MILITARY STANDARD

STANDARD GENERAL REQUIREMENTS FOR ELECTRONIC EQUIPMENT

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

NEW PAGES	DATE	SUPERSEDED PAGES	DATE
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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 70-1987	National Electrical Code

Code of Federal Regulations, Title 10, Chapter I, Part 20
Code of Federal Regulations, Title 21, Chapter I, Subchapter J
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 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 the Code of Federal Regulations (CFR), Title 21, Chapter I, Subchapter J, 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, CFR, Title 10, Chapter I, Part 20; OSHA Regulations, CFR, Title 29, Chapter XVII,Part 1910.96; and FDA Regulation, CFR, Title 21, 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 CFR, Title 21, Chapter I, Subchapter J, Part 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 reached 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 CFR, Title 21, Chapter I, Subchapter J, Part 1040.

(2) Military exempt laser labels: A permanent label shall be affixed on all military laser systems that have been certified exempt from CFR, Title 21, Part 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 CFR, Title 10, Chapter I, Part 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 CFR, Title 10, Chapter I, Part 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	15-180	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 the CFR, Title 29, Chapter XVII, Part 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 4

FUNGUS-INERT MATERIALS

1. Purpose. This requirement identifies those materials which are acceptable non-nutrients 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

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 table4-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 O 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 the Code of Federal Regulations, Title 29, Chapter XVII, Part 1910. Consideration of the toxicity of a substance should be given prior to material selection.

REQUIREMENT 11

INSULATING MATERIALS, ELECTRICAL

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

* 2. Documents applicable to Requirement 11:

L-P-516	Plastic Sheet and Plastic Rod, Thermosetting, Cast
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-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	Insulating 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-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 Polytetra-fluoroethylene, 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

ASTM D3295-81 PTFE Tubing, Specification for
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. Sleeving shall conform to MIL-I-631, MIL-I-3190, MIL-I-7444, MIL-I-22076, MIL-I-23053, or ASTM D3295.

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 Polyvinyl chloride. Polyvinyl chloride insulating materials shall not be used in aerospace applications.

5. Information for guidance only

5.1 Insulating materials, electrical. Insulating materials should be selected based on meeting or exceeding the use 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

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 the Code of Federal Regulations,Title 29, Chapter XVII, Part 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 of 1.5 threads. 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 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 aerospace equipment.

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 Air Force application requires prior approval of the procuring activity.

TABLE 20-I. Wire, electrical.

Spec No.	Title	Spec Type or Class	CONSTRUCTION 1/ Conductor: Material	Conductor: Coating	Conductor: Type	2/ Insulation: Primary	Insulation: Primary Cover	Insulation: Jacket/ Topcoat	Max Cond Temp °C	Max rms Volts	Remarks
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 use only
		MW								1000	
		HW								2500	
		HF				2A				1000	
MIL-W-5086	Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy	M5806/1	Cu/A	Sn				8	105	600	
		M5086/2						8, 11			
		M5086/4			Str	1		8		3000	
		M5086/5						9A	110	600	
		M5086/6	HSA	Ag							
		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								1000	
		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									
		M16878/14	Cu/A	Ag,Sn		2C			125	600	
		M16878/15		Sn						1000	
		M16878/16								600	
		M16878/17	Cu/A, HSA, CCW	Ag,Sn		1		8	105	3000	
		M16878/18								1000	
		M16878/19								3000	
		M16878/20		Ag		3B		3A,3B,4A, 13B 3/	200	250	
		M16878/21								600	
		M16878/22								1000	
		M16878/23		Ni		3A			260	250	
		M16878/24				3B				600	
		M16878/25				3A					
		M16878/26				3B				1000	
		M16878/27				3A					
		M16878/28				3B					
		M16878/29	Cu/A	Sn	Str	6			150	600	
		M16878/30								1000	
		M16878/31									
		M16878/32		Ag					200		
		M16878/33	Cu/A, CCW	Sn	S,Str	2A			75	600	
		M16878/34	Cu	Ag	Str	3B			200	1000	
		M16878/35		Ni					260		

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-19150	Wire, Insulated, Hard Drawn Copper		Cu/H			2A		8			
MIL-W-22759	Wire, Electric, Fluoropolymer Insulated, Copper or Copper Alloy	M22759/9	Cu/A	Ag	Str	3A			200	1000	
		M22759/10		Ni					260		
		M22759/11		Ag					200	600	
		M22759/12		Ni					260		
		M22759/14		Sn		4A		9B	135		
		M22759/15	HSA	Ag							
		M22759/16	Cu/A	Sn		17			150		
		M22759/17	HSA	Ag							
		M22759/18	Cu/A	Sn							
		M22759/19	HSA	Ag							
		M22759/21		Ni		3A			260	1000	
		M22759/22		Ag					200	600	
		M22759/23		Ni					260		
		M22759/31						7			
		M22759/32	Cu/A	Sn		21			150		
		M22759/33	HSA	Ag					200		
		M22759/34	Cu/A	Sn					150		
		M22759/35	HSA	Ag					200		
		M22759/41	Cu/A	Ni				21			
		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							
MIL-W-81381	Wire, Electric, Polyimide Insulated, Copper or Copper Alloy	M81381/7	Cu/A	Ag	Str	19		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							
		M81381/9	HSA	Ag			4B				
		M81381/10		Ni							
		M81381/11	Cu/A	Ag							
		M18381/12		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.

4.2 Identification. Hookup wires in the equipment shall be, insofar as practicable, distinctly coded in color or numbered. Short hookup wire, six inches 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 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.

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

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 six inches 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.

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
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-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 Polyamide Curing Agent
MIL-A-83377	Adhesive Bonding (Structural) for Aerospace and Other Systems, Requirements for
MIL-HDBK-691	Adhesive Bonding
ASTM Standard	Wood; Adhesives - Part 22
ASTM D2564-84	Solvent Cements for Polyvinyl Chloride (PVC) Plastic Pipe and Fittings, Specification for

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 the Code of Federal Regulations, Title 29, Chapter XVII, Part 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-181	MIL-A-8576	MIL-A-46146	MIL-A-83377
MMM-A-130	MMM-A-189	MIL-A-22397	MIL-A-48611	MIL-HDBK-691
MMM-A-132	MMM-A-1617	MIL-A-24179	MIL-A-52194	ASTM STD-Part 22
MMM-A-134	MIL-A-3920	MIL-A-25463	MIL-A-81236	ASTM D2564
MMM-A-138	MIL-A-5540	MIL-A-46050	MIL-A-81253	

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 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, Polytetra-fluoroethylene 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

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 the Code of Federal Regulations, Title 29, Chapter XVII, Part 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 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

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 Air Force Wright Aeronautical Laboratories, ATTN: MLSE, Wright-Patterson AFB OH 45433-6503.

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 the Code of Federal Regulations, Title 29, Chapter XVII, Part 1910. Consideration of the toxicity of a substance should be given prior to material selection.

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 B C	1.5 3 6	1.5 3 9.5	1.5 6 19
150-300	A B C	1.5 3 6	1.5 3 12.5	1.5 6 19
300-600	A B C	1.5 3 6	3 6 12.5	3 6 19
600-1000	A B C	3 6 12.5	9.5 19 38	12.5 25 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.

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