NOTICE OF CHANGE

METRIC

MIL-STD-454N
NOTICE 2
15 February 1994

MILITARY STANDARD

STANDARD GENERAL REQUIREMENTS FOR ELECTRONIC EQUIPMENT

TO ALL HOLDERS OF MIL-STD-454N:

1. THE FOLLOWING PAGES OF MIL-STD-454N HAVE BEEN REVISED OR ADDED AND SUPERSEDE THE PAGES LISTED:

NEW PAGES	DATE	SUPERSEDED PAGES	DATE
1-1	15 February 1994	1-1	3 May 1991
1-2	15 February 1994	1-2	3 May 1991
1-3	15 February 1994	1-3	30 June 1989
1-4	15 February 1994	1-4	30 June 1989
1-5	15 February 1994	1-5	30 June 1989
1-6	15 February 1994	1-6	30 October 1991
1-7	15 February 1994	1-7	30 June 1989
1-8	15 February 1994	1-8	30 June 1989
1-9	15 February 1994	1-9	30 June 1989
1-10	15 February 1994	1-10	30 June 1989
1-11/1-12	15 February 1994	1-11	30 June 1989
8-1	15 February 1994	8-1	30 April 1991
8-2	15 February 1994	8-2	30 April 1991
8-3/8-4	15 February 1994	NEW	---
37-1	15 February 1994	37-1	20 September 1988
37-2	15 February 1994	NEW	---
39-1	15 February 1994	39-1	20 September 1988
39-2	15 February 1994	NEW	---
62-1/62-2	15 February 1994	62-1	12 February 1988
74-1/74-2	15 February 1994	74-1	15 December 1989

2. MAKE THE FOLLOWING PEN AND INK CHANGES:

a. Page iii, Forward: In line 4, delete "eleven" and substitute "multiple".

b. Page iii, delete "MIL-E-5400" and substitute "MIL-STD-5400".

c. Requirement 11, page 11-1, paragraph 2: Delete "MIL-P-18177" and substitute "MIL-I-24768/2, /3, Insulation, Plastics, Laminated, Thermosetting, Glass-Cloth, Epoxy-Resin (Geb)".

Page 11-2, paragraph 2: Delete suffix letters from AMS documents. Delete "-81" from ASTM D3295-81.

Page 11-2, paragraph 4.5: Delete "MIL-P-18177" and substitute "MIL-I-24768/2, MIL-I-24768/3".

d. Requirement 26, page 26-2, table 26-I: Delete "MIL-P-79" and "MIL-P-997" with materials and associated data and substitute "MIL-I-24768 Insulation, Plastics, Laminated, Thermosetting, Types; GMG and GSG".

e. Requirement 46, notice 1, paragraph 2.j.: Delete instructions to delete MIL-M-13787, MIL-M-17054, MIL-M-19167, and MIL-M-19283. (Documents not referenced in requirement 46.)

f. Requirement 47, page 47-1, paragraph 4: In last sentence, insert a period following "activity" and delete remainder of the sentence.

g. Requirement 50, page 50-2, table 50-1: Interchange headers: MIL-L-6363 and MIL-L-7806. Delete "W-L-00111" and "W-L-00116".

h. Requirement 52, page 52-1, paragraphs 2 and 4.1: Delete "F-F-300" and add "ASTM F87".

i. Requirement 55, page 55-1, paragraph 2: Delete "EIA-310-C"; substitute "EIA 277".

j. Requirement 56, page 56-1, paragraph 4.8: Delete last sentence.

k. Requirement 67, page 67-1, paragraph 2: Delete "IEEE 200-175" and substitute "IEEE-200".

i. Requirement 76, page 76-3, paragraph 2: Delete "DOD-C-85045" and substitute "MIL-C-85045".

Page 76-3, delete "IEC-693-80" and substitute "IEC 693".

Page 76-3, paragraph 4.2: Delete "IEC-693-80" and substitute "IEC 693".

3. INDEX OF APPLICATION DOCUMENTS II-1. MAKE THE FOLLOWING PEN AND INK CHANGES:

Page I1-1 through I1-8, Index 1: Insert the following documents in number sequence:

Military standards	Requirement
MIL-STD-499	77
MIL-STD-973	72
MIL-STD-2036	FWD
MIL-STD-1326	77
MIL-STD-1388	1, 77
MIL-STD-1814	77
MIL-STD-2196 (SH)	76
Non Government documents	
ASTM - F1166	77
Other Government documents	
AFGS - 87256	77

Page I1-1 through I1-8, Index 1: Delete the following documents:

Military standards	Requirement
W-L-00111	50
W-L-00116	50
MIL-P-13949	17
MIL-C-28809	17
MIL-C-28870	17
MIL-P-50884	17
MIL-STD-275	17
MIL-STD-2118	17
MIL-STD-2119	17
Non Government documents	
ANSI/IPC-DW-425/11	17
ASTM A122-86	41
ASTM A139 IA139M-90	41
ASTM A151/A151M-89	41
ASTM A206-86a/A206M-87	4
ASTM A580-90	67

Page I2-2, Index 2, subject listings: Add "Integrated Diagnostics, Requirement 77".

4. RETAIN THIS NOTICE AND INSERT BEFORE TABLE OF CONTENTS.

5. Holders of MIL-STD-454N will verify that page changes and additions indicated above have been entered. This notice page will be retained as a check sheet. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the Military Standard is completely revised or canceled.

CONCLUDING MATERIAL

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

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

Other:
DLA - ES
FAA

Preparing activity:
Air Force - 10

Agent:
DLA - ES

(Project GDRQ-0147)

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-STD-1818	Electromagnetic Effects, Requirements for Systems.
MIL-HDBK-600	Guidelines for Identification, Markings, Labeling, Storage, and Transportation of Radioactive Commodities.
IEEE/ANSI C95.1	IEEE Standard For Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.
ANSI C95.2	Radio Frequency Radiation Hazard Warning Symbol.
ANSI N2.1	Radiation Symbol.
ANSI Z535.1	Safety Color Code.
ANSI Z535.2	Environmental and Facility Safety Signs.
ANSI Z535.3	Criteria for Safety Symbols.
ANSI Z535.4	Product Safety Signs and Labels.
ANSI Z535.5	Accident Prevention Tags (for Temporary Hazards).
NFPA 70	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.
29 CFR 1910	Code of Federal Regulations, Title 29, Chapter XVII, Part 1910.
ASTM F-1166	Human Engineering Design for Marine Systems, Equipment and Facilities, Standard Practices for.

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 Commercial off-the-shelf (COTS) equipment. Commercial off-the-shelf equipment that can be purchased through commercial retail or wholesale distributors as is (i.e., equipment that is available as a cataloged item) or with only minor modifications that do not alter its essential performance or functional characteristics. Modified COTS is commercial hardware that requires factory modifications for Government procurement and use.

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

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

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

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

3.6 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.

3.7 Leakage current. Leakage current is that current which flows through the equipment conductive paths to a solidly grounded source.

3.8 Procuring activity. That unit of the DoD which originates a procurement document for equipment or hardware.

4. Requirements

4.1 Commercial off-the-shelf (COTS) equipment. Commercial off-the-shelf equipment that has been listed or certified by an appropriate commercial standard by a Nationally Recognized Test Laboratory (NRTL) (e.g.: Underwriters Laboratories (UL), Canadian Standards Association (CSA), or TUV Rheinland (TUV)) shall be considered as having met the provision of this requirement and from a product safety perspective, shall be acceptable for use without further modification. Modified COTS equipment which has any modification to the primary power voltage (above 42.4 volts) areas requires recertification by a NRTL.

4.2 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.

4.3 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-1818 for Air Force systems, MIL-STD-1310 for shipboard systems, and NFPA 70, chapter 5, for ground systems, or as otherwise specified in the detail equipment specification.

4.4 Temperature. At an ambient temperature of 25°C, the operating temperature of control panels and operating controls shall not be greater than 49°C or less than 12°C. The temperature of other exposed parts subject to contact by operating personnel shall not exceed 60°C. The temperature of all other exposed surfaces shall not be greater than 70°C.

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

4.5.1 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. Equipment that utilizes Uninterruptable Power Supplies (UPS) shall have provisions to isolate the supply from the equipment.

4.5.2 Ground. The design and construction of equipment, excluding self-powered equipment, shall insure that all external electrically conductive 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.

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

4.5.2.2 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 have first-to-make, last-to-break features. 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 expected, by internally generated faults, to 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.

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

4.5.2.3 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.

4.5.2.4 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.

4.5.2.5 Leakage current. The equipment leakage current shall not exceed 5 milliamperes dc or rms. When excessive leakage currents are required by design or operational requirements, redundant grounding or double insulation methods shall be incorporated.

4.5.3 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.

4.5.3.1 Guards and barriers. All contacts, terminals and like devices having voltages greater than 30 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.

4.5.3.2 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.

4.5.3.3 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.

4.5.3.4 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 greater than 30 volts rms
(see 4.5.3.1).

4.5.3.5 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.

4.5.4 Protective devices

4.5.4.1 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 between 30 and 500 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 in excess of 30 volts rms 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.

4.5.4.2 Battleshort. In equipment with battleshort circuitry, an audio and visual warning system shall be installed in the equipment. The visual warning shall be clearly visible to operating personnel. The audio warning shall provide a means for manual silencing and automatic reset. Catastrophic fault interlocks shall not be bypassed.

4.5.4.3 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.

4.5.5 Discharging devices

4.5.5.1 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.

4.5.5.2 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 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.

4.5.6 Connectors. Connectors used in multiple electric circuits shall be selected to preclude mismatching. Where design considerations require plugs and receptacles of similar configuration in close proximity, the mating plugs and receptacles shall be physically keyed and 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. After disconnecting, energized connector contacts shall be inaccessible to personnel.

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

4.6.1 Microwave and RF radiation. All electronic equipment or electrical devices capable of emitting microwave or RF radiation between 3 kHz and 300 GHz shall be so designed, fabricated, shielded and operated as to avoid overexposure of personnel. Exposure to RF radiation shall meet the Controlled and/or Uncontrolled environment Maximum Permissible Exposure levels called out in IEEE/ANSI C95.1 In areas where unintended radiation levels exist, equipment design and installation in any unrestricted area accessible to personnel shall meet the uncontrolled environment requirements of IEEE/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.

4.6.2 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 milliroentgen (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.

4.6.3 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.

4.7 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.

4.7.1 Mechanical interconnection. The design shall provide positive means to prevent the inadvertent reversing or mismatching of fittings; couplings; fuel, oil, hydraulic, and pneumatic lines; and mechanical linkage. When prevention of mismatching 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.

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

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

4.7.4 Battery Enclosures. Battery enclosures shall be vented. The enclosure design shall prevent shattering, or fragmenting of enclosure parts and covers.

4.8 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 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 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 Z535.1 where applicable to electronic equipment.

b. For potentials between 70 and 500 volts, warning signs or labels shall be in accordance with ANSI Z535.1, class II, and ANSI Z535.4, and shall read, as a minimum, "WARNING - (Insert maximum voltage applicable) Volts."

c. For potentials in excess of 500 volts, warning signs or labels shall be in accordance with ANSI Z535.1, class I and ANSI Z535.4, 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 Z535.1 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 4.6.1 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 3 kHz and 300 GHz with intended electromagnetic radiation levels exceeding those in paragraph 4.6.1.

(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 1, 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.

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

f. Coding for accident prevention tags shall be in accordance with ANSI Z535.5.

g. Coding for safety labels on equipment shall be in accordance with ANSI Z535.4.

h. Coding for safety signs regarding facilities or the environment shall be in accordance with ANSI Z535.2.

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

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

4.9 Hazardous and restricted materials.

4.9.1 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.

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

4.9.3 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.

4.9.4 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.

4.9.5 Cadmium. Cadmium plating and devices using cadmium shall not be used unless specifically approved by the acquiring activity.

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 or ASTM F-1166 (for marine systems, equipment and facilities) 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 1-1. 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.

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.

TABLE 1-I. Probable effects of shock.

Current values (milliamperes)		Effects
AC 25 Hz to 400 z	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

5.2.3 Grounding to chassis. Ground connection to an electrically conductive chassis or frame should be mechanically secured by soldering to a spot welded 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 lock-washer. 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 greater 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: Safety signs and labels.

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/								
	None 3/	Guards and barriers 4.5.3.1	Enclosures 4.5.3.2, 4.5.4.1	Marking		Interlocks		Driving Devices	
				Warning 4.8	Danger 4.8	Bypassable 4.5.4.1b	Nonbypassable 4/ 4.5.4.1c	Automatic 4.5.5.1	Shorting rods 4.5.5.2
0-30 Volts	X								
>30-70 Volts		X				X		X	
>70-500 Volts		X		X		X		X	X
>500 Volts			X		X		X	X	X

1/ Table is used 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, designing 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 8

ELECTRICAL OVERLOAD PROTECTION

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

2. Documents applicable to Requirement 8:

ARINC 413	Guidance for Aircraft Electrical Power Utilization and Transient Protection.
ARINC 610	Guidance for Design and Integration of Aircraft Avionics Equipment in Simulators.
ARINC 609	Design Guidance for Aircraft Electrical Power Systems.
ARINC 607	Design Guidance For Avionic Equipment.
IEC 92 PT 202	Electrical Installations in Ships Part 202: Protection.
IEEE C62.41	Guide for Surge Voltages in Low Voltage AC Power Circuits (DOD Adopted).
IEEE C2	National Electrical Safety Code (ANSI/IEEE).
IEEE C62.11	Standard for Metal-Oxide Surge Arresters for AC Power Circuits.
IEEE C62.1	Standard for Surge Arresters for AC Power Circuits (DOD Adopted).
MIL-A-9094	Arrester, Lightning, General Specification For, Design of.
MIL-STD-1399	Interface Standard for Shipboard Systems; Section 300 Electrical Power.
MIL-STD-1539	Electrical Power, Direct Current, Space Vehicle Design Requirements.
MIL-STD-280	Definitions of Item Levels, Item Exchangeability, Models, and Related Terms.
NEMA 280	Application Guide For Ground Fault Circuit Interrupters Equipment.
NFPA 70	National Electrical Code.
SAE J-1428	Marine Circuit Breakers Recommended Practices.
SAE ARP 1199	Selection, Application, and Inspection of Electric Overcurrent Protective Devices (DOD Adopted).

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

4.1.1 General protection for equipment. General considerations for the design of electronic equipment shall be such that electrical overload protection shall be chosen from and tailored to those standards and specifications listed in section 2 of this requirement.

a. Current overload protection. Current overload protection shall be provided for primary circuits. Devices such as fuses, circuit breakers, time delays, cutouts, surge protectors, or solid state current interruption devices shall be used to open a circuit, whenever an overload or surge 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 operated 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 (class 1) a separable connector or the attached plug and receptacle 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.

b. 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 replacement of fuses without the use of any special tools.

c. 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 service.

d. Surge Protection. Electronic equipment sensitive to surges in the supply current shall be protected utilizing the guidelines of IEEE C62.1, 62.11, 62.41, or MIL-A-9094.

e. Ground Fault Isolation. Ground fault isolation devices shall be use to protect personnel in environments which may cause a hazard due to ground leakage. Ground fault circuit interrupter used shall be developed in accordance with NEMA 280. The source of selection of ground fault circuit interrupters shall be UL 943.

f. Protection for class 1 equipment. Overload protection shall be developed from the requirements of MIL-STD-1399 Section 300, ARINC 610, IEEE C2, IEC 92 PT 202, SAE J-1428, or SAE ARP 1199 as required by design.

4.2.1 Current overload protection. Current overload protection for equipment shall be provided by fuses or circuit breakers, and shall protect both sides of the input line. The protection shall be placed after the power switch. Circuit breakers shall not be used as switches unless such breakers have been specifically designed and tested for that type of service. Circuit breakers shall be mounted in a horizontal position. The circuit protection shall be placed on the front panel, when practicable.

4.2.2 Spare fuses. When fuses are used, a minimum of one spare fuse of equal size and rating shall be supplied within the equipment.

4.2.3 Protection for class 2 equipment. Design for class 2 equipment shall use ARINC 413, ARINC 607-1, ARINC 609, or MIL-STD-1539 for developing overload protection.

a. 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.

b. 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.

4.2.4 Protection for class 3 equipment. Direct current (dc) electrical power for space vehicles shall conform with MIL-STD-1539. Electrical overload protection shall not be provided in individual boxes or systems receiving power.

5. Information for guidance only

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

5.3 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.

5.4 Resettable fuses. Positive temperature coefficient (PTC) thermistors may be used to protect low current circuits. Minimum limit current is current required to switch at minimum ambient temperature. Maximum limit current is that current the thermistor must pass without switching at maximum ambient temperature. Applications: Telephone line fault protection, fuse for intermittent solenoids, over-current protection for transformers, locked rotor protection for fractional horse power motors.

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.
W-C-375	Circuit Breakers, Molded Case, Branch Circuit, and Service.
IEEE C37	Standard Electrical Power System Devices.
IEEE C62	Standard for Surge Arresters for AC Power Circuits (DOD Adopted).
NEMA 280	Application Guide for Ground Fault Circuit Interrupters.
NEMA AB 1	Molded Case Circuit Breakers and Molded Case Switches.
NEMA AB 3	Molded Case Circuit Breakers and Their Application.
NEMA LA 1	Surge Arresters.
SAE J 258	Circuit Breaker-Internal Mounted-Automatic Reset, Recommended Practices.
SAE J 553	Circuit Breakers, Recommended Practice: (DOD Adopted).
SAE J 1428	Marine Circuit Breakers, Recommended Practice.
UL 489	Molded Case Circuit Breakers and Circuit Breakers Enclosures (DOD Adopted).
UL 877	Circuit Breakers and Circuit Breaker Enclosures for Use in Hazardous (Classified) Locations.
UL 943	Ground Fault Circuit Interrupters (DOD Adopted).
UL 1449	Transient Voltage Surge Suppressors.

3. Definitions. Not applicable.

4. Requirements

4.1 Selection and application. Circuit breakers shall be selected from MIL-STD-1498, W-C-375, NEMA AB 1, AB-3, UL-489, and UL 877. Trip-free circuits breakers shall be used. Non-trip-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. Circuits 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. For shipboard installed equipment, circuit breakers shall be mounted on the horizontal axis.

4.5 Surge protection and ground fault protection. Surge arresters and ground fault detectors shall be selected from NEMA LA 1, UL 943, and 1449.

5. Information for guidance only.

5.1 Circuit breaker requirements. Guidance for circuit breaker requirements is contained in IEEE C37, SAE J 258, J 553, and J 1428 for determining application of circuit breakers.

5.2 Surge protection and ground fault protection guidance. Surge protection and ground fault protection guidance should be selected from IEEE C62 and NEMA 280.

REQUIREMENT 39

FUSES AND FUSE HOLDERS

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

2. Document applicable to Requirement 39:

IEC 127	Cartridge Fuse-Links for Miniature fuses.
IEC 269	Low-Voltage Fuses; Multi-Part.
IEC 282	High-Voltage Fuses; Multi-Part.
IEC 549	High-Voltage Fuses For External Protection Of Shunt Power Capacitors.
IEC 644	Specification for High Voltage Fuse Links for Motor Circuit Application.
IEC 691	Thermal Links.
IEC 787	Application Guide for The Selection of Fuse Links of High Voltage Fuses for Transformer Circuit Application.
IEEE C37.27	Standard Application Guide For Low Voltage A.C. Non-Integrally Fused Powered Circuit Breakers, Separate Mounted Current Limiting Fuses.
NEMA FU 1	Low Voltage Cartridge Fuses.
NEMA SG2	High Voltage Fuses: (DOD Adopted).
SAE J 156	Fusible Links.
SAE J 554	Electric Fuses (Cartridge Type).
SAE J 1284	Blade Type Electric fuses.
UL 198	Plug Fuses.
UL 275	Autocotive Glass-Tube Fuses.
UL 512	Fuse holders (DOD Adopted).
UL 1412	Fusing Resistors and Temperature-Limited Resistors for Radio and Television Type Appliances.
UL 1417	Special Fuses For Radio and Television Applications.
DESC DWG 87108	Fuses.
W-F-1814	Fuses, Cartridge, High-Interrupting Capacity.
MIL-F-5372	Fuses, Current Limiter Type Aircraft.

MIL-F-15160	Fuses, Instrument, Power, and Telephone.
MIL-F-19207	Fuses.
MIL-F-23419	Fuses, Instrument type, General Specification for.
MIL-STD-1360	Fuses, Fuse holders, and Associated Hardware, Selection and Use of.

3. Definitions. Not applicable.

4. Requirements. Relationship of the requirements sighted in this requirement to more than one class of equipment may apply. Selection shall be based on application.

5. Selection and application of industrial components. The following list shall be utilized in developing and selection of both commercial and ruggedized equipment, IEC 127, IEC 269, IEC 282, IEC 549, IEC 644, IEC 691, IEC 787, NEMA FU 1, NEMA SG2, SAE J 156, SAE J 554, SAE J 1284, UL 198, UL 275, and UL 1417.

6. Selection and application. Fuses, fuse holders, and associated hardware shall be selected from W-F-1814, MIL-STD-1360, DESC DWG 87108, MIL-F-23419, MIL-F-5372, MIL-F-15160, MIL-F-19207, or UL 512.

7. Extractor post type fuse holders. The load shall be connected to the fuse holder terminal that terminates in the removable cap assembly.

8. Information for guidance only.

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

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

11. Load current considerations. Fuse ratings are in terms of RMS, not average. Line currents are measured using an RMS reading instruments. Direct current lines having a pulsating component should be measured using a true RMS reading instrument. The following standards may be used as guidelines in developing fuse requirements; IEEE C37.027, UL 198, and UL 1412.

REQUIREMENT 62

HUMAN ENGINEERING

1. Purpose. This requirement offers guidance for 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 program requirements, design criteria, and related test and evaluation requirements must be directly specified in the contract or the system/equipment specification, as appropriate.

2. Documents application 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.
MIL-STD-1478	Task Performance Analysis.
MIL-STD-1800	Human Engineering Performance Requirements for Systems.
MIL-STD-1801	User/Computer Interface.

3. Definitions. Not applicable.

4. Requirements. Not applicable.

5. Information for guidance only.

a. Tasking requirements. 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, achieve required effectiveness of human performance during system operation, maintenance, and control, and make economical demands upon personnel resources, skills, training, and costs. MIL-H-46855 is the overall requirements document for the area. MIL-STD-1478 specifies task analysis efforts undertaken for Army systems as part of the human engineering effort pursuant to MIL-H-46855. These two documents must be tailored when applied; application guidance is offered in these documents.

b. Design criteria. MIL-STD-1472 which provides design criteria, may be selectively applied as requirements or guidance. MIL-STD-1800 and MIL-STD-1801 are Air Force MIL-PRIME documents that specify human engineering and user/computer interface respectively.

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 (Discontinued for Air Force Applications).
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-1818 (USAF)	Electromagnetic Effects Requirements for Systems (for Air Force Applications only).
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 (Use MIL-STD-1818 for AF Applications).
Aircraft and Space Vehicles	MIL-B-5087 (Use MIL-STD-1818 for AF Applications).
Ground Telecommunications C-E Equipment	MIL-STD-188-124.
Shipboard Equipment	MIL-STD-1310.
Ground Space Systems Facilities	MIL-STD-1542.
Other Army Ground Facilities	MIL-STD-1857.

5. Information for guidance only. Extensive guidance for grounding, bonding, and shielding may be found in MIL-HDBK-419.