable, Impingement (High Velocity Type)
MIL-B-23071	Blowers, Miniature, for Cooling Electronic Equipment, General Specification for
MIL-HDBK-251	Reliability/Design, Thermal Applications

3. Definitions

3.1 Auxiliary heating or cooling. External heating or cooling devices not normally part of the equipment configuration.

3.2 Cold plate. A heat transfer surface cooled by forced air or other heat transfer fluid to which heat dissipating parts are mounted.

3.3 Contaminant. Any foreign substance contained in air or other heat transfer fluid which adversely affects cooling performance, such as dust particles, lint, oil, sludge, etc.

3.4 Direct impingement. Passing cooling air over parts without the use of cold plates or heat exchangers.

3.5 Entrained water. Water condensed from the cooling air and carried along with the cooling air.

3.6 External source supplied cooling air. Forced air supplied from a conditioning source such as an air conditioner or aircraft environmental control system which is not normally a part of the electronic equipment.

3.7 Forced air cooling. The dissipation of heat to cooling air, including ram air, supplied by a source with sufficient pressure to flow through the unit.

3.8 Heat exchanger. An air-to-air or liquid-to-air finned duct arrangement which is used to transfer dissipated heat from a hot recirculating fluid to the cooling fluid by conduction through the finned surfaces.

3.9 Natural cooling. The dissipation of heat to surroundings by conduction, convection, radiation, or any combination thereof without the benefit of external cooling devices.

3.10 Part. An element or component used in the production of an electronic equipment or subsystem, such as a microcircuit, diode, transistor, capacitor, resistor, relay switch, or transformer.

3.11 Pressure drop (differential pressure). Resistance to flow usually measured as the static pressure difference across the electronic equipment from inlet to coolant outlet.

4. Requirements

4.1 Forced air cooling. Forced air cooling shall be used only when natural cooling is not adequate. Exhaust and recirculating fans and blowers shall be driven by ac brushless motors or by properly shielded dc motors. Miniature blowers shall conform to MIL-B-23071. Air filters shall be provided for air intakes for fan and blower cooled units when required to protect internal parts. Filters, when used, shall conform to F-F-300 or MIL-F-16552, and shall be removable for cleaning without disassembly of the equipment. All ventilation openings shall be designed and located to comply with electromagnetic interference, undesired radiation and enclosure requirements. Air exhaust shall be directed away from operating personnel.

4.1.1 External source. For equipment designed for use with external source supplied cooling air, which may contain entrained water or other contaminants detrimental to the equipment, precautionary measures shall be taken to avoid direct impingement on internal parts and circuitry by channeling or use of heat exchangers.

4.1.2 Aircraft application. Equipment that is intended for use in aircraft and requires forced air cooling shall be designed using cold plates or heat exchangers so that none of the cooling air will come into contact with internal parts, circuitry, or connectors.

4.2 Other cooling methods. Prior approval of the procuring activity shall be obtained when heat densities or other design requirements make the use of air for cooling impractical and alternate methods, such as liquid, evaporative, change of phase material, or heat pipes, are required.

5. Information for guidance only. The design factors which should be considered in determining the required fan or blower characteristics include such factors as amount of heat to be dissipated, the quantity of air to be delivered at the pressure drop of the enclosed equipment, the allowable noise

level, the permissible level of heat that may be exhausted into the surrounding environment, and other pertinent factors affecting the cooling requirement of the equipment. Induced drafts and ventilation by means of baffles and internal vents should be used to the greatest practicable extent. When practicable, ventilation and air exhaust openings should not be located in the top of enclosures or in front panels. When it is impractical to avoid direct impingement on internal parts and circuitry by channeling or use of heat exchangers, the water and contaminants should be removed from the cooling air by suitable water and contaminant removal devices.

5.1 External source. For equipment designed for use with external source supplied cooling air, minimum differential pressure (pressure drop) of the cooling air through the equipment heat exchanger or cold plate should be maintained, consistent with adequate cooling.

5.2 Design guidance. MIL-HDBK-251 may be used as a guide for detail information on thermal design of electronic equipment.

REQUIREMENT 53

WAVEGUIDES AND RELATED DEVICES

1. Purpose. This requirement establishes criteria for the selection and application of waveguides and related devices.

2. Documents applicable to Requirement 53:

MIL-G-24211	Gaskets, Waveguide Flange, General Specification for
MIL-S-55041	Switches, Waveguide, General Specification for
MIL-STD-1327	Flanges, Coaxial and Waveguide; and Coupling Assemblies, Selection of
MIL-STD-1328	Couplers, Directional (Coaxial Line, Waveguide, and Printed Circuit), Selection of
MIL-STD-1329	Switches, RF Coaxial, Selection of
MIL-STD-1352	Attenuators, Fixed and Variable, Selection of
MIL-STD-1358	Waveguides, Rectangular, Ridge and Circular, Selection of
MIL-STD-1636	Adapters, Coaxial to Waveguide, Selection of
MIL-STD-1637	Dummy Loads, Electrical, Waveguide, Coaxial, and Stripline, Selection of
MIL-STD-1638	Waveguide Assemblies, Rigid and Flexible, Selection of
MIL-STD-1639	Power Dividers, Power Combiners, and Power Divider/ Combiners, Selection of
MIL-STD-1640	Mixer Stages, Radio Frequency, Selection of
MIL-STD-2113	Radio Frequency Circulators and Isolators, Selection of
MIL-STD-2162	Amplifiers, Radio Frequency and Microwave, Solid State, Selection of
MIL-HDBK-216	RF Transmission Lines and Fittings
MIL-HDBK-660	Fabrication of Rigid Waveguide Assemblies (Sweep Bends and Twists)

3. Definitions. Not applicable.

4. Requirements. Waveguides and related devices shall be selected in accordance with the standards appearing in table 53-I and shall conform to a specification listed in the table or to a specification imposed by the listed standard.

5. Information for guidance only

5.1 RF transmission lines and fittings. MIL-HDBK-216 should be used as a technical information guide for RF transmission lines and fittings.

5.2 Rigid waveguide assemblies. MIL-HDBK-660 should be used as a guide to the fabrication of rigid waveguide assemblies where bends and twists are required to satisfy a particular application.

TABLE 53-I. Waveguides and related devices.

Item Description		Applicable Document
Adapters	Coaxial to Waveguide	MIL-STD-1636
Amplifier, RF and Microwave	DIP, Coaxial, TO, and Flatpack	MIL-STD-2162
Attenuators	Fixed and Variable Coaxial and Waveguide	MIL-STD-1352
Circulators	RF-SMA and Waveguide	MIL-STD-2113
Couplers	Directional Coaxial Waveguide and Prtd Ckt	MIL-STD-1328
Coupling Assemblies	Quick-Disconnect for Subminiature Waveguide Flanges	MIL-STD-1327
Dummy Loads	Waveguide, Coaxial and Stripline	MIL-STD-1637
Flanges	Waveguide and Coaxial	MIL-STD-1327
Gaskets	Pressure Sealing for Use With Cover Flanges and Flat Face	MIL-G-24211
Isolators	RF-SMA and Stripline	MIL-STD-2113
Mixer Stages	RF-DIP, Flatpack, TO and Connector	MIL-STD-1640
Power Dividers, Combiners and Divider/Combiners	Solder Terminals, Plug-In, Flatpack, TO and Connector	MIL-STD-1639
Switches	Waveguide to Waveguide Manual and Electro mechanically Operated	MIL-S-55041
	RF Coaxial	MIL-STD-1329
Waveguide Assemblies	Flexible and Rigid	MIL-STD-1638
Waveguides	Rigid Rectangular Rigid Circular, Single and Double Ridge	MIL-STD-1358

REQUIREMENT 54

MAINTAINABILITY

1. Purpose. This requirement offers guidance as to maintainability requirements which must be considered when preparing contractual documents. IT DOES NOT ESTABLISH REQUIREMENTS, AND MUST NOT BE REFERENCED IN CONTRACTUAL DOCUMENTS. Maintainability program tasks, quantitative requirements, and verification or demonstration requirements must be directly specified in the contract or the system/equipment specification, as appropriate.

2. Documents applicable to Requirement 54:

MIL-STD-470	Maintainability Program for Systems and Equipment
MIL-STD-471	Maintainability Verification/Demonstration/Evaluation
MIL-STD-721	Definitions of Terms for Reliability and Maintainability
MIL-HDBK-472	Maintainability Prediction

3. Definitions. Not applicable.

4. Requirements. Not applicable.

5. Information for guidance only

5.1 Maintainability program. Maintainability engineering and accounting tasks aimed at preventing, detecting, and correcting maintainability design deficiencies and providing maintainability related information essential to acquisition, operation, and support management should be included in contract requirements with the objective of establishing and maintaining an efficient maintainability program according to life cycle phase. MIL-STD-470 is the overall program document for the area. Other maintainability documents which may be invoked through MIL-STD-470 or which may be cited directly as a basis for contract requirements include MIL-STD-471, MIL-STD-721, and MIL-HDBK-472.

5.2 Quantitative requirements. Quantitative maintainability requirements and verification or demonstration requirements should be established as appropriate to program phase.

REQUIREMENT 55

ENCLOSURES

1. Purpose. This requirement establishes criteria for the design and construction of enclosures.

2. Documents applicable to Requirement 55:

MIL-C-172	Cases, Bases, Mounting, and Mounts, Vibration (For Use With Electronic Equipment in Aircraft)
MIL-M-81288	Mounting Bases, Flexible Plastic Foam
MIL-STD-108	Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment
EIA RS-310-C-77	Racks, Panels, and Associated Equipment

3. Definitions

3.1 Enclosures. Enclosures are housings such as consoles, cabinets, and cases, which are designed to provide protection and support to mechanisms, parts, and assemblies.

4. Requirements

4.1 Cases and mounting bases for airborne equipment. Materials, bonding, shielding and performance requirements of MIL-C-172 shall apply to all cases. Mounting bases shall conform to MIL-C-172 or MIL-M-81288, as applicable.

4.2 Degree of enclosure. Enclosures shall be designed in accordance with MIL-STD-108, table I for the degree of enclosure best suited to the application. Moisture absorbent materials such as open-celled foam shall not be used to fill moisture pockets.

4.3 Materials. Materials used shall be corrosion and deterioration resistant or coated to resist corrosion and deterioration.

4.4 Racks and panels. The internal clearance and the equipment mounting holes of racks and panels shall be in accordance with EIA RS-310-C.

4.5 Test requirements. Enclosures shall be tested as specified in MIL-STD-108.

5. Information for guidance only

5.1 Cases for aerospace ground support equipment. The detailed equipment specification or contract for the particular equipment will specify the type of case to be supplied by the contractor. Transit cases and combination type cases may not be required for ship, depot, or field shops wherever the area of use is protected or controlled for human occupancy.

5.2 Desiccants. Where moisture build up in sealed equipment cannot be tolerated, the use of desiccants or dehydrating agents should be considered.

5.3 Materials. Materials for the enclosure should be the lightest practical consistent with the strength required for sturdiness, serviceability and safety.

REQUIREMENT 56

ROTARY SERVO DEVICES

1. Purpose. This requirement establishes criteria for the selection and application of rotary servo devices such as servomotors, synchros, electrical resolvers, tachometer generators, encoders, and transolvers.

*2. Documents applicable to Requirement 56:

MIL-S-22432	Servomotors, General Specification
MIL-S-22820	Servomotor-Tachometer Generator AC, General Specification for
MIL-T-22821	Tachometer Generator AC, General Specification for
MIL-R-50781	Resolver, Electrical, Linear, General Specification for
MIL-E-81512	Encoder, Shaft Position to Digital, Contact Type, Altitude Reporting, General Specification for
MIL-S-81746	Servtorqs, General Specification for
MIL-S-81963	Servo Components, Precision Instrument, Rotating, Common Requirements and Tests, General Specification for
MIL-T-83727	Transolvers, General Specification for
MIL-E-85082	Encoders, Shaft Angle to Digital, General Specification for
MIL-STD-710	Synchros, 60 and 400 Cycle
MIL-STD-1451	Resolvers, Electrical, Selection of
MIL-HDBK-218	Application of Electrical Resolvers
MIL-HDBK-225	*Synchros, Description and Operation*
MIL-HDBK-231	Encoder, Shaft Angle to Digital

3. Definitions. Not applicable.

4. Requirements

4.1 Rotary servo devices. Rotary servo devices shall conform to MIL-S-81963 as applicable.

4.2 Servomotors. Servomotors shall conform to MIL-S-22432.

4.3 Synchros. Synchros shall be selected and applied in accordance with MIL-STD-710.

4.4 Electrical resolvers. Electrical resolvers shall be selected and applied in accordance with MIL-STD-1451.

4.5 Electrical linear resolvers. Electrical linear resolvers shall conform to MIL-R-50781.

4.6 Tachometer generators. Tachometer generators shall conform to MIL-T-22821.

4.7 Transolvers. Transolvers shall conform to MIL-T-83727.

4.8 Encoders. Encoders shall conform to MIL-E-85082 for general application. For altitude reporting applications, encoders shall conform to MIL-E-81512.

4.9 Servomotor-tachometer generators. Servomotor-tachometer generators shall conform to MIL-S-22820.

4.10 Servtorqs. Servtorqs shall conform to MIL-S-81746.

*5. Information for guidance only. The following documents contain additional information for application:

MIL-HDBK-218 (Resolvers)

MIL-HDBK-225 (Synchros)

MIL-HDBK-231 (Encoders)

REQUIREMENT 57

RELAYS

1. Purpose. This requirement establishes criteria for the selection and application of relays.

2. Documents applicable to Requirement 57:

MIL-R-83516 Relays, Reed, Dry, General Specification for
MIL-STD-1346 Relays, Selection and Application

3. Definitions. Not applicable.

4. Requirements

4.1 Selection. Unless otherwise specified, the order of precedence for relay selection shall be as follows:

a. Relays listed in MIL-STD-1346. Reed relays shall conform to MIL-R-83516.

b. DESC selected item drawing relays, subject to procuring activity approval.

c. Other relays, subject to procuring activity approval. Sufficient detail must be presented (e.g., contact loads, coil voltages of requested relay vs the standard part) to justify the use of the nonstandard part.

4.2 Application. Relays shall be applied in accordance with MIL-STD-1346. The use of reed relays in airborne applications requires procuring activity approval.

5. Information for guidance only. Not applicable.

REQUIREMENT 58

SWITCHES

1. Purpose. This requirement establishes criteria for the selection and application of switches and associated hardware. This requirement is not applicable to RF coaxial switches.

2. Documents applicable to Requirement 58:

MIL-S-12285	Switch, Thermostatic
MIL-S-15743	Switches, Rotary, Enclosed
MIL-S-18396	Switches, Meter and Control, Naval Shipboard
MIL-S-83731	Switch, Toggle, Unsealed and Sealed Toggle, General Specification for
MIL-STD-1132	Switches and Associated Hardware, Selection and Use of

3. Definitions. Not applicable.

4. Requirements

4.1 Selection and application. Switches and associated hardware shall be selected and applied in accordance with MIL-STD-1132. Switches required other than those listed in MIL-STD-1132 shall conform to one of the following specifications: MIL-S-12285, MIL-S-15743, MIL-S-18396, and MIL-S-83731.

5. Information for guidance only. Not applicable.

REQUIREMENT 59

BRAZING

1. Purpose. This requirement establishes criteria for brazing.

2. Document applicable to Requirement 59:

MIL-B-7883	Brazing of Steels, Copper, Copper Alloys, Nickel Alloys, Aluminum and Aluminum Alloys

3. Definitions. Not applicable.

4. Requirements. Brazing of steel, copper, copper alloys, nickel alloys, aluminum, and aluminum alloys shall be in accordance with MIL-B-7883.

5. Information for guidance only. Electrical connections of stranded or insulated wire or those having construction which may entrap fluxes should not be brazed.

REQUIREMENT 60

SOCKETS AND ACCESSORIES

1. Purpose. This requirement establishes criteria for the selection and application of sockets and accessories for plug-in parts.

2. Documents applicable to Requirement 60:

MIL-S-12883	Socket and Accessories for Plug-In Electronic Components, General Specification for
MIL-S-24251	Shield, Retainer (Bases), and Adapters, Electron Tube, Heat Dissipating, General Specification for
MIL-M-38527	Mounting Pads, Electrical-Electronic Component, General Specification for
MIL-S-83502	Sockets, Plug-In Electronic Components, Round Style, General Specification for
MIL-S-83734	Sockets, Plug-in Electronic Components, Dual-in-line (DIPs) and Single-in-line packages (SIPs), General Specification for

3. Definitions. Not applicable.

4. Requirements

4.1 Sockets. Sockets for plug-in electronic parts shall be of the single unit type and shall conform to MIL-S-12883, MIL-S-83502 or MIL-S-83734. The use of sockets for microcircuits requires approval of the procuring activity.

4.2 Shields. Heat dissipating tube shields shall conform to MIL-S-24251.

4.3 Mounting pads. Where mounting pads are required for use with small electrical or electronic devices, they shall conform to MIL-M-38527.

5. Information for guidance only

5.1 Use of sockets. The use of sockets in mission related and ground support equipment should be kept to a minimum, due to the possibility of intermittent connections during shock, vibration, and temperature cycling.

5.2 Shield bases. Shield bases, for use with heat dissipating shields, should be mounted on clean, smooth, metallic mating surfaces, to minimize the contact resistance (thermal and electrical) between the base and the supporting chassis.

REQUIREMENT 61

ELECTROMAGNETIC INTERFERENCE CONTROL

1. Purpose. This requirement establishes criteria for electromagnetic interference control.

2. Documents applicable to Requirement 61:

MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-469	Radar Engineering Design Requirements, Electromagnetic Compatibility
MIL-HDBK-253	Guidance for the Design and Test of Systems Protected Against the Effects of Electromagnetic Energy
NTIA Manual	National Telecommunications and Information Administration Manual of Regulations and Procedures for Radio Frequency Management

3. Definitions. Not applicable.

4. Requirements

4.1 General. Electromagnetic interference requirements shall be as specified in MIL-STD-461.

*4.2 Radar equipment. Radar systems and equipment shall also conform to the provisions of section 5.3 of the NTIA Manual as specified in the contract and to MIL-STD-469 except that MIL-STD-469 shall not be used for Air Force applications. In the event of conflict, the following descending order of precedence shall prevail: NTIA Manual, MIL-STD-469, MIL-STD-461.

4.3 Tests. Tests and test methods shall be as specified in MIL-STD-462. For other than Air Force applications, MIL-STD-469 shall also apply for radar equipment and systems.

5. Information for guidance only. MIL-HDBK-253 provides guidance for the design and test of electronic systems which are to be immune to the detrimental effects of electromagnetic energy.

REQUIREMENT 62

HUMAN ENGINEERING

1. Purpose. This requirement offers guidance as to human engineering requirements which must be considered when preparing contractual documents. IT DOES NOT ESTABLISH REQUIREMENTS, AND MUST NOT BE REFERENCED IN CONTRACTUAL DOCUMENTS. Human engineering requirements and related test and evaluation requirements must be directly specified in the contract or the system/equipment specification, as appropriate.

2. Documents applicable to Requirement 62:

MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment and Facilities
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities

3. Definitions. Not applicable.

4. Requirements. Not applicable.

5. Information for guidance only. Human engineering applied during development and acquisition of military systems, equipment, and facilities serves to achieve the effective integration of personnel into the design of the system. The objective of a human engineering effort is to develop or improve the crew/equipment/software interface and to achieve required effectiveness of human performance during system operation, maintenance and control and to make economical demands upon personnel resources, skills, training, and costs. MIL-H-46855 is the overall requirements document for the area. It must be tailored when applied; application guidance is offered in the document. MIL-STD-1472 provides design criteria which may be selectively applied as requirements or guidance.

REQUIREMENT 63

SPECIAL TOOLS

1. Purpose. This requirement establishes criteria for the selection and application of special tools.

2. documents applicable to Requirement 63. Not applicable.

3. Definitions.

3.1 Special tools. Tools, including jigs, fixtures, stands, and templates, not listed in the Federal Supply Catalog.

4. Requirements.

4.1 Approval. The use of any special tool shall be subject to the approval of the procuring activity.

4.2 Furnishing and stowing. Special tools needed for operation and organization level maintenance shall be furnished by the contractor and shall be mounted securely in each equipment in a convenient and accessible place, or in a central accessible location for an equipment array requiring such tools.

5. Information for guidance only. The design of equipment should be such that the need for special tools for tuning, adjustment, maintenance, replacement, and installation is kept to a minimum. Only when the required function cannot be provided by an existing standard tool should special tools be considered. Necessary tools should be identified as early as possible.

REQUIREMENT 64

MICROELECTRONIC DEVICES

1. Purpose. This requirement establishes criteria for the selection and application of microelectronic devices. These criteria are based on the objectives of achieving technological superiority, quality, reliability, and maintainability in military systems.

2. Documents applicable to Requirement 64:

MIL-M-38510 Microcircuits, General Specification for
MIL-H-38534 Hybrid Microcircuits, General Specification for
MIL-I-38535 Integrated Circuits (Microcircuits) Manufacturing, General Specification for
MIL-STD-785 Reliability Program for Systems and Equipment Development and Production
MIL-STD-883 Test Methods and Procedures for Microelectronics
MIL-STD-975 NASA Standard Electrical, Electronic and Electromechanical Parts List
MIL-STD-1547 Parts, Materials and Processes for Space and Launch Vehicles, Technical Requirements for
MIL-STD-1562 Lists of Standard Microcircuits
MIL-STD-1686 Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
MIL-BUL-103 List of Standardized Military Drawings (SMDs)
MIL-HDBK-217 Reliability Prediction of Electronic Equipment
ANSI/IEEE 1076-1987 VHSIC Hardware Description Language (VHDL)
VHSIC Interoperability Standards. Includes specifications for the TM-bus, ETM bus, Pi bus, and VHSIC Electrical Specification. (Copies available from Naval Research Laboratory, Code 5305, Washington, DC 20375-5000).
Tester Independent Support Software System (TISSS) Specifications (Copies available from TISSS Program Office, RL/ERD, Griffiss Air Force Base, NY 13441-5700).

3. Definitions

3.1 Microelectronic devices. Monolithic, hybrid, rf and microwave (hybrid/integrated) circuits, multichip microcircuits, and microcircuit modules.

3.2 Very high speed integrated circuits (VHSIC). A technology development program (1980-1989) for the design and manufacture of high speed digital integrated circuits with 1.25 and 0.5 micrometer feature sizes for military

applications. Many VHSIC's incorporate Built-In-Test and later VHSIC's will incorporate interoperability features. Table 64-II describes VHSIC characteristics.

3.3 Microwave/millimeter wave monolithic integrated circuits (MIMIC). Program to establish the capabilities to design, develop, manufacture and test analog microwave/ millimeter wave integrated circuits for use in military systems.

3.4 Advanced microcircuit technology. Microcircuit fabrication and design technology which is newly available for prototype designs and will be available for production in the near future (2-5 years). VHSIC and MIMIC are examples. For digital microcircuits, the performance capability can be approximately characterized by the minimum feature size, the clocking frequency, and the functional throughput rate. (See 5.1)

3.5 VHSIC hardware description language (VHDL). A high level computer language developed under the VHSIC program for describing the signal structure of electronic hardware (chips, modules, and subsystems). The language describes the signal flow and the structure of the device in terms of the basic circuit models, fundamental logic blocks, and higher level functional assemblies of logic blocks.

3.6 Qualified Device (Microcircuit). Any device or microcircuit which has met the requirements of MIL-M-35510, MIL-H-38543, or MIL-I-38535 and is listed on the associated QPL/QML listings.

3.7 Waveform and Vector Exchange Specification (WAVES). A high level computer language developed under the VHSIC and Advanced Tactical Fighter (ATF) programs for describing test vector and waveform stimuli for electronic hardware (chips, modules, and subsystems). The WAVES is compatible with the VHDL simulation language and simulation environments.

3.8 Application Specific Integrated Circuit (ASIC). Any microcircuit that is custom designed or any programmable microcircuit (e.g. EPROM, EEPROM, UVEPROM, PLA, PLD, gate array, sea of gates, standard cell library, etc.) that is programmed or personalized to perform a specific equipment or custom function.

4. Requirements

4.1 Selection

4.1.1 Technology. At each stage in new and re-engineered system designs, i.e., concept studies, demonstration and validation, and full scale

development, the advanced microcircuit technologies which meet reliability, performance, and cost requirements of the application shall be evaluated for use in the production phase.

4.1.2 Reliability. Microelectronic devices in military systems in full scale development and production shall, as a minimum, conform to the applicable product assurance level of MIL-M-38510, MIL-H-38534, or MIL-I-38535.

4.1.3 Order of precedence. Unless otherwise specified, the order of precedence shall be as follows:

a. Microcircuits listed in table I of MIL-STD-1562.

b. Other MIL-M-38510, MIL-H-38534, or MIL-I-38535 microcircuits not listed in tables III, IV and V of MIL-STD-1562.

c. Other microcircuits listed in table II of MIL-STD-1562 as preferred for new design, subject to procuring activity approval.

d. Active Standardized Military Drawing (SMD) or DESC drawing microcircuits not listed in tables III, IV and V of MIL-STD-1562, subject to procuring activity approval.

e. Other microcircuits (see 4.1.5), subject to procuring activity approval.

4.1.4 Qualified devices. When the contract or purchase order for new design, redesign, or part level upgrade of military hardware specifies the use of MIL-STD-883 class B or S microcircuits, and there is a qualified device of the required generic chip and package type or case outline, the qualified class device shall be the only device authorized in that design.

4.1.4.1 Space Applications. When qualified devices are not available or cannot be qualified by the manufacturer, the requirements of MIL-STD-975 or MIL-STD-1547 shall apply.

4.1.4.2 Other Applications. When a qualified device does not exist and a SMD device of the required generic chip and package type or case outline does exist, the SMD device shall be the preferred device authorized for that design.

4.1.5 Other microcircuits. For other than qualified devices, the following information shall be included in the nonstandard part approval request (except where identification of a military detail specification, or SMD number satisfies this requirement or other direction is given):

a. Device nomenclature, marking, configuration, functional requirements, parameters and limits sufficient to insure the required form, functions and interchangeability.

b. Required environmental, endurance (life) and other design capability tests.

c. Quality assurance requirements, including screening and lot quality conformance (acceptance) tests. As a minimum, devices shall be procured to all the requirements of MIL-STD-883 paragraph 1.2.1. Hybrid or integrated microcircuits shall be procured to the requirements of MIL-H-38534 or MIL-I-38535. The applicable detail specification, SMD or vendor/contractor document shall be specified for electrical performance, mechanical, and final electrical test requirements.

d. An evaluation of the projected availability and product assurance status for the time of production and through the projected life of the system.

e. Device design and test documentation in the VHDL and WAVES format (see 4.5.3 and 4.5.4).

4.1.6 Electrostatic sensitive parts. Microcircuits are susceptible to electrostatic discharge (ESD) damage. Microcircuit susceptibility is classified in MIL-STD-1686 and Test Method 3015 of MIL-STD-883. When device susceptibility is not available, it can be determined using Test Method 3015 or Appendix B of MIL-STD-1686. Microcircuits from the ESDS Class necessary to meet system ESD requirements shall be selected. ESD susceptibility of microcircuits are listed in the associated QPL/QML listings of MIL-M-38510 for JAN devices and MIL-H-38534 or MIL-I-38535 for the individual device.

4.2 Programmable devices. Use of programmable devices, regardless of type, requires approval of the procuring activity.

4.3 Fusible link devices. When fusible link devices (PROMs, PALs, PLDs, etc) are programmed by the user, parametric and functional electrical tests in accordance with MIL-STD-883, Method 5005, Group A, Subgroups 7 and 9 as a minimum, shall be performed after programming to verify the specific program configuration and effectiveness of link fusing. This testing shall be done on a 100% basis when performing board or subsystem/system simulations.

4.4 Packages. Microcircuit devices used in equipment shall be hermetically sealed in glass, metal or ceramic (or combinations of these) packages. No organic or polymeric materials such as lacquers, varnishes, coatings, adhesives, or greases shall be used inside the microcircuit package, unless otherwise specified. No desiccants shall be contained in the microcircuit package, unless otherwise specified.

4.5 Device design and test documentation

4.5.1 ASIC documentation in VHDL. Digital Application-Specific Integrated Circuits (ASICs) designed after 30 September 1988 shall be documented by means of structural and behavioral VHSIC Hardware Description Language (VHDL) descriptions in accordance with IEEE 1076. (See paragraph 5.7) Behavioral VHDL descriptions shall include function and timing at the ports accurate enough to enable the performance of test generation and determination of fault detection/fault isolation levels at the integrated circuits pins when performing board or subsystem simulations.

4.5.2 Fault coverage. For all digital microcircuits developed or modified after 31 December 1991, fault coverage shall be documented in accordance with MIL-STD-883 Test Method 5012 for all manufacturing-level logic tests.

4.5.3 Qualified Device Documentation in VHDL. Digital qualified devices for use in board level designs after 31 December 1991 shall be documented by means of behavioral VHDL descriptions in accordance with ANSI/IEEE 1076. (See paragraph 5.7) Behavioral VHDL descriptions shall include function and timing at the port accurate enough to perform test generation and determine fault detection/fault isolation levels at the integrated circuit pins.

4.5.4 ASIC test stimuli documentation in WAVES. Digital ASICs designed after 31 December 1991 shall have all test vectors and test waveforms documented and delivered to the Government in the WAVES format.

4.6 Cost considerations. Microelectronic devices shall be selected on the basis of overall life cycle cost.

5. Information for guidance only

5.1 Technology progression. The use of advanced microcircuit technology should be considered and evaluated in the design of all systems/equipment. For critical weapon systems applications, and for system development schedules projected to be longer than four years, the performance advantages provided by advanced technologies, such as VHSIC and MIMIC, should be evaluated early in the system development phases for use in the procurement stage.

5.1.1 Projected availability. The projected availability of advanced digital (VHSIC) technologies for use in progressive stages of system development is provided in table 64-I to aid in performing this evaluation.

TABLE 64-I. Digital technology progression prediction.

Year	Concept I	D&V II	FSD III	P&D
1987	.5 - 1.0	1.0 - 1.25	1.0 - 1.25	1.25 - 1.5
1988	.5 - .8	.8 - 1.0	1.0 - 1.25	1.0 - 1.25
1989	.5 - .7	.7 - 1.0	.8 - 1.0	1.0 - 1.25
1990	.4 - .6	.5 - .8	.6 - 1.0	.8 - 1.0
1991	.4 - .5	.5 - .6	.6 - .8	.7 - .8
1992	.3 - .4	.4 - .6	.5 - .7	.6 - .7
1993	.25 - .3	.3 - .5	.4 - .6	.5 - .6
1994	.25 - .3	.4	.5	

D&V: Demonstration and Validation

FSD: Full Scale Development

P&D: Production and Deployment

I, II, III: System Development Milestones

5.1.2 Performance characteristics. The numbers in table 64-I represent the "minimum feature size" which generally characterizes the performance and characteristics of digital technology. (See table 64-II.)

5.2 Reliability prediction. When required, microcircuit reliability predictions should be prepared in accordance with MIL-HDBK-217.

5.2.1 Reliability prediction. When required, microcircuit reliability predictions should be prepared in accordance with MIL-HDBK 217.

5.2.2 Reliability assurance. A plan should be in place to assure that microelectronic devices meet the reliability requirement of paragraph 4.1.2 at the time of full scale development. This plan should provide for resubmission of parts list, if so invoked by contract, through DESC/MPCAG prior to procurement of parts to be used in actual production to assure that all evaluations are based on the most recent standardization status.

5.3 Microcircuit obsolescence. Due to rapid technology advances, many military and commercial microcircuits listed in specifications and catalogs are either obsolete or are nearing obsolescence. The use of these devices will affect the mission objectives of the using equipment. For Navy equipment current information on microcircuits that may be nearing obsolescence may be obtained from the Naval Avionics Center, Code 435, Indianapolis, Indiana 46219-2189, telephone (317) 353-3767.

5.4 Use of non-hermetic microcircuits. Upon specific request and approval by the procuring activity to waive the requirements of 4.1, non-hermetic microcircuits may be considered for use in ground fixed (GF) or ground benign (GB) environments as defined in MIL-HDBK-217. They should meet all the requirements of the equipment specification, temperature and humidity should be completely controlled in transit, storage, and application. Provisions should be made for logistic availability.

TABLE 64-II. Performance characteristics - digital microelectronics.

Characteristic	Units		
Min feature size	micrometers	1.25	0.5
Temperature range	degrees Celsius	-55 to 125	-55 to 125
Min clock frequency	MHz	25	100 on chip
FTR	gate Hz/sq cm	5 exp 11	1 exp 13
Testability		98% of detectable faults	98% of detectable faults
BIT fault coverage			
stuck at	%	95	95
stuck open (CMOS)	%		75
Test bus		ETM or TM*	ETM or TM*
Interoperability		yes	yes

*IAW VHSIC Interoperability Standard

5.5 Testability. New and upgraded systems should exploit chip level built-in-test features to enhance the testability and operational availability of the module or system. When advanced digital modules or boards are developed, microcircuits incorporating the VHSIC ETM-BUS or VHSIC TM-BUS should be used. (See VHSIC Interoperability Standards.)

5.6 Life cycle cost evaluation. The following factors should be considered in estimating life cycle costs associated with selection of microcircuit devices or technologies: a) effect of built-in-test on repair, maintainability, operational availability, and reconfigurability; and b) value of VHDL descriptions of chips, modules, and boards in resupply, multiple source development, and design upgrade.

5.7 ASIC Documentation Reference. Data Item Description, DI-EGDS-80811, provides the documentation preparation and delivery instructions for ASIC

REQUIREMENT 65

CABLE, COAXIAL (RF)

1. Purpose. This requirement establishes criteria for the selection and application of coaxial radio frequency (rf) cable.

2. Documents applicable to Requirement 65:

MIL-C-17	Cable, Radio Frequency, Flexible and Semirigid, General Specification for
MIL-L-3890	Lines, Radio Frequency Transmission (Coaxial, Air Dielectric)
MIL-C-22931	Cable, Radio Frequency, Semirigid, Coaxial, Semi-Air Dielectric, General Specification for
MIL-C-23806	Cable, Radio Frequency, Coaxial, Semirigid, Foam Dielectric, General Specification for
MIL-HDBK-216	RF Transmission Lines and Fittings

3. Definitions. Not applicable.

4. Requirements

4.1 Cable selection. Selection of coaxial cable shall be in accordance with MIL-C-17, MIL-L-3890, MIL-C-22931 or MIL-C-23806. Other types of cable may be used provided they are selected from specifications acceptable for the specific application and approved by the procuring activity.

*4.2 Application restriction. Cables with polyvinyl chloride insulation shall not be used in aerospace applications. Use of these cables in any other application requires prior approval by the procuring activity.

5. Information for guidance only

5.1 Application guidance. MIL-HDBK-216 may be used as a technical information guide to applications of transmission lines and fittings.

5.2 Critical circuits. For use above 400 MHz and in critical rf circuits, elements such as environmental requirements, short leads, and grounding should be considered in design application, along with critical electrical characteristics such as attenuation, capacitance, and structural return loss.

REQUIREMENT 66

CABLE, MULTICONDUCTOR

1. Purpose. This requirement establishes criteria for selection and application of electrical multiconductor cable for use within electronic equipment.

*2. Documents applicable to Requirement 66:

QQ-W-343	Wire, Electrical, Copper (Uninsulated)
MIL-C-17	Cables, Radio Frequency, Flexible and Semirigid, General Specification for
MIL-C-442	Cable (Wire), Two Conductor, Parallel
MIL-C-3432	Cable (Power and Special Purpose) and Wire, Electrical (300 and 600 Volts)
MIL-W-5086	Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy
MIL-W-5845	Wire, Electrical, Iron and Constantan, Thermocouple
MIL-W-5846	Wire, Electrical, Chromel and/or Alumel, Thermocouple
MIL-W-5908	Wire, Electrical, Copper and Constantan, Thermocouple
MIL-C-7078	Cable, Electric, Aerospace Vehicle, General Specification for
MIL-W-8777	Wire, Electrical, Silicone-Insulated, Copper, 600 Volt, 200°C
MIL-C-13777	Cable, Special Purpose, Electrical: General Specification for
MIL-W-16878	Wire, Electrical, Insulated, General Specification for
MIL-C-19547	Cable, Electrical, Special Purpose, Shore Use
MIL-W-22759	Wire, Electric, Fluoropolymer-Insulated, Copper or Copper Alloy
MIL-C-23437	Cable, Electrical, Shielded Pairs
MIL-C-24640	Cable, Electrical, Lightweight, for Shipboard Use, General Specification for
MIL-C-24643	Cable and Cord, Electrical, Low Smoke, for Shipboard Use, General Specification for
MIL-W-25038	Wire, Electrical, High Temperature and Fire Resistant, Aircraft
MIL-C-27072	Cable, Special Purpose, Electrical, Multiconductor
MIL-C-27500	Cable, Electrical, Shielded and Unshielded, Aerospace
MIL-C-49055	Cable, Power, Electrical (Flexible, Flat, Unshielded) (Round Conductor), General Specification for
MIL-C-55021	Cable, Twisted Pairs and Triples, Internal Hookup, General Specification for

MIL-W-81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy
MIL-W-81381	Wire, Electric, Polyimide-Insulated, Copper or Copper Alloy
ASTM A580-90	Wire, Steel, Stainless and Heat Resisting
ASTM B33-74	Tinned Soft or Annealed Copper Wire for Electrical Purposes

3. Definitions. Not applicable.

4. Requirements

4.1 Selection and application. Selection and application of multiconductor cable shall be in accordance with table 66-I.

4.2 Solid or stranded. Either solid or stranded conductors may be used (within the restrictions of the particular wire or cable specification) except that (a) with the exception of thermocouple and flat cable wire, only stranded wire shall be used in aerospace applications, and (b) for other applications stranded wire shall be used when so indicated by the equipment application. Specifically, with the exception of flat multiconductor flexible cable, stranded wire shall be used for wires and cables which are normally flexed in use and servicing of the equipment, such as cables attached to the movable half of detachable connectors.

4.3 Application restrictions

4.3.1 Cable containing MIL-W-16878 wire shall not be used for Air Force or Navy aerospace applications.

4.3.2 Cables with polyvinyl chloride insulation shall not be used in aerospace applications. Use of these cables in any other application requires prior approval of the procuring activity.

4.3.3 MIL-W-22759 wire with only single polytetrafluoroethylene insulation used in Air Force space and missile applications shall require the approval of the procuring activity.

4.3.4 Silver plated copper wire shall not be used in applications involving Army missile systems.

5. Information for guidance only. Not applicable.

*TABLE 66-I. Cable, multiconductor.

Spec No.	Title	Basic Wire Specs	Conductor			Shield Braid 3/			Jacket 3/		Remarks
			No. of Cond	Volts RMS	Temp 2/	Strand Material	Strand Coating	% Coverage	Material 1/	Type	
MIL-C-442	Cable, (Wire), Two Conductor, Parallel	QQ-W-343 & Insulation	2	300	Flexibility at -40°C or -55°C				Vinyl-polymer or synthetic (styrene butadiene) rubber or natural rubber		Lead wire for firing explosive charges
MIL-C-3432	Cable (Power and Special Purpose) and Wire, Electrical (300 & 600V)	QQ-W-343 & Insulation	Unlimited and mixed sizes 4/ 5/	300 & 600	-40°C to +65°C or -55°C to +75°C	None or Copper	Tin	85	Styrene butadiene rubber, chloroprene rubber, ethylene-propylene -dinne, rubber, polyurethan thermoplastic elastomer, or natural rubber	Extruded & vulcanized	
MIL-C-7078	Cable, Electric, Aerospace Vehicle	M5086/1	2-7	600	105°C	Copper	Tin		None		(a)Fluorinated ethylene propylene (b) Polytetrafluoroethylene
		M5086/2	1-7			Copper	Tin		Polyamide (Nylon)	Extruded or ImpregBraid	
		M5086/3	1-7								
		M22759/12	1-7		260°C	Copper	Nickel	85	(a)	Extruded	
		M22759/23	1-7		260°C	Copper	Nickel	85	(b)	Extruded or tape	
		M81044/9	1-7		110°C	Copper	Tin	85	Polyvinylidene fluoride	Extruded	
		M81381/8 /10 and /14	2-7 1-7		200°C 200°C	Copper	Nickel	85	FEP/polyimide	Film Tape	
		M81381/11	2-7		200°C						
		M81381/12	1-7		150°C	Copper	Tin	85	FEP/polyimide	Film Tape	
		M81381/13	1-7		200°C	Copper	Nickel	85			
MIL-C-13777	Cable, Special Purpose, Electrical	MIL-C-17 QQ-W-343 ASTM-A580 & Insulation	2-78 6/	600	-53°C to +71°C	Copper	Tin	80	Sheath Polychloroprene Primary Insulation Polyethylene	Extruded & vulcanized Extruded	See Note 7

TABLE 66-I. Cable, multiconductor. - Continued

Spec No.	Title	Basic Wire Specs	Conductor			Shield Braid 3/			Jacket 3/		Remarks
			No. of Cond	Volts RMS	Temp 2/	Strand Material	Strand Coating	% Coverage	Material 1/	Type	
MIL-C-19547	Cable, Electrical, Special purpose, Shore Use	ASTM B33-74 & Insulation	Multiple twisted pairs, 6-100 pairs	600	75°C	Corrugated Aluminun		100	Polyethylene	Extruded	For use as telephone & telegraph signal cables in shore communications
MIL-C-23437	Cable, Electrical, Shielded Pairs	MIL-W-16878/1	Shielded & jacketed twisted pairs 1 pair-104 pairs	600	105°	Copper	Tin	90	PVC	Extruded	For use within shore communications stations, not to be used on board ship
						Note: Shield Applied over each pair					
MIL-C-24640	Cable, Electrical, Lightweight, for shipboard use	MIL-W-81044	2-77 pair	600	150°C	Copper tape	Tinned	85%	Crosslinked, polyalkene, crosslinked alkaneimid, polymer, or polyarylene	Extruded	
MIL-C-27072	Cable Special Purpose, Electrical, Multiconductor	MIL-C-17	2-36	Various	Not Spec	Copper	Tin, Silver	85	Sheath of PVC, polyethylene, polychloroprene, polyamide, TFE-Teflon, or FEP-Teflon		Flexible mulitconductor cable for use in protected areas: tunnels, wire ways, instrument racks, and conduit. Polyethylene jacketed cable suitable for underwater or direct burial applications only. M16878/6 and /13 not for aerospace applications
		MIL-W-5845		Various	Not Spec						
		MIL-W-5846		Various	Not Spec						
		MIL-W-5908		Various	Not Spec						
		M16878/1		600	105°C						
		M16878/2		1000	105°C						
		M16878/3		3000	105°C						
		M16878/4		600	200°C						
		M16878/5		1000	200°C						
		M16878/6		250	200°C						
		M16878/10		600	75°C						
		M16878/13		250	200°C						
						Note: MIL-C-27072 applicable detail specification sheets control materials for each specific cable configuration.					

*TABLE 66-I. Cable, multiconductor. - Continued

Spec No.	Title	Basic Wire Specs	Conductor: No. of Cond	Conductor: Volts RMS	Conductor: Temp 2/	Shield Braid 3/: Strand Material	Shield Braid 3/: Strand Coating	Shield Braid 3/: % Coverage	Jacket 3/: Material 1/	Jacket 3/: Type	Remarks
MIL-C-27500	Cable, Electrical, Shielded and Unshielded, Aerospace	MIL-W-8777	1-7	600	200°C	Various	Various	85	Various	Braided	For general aerospace flight vehicle applications
		MIL-W-22759	1-7	Various	Various	Various	Various	85	Various	Extruded or Braided	
		MIL-W-25038	1-7	600	260°C	Various	Various	85	TFE coated glass fiber	Braided	
		MIL-W-81044	1-7	600	150°C	Various	Various	85	Various	Extruded	
		MIL-W-81381	1-7	600	Various	Various	Various	85	Various	Tape	
MIL-C-49055	Cables, Power Electrical, (Flexible, Flat, Unshielded), (Round Conductor), General Specification for	MIL-C-49055/1 MIL-C-49055/11 MIL-C-49055/12 MIL-C-49055/13 MIL-C-49055/14 MIL-C-49055/15 MIL-C-49055/16 MIL-C-49055/17	Note: MIL-C-49055 applicable detail specification sheets control the number of conductors and materials for each specific cable configuration.								
MIL-C-55021	Cable, Twisted Pairs & Triples, Internal Hookup, General Specification for	MIL-W-16878	2-3	600 to 1000	-40°C to +105°C or -65°C to +200°C	None or Copper	Tin, Silver or Nickel	90	None PVC, Nylon TFE-Teflon	Extruded Extruded or Tape	

*TABLE 66-I. Cable, multiconductor. - Continued

NOTES:

1 Polyester - Polyethylene Terephthalate
TFE-Teflon - Polytetrafluoroethylene
PVC - Polyvinly chloride (Not to be used in airborne applications)
KEL-F - Polymonochlorotrifluoroethylene
FEP-Teflon - Fluorinated ethylene propylene
PVF - Polyvinylidene fluoride

2 See applicable detail specification sheet for temperature limitation.

3 See applicable detail specification sheet for materials control of specific cable configurations

4 Although the specification does not limit the number of conductors in a cable, the size, weight, and flexibility are determining factors.

5 Available in three classifications:

Class L - Light Duty - to withstand severe flexing and frequent manipulation

Class M - Medium Duty - to withstand severe flexing and mechanical abuse

Class H - Heavy Duty - to withstand sever flexing and mechanical abuse and ability to withstand severe service impacts such as to be run over by tanks or trucks

6 See applicable detail specification sheet for mechanical test requirements for cold bend, cold bend torque, impact bend, and twist.

7 For use under abusive mechanical conditions and where resistance to weather, oil and ozone are requirements.

REQUIREMENT 67

MARKING

1. Purpose. This requirement establishes criteria for external and internal markings on equipment, assemblies and component parts. Marking for safety, shipping and handling is not within the scope of this requirement.

2. Documents applicable to Requirement 67:

L-S-300	Sheeting and Tape, Reflecting, Nonexposed Lens, Adhesive Backing
MIL-M-13231	Marking of Electronic Items
MIL-P-15024	Plate, Tags and Bands for Identification of Equipment
MIL-N-18307	Nomenclature and Identification for Electronic, Aeronautical and Aeronautical Support Equipment, Including Ground Support Equipment
MIL-S-81963	Servo-Components Precision Instrument, Rotating, Common Requirements and Tests, General Specification for
MIL-STD-12	Abbreviations for Use on Drawings, Specifications, Standards and in Technical Documents.
MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-155	Joint Photographic Type Designation System
MIL-STD-195	Marking of Connections for Electrical Assemblies
MIL-STD-196	Joint Electronics Type Designation System
MIL-STD-280	Definitions of Item Levels, Item Exchangeability, Models, and Related Terms
MIL-STD-411	Aircrew Station Signals
MIL-STD-783	Legends for Use in Aircrew Stations and on Airborne Equipment
MIL-STD-1189	Bar Code Symbology Standard
MIL-STD-1285	Marking of Electrical and Electronic Parts
IEEE 200-1975	Electrical and Electronic Parts and Equipments, Reference Designations for

3. Definitions. Not applicable.

4. Requirements

4.1 Patent information. At the manufacturer's option, patent information may be included on equipment, subject to the following restrictions:

a. The identification plate may contain patent information when approved by the procuring activity.

b. The location of and method used to mark patent information shall not conflict with any specified equipment requirements, such as marking, enclosure integrity, control and indicator locations, etc.

c. Patent information shall not be located on or in equipment having a security classification of confidential or higher, with the exception that patented items used in security classified equipment, when marked, shall be marked in such a manner that patent information will be visible only when the item is removed or disassembled for repair or replacement.

4.2 Symbology

4.2.1 Reference designations. Except for external connectors and cables, reference designations shall be employed to identify the location of each item for its particular circuit application. The identification and marking of reference designators for parts and equipment shall be in accordance with IEEE 200. On subminiaturized assemblies, such as printed or etched boards or other forms of assembly where space is at a premium, the reference designations need not be marked. In lieu thereof, reference designation marking shall be shown by means of pictorial diagrams, line drawings, photographs, or other media to provide for circuit identification (by means of reference designations) in the appropriate handbooks for the equipment. It shall not be mandatory to mark the reference designations of parts in nonrepairable subassemblies. Connectors may be further identified on that side of the panel to which the mating connector attaches, by a name denoting the function of the cable attached thereto. External cables shall be assigned reference designations W1, W2, etc, in accordance with IEEE 200. The numerical portions of the reference designations shall be consecutive, where practicable.

4.2.2 Abbreviations and legends. Abbreviations and legends shall conform to MIL-STD-12, MIL-STD-411, or MIL-STD-783, as applicable.

4.3 Marking methods. Equipment, parts and assemblies shall be permanently marked or identified. Permanency and legibility shall be as required in MIL-STD-130.

4.3.1 Direct marking. Markings may be applied directly to a part or an assembly by die or rubber stamping, etching, engraving, molding, casting, forging, decalcomania transfer, stenciling, or silk screening.

4.3.2 Plates. Information and identification plates shall conform to and shall be marked in accordance with MIL-P-15024.

4.3.2.1 Identification (ID) plates. The ID plate shall be fastened in such a manner as to remain firmly affixed throughout the normal life expectancy of the item to which it is attached. Type G, adhesive-backed metal, ID plates shall be used on hermetically sealed items, magnesium cases, or other items where mounting of a plate by mechanical fasteners is impractical.

4.3.2.2 ID plate location. Plates shall be located so that they are not obscured by other parts.

4.3.3 Marking cables, cords and wires. The following methods shall be used to mark cables, cords and wires:

a. Molded on the cable or cord.

b. Stamped on the cable, cord or wire.

c. Bands in accordance with MIL-P-15024, securely attached or captivated.

d. Adhesive tag or tape that will withstand the applicable environmental requirements.

4.4 Bar codes. Bar codes shall conform to MIL-STD-1189.

4.5 Type designated items. Each item which is type designated in accordance with MIL-STD-196 or MIL-STD-155 shall contain an identification marking in accordance with MIL-N-18307 for Navy and Air Force or MIL-M-13231 for Army. These items are systems (electrical-electronic), sets, groups, and some units and assemblies, as defined in MIL-STD-280.

4.6 Fuse holders. The current rating of fuses shall be marked adjacent to the fuse holder. In addition, "SPARE" shall be marked adjacent to each spare fuse holder.

4.7 Connections. Marking adjacent to plugs, jacks and other electrical connectors shall identify the connected circuits to preclude cross connections. The connections to electrical parts such as motors, generators and transformer shall be marked in accordance with MIL-STD-195.

4.8 Servo-component connections and markings. Servo-component marking and connection identification shall conform to MIL-S-81963.

4.9 Controls and indicating devices. Markings shall be provided on the front of each exterior and interior panel and panel door, also on control mounting surfaces of each chassis, subpanel, etc, to clearly (though necessarily briefly) designate the functions and operations of all controls, fuses, and indicating devices mounted thereon, protruding through, or available through access holes therein. All markings shall be located on the panel or chassis in correct relationship to the respective designated items.

4.10 Sockets. The chassis shall be marked to identify both sockets and parts, modules or assemblies to be plugged into the sockets. The side of the chassis upon which items are plugged into sockets shall be marked, adjacent

to each socket, with the reference designation for the item. The reverse side of the chassis shall be marked, adjacent to each socket, with the reference designation used in the circuit diagram and table of parts to identify the socket itself. If space does not permit marking of reference designations for sockets and parts, modules, or assemblies mounted in sockets, a location diagram shall be placed where it is visible when viewing the chassis, and shall display the markings described herein.

4.11 Cables, cords and wires. All cables, cords and wires which require disconnection to remove units for servicing and maintenance shall be uniquely identified.

4.12 Printed wiring boards. Markings on printed wiring boards shall not interfere with electrical operation. When ink is used, it shall be non-conductive. Markings shall be considered when leakage (creepage) distances are determined.

4.13 Replaceable parts and assemblies. Replaceable parts and assemblies shall be marked for identification in accordance with MIL-STD-1285 or MIL-STD-130, as applicable.

4.14 Programmable items. Equipments which are software programmable shall indicate the identifying number and revision of the software program which has been loaded into memory. The preferred method is to provide either a local or a remote display which is under the control of the software program. However, when the use of a display is not practical, the equipment enclosure shall be marked with the information as follows:

4.14.1 Preproduction and production equipment shall be marked with the identifying number and revision of the software program. The identifying number shall be preceded by the words "software program".

4.14.2 Development equipment shall be marked in a manner similar to preproduction and production equipment, except that means shall be provided to easily change the revision letter by the use of a matte surface for hand marking or by using selfadhesive labels. The use of the revision letter or number and a patch letter or number is permissible.

4.14.3 The marking requirement does not apply when changes to the software program are accomplished by making a hardware change (for example, when the software program resides in fusible link devices such as PROMs). In such cases, the marking requirements applicable to a hardware change shall apply.

5. Information for guidance only

5.1 Reflective markers. Where reflective markers are required reflective polyester tape in accordance with L-S-300 may be used.

REQUIREMENT 68

READOUTS AND DISPLAYS

1. Purpose. This requirement establishes criteria for the selection of readouts and displays.

*2. Documents applicable to Requirement 68:

MIL-D-28803	Display, Optoelectronic, Readouts, Segmented, General Specification for
MIL-D-87157	Displays, Diode, Light Emitting, Solid State, General Specification for

3. Definitions. Readouts and displays are devices which are designed primarily to convert electrical information into alphanumeric or symbolic presentations. These devices may contain integrated circuitry to function as decoders or drivers.

4. Requirements

*4.1 Optoelectronic type readouts. Incandescent type readouts shall conform to MIL-D-28803.

4.2 Light emitting diode displays. Visible light emitting diode displays shall conform to MIL-D-87157, quality level A or B.

5. Information for guidance only. Not applicable.

REQUIREMENT 69

INTERNAL WIRING PRACTICES

1. Purpose. This requirement establishes criteria for internal wiring practices.

2. Documents applicable to Requirement 69:

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, Electronic, and Associated Equipment)
MIL-I-631	Insulation, Electrical, Synthetic-Resin Composition, Non-Rigid
MIL-T-713	Twine, Fibrous: Impregnated, Lacing and Tying
MIL-I-3158	Insulation Tape, Electrical Glass-Fiber (Resin Filled); and Cord, Fibrous-Glass
MIL-I-3190	Insulation Sleeving, Electrical, Flexible, Coated, General Specification for
MIL-T-7928	Terminals, Lug: Splices, Conductors: Crimp Style, Copper, General Specification for
MIL-I-22076	Insulation Tubing, Electrical, Non-Rigid, Vinyl, Very Low Temperature Grade
MIL-I-23053	Insulation Sleeving, Electrical, Heat Shrinkable, General Specification for
MIL-S-23190	Straps, Clamps, and Mounting Hardware, Plastic and Metal for Cable Harness Tying and Support
MIL-T-43435	Tape, Lacing and Tying
MIL-STD-108	Definition of and Basic Requirements for Enclosure for Electric and Electronic Equipment
MIL-STD-1130	Connections, Electrical, Solderless, Wrapped

3. Definitions. Not applicable.

4. Requirements

4.1 Clearance and leakage (creepage) distances. Clearance 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 specified in the equipment specification. For electrical clearance and leakage distances, see table 69-I.

4.2 Through hole protection. Whenever wires are run through holes in metal partitions, shields, and the like, less than 3 mm in thickness, the holes

shall be equipped with suitable mechanical protection (grommet) of insulation. Panels 3 mm or more in thickness either shall have grommets or shall have the hole edges rounded to a minimum radius of 1.5 mm.

TABLE 69-I. Electrical clearance and leakage (creepage) distances.

Voltage ac (rms) or dc	Condition	Clearance (mm)	Leakage Distances (mm)	
			Enclosure I	Enclosure II
To 150	A	1.5	1.5	1.5
	B	3	3	6
	C	6	9.5	19
150-300	A	1.5	1.5	1.5
	B	3	3	6
	C	6	12.5	19
300-600	A	1.5	3	3
	B	3	6	6
	C	6	12.5	19
600-1000	A	3	9.5	12.5
	B	6	19	25
	C	12.5	38	50

Condition A. For use where the effect of a short circuit is limited to the unit, and where normal operating power does not exceed 50 watts.

Condition B. For use where short circuit protection in the form of fuses, circuit breakers, etc, is provided, and where normal operating power does not exceed 2000 watts.

Condition C. For use where short circuit protection in the form of fuses, circuit breakers, etc, is provided, and where normal operating power exceeds 2000 watts.

Enclosure I. Enclosure I is an equipment enclosure which has no openings, or in which the openings are so constructed that drops of liquid or solid particles striking the enclosure at any angle from 0_ to 15_ from the downward vertical cannot enter the enclosure either directly or by striking and running along a horizontal or inwardly inclined surface. (*Drip-proof enclosure for other than motors, generators, and similar machines* of MIL-STD-108 meets the description).

Enclosure II. Enclosure II is any equipment enclosure which affords less protection than enclosure I.

4.3 Wiring arrangement. Wiring shall be arranged to permit bundling by one or more of the following methods or permanently mounted in cable ducts.

4.3.1 Lacing. Twine shall be in accordance with Type P of MIL-T-713. Tape shall conform to MIL-T-43435. Cordage shall be in accordance with Type SR-4.5 of MIL-I-3158.

4.3.2 Binding. Tape for binding shall be as specified in MIL-T-43435.

4.3.3 Sleeving insulation. Sleeving insulation shall conform to MIL-I-631, MIL-I-3190, MIL-I-22076, or MIL-I-23053.

4.3.4 Wrapping and tying. Plastic devices for wrapping and tying of wires shall conform to MIL-S-23190.

4.4 Solderless wrapped wire connections. Solderless wrapped wire connections shall be in accordance with MIL-STD-1130. Procuring activity approval is required for Navy airborne and Army missile applications.

4.5 Clamped connections. In no case shall electrical connections depend upon wires, lugs, terminals, and the like, clamped between a metallic member and an insulating material of other than a ceramic or vitric nature. Such connections shall be clamped between metal members, preferably, such as an assembly of two nuts, two washers and a machine screw.

4.6 Connectors, insulation sleeving. Unpotted connectors furnished as integral wired in parts of articles of equipment shall have a piece of insulating tubing placed over each wire in the connector. The tubing shall be long enough to cover the contact and at least 12.5 mm of insulation of the wire attached to it; but in no case shall the length of the tubing exceed 50 mm. The minimum length of 12.5 mm may be reduced to 4.5 mm where restricted volume does not permit longer tubing (such as in miniaturized electronic subassemblies). The tubing shall fit tightly over the contact or be tied securely enough so that it will not slide off. If bare wire is used, the tubing shall be long enough to extend at least 6 mm beyond the contact, metal

shell or clamp, whichever projects the farthest. This paragraph does not apply to connectors with body insulated crimp-on contacts, to insulation displacement connectors or mass soldered flat cable connectors, nor does it apply to wire wrapped connectors in accordance with MIL-STD-1130.

5. Information for guidance only

5.1 Wiring arrangement. All wiring should be arranged in a neat and workmanlike manner. The use of preformed cables and wiring harness is preferred to the point-to-point method of wiring. Wires should be bundled and routed to minimize electrical coupling. Unless suitably protected, wire or cable attached to sensitive circuits should not be placed adjacent to a disturbing circuit.

5.2 Internal wiring. Stranded wire is preferred; however, solid wire may be used in the equipment, provided such wire is so insulated or held in place that it does not fail or show excessive motion likely to result in failure when the equipment is subjected to vibration and shock encountered under the specified service conditions. An uninterrupted wire is preferable to a junction. The following descending order of preference exists when junctions are used, and the choice of the listed junctions should be determined by consideration of reliability factors, maintenance factors, and manufacturing procedures:

a. Permanent splices.

b. Bolted connections.

c. Connectors.

5.3 Wiring protection. The wiring should be secured and protected against chafing due to vibration or movement (such as slide out racks or drawers). For securing of wiring, polyamide clamps or wrapping and tying devices with integral mounting facilities or adhesive bonding are preferred. Metal clamps, if used, should be cushioned. Individual conductors thus secured should lie essentially parallel.

5.4 Cable ducts. Where cable ducts are employed, provisions should be made for the removal of any wire that may become faulty. For example, covers may be employed at intervals to aid in the removal of a faulty wire.

5.5 Bend radius. The bend radius of polyethylene cable should not be less than five times the cable diameter to avoid establishing a permanent set in the cable.

5.6 Sleeving. Flexible plastic sleeving, either nonflammable, self extinguishing, or flame retardant, should be used on cables subject to flexing, such as panel door cables. The sleeving should be secured under cable clamps at each end, and the cable should be formed and secured so that the cable will not be subject to abrasion in its normal flexing motion. In cases where abrasion cannot be avoided, additional protection should be provided.

5.7 Panel door cables. Wiring to parts on a hinged door should be in a single cable if possible, arranged to flex without being damaged when the door is opened and closed.

5.8 Slack. Wires and cable should be as short as practicable, except that sufficient slack should be provided to:

a. Prevent undue stress on cable forms, wires and connections, including connections to resiliently supported parts,

b. Enable parts to be removed and replaced during servicing without disconnecting other parts,

c. Facilitate field repair of broken or cut wires,

d. Permit units in drawers and slide out racks to be pulled out to the limit of the slide or support travel without breaking connections. Units which are difficult to connect when mounted, should be capable of movement to a more convenient position for connecting and disconnecting cables. When drawers or racks are fully extended and rotated, if rotatable, the cable bend radius should not be less than three times the cable assembly diameter. When flat molded cable assemblies are used, the bend radius should not be less than ten times the cable assembly thickness,

e. Permit replacement of the connected part at least twice. Exceptions to this provision are cases where rf leads must be as short as possible for electrical reasons, when fixed path rotating is specified, or the amount of slack is limited by space available,

f. Ensure freedom of motion of lugs or terminals normally intended to have some degree of movement.

5.9 Support. Wire and cable should be properly supported and secured to prevent undue stress on the conductors and terminals and undue change in position of the wire or cable during and after subjection of the equipment to specified service conditions, or after service or repair of the equipment in

a normal manner. When shielding on wire or cable is unprotected by an outer insulation, adequate support is necessary to prevent the shielding from coming in contact with exposed terminals or conductors. Twine or tape should not be used for securing wire and cable.

5.10 Cable and harness design. Cables and separable harnesses should be of the two-connector type. The two connectors should be of the same number of contacts and all contacts should be wired point-to-point (i.e., pin 1 to pin 1, pin A to pin A, or pin 1 to pin A and up in sequence). A minimum number of connector types and contact configurations within a type should be used consistent with non-crossmating requirements and circuit and spare considerations.

5.11 Solderless crimp connections. Solderless crimp connections should meet the following requirements:

a. Insulated, solderless lugs are preferred and should conform to MIL-T-7928.

b. Where thermal or other considerations prevent the use of insulated lugs, non-insulated solderless lugs conforming to MIL-T-7928 should be used, provided they are covered with an insulating sleeve.

5.12 Fungus protection. Prior to attachment of terminals to prepared lengths of cables which contain materials that will support fungus, the ends should be protected against entrance of moisture and fungus by treatment with a fungicidal varnish conforming to MIL-V-173 in accordance with MIL-T-152.

REQUIREMENT 70

ELECTRICAL FILTERS

1. Purpose. This requirement establishes criteria for the selection and application of electrical filters.

2. Document applicable to Requirement 70:

MIL-STD-1395 Filters and Networks, Selection and Use of

3. Definitions. Not applicable.

4. Requirements. Electrical filters shall be selected and applied in accordance with MIL-STD-1395.

5. Information for guidance only. Not applicable.

REQUIREMENT 71

CABLE AND WIRE, INTERCONNECTION

1. Purpose. This requirement establishes criteria for the selection and application of electric cable and wire used for interconnection between units.

*2. Documents applicable to Requirement 71:

QQ-W-343	Wire, Electrical, Copper (Uninsulated)
MIL-C-17	Cables, Radio Frequency, Flexible and Semi-rigid, General Specification for
MIL-W-76	Wire and Cable, Hookup, Electrical, Insulated
MIL-C-442	Cable, Two Conductor, Parallel
MIL-C-3432	Cable (Power and Special Purpose) and Wire, Electrical (300 and 600 Volts)
MIL-W-5086	Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy
MIL-W-5845	Wire, Electrical, Iron and Constantan, Thermocouple
MIL-W-5846	Wire, Electrical, Chromel and Alumel, Thermocouple
MIL-W-5908	Wire, Electrical, Copper and Constantan, Thermocouple
MIL-C-7078	Cable, Electric, Aerospace Vehicle, General Specification for
MIL-W-8777	Wire, Electrical, Silicone-Insulated, Copper, 600 Volt, 200°C
MIL-C-13777	Cable, Special Purpose, Electrical: General Specification for
MIL-W-16878	Wire, Electrical, Insulated, General Specification for
MIL-W-19150	Wire, Insulated, Hard Drawn Copper
MIL-C-19547	Cable, Electrical, Special Purpose, Shore Use
MIL-W-22759	Wire, Electric, Fluoropolymer-Insulated, Copper or Copper Alloy
MIL-C-23437	Cable, Electrical, Shielded Pairs
MIL-C-24640	Cable, Electrical, Lightweight, for Shipboard Use, General Specification for
MIL-C-24643	Cable and Cord, Electrical, Low Smoke, for Shipboard Use, General Specification for
MIL-W-25038	Wire, Electrical, High Temperature and Fire Resistant, General Specification for
MIL-C-27072	Cable, Special Purpose, Electrical, Multiconductor
MIL-C-27500	Cable, Electrical, Shielded and Unshielded, Aerospace
MIL-C-55021	Cables, Twisted Pairs and Triples, Internal Hookup, General Specification for
MIL-W-81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy

MIL-W-81381	Wire, Electric, Polyimide-Insulated, Copper or Copper Alloy
MS25471	Wire, Electrical, Silicone Insulated, Copper, 600 Volt, 200°C, Polyester Jacket
MS27110	Wire, Electrical, Silicone Insulated, Copper, 600 Volt, 200°C, FEP Jacket
ASTM A580-90	Wire, Steel, Stainless and Heat Resistant
ASTM B33-74	Tinned Soft or Annealed Copper Wire for Electrical Purposes

3. Definitions

3.1 Interconnecting wire. Insulated, single-conductor wire used to carry electric current between units.

3.2 Interconnecting cable. Two or more insulated conductors contained in a common covering or one or more insulated conductors with a gross metallic shield outer conductor used to carry electrical current between units.

4. Requirements

4.1 Wire selection. Selection of wire for interconnection between units shall be in accordance with table 71-I.

4.2 Multiconductor cable selection. Selection of multiconductor cable for interconnection between units shall be in accordance with table 71-II.

4.3 Application restrictions

4.3.1 MIL-W-76 shall be used for Army application only (see 4.3.3).

4.3.2 MIL-W-16878 shall not be used for Air Force or Navy aerospace applications.

4.3.3 Cable or wire with polyvinyl chloride insulation shall not be used in aerospace applications. Use of these wires or cables in any other application requires prior approval of the procuring activity.

4.3.4 MIL-W-22759 wire with only single polytetrafluoroethylene insulation used in Air Force space and missile applications shall require the approval of the procuring activity.

4.3.5 Use of aluminum wire requires specific approval by the procuring activity.

4.3.6 Silver plated copper wire shall not be used in applications involving Army missile systems.

5. Information for guidance only

5.1 Pulsed or rf signals. All interconnecting cables carrying pulsed or rf signals should be coaxial cables or waveguides and should be terminated, when possible, in the characteristic impedance of the transmitting media.

* TABLE 71-1. Wire, electrical, interconnection

Spec No.	Title	Spec Type or Class	CONSTRUCTION 1/ Conductor Material	Coating	Type	2/ Insulation Primary	Primary Cover	Jacket/ Topcoat	Max Cond Temp °C	Max rms Volts	Remarks
MIL-W-76	Wire and Cable, Hookup, Electrical Insulated	LW MH HW HF	Cu/A or CCW	Sn	S, Str	1 2A	8,10, 13A 3/	8,10, 13A 3/	80	300 1000 2500 1000	See Notes 4 and 5. For Army use only
MIL-W-5086	Wire, Electric, PVC Insulated, Copper or Copper Alloy	M5086/1 M5086/2 M5086/3 M5086/4 M5086/5 M5086/6 M5086/7	Cu/A HSA Cu/A	Sn Ag Sn	Str	1	13A	8 8, 11 8 9A 8	105 110 105	600 3000 600	Medium weight See Note 4
MIL-W-8777	Wire, Electrical, Silicone Insulated, Copper, 600 V 200°C	MS25471 MS27110	Cu/A	Ag	Str	6	13A	12 4A	200	600	
MIL-W-16878	Wire, electrical, Insulated, High Temperature	M16878/1 M16878/2 M16878/3 M16878/4 M16878/5 M16878/6 M16878/7 M16878/8 M16878/10 M16878/11 M16878/12 M16878/13 M16878/14 M16878/15	Cu/A, HSA, CCW Cu/A Cu/A, CCW Cu/A	Ag,Sn Ag Sn Ag Ag,Sn Sn	S,Str	1 3A 6 2A 4A 2C	8,10,11 4A,8, 10,11 8,10,11	1,8,10,11 3A,3B,4A 13B 3/ 4A,8,10, 11 4A	105 200 75 200 125	600 1000 3000 600 1000 250 600 1000 600 1000 250 600 1000	See Note 4

TABLE 71-1. Wire, electrical, interconnection. - Continued

Spec No.	Title	Spec Type or Class	CONSTRUCTION 1/ Conductor Material	Coating	Type	2/ Insulation Primary	Primary Cover	Jacket/ Topcoat	Max Cond Temp °C	Max rms Volts	Remarks
MIL-W-16878 Cont.	Wire, electrical, Insulated, High Temperature	M16878/16								600	
		M16878/17								3000	
		M16878/18		Ag,Sn		1		8	105	1000	
		M16878/19	Cu/A,							3000	
		M16878/20	HSA,					3A,3B,4a,		250	
		M16878/21	CCW	Ag		3B		13B 3/	200	600	
		M16878/22	Cu/A,							1000	See Note 4
		M16878/23	HSA,			3A				250	
		M16878/24	CCW			3B		3A,3B,4A			
		M16878/25		Ni		3A		13B 3/	260	600	
		M16878/26				3B					
		M16878/27				3A				1000	
		M16878/28				3B					
		M16878/29								600	
		M16878/30	Cu/A	Sn	Str	6			150		
		M16878/31								1000	
		M16878/32		Ag					200		
		M16878/33	Cu/A	Sn	S,Str	2A			75	600	
			CCW								
		M16878/34	Cu/A	Ag	Str	3B			200	1000	
		M16878/35		Ni					260		
MIL-W-19150	Wire, Insulated, Hard-Drawn Copper		Cu/H			2A		8			
MIL-W-22759	Wire, Electric, Fluoropolymer-insulated, Copper or Coper Alloy	M22759/1		Ag		3A,3B,		13B	200		
		M22759/2		Ni		3D			260		
		M22759/3				3B,3D	13B	3B			
		M22759/4		Ag				4A	200	600	
		M22759/5				3C					
		M22759/6		Ni					260		

TABLE 71-1. Wire, electrical, interconnection. - Continued

Spec No.	Title	Spec Type or Class	CONSTRUCTION 1/ Conductor Material	Coating	Type	2/ Insulation Primary	Primary Cover	Jacket/ Topcoat	Max Cond Temp °C	Max rms Volts	Remarks
MIL-W-22759 Cont.	Wire, Electric, Fluoropolymer-insulated, Copper or Copper Alloy	M22759/7	CuA	Ag					200		Medium weight
		M22759/8		Ni					260		Medium weight
		M22759/9		Ag					200	1000	
		M22759/10		Ni		3A			260		
		M22759/11		Ag					200		
		M22759/12		Ni					260		
		M22759/13		Sn							Medium weight
		M22759/14				4A		9A	135		Light weight
		M22759/15	HSA	Ag						600	Light weight
		M22759/16	Cu/A	Sn							Medium weight
		M22759/17	HSA	Ag	Str	18			150		Medium weight
		M22759/18	Cu/A	Sn							Light weight
		M22759/19		Ag					150		Light weight
		M22759/20							200	1000	
		M22759/21	HSA	Ni				3A	260		
		M22759/22		Ag					200		
		M22759/23		Ni					260		
		M22759/28	Cu/A	Ag	Str				200		
		M22759/29		Ni		3A		7B	260		
		M22759/30	HSA	Ag					200		
		M22759/31		Ni							
		M22759/32	Cu/A	Sn					150	600	
		M22759/33	HSA	Ag					200		
		M22759/34	Cu/A	Sn					150		
		M22759/35	HSA	Ag		20		20			
		M22759/41	Cu/A	Ni							
		M22759/42	HSA						200		
		M22759/43	Cu/A	Ag							

TABLE 71-1. Wire, electrical, interconnection. - Continued

Spec No.	Title	Spec Type or Class	CONSTRUCTION 1/ Conductor Material	Conductor Coating	Insulation Type	2/ Insulation Primary	Primary Cover	Jacket/ Topcoat	Max Cond Temp °C	Max rms Volts	Remarks
MIL-W-25038	Wire, Electrical, High Temperature and Fire Resistant	M25038/1	Cu/A	Ni clad	Str	15	3B	13B	288	600	Critical circuits where electrical integrity must be maintained during fire (1093°C flame/ 5 min)
MIL-W-81044	Wire,Electric,Cross-linked Polyalkene, Cross-linked Alkane-imide Polymer, etc Insulated, Copper or Copper Alloy	M81044/6	Cu/A	Sn	Str	2B		9B	150	600	Sheets /12 & /13 light weight - See Note 4
		M81044/7	HSA	Ag							
		M81044/9	Cu/A	Sn							Sheets /9 & /10 medium weight. See application temp limitation stipulated on detail specification sheet
		M81044/10	HSA	Ag							
		M81044/12	Cu/A	Sn							
		M81044/12	HSA	Ag							
MIL-W-81381	Wire, Electric, Polyimide Insulated, Copper or Copper Alloy	M81381/7	Cu/A	Ag	Str	7A		17	200	600	Sheets /7 through /10 light weight
		M81381/8		Ni							
		M81381/9	HSA	Ag							Sheets /11 through /14 medium weight
		M81381/10		Ni							
		M81381/11	Cu/A	Ag				15 or 17			Sheets /17 through /20 light weight, single wrap primary
		M81381/12		Ni							
		M81381/13	HSA	Ag							
		M81381/14		Ni							Interconnect wiring where weight, space, and high temperature capability are critical
		M81381/17	Cu/A	Ag							
		M81381/18		Ni				17			
		M81381/19	HSA	Ag							
		M81381/20		Ni							Sheets /7 through /10 & 17/ through /20 - See Note 4
		M81381/21	Cu/A	Sn					105		
		M81381/22						15 or 17			3B jackets in sheets /11, /12 & /22 are in sized 8 and larger

NOTES:

1/

Conductor Code		Description
Material	Cu/A	Copper, annealed
	Cu/H	Copper, hard-drawn
	CCW	Copper covered steel
	HSA	High strength copper alloy
	Al	Aluminum
Coating	Sn	Tin
	Ag	Silver
	Ni	Nickel
Type	S	Solid
	Str	Stranded

3/ When specified on purchase order.

4/ Wire intended for use in electronic equipment hook-up applications. It may also be used as an interconnecting wire when an additional jacket or other mechanical protection is provided.

5/ Various combinations of primary, primary cover, and jacket insulations and unshielded, shielded, etc, constructions are available to meet application requirements. See detail wire specification.

2/

Insulation Code	Description
1	Polyvinyl chloride/extruded
2A	Polyethylene/extruded
2B	Polyalkene/cross-linked extruded
2C	Polyethylene/cross-linked/modified/extruded
3A	Polytetrafluoroethylene/extruded (TFE Teflon)
3B	Polytetrafluoroethylene/tape
3C	Polytetrafluoroethylene/mineral filled/extruded
3D	Polytetrafluoroethylene impregnated glass type
4A	Fluorinated-ethylene propylene/extruded (FEP Teflon)
4B	Fluorinated-ethylene propylene/dispersion
5	Monochlorotrifluoroethylene/extruded (Kel-F)
6	Silicone rubber/extruded
7A	FEP/polyimide film (Kapton)
7B	Polymide lacquer (Pure ML)
8	Polymide/extruder (Nylon)
9A	Polyvinylidene fluoride/extruded (Kynar)
9B	Polyvinylidene fluoride/extruded/cross-linked
10	Braid/synthetic yarn/lacquer impregnated
11	Braid/nylon/impregnated
12	Braid/polyester/impregnated
13A	Braid/glass fiber/impregnated
13B	Braid/TFE coated glass fiber/TFE finish
14	Braid/asbestos/TFE impregnated
15	Braid, weave or wrap/inorganic fiber
16	Alkane-imide polymer/extruded/cross-linked
17	Modified aromatic polyimide
18	Ethylene-tetrafluoroethylene/extruded (Tefzel)
19	Polyarylene/extruded
20	Cross-linked, extruded, modified ethylene-tetrafluoroethylene

*TABLE 71-II. Cable, multiconductor, interconnection.

Spec No.	Title	Basic Wire Specs	Conductor			Shield Braid 3/			Jacket 3/		Remarks
			No. of Cond	Volts RMS	Temp 2/	Strand Material	Strand Coating	% Coverage	Material 1/	Type	
MIL-C-442	Cable, (Wire), Two Conductor, Parallel	QQ-W-343 & Insulation	2	300	Flexibility at -40°C or -55°C				Vinyl-polymer or synthetic (styrene butadiene) rubber or natural rubber		Lead wire for firing explosive charges
MIL-C-3432	Cable (Power and Special (Purpose)and Wire, Electrical (300 & 600V)	QQ-W-343 & Insulation	Unlimited and mixed sizes 4/ 5/	300 & 600	-40°C to +65°C or -55°C to +75°C	None or Copper	Tin	85	Styrene butadiene Rubber, chloroprene rubber, ethylene-propylene rubber, ethylene-propylene-dienne rubber, polyurethane thermoplastic elestomer, or natural rubber	Extruded & Vulcanized	
MIL-C-7078	Cable, Electric, Aerospace Vehicle	M5086/1	2-7	600	105°C	Copper	Tin		None		
		M5086/2	1-7			Copper	Tin		Polyamide (Nylon)	Extruded or ImpregBaird	
		M5086/3	1-7								
		M22759/12	1-7		260°C	Copper	Nickel	85	(a)	Extruded	(a) Fluorinated ethylene propylene
		M22759-23	1-7		260°C	Copper	Nickel	85	(b)	Extruded or tape	
		M81044/9	1-7		110°C	Copper	Tin	85	Polyvinylidene fluoride	Extruded	(b) Polytetrafluoroethylene
		M81381/8	2-7		200°C						
		/10 and /14	1-7		200°C	Copper	Nickel	85	FEP/polyimide	Film Tape	
		M81381/11	2-7		200°C						

TABLE 71-II. Cable, multiconductor, interconnection. - Continued

Spec No.	Title	Basic Wire Specs	Conductor			Shield Braid 3/			Jacket 3/		Remarks
			No. of Cond	Volts RMS	Temp 2/	Strand Material	Strand Coating	% Coverage	Material 1/	Type	
MIL-C-442 cont.	Cable, (Wire), Two Conductor, Parallel	MS1381/12 MS1381/13	1-7 1-7		150°C 200°C	Copper Copper	Tin Nickel	85 85	FKP/polyimide	Film Tape	
MIL-C-13777	Cable, Special Purpose Electrical	MIL-C-17 QQ-W-343 ASTM A580 &Insulation	2-78 6/	600	-53°C to	Copper	Tin	80	Sheath Poly-Chloroprene Primary Insulation Polyethylene	Extruded & vulcanized Extruded	See Note 7
MIL-C-19547	Cable, Electrical, Special purpose Shore use	ASTM B33-74 &Insulation	Multiple twisted pairs, 6-100 pairs	600	75°C	Corrugated Aluminum		100	Polyethylene	Extruded	For use as tele-phone & telegraph signal cables in shore communications
MIL-C-23437	Cable, Electrical, Shielded Pairs	MIL-W-16878/1	Shielded & Jacketed twisted pairs 1 pair - 104 pairs	600	105°	Copper Note: Shield applied over each pair	Tin	90	PVC	Extruded	For use within shore communications stations, not to be used on board ship
MIL-C-24640	Cable, Electrical, Light weight for shipboard use	MIL-W-81044	2-77 pair	600	150°C	Copper Tape	Tinned	85	Crosslinked Polyalkene, Crosslinked Alkaneimide polymer, or Polyarylene	Extruded	

TABLE 71-II. Cable, multiconductor, interconnection. - Continued

Spec No.	Title	Basic Wire Specs	Conductor			Shield Braid 3/			Jacket 3/		Remarks
			No. of Cond	Volts RMS	Temp 2/	Strand Material	Strand Coating	% Coverage	Material 1/	Type	
MIL-C-27072	Cable Special Purpose, Electrical, Multi-conductor	MIL-C-17	2-36	Various	Not Spec	Copper	Tin, Silver	85	Sheath of PVC, polyethylene, polychloroprene, polyamide, TFE-Teflon, or FEP-Teflon		Flexible multi-conductor cable for use in protected, wire ways, instrument racks, and conduit, Polyethylene jacketed cable suitalbe for underwater or direct burial applications only. M16878/6 and /13 not for aerospace applications.
		MIL-W-5845		Various	Not spec						
		MIL-W-5846		Various	Not spec						
		MIL-W-5908		Various	Not spec						
		M16878/1		600	105°C						
		M16878/2		1000	105°C						
		M16878/3		3000	105°C						
		M16878/4		600	200°C						
		M16878/5		1000	200°C						
		M16878/6		250	200°C						
		M16878/10		600	75°C						
		M16878/13		250	200°C						
						Note: MIL-C-27072 applicable detail specification sheets control materials for each specific cable configuration.					
MIL-C-27500	Cable, Electrical, Shielded and Unshielded, Aerospace	MIL-W-8777	1-7	600	200°C	Various	Various	85	Various	Braided	For general aerospace flight vehicle applications
		MIL-W-22759	1-7	Various	Various	Various	Various	85	Various	Extruded or Braided	
		MIL-W-25038	1-7	600	260°C	Various	Various	85	TFE coated glass fiber	Braided	
		MIL-W-81044	1-7	600	150°C	Various	Various	85	Various	Extruded	
		MIL-W-81381	1-7	600	Various	Various	Various	85	Various	Tape	

TABLE 71-II. Cable, multiconductor, interconnection. - Continued

Spec No.	Title	Basic Wire Specs	Conductor			Shield Braid 3/			Jacket 3/		Remarks
			No. of Cond	Volts RMS	Temp 2/	Strand Material	Strand Coating	% Cover-age	Material 1/	Type	
MIL-C-55021	Cable, Twisted Pairs & Triples, Internal Hookup, General Specification for	MIL-W-16878	2-3	600 to 1000	-40°C to +105°C or -65°C to +200°C	None or Copper	Tin, Silver or Nickel	90	None PVC, Nylon TFE-Teflon	Extruded Extruded or Tape	

NOTES: 1/ Polyester - Polyethylene Terephthalate
TFE-Teflon - Polytetrafluoroethylene
PVC - Polyvinyl chloride (Not to be used in airborne applications)
KEL-F - Polymonochlorotribluoroethylene
FEP-Teflon - Fluorinated ethylene propylene
PVF - Polyvinylidene fluoride

2/ See applicable detail specification sheet for temperature limitations.

3/ See applicable detail specification sheet for materials control of specific cable configurations

4/ Although the specification does not limit the number of conductors in a cable, the size, weight, and flexibility are determining factors.

5/ Available in three classifications:

Class L - Light Duty - to withstand severe flexing and frequent manipulation

Class M - Medium Duty - to withstand severe flexing and mechanical abuse

Class H - Heavy Duty - to withstand severe flexing and mechanical abuse and ability to withstand severe service impacts such as to be run over by tanks or trucks

6/ See applicable detail specification sheet for mechanical test requirements for cold bend, cold bend torque, impact bend, and twist.

7/ For use under abusive mechanical conditions and where resistance to weather, oil and ozone are requirements.

REQUIREMENT 72

SUBSTITUTABILITY

1. Purpose. This requirement establishes criteria for the selection and application of substitute parts.

2. Documents applicable to Requirement 72:

MIL-STD-480	Configuration Control - Engineering Changes, Deviations and Waivers
MIL-STD-983	Substitution List for Microcircuits

3. Definitions. Not applicable.

4. Requirements

4.1 Military parts. Substitution of parts covered by military specifications and standards that include substitutability or supersession information is acceptable. This type substitution does not require submission of engineering change proposals, deviations, or waivers in accordance with MIL-STD-480.

4.2 Commercial parts. When the equipment design specifies a commercial part, a military specification part may be substituted when the form, fit and functional characteristics of the military part are equal to or better than those of the specified commercial part under equivalent environmental conditions. Applicable microcircuits are listed in MIL-STD-983. Other substitutions are subject to applicable configuration control procedures of MIL-STD-480.

4.3 Unavailable parts. When the equipment design specifies a part that is unavailable, a substitute part which meets the form, fit and functional characteristics of the specified part may be substituted after approval is obtained from the applicable procuring activity. Applicable microcircuits are listed in MIL-STD-983. Other substitutions are subject to the applicable configuration control procedures of MIL-STD-480.

4.4 Initial qualification/reliability demonstration. Substitute parts with quality/reliability characteristics superior to those specified in the parts list shall not be used in equipment to be subjected to initial qualification or demonstration tests.

5. Information for guidance only. Not applicable.

REQUIREMENT 73

STANDARD ELECTRONIC MODULES

1. Purpose. This requirement establishes criteria for the selection and application of standard electronic modules (SEM).

*2. Documents applicable to Requirement 73:

MIL-M-28787	Modules, Standard Electronic, General Specification for
MIL-STD-1378	Requirements for Employing Standard Electronic Modules
MIL-STD-1389	Design Requirements for Standard Electronic Modules
MIL-HDBK-246	Program Managers Guide for the Standard Electronic Modules Program

3. Definitions. Not applicable.

4. Requirements. Requirements for the design and application of standard electronic modules shall be in accordance with MIL-STD-1389 and MIL-STD-1378. Standard electronic modules shall be in accordance with MIL-M-28787.

*5. Information for guidance only. Guidance for program and acquisition managers as to the applicability of SEMs for specific system/equipment acquisitions is provided in MIL-HDBK-246.

REQUIREMENT 74

GROUNDING, BONDING, AND SHIELDING

1. Purpose. This requirement establishes grounding, bonding, and shielding interface criteria for installation of electronic equipment.

2. Documents applicable to Requirement 74:

MIL-B-5087	Bonding, Electrical, and Lightning Protection, for Aerospace Systems
MIL-STD-188-124	Grounding, Bonding, and Shielding for Common Long Haul/Tactical Communication Systems Including Ground Based Communications-Electronics Facilities and Equipments
MIL-STD-1310	Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety Shielding
MIL-STD-1542	Electromagnetic Compatibility (EMC) and Grounding Requirements for Space System Facilities
MIL-STD-1857	Grounding, Bonding, and Shielding Design Practices
MIL-HDBK-419	Ground, Bonding, and Shielding for Electronic Equipments and Facilities

3. Definitions. Not applicable.

4. Requirements. Grounding, bonding, and shielding provisions shall be incorporated into equipment design, as necessary, to enable installation of equipment into the applicable platform or facility. The grounding, bonding, and shielding installation and interface requirements are specified in the following documents:

Aerospace ground support facilities	MIL-B-5087
Aircraft and space vehicles	MIL-B-5087
Ground telecommunications C-E equipment	MIL-STD-188-124
Shipboard equipment	MIL-STD-1310
Ground space systems facilities	MIL-STD-1542
Other Army ground equipment	MIL-STD-1857

5. Information for guidance only. Extensive guidance for grounding, bonding, and shielding may be found in MIL-HDBK-419.

REQUIREMENT 75

ELECTROSTATIC DISCHARGE CONTROL

1. Purpose. This requirement offers guidance regarding the handling and control of electronic parts and assemblies that are susceptible to damage or degradation from electrostatic discharge. IT DOES NOT ESTABLISH REQUIREMENTS AND MUST NOT BE REFERENCED IN CONTRACTUAL DOCUMENTS. Requirements for the establishment and implementation of an electrostatic discharge (ESD) control program in accordance with MIL-STD-1686 must be directly specified in the contract or equipment specification.

2. Documents applicable to Requirement 75:

MIL-M-38510	Microcircuits, General Specification for
MIL-STD-883	Test Methods and Procedures for Microelectronics
MIL-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (excluding electrically initiated explosive devices)
DOD-HDBK-263	Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (excluding electrically initiated explosive devices)

3. Definitions. Definitions of applicable terminology may be found in MIL-M-38510, MIL-STD-883, MIL-STD-1686, and DOD-HDBK-263.

4. Requirements. Not applicable.

5. Information for guidance only

5.1 ESD control program. MIL-STD-1686 establishes the requirements for the establishment, implementation, and monitoring of an ESD control program, including identification of electrostatic discharge sensitive (ESDS) items, classification of ESD sensitivity levels, control program elements, extent of program element applicability to each acquisition, protective measures to be employed in equipment design, handling, storage, and packaging of ESDS items, protected work areas, personnel training, ESD audits and program reviews, and tailoring. Appendix A of MIL-STD-1686 establishes the criteria and procedure for classifying ESDS parts by test. Appendix B of MIL-STD-1686 identifies and classifies ESDS items. DOD-HDBK-263 provides guidelines for the establishment and implementation of an ESD control program in accordance with MIL-STD-1686.

5.2 General guidelines for an ESD control program. Any program designed for the prevention of ESD damage to ESDS parts and assemblies should be based on the following considerations:

a. Identification of ESDS parts and assemblies and determination of sensitivity

b. Minimization of static charge generation

c. Reduction of stored charges (grounding)

d. Isolation of ESDS parts (Faraday shielding and line transient protection)

e. Proper handling, storage, and transportation of ESDS parts and assemblies

f. Personnel training and certification

g. Protected work areas.

REQUIREMENT 76

FIBER OPTICS

1. Purpose. This requirement establishes the criteria for the selection, application and testing of fiber optic material, devices and accessories.

2. Documents applicable to Requirement 76:

MIL-STD-188-111	Subsystem Design and Engineering Standards for Common Long Haul and Tactical Fiber Optics Communications
MIL-STD-790	Product Assurance Program Requirements for Electronic and Fiber Optic Parts Specifications
DOD-STD-1678	Fiber Optic Test Methods and Instrumentation
DOD-STD-1863	Interface Designs and Dimensions for Fiber Optic Interconnection Devices
DOD-STD-1864	Fiber Optic Symbols
MIL-STD-2163	Insert Arrangements for MIL-C-28876 (Navy) Environment Resisting Fiber Optic Connectors
MIL-C-22520/10	Crimping Tool, Terminal, Hand
DOD-D-24620	Detector, PIN, Fiber Optic (Metric)
MIL-C-24621	Coupler, Passive, Fiber Optic, General Specification for (Metric)
DOD-S-24622	Sourses, LED, Fiber Optic (Metric)
MIL-S-24623	Splice, Fiber Optic Cable, General Specification for (Metric)
MIL-H-24626 Optic	Harness Assemblies, Cable, Pressure Proof, Fiber
MIL-P-24627	Penetrators, Bulkhead, Connectorized, Fiber Optic (for Inboard Use on Navy Ships and Submarines)
MIL-P-24628	Penetrators, Hull, Connectorized, Connectors, Pressure Proof, Fiber Optic, Submarine

MIL-S-24725	Switches, Fiber Optic, Shipboard, Electrical Nonlatching, Bypass, Multimode Cable, Standalone (Metric)
MIL-A-24726	Attenuators, Fiber Optic, Shipboard, General Specification for
MIL-R-24727	Rotary Joints, Fiber Optic, Shipboard (Metric), General Specification for
MIL-I-24728	Interconnection Box, Fiber Optic, Metric, General Specification for
MIL-M-24731	Multiplexers, Demultiplexers, Multiplexers, Demultiplexers (Muldems), Frequency Division, Fiber Optic, Interfaceable, Shipboard (Metric), General Specification for
MIL-L-24732	Light Sources, Rigid and Flexible, Fiberscope, Fiber Optic (Metric), General Specification for
MIL-C-24733	Controllers, Interface Unit, Fiber Optic (Metric), General Specification for
MIL-F-24734	Fiberscope, Fiber Optic (Metric), General Specification for
MIL-T-24735	Transmitters, Light Signal, Analog, Fiber Optic (Metric), General Specification for
MIL-M-24736	Multiplexers, Demultiplexers, Multiplexers, Demultiplexers (Muldems), Time Division, Fiber Optic, Interfaceable, Shipboard (Metric), General Specification for
MIL-R-24737	Receivers, Light Signal, Analog, Fiber Optic, Shipboard (Metric), General Specification for
MIL-C-28876	Connectors, Fiber Optic, Environment Resisting (for Navy Shipboard Applications)
MIL-T-29504	Termini, Fiber Optic Connector, Removable
MIL-F-49291	Fiber, Optical, General Specification for

MIL-C-49292	Cable Assembly, Nonpressurized, General Specification for
MIL-I-81969	Installing and Removal Tools, Electrical Contact, General Specification for
MIL-C-83522	Connectors, Fiber Optic, Single Terminus, General Specification for
MIL-T-83523	Tools, Fiber Optic, General Specification for
MIL-M-83524	Microscope, Optical, for Field Inspection of Optical Fibers
MIL-K-83525	Kit, Portable Optical Microscope, Militarized, 200X Magnification for Field Inspection of Optical Fibers
MIL-C-83526	Connector, Fiber Optic, Circular, Environment Resisting, Hermaphroditic, General Specification for
MIL-C-83532	Connectors, Fiber Optic
MIL-M-83533	Maintenance Kit, Fiber Optic Components, General Specifiction for
DOD-C-85045	Cable, Fiber Optic, Environment Resisting (for Navy Shipboard Application), General Specification for
MIL-HDBK-277	Fiber Optic Checkout Procedure for Military Applications
MIL-HDBK-278	System Design Guide for Applying Fiber Optic Technology to Shipboard Systems
MIL-HDBK-282	Fiber Optic Cable Installation Procedures
MIL-HDBK-415 Systems	Design Handbook for Fiber Optic Communications
IEC-693-80	Optical Fibers, Dimensions of
IEEE-STD-812-84	IEEE Standard Definitions of Terms Relating to Fiber Optics

3. Definitions.

3.1 Definitions of terminology used in fiber optics technology shall be as contained in IEEE-STD-812.

4. Requirements

4.1 Symbology. Graphic symbols for fiber optic parts for use on engineering drawings, specifications, etc, shall be as contained in DOD-STD-1864.

4.2 Dimensions. Dimensions for optical fibers shall be as specified in IEC-693-80 and MIL-F-49291.

4.3 Interface designs and dimensions. Standard interface designs, dimensions and termination types for use in fiber optic connectors and couplers shall be as specified in DOD-STD-1863.

4.4 System and subsystem design. Fiber optic system and subsystem designs shall be in accordance with the criteria specified in MIL-STD-188-111 (see 5.1 also).

4.5 Test procedures. Standardized test procedures for fiber optic components shall be as specified in DOD-STD-1678.

4.6 Light sources.

4.6.1 Light emitting diodes (LEDs). Fiber optic LED sources shall conform to the requirements of DOD-S-24622.

4.6.2 Fiberscope light sources. Fiber optic light sources for rigid and flexible fiberscopes shall conform to the requirements of MIL-L-24732.

4.7 Splices. Fiber optic splices shall conform to the requirements of MIL-S-24623.

4.8 Cables. Fiber optic cables shall conform to the requirements of DOD-C-85045.

4.9 Cable assemblies. Cable assemblies shall conform to the requirements of MIL-C-49292.

4.10 Harness assemblies. Fiber optic harness assemblies shall conform to the requirements of MIL-H-24626.

4.11 Connectors. Fiber optic connectors shall conform to the requirements of MIL-C-28876, MIL-C-83522, MIL-C-83526 or MIL-C-83532. Insert arrangements for MIL-C-28876 connectors shall conform to MIL-STD-2163. Removable terminals for fiber optic connectors shall conform to MIL-T-29504.

4.12 Penetrators. Fiber optic penetrators (hull or bulkhead) shall conform to the requirements of MIL-P-24627 or MIL-P-24628.

4.13 Detectors. Fiber optic detectors shall conform to the requirements of DOD-D-24620.

4.14 Couplers. Fiber optic couplers shall conform to the requirements of MIL-C-24621.

4.15 Rotary joints. Fiber optic rotary joints shall conform to the requirements of MIL-R-24727.

4.16 Interconnection boxes. Fiber optic interconnection boxes shall conform to the requirements of MIL-I-24728.

4.17 Multiplexers and demultiplexers.

4.17.1 Frequency division. Fiber optic frequency division multiplexers and demultiplexers shall conform to the requirements of MIL-M-24731.

4.17.2 Time division. Fiber optic time division multiplexers and demultiplexers shall conform to the requirements of MIL-M-24736.

4.18 Controllers, interface unit. Fiber optic controllers shall conform to the requirements of MIL-C-24733.

4.19 Fiberscopes. Fiber optic fiberscopes shall conform to the requirements of MIL-F-24734.

4.20 Transmitters, analog. Fiber optic analog transmitters shall conform to the requirements of MIL-T-24735.

4.21 Receivers, analog. Fiber optic analog receivers shall conform to the requirements of MIL-R-24737.

4.22 Attenuators. Fiber optic attenuators shall conform to the requirements of MIL-A-24726.

4.23 Switches. Fiber optic switches shall conform to the requirements of MIL-S-24725.

4.24 Tools and inspection equipment. Fiber optic tools, inspection equipment, and related kits shall conform to the requirements of MIL-I-81969, MIL-T-83523, MIL-M-83524, MIL-K-83525, MIL-M-83533 and MIL-C-22520/10.

5. Information for guidance only.

5.1 Design guides. Fiber optic system design guide information is available in MIL-HDBK-415 and MIL-HDBK-278.

5.2 Installation and checkout procedures. Guidance for installation and checkout procedures is contained in MIL-HDBK-277 and MIL-HDBK-282.

5.3 Product assurance program. When a requirement exists for the implementation of a fiber optic product assurance program, refer to MIL-STD-790.

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	MIL-STD-454N	92/06/30

3. DOCUMENT TITLE
Standard General Requirements for Electronic Equipment

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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a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
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