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DEPARTMENT OF DEFENSE HANDBOOK

GENERAL GUIDELINES FOR ELECTRONIC EQUIPMENT

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 Do not cite this document as a requirement.

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FOREWORD

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

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

3. This handbook is the technical baseline for the design and construction of electronic equipment for the Department of Defense. It captures in one document, under suitable subject heading, fundamental design guidelines for multiple general electronic specifications. The opportunity to focus on a single document, afforded to contractors, results in substantial savings to the Government. This handbook was prepared by, and is regularly updated through, the cooperative efforts of Government and industry. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

DOD-E-8983	Electronic Equipment, Aerospace, Extended Space Environment, General Specification for.
MIL-F-18870	Fire Control Equipment, Naval Ship and Shore, General Specification for.
MIL-PRF-28800	Test Equipment for Use with Electrical and Electronic Equipment, General Specification for.
MIL-HDBK-2036	Electronic Equipment Specifications, Preparation of.

4. Comments, suggestions, or questions on this document should be addressed to (Defense Supply Center, Columbus, ATTN: DSCC-VSC, P.O. Box 3990, Columbus, OH 43218-3990) or emailed to (mailto:DSCC.PartsSupport@dla.mil). Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil.

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CONCLUDING MATERIAL

1. SCOPE

1.1 Guidelines applicable to electronic equipment. This handbook provides guidance and lessons learned in the selection of documentation for the design of electronic equipment. This handbook is for guidance only and cannot be cited as a requirement. If it is, the contractor does not have to comply.

1.2 Revision of guidelines. Revisions of individual guidelines are indicated by a date below the guideline number located at the bottom of the page. When the basic document is revised, those guidelines not affected by change retain their existing date.

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

1.3. Method of reference. Guidelines contained herein should be referenced by specifying this handbook and the guideline number for guidance only.

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

2. APPLICABLE DOCUMENTS.

2.1 Individual guidelines. See section 2 of each individual guideline for a listing of applicable documents. Documents referenced in the individual guidelines apply to the extent specified herein.

(Copies of these documents are available online at https://assist.dla.mil .)

2.2 Industry addresses. Addresses for obtaining documents referenced in the guidelines but not obtainable from the Government are as follows:

Symbol	Address
AGMA	American Gear Manufacturers' Association 1500 King Street, Suite 12 Arlington VA 22314
AIA	Aerospace Industries Association 1000 Wilson Boulevard, Suite 1700 Arlington, VA 22209-3928
AMS ARP	Society of Automotive Engineers, Inc. 400 Commonwealth Drive Warrendale PA 15096
ANSI	American National Standards Institute 11 West 42nd Street New York NY 10036
ASME	American Society of Mechanical Engineers 22 Law Drive P.O. Box 2900 Fairfield NJ 07007-2900
ASM	American Society for Metals Metals Park OH 44073
ASTM	American Society for Testing and Materials 100 Barr Harbor Drive West Conshohockan PA 19428-2959
AWS	American Welding Society 550 NW LeJeune Road Miami FL 33126
EIA	Electronic Industries Alliance 2500 Wilson Blvd. Arlington VA 22201-3834
GEIA	Government Electronics and Information Association 777 East Eisenhower Parkway Ann Arbor, MI, USA 48108
IEEE	Institute of Electrical and Electronics Engineers IEEE Service Center 445 Hoes Lane PO Box 1331 Piscataway NJ 08855-1331
IPC	Institute for Interconnecting and Packaging Electronic Circuits 2215 Sanders Rd. Suite 200 South Northbrook IL 60062

NAS	National Standards Association 1200 Quince Orchard Boulevard Gaithersburg MD 20878
NFPA	National Fire Protection Association Batterymarch Park Quincy MA 02269-9101
UL	Underwriters Laboratories, Incorporated 333 Pfingsten Road Northbrook IL 60062

3. DEFINITIONS

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

3.2 Other definitions and terms. Other definitions and terms are defined in the individual guidelines

4. GENERAL GUIDELINES

4.1 Application. The guidelines contained herein are intended to provide uniform guidelines applicable to electronic equipment, unless otherwise specified in the guideline.

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

5. DETAIL GUIDELINES

5.1 Individual guidelines for electronic equipment. The individual guidelines for electronic equipment are located after section 6.

6. NOTES

6.1 Subject term (key word) listing.

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

6.2 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

GUIDELINE 1

SAFETY DESIGN CRITERIA - PERSONNEL HAZARDS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-STD-464	Electromagnetic Environmental Effects Requirements for Systems.
MIL-STD-1310	Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety.
MIL-STD-1425	Safety Design Requirements for Military Lasers and Associated Support Equipment.
MIL-STD-1472	Human Engineering.
DOD Manual 6050.5	DoD Hazardous Materials Information System Procedure.
10 CFR 20	Code of Federal Regulations, Title 10, Chapter I, Part 20.
21 CFR 1000-1050	Code of Federal Regulations, Title 21, Chapter I, Parts 1000-1050.
29 CFR 1910	Code of Federal Regulations, Title 29, Chapter XVII, Part 1910.
ANSI N2.1	Radiation Symbol.
ANSI Z136.1	Safe Use of Lasers.
ASTM F 1166	Standard Practice for Human Engineering Design for Marine Systems, Equipment and Facilities.
IEEE C95.1	Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.
IEEE C95.2	Radio-Frequency energy and current flow Symbols.
NEMA Z535.1	Safety Colors.
NEMA Z535.2	Environmental and Facility Safety Signs.
NEMA Z535.3	Criteria for Safety Symbols.
NEMA Z535.4	Product Safety Signs and Labels.
NEMA Z535.5	Safety Tags and Barricade Tapes (for Temporary Hazards).
NFPA 70	National Electrical Code.

3. Definitions.

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

3.2 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.

3.3 Commercial off-the-shelf (COTS) equipment. COTS equipment that can be purchased through commercial retail or wholesale distributors as is (e.g., equipment that is available as a cataloged item) or with only minor modifications that does not alter its form, fit, or functional characteristics.

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

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

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

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

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

3.8 Procuring activity. A unit of the Department of Defense (DoD) which originates a procurement document for equipment or hardware.

4. General guidelines.

4.1 COTS equipment. COTS equipment that has been listed or certified to an appropriate commercial standard by a Nationally Recognized Test Laboratory (NRTL) (e.g., Underwriter's Laboratories (UL), Canadian Standards Association (CSA), or TUV Rheinland (TUV)) should be considered as having met the provisions of this guideline and from a product safety perspective, should be accepted for use without further modification. COTS equipment which has any modifications, and is required to meet commercial standards, should be recertified a NRTL.

4.2 Fail-safe. The design and development of all military electronic equipment should 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 should be bonded in accordance with MIL-STD-464 for aerospace systems, MIL-STD-1310 for shipboard systems, and NFPA 70, for facilities, or as otherwise specified in the equipment specification.

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

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

4.5.1 Power. Means should 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 should be in accordance with the applicable regulations or requirements. If a main power switch is provided, it should be clearly labeled as such and should cut off all power to the complete equipment. Equipment that utilizes Uninterruptable Power Supplies (UPS) should have provisions to isolate the supply from the equipment.

4.5.2 Ground. The design and construction of equipment, excluding self-powered equipment, should ensure 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 should include consideration of ground currents and voltage limits (possible arcing) established on a basis of hazardous location. Antenna and transmission line terminals should be at ground potential, except for Radio Frequency (RF) energy on their external surfaces.

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

4.5.2.2 Grounding methods. Plugs for use with metal cased portable tools and equipment should 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 should make first, break last. Ground connections to shields, hinges, and other mechanical parts should not be used to complete electrical circuits. Any external or interconnecting cable, where a ground is part of the circuit, should 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, should the shield be depended upon for a current-carrying ground connection. Static and safety grounds should not be used to complete electrical circuits. A point on the electrically conductive chassis or equipment frame should serve as the common tie point for static and safety grounding. The path from the tie point to ground should:

a. Be continuous and permanent.

b. Have ample carrying capacity to conduct safely any fault currents that may be expected to be imposed on it by internally generated faults.

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.

4.5.2.3 Hinged or slide-mounted panels and doors. Hinges or slides should not be used for grounding paths. Panels and doors containing meters, switches, test points, etc., should be attached or hinged in such a manner as to ensure 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 should 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 capacity to ensure the reliable and immediate tripping of equipment overcurrent protection devices.

4.5.2.4 Shielding. Except where a conflict with single-point shield grounding guidelines would be created, shielding on wire or cable should be grounded to the chassis or frame. The shielding should 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 should 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 should not exceed 5.0 milliamperes dc or rms. When excessive leakage currents are required by design or operational requirements, redundant grounding or double insulation methods should be incorporated.

4.5.3 Accidental contact. The design should 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 should 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 should be completely enclosed from the remainder of the assembly and equipped with non-bypassable 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 should be provided with test points so that these voltages can be measured at a relatively low potential level. In no case should the potential exceed 300 volts peak relative to ground. Test points with voltages above 30 volts should 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 should 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 should be protected from accidental contact in the same manner as for ac voltages greater than 30 volts rms. (see 4.5.3.1. of this guideline)

4.5.3.5 Main power switch. The power input side of the main power switch and the incoming power line connections should 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 should 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 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 should 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 should be provided to indicate when the interlock is bypassed.

c. Non-bypassable 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 Battle short indicator. In equipment with battleshort circuitry, an audio and visual warning system should be installed in the equipment. The visual warning should be clearly visible to operating personal. The audio warning should provide a means for manual silencing and automatic reset. Catastrophic fault interlocks should not be bypassed.

4.5.4.3 Safety switches. Safety switches, which will deactivate associated mechanical drive units, should be provided for the purpose of disconnecting these units without disconnecting other parts of the equipment. Such remotely located units and assemblies should have provision for non-overrideable 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 should 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 should ensure that the capacitor or high voltage circuit is discharged to 30 volts or less within two seconds. These protective devices should be positive acting, highly reliable, and should 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 should consist of at least two equal valued resistors in parallel.

4.5.5.2 Shorting rods. Shorting rods should be provided with all transmitting equipment where voltages are in excess of 70 volts rms or dc. Where size permits, shorting rods should be stored within the transmitting equipment, permanently attached, and readily accessible to maintenance personnel. The permanently attached rod should 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 should be provided to permit attachment of a portable shorting rod. The connection to the stud should be such that accidental loosening, or high resistance to the ground is prevented.

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

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”, should 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 should be so designed, fabricated, shielded, and operated as to avoid overexposure of personnel. Exposure to RF radiation should meet the Controlled and Uncontrolled environment Maximum Permissible Exposure Levels called out in IEEE C95.1. In areas where unintended radiation levels exist,

equipment design and installation in any unrestricted area accessible to personnel should meet the Uncontrolled environment requirements of IEEE C95.1. Shields, covers, doors, etc, which when opened or removed will allow microwave and RF radiation to exceed the above, should be provided with non-bypassable interlocks.

4.6.2 X radiation. All electronic or electrical devices capable of producing X radiation should be so designed, fabricated, shielded, and operated as to keep personnel exposure as low as reasonably achievable. For equipment and installation design, shielding guidelines should be maintained at all times which limit radiation levels to not greater than 2 milliroentgens (mr) in any 1 hour and 100 mr in any 7 consecutive days at the operator position or within 5 cm from the equipment (whichever is closer) in any unrestricted area accessible to personnel. In addition, these levels should 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 for each calendar quarter or 500 millirem for each year. Other exposure should be based on application criteria and limits as required by “Nuclear Regulatory Commission Rules and Regulations”, 10 CFR 20; OSHA Regulations 29 CFR 1910 PT.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 should be provided with non-bypassable interlocks.

4.6.3 Laser radiation. Laser equipment and system design, installation, and operational and maintenance procedures should conform to 21 CFR 1040 and ANSI Z136.1. If these cannot be met because of operational requirements, an exemption should be requested from the FDA through the procuring activity, and applicable military laser safety requirements in MIL-STD-1425 will be considered.

4.7 Mechanical. The design of the equipment should provide personnel maximum access and safety while installing, operating, and maintaining the equipment. Equipment design should include provisions to prevent accidental pulling out of drawers or rack mounted equipment components. Suitable protection should 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 should be avoided. Doors or hinged covers should be rounded at the corners and provided with stops to hold them open.

4.7.1 Mechanical interconnection. The design should 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 should 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 should be selected and located so that accidental contact by personnel will not operate the switch.

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

4.7.4 Battery enclosures. Battery enclosures should be vented. The enclosure design should prevent shattering or fragmenting of enclosure parts, or covers ,in the event of a violent gas venting or rupture of battery cells causing explosive high pressure within the compartment.

4.8 Equipment safety markings. Danger, warning, caution, signs, labels, tags, and markings should be used to warn of specific hazards such as voltage, current, thermal, or physical. The signs, labels, tags, and markings should be as permanent as the normal life expectancy of the equipment on which they are affixed. Guards, barriers, access doors, covers, or plates should be marked to indicate the hazard which may be present upon removal of such devices. When possible, marking should be located such that it is not removed when the barrier or access door is removed. Additionally, hazards internal to a unit should 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 should be marked with color codes in accordance with NEMA Z535.1 where applicable to electronic equipment.

b. For potentials between 70 and 500 volts, warning signs, labels, or tags should be in accordance with NEMA Z535.3, NEMA Z535.4, or NEMA Z535.5 and contain the single word "WARNING", and the maximum voltage applicable (e.g., 110 VAC).

c. For potentials in excess of 500 volts, warning signs, labels, or tags should be in accordance with NEMA Z535.3, NEMA Z535.4, or NEMA Z535.5 and contain the single word "DANGER", the descriptive words "High Voltage" and the maximum voltage applicable (e.g., High Voltage 550 VAC).

d. Microwave or RF radiation warning signs, labels, or tags should be in accordance with NEMA Z535.3, NEMA Z535.4, or NEMA Z535.5, and IEEE C95.2. Labels should 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 4.6.1, should be labeled. Minimum safe clearance distances should be clearly marked. Warning signs should 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 4.6.1.

e. Laser labels.

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

(2) Military exempt laser labels: A permanent label should be affixed on all military laser systems that have been certified exempt from 21 CFR 1040 "Performance Standards for Light-Emitting Products". The label tags should be in accordance with NEMA Z535.3, NEMA Z535.4, or NEMA Z535.5, and should use the single word CAUTION, and should read:

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 should be labeled in accordance with 10 CFR 20.

g. Coding for accident prevention tags should be in accordance with NEMA Z535.5.

h. Coding for safety labels on equipment should be in accordance with NEMA Z535.4.

i. Coding for safety signs regarding facilities or the environment should be in accordance with NEMA Z535.3.

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

k. Ionizing radiation hazard symbols should be in accordance with ANSI N2.1.

l. Symbols used on hazard warning signs, labels,or tags should be IAW NEMA Z535.2.

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, should not liberate gases which combine with the atmosphere to form an acid or corrosive alkali, nor should they liberate toxic or corrosive fumes which would be detrimental to the performance of the equipment or health of personnel. The materials also should not liberate gases which will produce an explosive atmosphere.

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

GUIDELINE 1

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

4.9.4 Glass fibers. Glass fiber materials should not be used as the outer surface or covering on cables, wire, or other items where they may cause skin irritation to operating personnel. When maintenance procedures require access to glass fibers, such as insulation, a proper caution note should be provided.

4.9.5 Cadmium. Cadmium plating, and devices using cadmium, should not be used unless specifically approved by the procuring activity.

5. Detail guidelines.

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 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 guidelines 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 guidelines may be relaxed.

TABLE 1-I. Probable effects of shock.

Current values (milliamperes)		Effects
AC 25 Hz to 400 Hz	DC	
0 to 1	0-4	Perception
1 to 4	4-15	Surprise
4 to 21	15-80	Reflex action
21 to 40	80-160	Muscular inhibition
40 to 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 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 bolthole, may be covered with a corrosion resistant surface film only if the resistance through the film is not more than 0.02 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. Hazard warning - 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 guidelines of this handbook and will 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 non-bypassable interlocks. (An example of 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 guidelines 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.

GUIDELINE 1

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. DOD Manual 6050.5 references known electronic items which require marking and may be used as a guide.

5.5 Materials. Certain chemicals have been identified by 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.

GUIDELINE 1

TABLE 1-II. Suitable protective measures. 1/

Voltage range	Type of protection 2/								
				Marking		Interlocks		Discharge devices	
	None 3/	Guards and barriers (4.5.3.1)	Enclosures (4.5.3.2, 4.5.4.1)	Warning (4.8b)	Danger (4.8c)	Bypassable (4.5.4.1b)	Non-bypassable (4.5.4.1c) 4/	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	X

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

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

3/ Although no specific guidance exist for servicing 0-30 volts, designs should be reviewed for possible hazards in accordance with table 1-I.

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

GUIDELINE 2

CAPACITORS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-PRF-39006/22	Capacitors, Fixed, Electrolytic (Nonsolid Electrolyte), Tantalum, (Polarized, Sintered Slug), 85° C (Voltage Derated to 125° C), Established Reliability, Style CLR79.
MIL-PRF-39006/25	Capacitors, Fixed, Electrolytic (Nonsolid Electrolyte), Tantalum, (Polarized, Sintered Slug Extended Range), 85° C (Voltage Derated to 125° C), Established Reliability, Style CLR81.
MIL-HDBK-198	Capacitors, Selection and Use of.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Selection. Capacitors should be selected and applied in accordance with MIL-HDBK-198.

4.2 Fixed, Tantalum Electrolytic. For Naval Air Systems Command, the use of wet slug tantalum capacitors (except tantalum cased units in accordance with MIL-PRF-39006/22 and MIL-PRF-39006/25) requires the approval of the procuring activity. Silver cased tantalum capacitors should not be used.

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 3

FLAMMABILITY

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-STD-202	Electronic and Electrical Component Parts.
ASTM D 635	Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.,
ASTM D 1000	Standard Test Method for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications,.
UL 94	UL Standard for Safety Test for Flammability of Plastic Materials for Parts in Devices and Appliances.

3. Definitions.

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

4. General guidelines.

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

5. Detail guidelines.

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

5.2 Other flammability test. If the specification does not have such a test, testing should be in accordance with ASTM D635, ASTM D 1000, or MIL-STD-202, Method 111, as applicable.

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

GUIDELINE 4

FUNGUS-INERT MATERIALS

1. Purpose. This guideline identifies those materials which are acceptable non-nutrients of fungus and establishes conditions under which fungus nutrient materials are acceptable.

2. Applicable documents The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

SAE AS12500	Corrosion Prevention and Deterioration Control in Electronic Components and Assemblies.
MIL-STD-810	Environmental Engineering Considerations and Laboratory Tests.
29 CFR PT1910	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. General guidelines.

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

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

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

4.4 Fungus testing. Table 1-I Group II materials should be subjected to the fungus test specified in method 508 of MIL-STD-810 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 guidelines of table 508-I, method 508 of MIL-STD-810, is sufficient evidence of acceptability.

GUIDELINE 4

TABLE 4-I. Fungi susceptibility of materials.

Group I - Fungus-inert materials (Fungus-inert in all modified states and grades)	
Acrylics	Polyamide 1/
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.

GUIDELINE 4

5. Detail Guidelines

5.1 Process-related materials. Processing materials to be tested for fungus resistance in accordance with 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 may be applied in accordance with SAE AS12500 after the part is cleaned. The MFP varnish should not be applied to any part where the treatment will interfere with performance.

5.3 Carcinogens. Certain chemicals have been identified in the Occupational Safety and Health Act (OSHA) as cancer-producing substances (carcinogens). Before using any materials which might contain these chemicals, they should be evaluated in accordance with 29 CFR 1910. Consideration of the toxicity of a substance should be given prior to material selection.

GUIDELINE 5

SOLDERING

1. Purpose. This guideline establishes the basis for soldering of electrical and electronic assemblies and non-electrical soldered connections.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

IPC/EIA J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies.

3. Definitions. This section not applicable to this guideline.

4. General guidelines

4.1 Soldering of electrical and electronic equipment. Electrical and electronic equipment should be assembled, soldered, and cleaned in accordance with the guidelines of IPC/EIA J-STD-001.

4.2 Workmanship. Workmanship may be checked in accordance with IPC/EIA J-STD-001.

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 6

BEARINGS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-B-8942	Bearings, Plain, TFE Lined, Self-Aligning.
MIL-B-8943	Bearing, Journal - Plain and Flanged, TFE Lined.
MIL-B-8948	Bearing, Plain, Rod End, TFE Lined, Self-Aligning.
MIL-B-81793	Bearings, Ball, Annular, For Instruments and Precision Rotating Components.
A-A-52401	Bearing, Sleeve (Steel-Backed).
A-A-52414	Bearing, Roller, Thrust.
SAE AS13341	Process for Barrier Coating of Anti-Friction Bearings.
SAE AS81934	Bearings, Sleeve, Plain and Flanged, Self-Lubricating.
SAE AS81936	Bearings, Plain, Self-Aligning (CuBe Ball, CRES Race), General Specification for.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

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

MIL-B-81793	A-A-52414	SAE AS 13341
MIL-B-8942	A-A-52401	SAE AS 81934
MIL-B-8943		SAE AS 81936
MIL-B-8948		

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

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

4.4 Barrier coating. Bearings requiring a barrier coating should be coated in accordance with SAE AS13341.

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

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

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

5. Detail guidelines.

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

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

GUIDELINE 7

INTERCHANGEABILITY

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

2. Applicable documents The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-HDBK-505	Definitions of Item Levels, Item Exchangeability, Models, and Related Terms.
MIL-HDBK-1547	Electronic Parts, Materials, and Processes for Space and Launch Vehicles.

3. Definitions.

3.1 Assembly, interchangeable item, part, subassembly, and substitute item. The terms assembly, interchangeable item, part, subassembly, and substitute item are defined in MIL-HDBK-505.

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

4. General guidelines.

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

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

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 8

ELECTRICAL OVERLOAD PROTECTION

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

2. Applicable documents The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-HDBK-505	Definitions of Item Levels, Item Exchangeability, Models, and Related Terms.
NFPA 70	National Electrical Code.

3. Definitions.

3.1 Class 1 equipment. Ground and shipboard, including test and check-out ground equipment.

3.2 Class 2 equipment. Manned aerospace equipment.

3.3 Class 3 equipment. Unmanned aerospace equipment.

4. General guidelines. The guidelines specified herein should apply only to equipment and systems as defined in MIL-HDBK-505 for Class 1 and Class 2 equipment.

4.1 Protection for Class 1 equipment.

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

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

4.1.3 Circuit breakers. Circuit breakers should give a visual indication when tripped. Holding the switching device closed on an overload should not prevent tripping of the breaker. Multi-pole circuit breakers should be used for three-phase equipment and should disconnect all phases if an overload occurs in any one phase. Circuit breakers should not be used as switches unless such breakers have been specifically designed and tested for that type service.

4.2 Protection for Class 2 equipment.

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

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

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

GUIDELINE 8

5. Detail guidelines.

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

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

GUIDELINE 9

WORKMANSHIP

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

2. Applicable documents This section not applicable to this guideline.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

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

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

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

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

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

5. Detail guidelines.

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

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

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

GUIDELINE 10

ELECTRICAL CONNECTORS

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

2. Applicable documents The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-J-641	Jacks, Telephone, General Specification for.
MIL-P-642	Plugs, Telephone, and Accessory Screws, General Specification for.
MIL-DTL-5015	Connectors, Electrical, Circular Threaded, AN Type, General Specification for.
MIL-DTL-21097	Connectors, Electrical, Printed Wiring Board, General Purpose, General Specification for.
MIL-DTL-21617	Connectors, Plug and Receptacle, Electrical, Rectangular, Polarized Shell, Miniature Type, General Specification for.
MIL-DTL-22992	Connectors, Plugs and Receptacles, Electrical, Waterproof, Quick Disconnect, Heavy Duty Type, General Specification for.
MIL-DTL-24308	Connectors, Electrical, Rectangular, Nonenvironmental, Miniature, Polarized Shell, Rack and Panel, General Specification for.
MIL-DTL-26518	Connectors, Electrical, Miniature, Rack and Panel, Environment Resistant, 200 Degrees C Ambient Temperature, General Specification for.
MIL-DTL-28748	Connector, Plug and Receptacle, Rectangular, Rack and Panel Solder Type and Crimp Type Contacts, General Specification for.
MIL-C-28754	Connectors, Electrical, Modular, and Component Parts, General Specification for.
MIL-DTL-28804	Connectors, Plug and Receptacle, Electric, Rectangular, High Density, Polarization Center Jackscrew, General Specification for.
MIL-C-29600	Connector, Electrical, Circular, Miniature, Composite, High Density, Quick Coupling, Environment Resistant, Removable Crimp Contacts Associated Hardware, General Specifications for.
MIL-DTL-32139	Connectors, Electrical, Rectangular, Nanominiature, Polarized Shell, General Specification for.
MIL-PRF-31031	Connectors, Electrical, Plugs and Receptacles, Coaxial, Radio Frequency, High Reliability, For Flexible and Semirigid Cables, General Specification for.
MIL-DTL-38999	Connector, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded, and Breech Coupling), Environment Resistant, Removable Crimp and Hermetic Solder Contacts, General Specification for.
MIL-PRF-39012	Connectors, Coaxial, Radio Frequency, General Specification for.
MIL-DTL-39024	Jack, Tip (Test Point, Panel or Printed Wiring Type), General Specification for.
MIL-PRF-49142	Connector, Triaxial, Radio Frequency, General Specification for.
MIL-DTL-55116	Connector, Miniature Audio, Five-Pin and Six-Pin, General Specification for.
MIL-DTL-55181	Connectors, Plug and Receptacle, Intermediate Power (Electrical, Waterproof), Type MW, General Specification for.
MIL-DTL-55302	Connectors, Printed Circuit Subassembly and Accessories
MIL-PRF-55339	Adapters, Connectors, Coaxial, Radio Frequency (Between Series and Within Series) General Specification for.
MIL-C-81659	Connectors, Electrical Rectangular, Crimp Contacts, General Specification for.
MIL-DTL-83503	Connectors, Electrical, Flat Cable, and/or Printed Wiring Board, Nonenvironmental, General Specification for.
MIL-DTL-83513	Connectors, Electrical, Rectangular, Microminiature, Polarized Shell, General Specification for.
MIL-DTL-83517	Connector, Coaxial, Radio Frequency for Coaxial, Strip or Microstrip Transmission Line, General Specification for.
MIL-DTL-83723	Connector, Electrical (Circular, Environment Resisting), Receptacles and Plugs, General Specification for.
MIL-DTL-83733	Connectors, Electrical Miniature, Rectangular Type, Rack to Panel, Environment Resisting, 200°C Total Continuous Operating Temperature, General Specification for.
EIA RS 297	Cable Connectors for Audio Facilities for Radio Broadcasting

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Selection. Intended use information contained in the individual connector specifications should be considered prior to making connector selections. Contact crimp, installing and removal tools should be in accordance with the individual connector specifications. However, contractors may use tooling as recommended by the contact or tooling manufacturer provided that the finished crimp meets all of the performance guidelines of the contact and connector specification. The variety of these tools required within a system should be kept to a minimum. Maintenance instructions and other data supplied by the contractor should list the military standard tools and contacts.

4.2 Audio frequency and communication connectors, special purpose. Connectors conforming to MIL-DTL-55116 should be used in audio frequency applications, such as head sets and chest sets, excluding pilots' helmets. For low level, three wire and audio input circuits in fixed plant non-tactical sound equipment, connectors conforming to EIA RS 297 should be used.

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

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

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

TABLE 10-I. Abbreviations for thermocouple materials.

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

4.4 Heavy duty connectors.

4.4.1 Power connectors (40 to 200 amperes). All power connectors for any ground application should conform to MIL-DTL-22992 and should be used with heavy duty jacketed cable as specified on the insert standards. Intermediate power connectors should conform to MIL-DTL-55181.

4.4.2 General purpose and shipboard. Connectors for general purpose heavy duty applications and shipboard power applications should conform to MIL-DTL-22992. Connectors used for external applications should be pressurized and waterproof in the mated and unmated condition in accordance with the guidelines of classes C or L. Connectors used internally (within a protective enclosure such as a shelter) may be in accordance with class R provided waterproofing or pressurization is not a guideline for the application.

4.5 General utility connectors. Polarized connectors are the preferred styles and should be used where automatic grounding will be provided to ensure safety to equipment and personnel.

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

4.7 Test jacks. Test jacks should conform toMIL-DTL-39024. Jacks or receptacles for use as RF test points should be selected in accordance with 4.8.

4.8 RF connectors. RF connectors should conform to MIL-PRF-39012. Adapters used with RF connectors should conform to MIL-PRF-55339. Connectors meeting High-Reliability requirements should conform to MIL-PRF-31031. Triaxial RF connectors should conform to MIL-PRF-49142.

4.9 Connectors for printed wiring. Printed circuit connectors should conform to MIL-DTL-21097 and MIL-DTL-55302.

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

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

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

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

4.11.2 Extra connectors. An extra connector should not be used to meet this guideline without the approval of the procuring activity.

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

4.11.4 Crimp contact connectors. When crimp contact environmentally sealed connectors are used, all contact positions should be filled with contacts. Crimp connectors should conform to MIL-C-81659.

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

4.11.6 Potted connectors. For potted connectors, each unused contact should have a maximum gauge wire of 150 mm minimum length attached and identified with the contact designation for future use. For connectors external to the unit, the wire end should be suitably capped to prevent moisture from entering the connector.

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

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

4.14 Fireproof connectors. Fireproof and firewall connectors should be class K and should conform to MIL-DTL-83723, MIL-DTL-38999, or MIL-DTL-5015. Where it is necessary to maintain electrical continuity for a limited time under continuous flame, both the receptacle and mating plug should be class K. If flame integrity only is necessary without the need for electrical continuity, a class K receptacle should be used, but the mating plug may be of any type and class. In all cases, the plug and receptacle should be environment resisting.

4.15 Filter pin connectors. Electrical connectors incorporating filter pins should be considered for use only when conventional electrical filters are not acceptable.

4.16 Composite connectors. Miniature composite environment resisting connectors should conform to MIL-C-29600 or MIL-DTL-38999.

4.17 Rack and panel connectors. Rack and panel connectors should conform to MIL-DTL-24308, MIL-DTL-26518, MIL-DTL-28748, and MIL-DTL-83733.

4.18 Miniature type connectors. Miniature type connectors should conform to MIL-DTL-21617, MIL-DTL-32139, and MIL-DTL-83513.

4.19 Modular component parts. Modular and component parts should conform to MIL-C-28754.

4.20 High density connectors. High density connectors should conform to MIL-DTL-28804 and MIL-DTL-38999.

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 11

INSULATING MATERIALS, ELECTRICAL

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

2. Applicable documents The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

L-P-516	Plastic Sheet and Plastic Rod, Thermosetting, Cast.
MIL-I-631	Insulation, Electrical, Synthetic-Resin Composition, Nonrigid.
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-17205	Insulation Cloth and Tape, Electrical, Glass Fiber, Varnished.
MIL-I-19166	Insulation Tape, Electrical, High-Temperature, Glass Fiber, Pressure-Sensitive.
MIL-I-22076	Insulation Tubing, Electrical, Nonrigid, Vinyl, Very Low Temperature Grade.
MIL-I-22129	Insulation Tubing, Electrical, Polytetrafluoroethylene Resin, Nonrigid.
MIL-I-23264	Insulators, Ceramic, Electrical and Electronic, General Specification for.
MIL-I-24092	Insulating Varnishes and Solventless Resins for Application by the Dip Process.
MIL-I-24391	Insulation Tape, Electrical, Plastic, Pressure-Sensitive.
MIL-I-24768/2	Insulation, Plastics, Laminated, Thermosetting, Glass Cloth, Epoxy-Resin (GEE).
MIL-I-24768/3	Insulation, Plastics, Laminated, Thermosetting, Glass Cloth, Epoxy-Resin (GEB).
A-A-59770	Insulation Tape, Electrical, Pressure Sensitive Adhesive and Pressure Sensitive Thermosetting Adhesive.
SAE AMS 3638	Tubing, Irradiated Polyolefin Plastic, Electrical Insulation Pigmented, Semi-Rigid, Heat-Shrinkable, 2 to 1 Shrink Ratio.
SAE AMS 3653	Tubing, Electrical Insulation Standard Wall, Extruded Polytetrafluoroethylene (PTFE).
SAE AMS 3654	Tubing, Electrical Insulation Light Wall, Extruded Polytetrafluoroethylene (PTFE).
SAE AMS 3655	Tubing, Electrical Insulation Thin Wall, Extruded Polytetrafluoroethylene (PTFE).
ASTM D 3295	Standard Specification for PTFE Tubing, Minature Beading and Sprial Cut Tubing.
ASTM D 4388	Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes.
29 CFR 1910	Code of Federal Regulations, Title 29, Chapter XVII, Part 1910.
NEMA FI 3	Calendered Aramid Papers Used for Electrical Insulation.
NEMA RE 2	Electrical Insulating Varnish.
SAE AS 81765	Insulating Components, Molded, Electrical, Heat Shrinkable, General Specification For.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Ceramics. Ceramic insulators should conform to MIL-I-23264.

4.2 Electrical tape. Tape should be selected from the types in MIL-I-3158, A-A-59770, MIL-I-17205, MIL-I-19166, MIL-I-24391, and ASTM D 4388.

4.3 Sleeving and tubing. Sleeving and tubing should conform to MIL-I-631, MIL-I-3190, MIL-I-22076, MIL-I-22129, SAE AMS 3638, SAE AMS 3653, SAE AMS 3654, SAE AMS 3655, or ASTM D 3295. MIL-I-631 should also apply to film, film tape, and sheet and sheet tape forms of insulation.

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

4.5 Plastic, thermosetting, laminated. Materials selected should conform to MIL-I-24768/2 and MIL-I-24768/3 or NEMA FI 3. The preferred base is glass cloth. Electrical insulators fabricated from laminated thermosetting-plastic

sheets, plates, rods, and tubes (except transparent plastics) should 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. Molded parts which undergo subsequent machining should be vacuum impregnated with a suitable moisture barrier material and dried after all surface-breaking operations have been completed. Cotton and linen should 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, electrical insulating. Insulating varnish should conform to NEMA RE 2 or MIL-I-24092.

4.8 Heat shrinkable insulators. For applications requiring heat shrinkable insulators other than sleeving, such as strain relief boots or enclosure feed throughs, the material should conform to SAE AS81765.

4.9 Polyvinyl chloride. Polyvinyl chloride insulating materials should not be used in aerospace applications. Their use in other applications requires procuring activity approval.

5. Detail guidelines.

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

a. Temperature endurance.

b. Moisture absorption and penetration.

c. Fungus resistance.

d. Dielectric strength.

e. Dielectric constant.

f. Mechanical strength.

g. Dissipation factor.

h. Ozone resistance.

i. Flammability.

5.2 Carcinogens. Certain chemicals have been identified in the Occupational Safety and Health Act (OSHA) as cancer-producing substances (carcinogens). Before using any materials which might contain these chemicals, they should be evaluated in accordance with 29 CFR 1910. Consideration of the toxicity of a substance should be given prior to material selection. Consideration of hazards should address all stages of the equipment lifecycle from fabrication to assembly, to installation, use maintenance, and decomposition during failure analysis and troubleshooting.

GUIDELINE 12

FASTENER HARDWARE

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

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 (Inch) and Slotted Headless (Inch and Metric).
FF-W-84	Washers, Lock (Spring).
FF-W-92	Washer, Flat (Plain).
FF-W-100	Washer, Lock, (Tooth).
MIL-DTL-1222	Studs, Bolts, Screws and Nuts for Applications Where A High Degree of Reliability is Required; General Specification for.
MIL-R-7885	Rivets, Blind, Structural, Mechanically Locked Spindle and Friction Locked Spindle, General Specification for.
MIL-DTL-18240	Fastener Element, Self-Locking, Threaded Fastener, 250 Deg. F Maximum.
MIL-R-24243	Rivets, Blind, Nonstructural, Retained Mandrel, General Specification for.
A-A-59313	Thread, Compound; Antiseize, Zinc Dust-Petrolatum.
AIA/NAS 498	Fasteners, Alloy Steel Externally Threaded, 95 KSI Fsu, 450 Degrees F.
AIA/NAS 547	Fastener; Rotary, Quick-Operating, High Strength.
AIA/NAS 1686	Rivet, Blind, Aluminum Sleeve, Mechanically Locked Spindle, Bulbed.
AIA/NAS 1687	Rivet, Blind, Monel and Inconel Sleeve, Mechanically Locked Spindle, Bulbed.
AIA/NASM5591	Fasteners, Panel; Nonstructural.
AIA/NASM5674	Rivets, Structural, Aluminum Alloy, Titanium Columbium Alloy, General Specification for.
AIA/NASM6812	Fasteners, Externally Threaded Alloy Steel Corrosion Resistant Steel.
AIA/NASM7838	Bolt, Internal Wrenching, 160 KSI FTU.
AIA/NASM8814	Rivets, Blind, Nonstructural Type.
AIA/NASM8831	Fasteners, Alloy Steel, 450 Degrees F Externally Threaded, 180 KSI Ftu, 108 KSI Fsu, Fatigue Rated.
AIA/NASM22978	Fastener, Rotary, Quick-Operating, High-Strength.
AIA/NASM25027	Nut, Self-Locking 250 Degrees F, 450 Degrees F, and 800 Degrees F.
AIA/NASM27384	Rivet, Blind, Drive Type.
AIA/NASM33522	Rivets, Blind, Structural, Mechanically Locked and Friction Retainer Spindle, (Reliability and Maintainability), Design and Construction Requirements for.
AIA/NASM33540	Safety Wiring, Safety Cabling, Cotter Pinning, General Practices for.
AIA/NASM33557	Nonstructural Rivets for Blind Attachment; Limitations for Design and Usage.
FED-STD-H28/2	Screw-Thread Standards for Federal Services, Section 2 Unified Inch Screw Threads - UN and UNR Thread Forms.
ASME B1.1	Unified Inch Screw Threads (UN and UNR Thread Form).
ASME B1.13M	Metric Screw Threads: M Profile.
ASME B18.2.1	Square and Hex Bolts and Screws (Inch Series).
ASME B18.3	Socket Cap, Shoulder, and Set Screws, Hex and Spline Keys (Inch Series).
ASME B18.6.3	Machine Screws and Machine Screw Nuts.
ASME B18.6.7M	Metric Machine Screws.
ASME B18.21.1	Lock Washers (Inch Series).
ASME B18.22.1	Plain Washers.
ASME B18.24	Part Identifying Number (PIN) Code System Standard for B18 Fastener Products.
ASME B18.29.1	Helical Coil Screw Thread Inserts – Free Running and Screw Locking (Inch Series).
ASTM A 325	Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.

ASTM A 354	Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners.
ASTM A 449	Standard Specification for Quenched and Tempered Steel Bolts and Studs.
ASTM A 490	Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength.
ASTM D5363	Anaerobic Single-Component Adhesives (AN).
SAE AS 8879	Screw Threads - UNJ Profile, Inch Controlled Radius Root with Increased Minor Diameter.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Threaded fasteners and related parts.

4.1.1 Threaded fasteners. ASME B18 Commercial/Industrial fastener standards covering inch and metric externally threaded, internally threaded, and non-threaded fastener products should be specified in conformance with ASME B18.24 “Part Identifying Number (PIN) Code System Standard” for B18 Fastener Products.

4.1.2 Screw threads. Screw thread selection should be based on the using applications in accordance with the following.

a. Screw threads should be in accordance with FED-STD-H28/2, ASME B1.1, or ASME B1.13M in applications where the threaded fasteners are required to mate with or mount threaded commercial equipment or devices.

b. Screw threads should be in accordance with SAE AS 8879 for applications requiring high strength or high fatigue life. (Caution should be exercised where a SAE AS 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 should be selected in accordance with SAE AS 8879.

4.1.3 Screws. Screws should conform to the specifications listed below.

a. Machine screws should conform to FF-S-92, ASME B18.6.3, or ASME B18.6.7M.

b. Cap screws should conform to FF-S-85, FF-S-86, or ASME B18.2.1.

c. Set-screws should conform to FF-S-200, FF-S-210, or ASME B18.3.

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

4.1.4 Bolts. Bolts should conform to the specifications listed below.

a. Hex bolts should conform to one of the following specifications:
ASME B18.2.1 ASTM A 325 ASTM A 490.
ASTM A 449 ASTM A 354

b. Bolt studs should conform to MIL-DTL-1222.

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

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

e. High tensile strength bolts should conform to NASM-8831.

f. Shear bolts should conform to NAS498.

4.1.5 Nuts. Nuts should conform to the specifications listed below.

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

b. High temperature nuts should conform to MIL-DTL-1222.

c. Self-locking nuts should conform to NASM25027.

4.1.5.1 Sheet spring nuts. Sheet spring nuts should not be used without specific approval of the procuring agency.

4.1.6 Safety wiring and cotter pins. Application of safety wiring and cotter pins should conform to NASM33540.

4.1.7 Quarter turn fasteners. Quarter turn fasteners should conform to NASM5591.

4.1.8 Rotary quick operating high strength fasteners. Rotary quick operating high strength fasteners should conform to NASM22978 or NAS 547.

4.1.9. Lock washers. Lock washers should conform to the specifications listed below.

a. Spring lock washers should conform to FF-W-84 or ASME B18.21.1.

b. Tooth lock washers should conform to FF-W-100 or ASME B18.21.1.

4.1.10 Flat washers. Flat washers should conform to FF-W-92 or ASME B18.22.1.

4.1.11 Thread-locking and retaining compounds. Thread-locking and retaining compounds should conform to ASTM D 5363.

4.1.12 Antiseize compounds. Antiseize compounds should conform to A-A-59313.

4.1.13 Helical coil. Helical coil screw thread Inserts should conform to ASME B18.29.1.

4.2 Rivets.

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

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

b. Nonstructural blind rivets should conform to NASM8814.

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

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

a. Aluminum and Aluminum Alloy solid rivets should conform to NASM 5674.

b. Structural, blind, pull-stem rivets should conform to MIL-R-7885, NAS 1686, or NAS 1687.

c. Blind, drive type rivets should conform to NASM27384.

5. Detail guidelines.

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 should 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 one and a half times the nominal diameter of the internal thread. Where the material thickness is insufficient to accommodate a one and a half 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 lock washers or self-locking threaded inserts are not used, a thread-locking compound in accordance with 4.1.11 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 4.1.11 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 4.1.12 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 length equivalent to one and a half thread pitches plus the chamber. Maximum length should be limited by the nearest larger standard screw length. For highly stressed applications, screws or bolts should have a minimum thread engagement of one and a half 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, should not be less than one and a half times the rivet diameter. Design and limitations of rivets should be in accordance with NASM33522 and NASM33557. 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 4.1.11 applied to the threads.

e. Safety wire through drilled heads in accordance with 4.1.6.

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 4.1.11. 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.

GUIDELINE 13

STRUCTURAL WELDING

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-STD-22	Welded Joint Design.
MIL-HDBK-730	Materials Joining.
MMPDS	Metallic Materials Properties Development and Standardization.
TACOM DWG 12479550	Arc Welding Procedures for Constructional Steel.
AWS-D 17.	Specification for Fusion Welding for Aerospace Applications.
AWS A2.4	Standard Symbols for Welding, Brazing, and Nondestructive Examination.
AWS A3.0	Standard Welding Terms and Definitions Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying.
SAE AMS 2680	Electron Beam Welding, for Fatigue Critical Application.
SAE AMS 2681	Welding, Electron-Beam.
SAE AMS W 6858	Welding, Resistance: Spot and Seam.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Arc and gas welding. Welding by arc and gas methods should be performed by operators who have passed the applicable certification tests and have a certificate of proficiency in accordance with AWS-D17.1. Welding of aluminum, magnesium, and steel alloys should conform to AWS-D17.1.

4.2 Resistance welding. Resistance welding of joints should conform to SAE AMS-W-6858.

5. Detail guidelines

5.1 Welding. The joint areas of all parts to be welded should be cleaned of contaminants and materials which may be detrimental to obtaining satisfactory welds. Degradation of material properties in the heat affected zone caused by welding should be considered. Weldments should be stress relieved when induced stress resulting from welding, design configuration, or materials welded may be harmful. See AWS A2.4 for welding symbols, AWS A3.0 for welding terms and definitions, and MIL-STD-22 for welded joint designs. MIL-HDBK-730 provides guidance in this field of materials joining and its related processes.

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

5.3 Noncritical applications. In ground equipment applications, welding procedures in accordance with Tacom Drawing 12479550 may be used where, if the weld should fail, it will not compromise personnel or equipment safety or prevent completion of the mission.

5.4 Other methods. Other welding methods, such as the electron beam process of SAE AMS 2680 and SAE AMS 2681, may be used provided approval is obtained from the procuring activity.

GUIDELINE 14

TRANSFORMERS, INDUCTORS, AND COILS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-PRF-27	Transformers and Inductors (Audio, Power, and High-Pulse), General Specification for
MIL-PRF-15305	Coils, Fixed and Variable, Radio Frequency, General Specification for
MIL-PRF-21038	Transformers, Pulse, Low Power, General Specification for
MIL-PRF-39010	Coils, Radio Frequency, Fixed, Molded, Established Reliability, General Specification for
MIL-PRF-83446	Coils, Radio Frequency, Chip, Fixed or Variable, General Specification for
MIL-T-55631	Transformer, Intermediate Frequency, Radio Frequency, and Discriminator, General Specification for
MIL-T-83721	Transformers, Variable, Power, General Specification for
MIL-STD-981	Design, Manufacturing and Quality Standards for Custom Electromagnetic Devices for Space Applications

3. Definitions. This section not applicable to this guideline.

4. General Guidelines.

4.1 Selection. Selection of transformers, inductors, and coils should be in accordance with the following sections.

4.1.1 Transformers and Inductor. Power transformers, power inductors, audio transformers, audio inductors, high power pulse transformers, charging inductors, saturable transformers and saturable inductors should conform to MIL-PRF-27.

4.1.2 Coils, radio frequency, fixed and variable. Coils, radio frequency, fixed and variable should conform to MIL-PRF-15305.

4.1.3 Transformers, pulse, low power. Low power pulse transformers should conform to MIL-PRF-21038.

4.1.4 Coils, radio frequency, fixed, molded, established reliability (ER). ER and non-ER fixed, radio frequency, molded coils should conform to MIL-PRF-39010.

4.1.5 Coils, radio frequency, chip, fixed or variable. Requirements for fixed or variable, chip coils should conform to MIL-PRF-83446.

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

4.1.7 Variable transformers. Variable transformers should conform to MIL-T-83721.

4.1.8 Custom electromagnetic devices for space applications. Custom electromagnetic devices for space applications should conform to MIL-STD-981.

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 15

METALS, CORROSION RESISTANCE

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-STD-889 Dissimilar Metals

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Corrosion resistant. Metals should be corrosion resistant or should be coated or metallurgically processed to resist corrosion.

4.2 Metallic parts. Materials and processes for metallic parts should conform to applicable requirements in MIL-STD-889.

5. Detail guidelines.

5.1 Selection of metals. The environmental severity to which the equipment will be exposed should be considered in selection of metals.

5.2 Noncorrosion resistant. The use of noncorrosion resistant steel alloys, except where specifically required for electronic purposes, should be kept to a minimum.

GUIDELINE 16

DISSIMILAR METALS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-STD-889	Dissimilar Metals

3. Definitions. This section not applicable to this guideline.

4. General Guidelines.

4.1 Selection of metals. Selection of metals for use in electronic equipment should be made in accordance with the requirements of MIL-STD-889.

5. Detail Guidelines.

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

GUIDELINE 17

PRINTED WIRING

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

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

3. Definitions. This section not applicable to this guideline.

4. General Guidelines.

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

4.2 Rigid printed wiring assemblies. Rigid printed wiring assemblies consisting of rigid printed wiring boards, on which separately manufactured parts have been added, should conform to MIL-HDBK-1861.

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

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

4.5 Discrete wiring boards. Discrete wiring boards with plated-through holes should be in accordance with MIL-HDBK-1861.

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

5. Detail guidelines.

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

GUIDELINE 18

DERATING OF ELECTRONIC PARTS AND MATERIALS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-HDBK-1547 Electronic Parts, Materials, and Processes for Space and Launch Vehicles

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

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

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

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 19

TERMINATIONS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-DTL-15659	Terminal, Lug; Solder, Copper and Phosphor Bronze.
MIL-T-55156	Terminals, Lug, Splices, Conductor; Screw Type, General Specification for.
MIL-HDBK-1277	Splices, Chips, Terminals, Terminal Boards, Binding Posts, Electrical.
A-A-59125	Terminal Boards, Molded, Barrier Screw and Stud Types and Associated Accessories.
SAE AS 7928	Terminals, Lug: Splices, Conductor: Crimp Style, Copper, General Specification for.
SAE AS 27212	Terminal Board Assembly, Molded-In- Stud, Electric.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Terminals. Lug terminals, stud terminals, feed-through terminals, and binding posts should be selected from MIL-HDBK-1277.

4.1.1 Lug terminals. Lug terminals should conform to one of the following specifications:

MIL-DTL-15659	Solder
MIL-T-55156	Screw

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

4.2 Terminal boards. Terminal boards should be selected from MIL-HDBK-1277.

4.2.1 Number of lugs per terminal. The maximum number of lugs to be connected to any one terminal on a terminal board should be two for screw-type terminal boards covered by A-A-59125 and as specified in the specification sheets for stud-type terminal boards. Not more than four lugs should be connected to any one terminal of a board covered by SAE AS27212. Accessories such as stud connectors, straddle plates, jumpers, and terminal board lugs should be counted as lugs for this purpose.

4.3 Terminal junction systems. Terminal junction systems should be selected from MIL-HDBK-1277.

5. Detail guidelines.

5.1 Crimping. Crimping of terminal lugs should be so accomplished that the connections will meet the resistance (voltage drop), and tensile strength requirements, and tests of SAE AS 7928.

GUIDELINE 20

WIRE, HOOKUP, INTERNAL

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-DTL-16878	Wire, Electrical, Insulated, General Specification for.
MIL-DTL-81381	Wire, Electric, Polyimide-Insulated, Copper or Copper Alloy.
A-A-59551	Wire, Electrical, Copper (Uninsulated).
MIL-STD-681	Identification Coding and Application of Hook-Up and Lead Wire.
ASTM B 298	Standard Specification for Silver-Coated Soft or Annealed Copper Wire.
SAE AS 22759	Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy.
SAE AS 50861	Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy.
SAE AS 81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-Imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy.
SAE AS81822	Wire, Electrical, Solderless Wrap, Insulated and Uninsulated.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

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

4.1.1 MIL-DTL-16878 usage. MIL-DTL-16878 should not be used for Air Force or Navy aerospace applications.

4.1.2 SAE AS 22759 usage. SAE AS 22759 wire with only single polytetrafluoroethylene insulation used in Air Force space and missile applications should require the approval of the procuring activity.

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

4.1.4 Silver plated copper wire. Silver plated copper wire should not be used in applications involving Army missile systems without certification by the wire manufacturer that it passes the sodium polysulfide test in accordance with ASTM B 298. Silver plated copper wire should not be used in conjunction with water-soluble solder fluxes. Wire should be stored and handled in such a way so as to minimize exposure to moisture.

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

4.3 Bare wire. Bare hookup wire should be type H, class S, soft or drawn and annealed, and coated, and should conform to A-A-59551. Bare hookup wire should not be used unless insulated wire is impractical because of circuit characteristics or shortness of wire run.

5. Detail guidelines.

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

parts. There are some other instances, such as wire wrapping, where a solid conductor may be required regardless of length.

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

5.3 Stranded copper conductor test. The following test procedure should be used for stranded conductors since the ASTM B 298 procedure covers only a single, round conductor.

5.3.1 Sodium polysulfide test. Stranded samples of annealed copper or copper alloy conductors should be tested in accordance with ASTM B 298. When this test is performed, one factor which should be taken in to consideration is that the ASTM test applies to single end wires taken before stranding. Thus, the applicability of the polysulfide test is restricted by the ASTM in recognition of the abrasion to the wire inherent in the stranding process. As a result, the following exceptions and criteria apply when testing stranded product:

a. Examination of the samples to occur immediately after the solution cycle.

b. Samples to be immersed into the solution in the as-stranded condition.

(1) Unilay constructions to be tested as the whole conductor.

(2) Concentric constructions to be tested as whole conductor.

(3) Two members from each layer of rope constructions to be tested after they have been carefully removed from the finished rope.

GUIDELINE 20

TABLE 20-I. Wire, electrical

Spec no	Title	Construction: Spec type or class	Material	Conductor Coating 1/	Type	Primary	Insulation Primary Cover 2/	Jacket topcoat	Max Cond temp °C	Max rms volts
MIL-W-5086	Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy	SAE AS 50861	Cu/A	Sn				8	105	600
		SAE AS 50861						8, 11		
		SAE AS 50861	HSA	Ag	Str	1		8	110	3000
		SAE AS 50861						9A		
		SAE AS 50861								600
		SAE AS 50861	Cu/A	Sn				8	105	
MIL-DTL-16878 See Note 4	Wire, Electrical, Insulated	M16878/1	Cu/A, HSA, CCW	Ag, Sn	S,Str	1	8,10,11	1,8,10, 11	105	600
		M16878/2								1000
		M16878/3								3000
		M16878/4		Ag		3A		3/ 3A, 3B, 4A, 13B	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	
		M16878/12								1000
		M16878/13								250
		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		3/ 3A, 3B, 4A 13B	200	250
		M16878/21								600
		M16878/22								1000
		M16878/23		Ni		3A			260	250
		M16878/24				3B				600
		M16878/25				3A				
		M16878/26				3B				
		M16878/27				3A				1000

Spec no	Title	Construction							Max Cond temp °C	Max rms volts
		Spec type or class	Material	Conductor Coating 1/	Type	Primary	Insulation Primary Cover 2/	Jacket topcoat		
		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	
SAE-AS22759 See Note 4	Wire, Electrical, Fluoropolymer Insulated, Copper or Copper Alloy	M22759/9	Cu/A	Ag	Str	3A			200	1000
		M22759/10		Ni					260	
		M22759/11		Ag					200	
		M22759/12		Ni					260	
		M22759/14		Sn		4A		9B	135	
		M22759/15	HSA	Ag						600
		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				21	150	
		M22759/35	HSA	Ag					200	
		M22759/41	Cu/A	Ni						
		M22759/42	HSA							
		M22759/43	Cu/A	Ag						
SAE-AS81044 See Note 5	Wire, Electric, Crosslinked Poly-alkene, etc.	AS81044/12	Cu/A	Sn	Str	2B		9B	150	600
		AS81044/13	HSA	Ag						

GUIDELINE 20

Spec no	Title	Construction							Max Cond temp °C	Max rms volts
		Spec type or class	Material	Conductor Coating 1/	Type	Primary	Insulation Primary Cover 2/	Jacket topcoat		
	Insulated									
MIL-DTL-81381 See Note 6	Wire, Electric, Polymide-Insulated, Copper or Copper Alloy	M81381/7	Cu/A	Ag	Str	19		20	200	600
		M81381/8		Ni						
		M81381/9	HSA	Ag			4B			
		M81381/10		Ni						
		M81381/11	Cu/A	Ag						
		M81381/12		Ni						
		M81381/13	HSA	Ag						
		M81381/14		Ni						
		M81381/17	Cu/A	Ag						
		M81381/18		Ni						
		M81381/19	HSA	Ag						
		M81381/20		Ni						
		M81381/21	Cu/A	Sn					150	
		M81381/22								

TABLE 20-I. Wire, electrical - Continued.

1/ Conductor Code		Description
Material	Cu/A	Copper, annealed
	Cu/H	Copper, hard drawn
	CCW	Copper, covered steel
	HAS	High strength copper alloy
	A1	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 wire specifications.

5/ See application temp limitation on spec sheet.

6/ /11, /12, and /22 have a bright aromatic poly-amide braid with clear finisher coatings on 8 AWG and larger.

GUIDELINE 21

CASTINGS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-STD-276	Impregnation of Porous Metal Castings And Powdered Metal Components.
SAE AMS-STD-2175	Castings, Classification and Inspection of.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

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

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

4.3 Classification and inspection. Castings should be classified and inspected in accordance with SAE AMS-STD-2175.

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

5. Detail guidelines.

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

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

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

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

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

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

GUIDELINE 22

PARTS MANAGEMENT

1. Purpose. This guideline offers guidance as to parts management and selection which may be considered when preparing contractual documents. Parts management and selection should be directly specified in the contract or the system/equipment specification, as appropriate.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-STD-3018	Parts Management.
SD-19	Life Cycle Cost Savings Through Parts Management.
AIAA R-100	Recommended Practice for Parts Management.

3. Definitions. This section not applicable to this guideline.

4. General guidelines. This section not applicable to this guideline.

5. Detail guidelines.

5.1 Parts management program. SD-19 provides Government and industry managers a pragmatic approach toward parts management to keep weapon system acquisition cost, total ownership cost, and supportability cost at a manageable level. When used in conjunction with MIL-STD-3018, “Parts Management”, the guidance herein will help achieve successful parts management support to acquisition strategy. This document offers guidance to individuals who are defining parts management needs in contracts; establishing a parts management process for prime contractors, suppliers, and subcontractors; and looking for an efficient and a manageable part selection process. MIL-STD-3018 establishes procedures covering the submission, review, and approval of Program Parts Selection Lists, and changes thereto. The objective is to achieve life cycle cost savings and cost avoidances by:

a. Assisting equipment or system managers and their contractors in the selection of parts commensurate with contractual requirements.
b. Minimizing the variety of parts used in new design.
c. Enhancing interchangeability, reliability, and maintainability of military equipment and supplies.
d. Conserving resources.
e. Assuring long term availability of parts. MIL-STD-3018should be tailored when applied; application guidance is offered in the document.

5.2 Parts management program for spacecraft and launch vehicles. (Not applicable to NASA programs.) AIAA-R-100 establishes the criteria and guidelines for the preparation and implementation of a Parts, Materials, and Processes Standardization Control and Management Program for use during the design, development, fabrication, and test of spacecraft and launch vehicles. The implementation of this handbook is intended to:

a. Ensure total, integrated, and coordinated management of the selection, application, procurement, and standardization of parts, materials and processes.
b. Reduce program costs.
c. Improve the standardization and reliability of program parts, materials, and processes.
d. Assure long term availability of parts.

GUIDELINE 23

ADHESIVES

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MMM-A-121	Adhesive, Bonding, Vulcanized Synthetic Rubber to Steel.
MMM-A-132	Adhesives, 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	Adhesives, Phenol, Resorcinol, or Melamine Base.
MMM-A-189	Adhesive, Synthetic-Rubber, Thermoplastic, General Purpose.
MIL-A-3920	Adhesive, Optical, Thermosetting.
MIL-A-22397	Adhesive, Phenol and Resorcinol Resin Base (for Marine Service Use).
MIL-A-24179	Adhesive, Flexible Unicellular-Plastic Thermal Insulation.
MIL-A-46146	Adhesive-Sealants, Silicone, RTV, Non Corrosive (For Use With Sensitive Metals and Equipment).
MIL-HDBK-691	Adhesive Bonding.
29 CFR 1910	Code of Federal Regulations, Title 29, Chapter XVII, Part 1910.
A-A-1936	Adhesives, Contact, Neoprene Rubber.
A-A-3097	Adhesives, Cyanoacrylate, Rapid Room Temperature-Curing, Solventless.
SAE AMS-A-8576	Adhesive, Acrylic Base, for Acrylic Plastic.
SAE AMS-A-25463	Adhesive, Film Form, Metallic Structural Sandwich Construction.

3. Definitions. This section not applicable to this guideline.

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. General guidelines. This section not applicable to this guideline.

5. Detail guidelines.

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 nonaxial 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 adherents are porous, successive thin coats of adhesive should be applied to completely seal the surface, and each coat should be dry before the next coat is applied. This procedure should be used instead of the application of one thick adhesive coat to the porous surface, except in the case of silicone adhesives. In general, the thicker the adhesive layer, the lower the shear resistance, but the higher the strength to impact and peeling.

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

5.5 Carcinogens. Certain chemicals have been identified in the Occupational Safety and Health Act (OSHA) as cancer producing substances (carcinogens). Before using any materials which might contain carcinogens, they should be evaluated in accordance with 29 CFR 1910. Consideration of the toxicity of a substance should be given prior to material selection.

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

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

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

MMM-A-121	MIL-A-3920	A-A-1936
MMM-A-132	MIL-A-22397	A-A-3097
MMM-A-134	MIL-A-24179	SAE AMS-A-8576
MMM-A-138	MIL-A-46146	SAE AMS-A-25463
MMM-A-181	MIL-HDBK-691	
MMM-A-189		

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.

GUIDELINE 24

WELDS, RESISTANCE, ELECTRICAL INTERCONNECTIONS

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

2. Applicable documents. This section not applicable to this guideline.

3. Definitions. This section not applicable to this guideline.

4. General guidelines. This section not applicable to this guideline.

5. Detail guidelines.

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

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

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

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

GUIDELINE 25

ELECTRICAL POWER

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

2. Applicable documents.

MIL-STD-704	Aircraft Electric Power Characteristics.
MIL-STD-1275	Characteristics of 28 Volt DC Electrical Systems in Military Vehicles.
MIL-STD-1399	Interface Standard for Shipboard Systems.
MIL-HDBK-411	Power and The Environment for Sensitive DoD Electronic Equipment.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Airborne. The electrical power guidelines for airborne and associated equipment should be in accordance with MIL-STD-704.

4.2 Shipboard. The electrical power guidelines for shipboard and associated equipment should be in accordance with type I or type II of section 300 of MIL-STD-1399.

4.3 Ground vehicles. The electrical power guidelines for military ground vehicles should be in accordance with MIL-STD-1275.

5. Detail guidelines.

5.1 Critical fixed communications and related automatic data processing facilities. MIL-HDBK-411 provides the electrical power guidelines for critical communications and related automatic data processing equipment and should be for a nominal -48 V dc uninterruptible power supply.

GUIDELINE 26

ARC-RESISTANT MATERIALS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

L-P-516	Plastic Sheet and Plastic Rod, Thermosetting, Cast.
MIL-I-24768	Insulation, Plastics, Laminated, Thermosetting, General Specification for.
A-A-59588	Rubber, Silicone.
ASTM D 495	Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.
ASTM D 5213	Standard Specification for Polymeric Resin Film for Electrical Insulation and Dielectric Applications.
ASTM D 5948	Standard Specification for Molding Compounds, Thermosetting.
29 CFR 1910	Code of Federal Regulations, Title 29, Chapter XVII, Part 1910.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Materials. Materials should conform to table 26-I. The materials listed have passed the minimum guidelines of 115 seconds when subjected to the arc-resistance test of ASTM D 495 and are listed in approximate order of arc resistance.

5. Detail guidelines.

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

5.2 Carcinogens. Certain chemicals have been identified in the Occupational Safety and Health Act (OSHA) as cancer-producing substances (carcinogens). Before using any materials which might contain these chemicals, they should be evaluated in accordance with 29 CFR 1910. Consideration of the toxicity of a substance should be given prior to material selection.

GUIDELINE 26

TABLE 26-I. Arc-resistant materials.

Materials	Specification	Types
Plastic(s), thermosetting, molding		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	ASTM D 5948	MEE
Laminated rods and tubes, Laminated sheets	MIL-I-24768	GMG
Glass cloth, silicone resin	MIL-I-24768	GSG
Sheet and rod, cast	L-P-516	E-2
Sheet and strip, polyimide	ASTM D 5213	All
Silicone rubber	A-A-59588	All

GUIDELINE 27

BATTERIES

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

W-B-133	Battery, Storage, Lead-Acid (Industrial Motive Power Service).
MIL-PRF-8565	Batteries, Storage, Aircraft, General Specification for.
MIL-B-18013	Battery, Storage, Support Equipment, General Specification for.
DOD-B-24541	Battery Cells and Elements, Lead-Acid, Main Storage, Submarine; General Specification for.
MIL-B-29595	Batteries and Cells, Lithium, Aircraft, General Specification for.
MIL-PRF-49450	Battery, Rechargeable, Nickel-Cadmium, Vented, Aircraft.
MIL-PRF-49471	Batteries, Non-Rechargeable, High Performance.
MIL-PRF-81757	Batteries and Cells, Storage, Nickel-Cadmium, Aircraft, General Specification for.
DOD-STD-1578	Nickel-Cadmium Battery Usage Practices for Space Vehicles.
ANSI C18.1M	Dry Cells and Batteries-Specifications.
SAE J537	Storage Batteries.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

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

4.1.1 Army applications. Battery power for Army equipment (development and nondevelopment type) and other service developed equipment adopted by the Army should be selected in accordance with guidance available from the Army Communications-Electronics Command, Ft. Monmouth, NJ. The point of contact is:

Headquarters, Communications-Electronics Command
Attn: AMSEL-LC-P-AMC
Ft. Monmouth, NJ 07703
DSN 992-2411 or commercial (732) 532-2411

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

4.1.3 Lithium batteries. When lithium batteries are to be used in an equipment, direction on their use, transportation, storage, and disposal should be requested through the procuring activity from the following sources:

For Army:	US Army Communications-Electronics Command AMSEL-LC-P-AMC Ft Monmouth NJ 07703
For Navy:	Naval Surface Warfare Center Crane Division 300 Highway 361 Crane, IN 47522-3235
For Air Force:	AFMC/LGYE 4375 Chidlaw Road Post 119C Wright Patterson OH 45433−5006

4.2 Rechargeable batteries. Rechargeable batteries should conform to MIL-PRF-8565, DOD-B-24541, MIL-PRF-49450, DOD-STD-1578, W-B-133, or SAE J537.

4.3 Nonrechargeable batteries. Nonrechargeable batteries should conform to MIL-B-29595, MIL-PRF-49471, or ANSI C18.1M.

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

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

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

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

5. Detail guidelines.

5.1 Battery compartment. The battery compartment should be provided with devices to firmly secure the batteries. Adequate room should be provided for battery installation, maintenance, testing, and removal without disassembly of the equipment. The battery compartment should prevent pressure build-up from heat, gases, liquids, or chemicals released during battery operation, charging, deterioration, or rupture, and should also prevent such materials from entering the electronic compartment.

5.2 Magnesium dry batteries. When magnesium dry batteries are used, extra precautions should be observed since these batteries give off heat at high rates of discharge (less than 10 hours) and evolve hydrogen.

GUIDELINE 28

CONTROLS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

NASM28728 Dial, Control, Multi-Turn Counters, General Specification for

3. Definitions.

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

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

4. General Guidelines.

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

4.2 Accessibility.

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

4.2.2 Adjustment controls. Adjustment controls that are required for periodic alignment or calibration should be mounted behind covered openings, such as access doors, on the surfaces of the equipment accessible when installed. When not adjustable by hand, controls should be designed to accept a common screwdriver blade tip. Controls which infrequently require adjustment need not be accessible from the operating panel, but should be readily accessible for servicing when the equipment is opened for maintenance purposes.

4.3 Mechanical characteristics.

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

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

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

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

4.3.5 Control knobs and handles. Control knobs and handles should have high impact strength and should be firmly secured to the control shafts by use of setscrews wherever that type of fastener is applicable. Plastic knobs and handles should have metal inserts for setscrews and should not warp or crack.

4.3.6 Multiturn counters control dials. Manually operated multiturn counters control dials should conform to NASM28728.

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

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

5. Detail guidelines.

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

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

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

GUIDELINE 29

ELECTRON TUBES

1. Purpose. This guideline establishes criteria to support the design and testing of electron tube devices and their application equipment.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-PRF-1	Electron Tubes, General Specification for.
MIL-STD-1311	Test Methods for Electron Tubes.
QPL-1	Qualified Products List of Products Qualified Under Performance Specification MIL-PRF-1 Electron Tubes, General Specification for.

3. Definitions. Terms, definitions, methods, abbreviations, and symbols used in conjunction with electron tubes are found in appendices of MIL-PRF-1.

4. General guidelines.

4.1 General requirements and classification. General requirements and ratings for electron tubes used by the military are found in MIL-PRF-1. The main category into which each tube is classified is indicated in the title of the tube specification sheet (TSS).

4.2 Production, test and reliability. Manufacture of electron tubes will use production and test facilities and a quality and reliability assurance program adequate to ensure compliance with MIL-PRF-1 and its corresponding TSS.

4.3 Qualification. Adequacy of electron tube manufacturer to meet the acceptance requirements of MIL-PRF-1 and the TSS is determined by the qualifying activity. Uniform methods for testing environmental, physical, and electrical characteristics of electron tubes as required by MIL-PRF-1 and the TSS are provided by MIL-STD-1311.

4.3.1 Delivery. Only electron tubes inspected for and meeting all requirements of MIL-PRF-1 and the TSS are to be marked as compliant and delivered. Tubes furnished under MIL-PRF-1 are either tubes authorized by the qualifying activity for listing on the qualified products list (QPL) or tubes passing first article inspection (determined by TSS and Contracting Officer). The QPL cross references tube designation numbers with TSS numbers and qualified manufacturers and is updated annually. The Contracting Officer can waive first article acceptance for manufacturers who pass first article testing on previous, recent contracts.

4.4 Critical interfaces. Critical interfaces of an electron tube are specified in appendices of MIL-PRF-1 and in the TSS.

5. Detailed guidelines. Equipment using tubes manufactured in accordance with MIL-PRF-1 should be designed so that the tubes perform satisfactorily in the normal service for which the equipment is designed. The use of characteristics not controlled by MIL-PRF-1 is not permitted without specific military command or service approval.

GUIDELINE 30

SEMICONDUCTOR DEVICES

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-PRF-19500	Semiconductor Devices, General Specification for
QML-19500	Qualified Manufacturers List of Products Qualified Under Performance Specification MIL-PRF-19500 Semiconductor Devices, General Specification for.
TEOOO-AB-GTP-010	Parts Requirements and Application Manual for Navy

3. Definitions.

3.1 Qualified device (semiconductors): Any device or semiconductor which has met the requirements of MIL-PRF-19500 and is listed on the associated Qualified Manufacturers Listing (QML).

3.2 Reliability. The probability of a part performing its specified purpose for the period intended under the operating conditions encountered.

3.3 Derating. The method of reducing stress or making quantitative allowances for a part's functional degradation. Consequently, derating is a means to reduce failures and extending part life. In addition, derating helps protect parts from unforeseen application anomalies and overstresses. See guideline 18.

4. General Guidelines.

4.1 Application. The use of semiconductor devices should be qualified and monitored to the application and environment they are used in. The "Parts Requirements and Application Manual for the Navy", TEOOO-AB-GTP-010, is recommended to be used as guidance.

4.2 Parts standardization. Parts standardization is encouraged. Standardization positively affects logistic supportability, the overall life cycle costs, obsolete part issues, as well as the quality and reliability of the devices. Standard semiconductor devices are manufactured in accordance with MIL-PRF-19500 and are listed in QML-19500, and in electronic format on the DSCC web site.

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 31

MOISTURE POCKETS

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

2. Applicable documents. This section not applicable to this guideline.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

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

5. Detail guidelines.

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

5.2 Sealed equipment. In sealed equipment or assemblies such as waveguides, the use of desiccants or other methods, such as gas purging, is not restricted.

GUIDELINE 32

TEST PROVISIONS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-HDBK-2165 Testability Program for Systems and Equipments

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

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

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

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

5. Detail guidelines.

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

GUIDELINE 33

RESISTORS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-HDBK-199 Resistors, Selection and Use of

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Selection. Resistors should be selected and applied in accordance with MIL-HDBK-199.

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 34

NOMENCLATURE

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-STD-196 Joint Electronics Type Designation System.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Nomenclature. Item names and type designations for electronic equipment should be established in accordance with MIL-STD-196.

5. Detail guidelines.

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

GUIDELINE 35

RELIABILITY

1. Purpose. This reliability guideline should be considered when preparing contractual documents. Reliability program tasks, quantitative requirements, and verification or demonstration requirements may be directly specified in the contract or the system/equipment specification, as appropriate.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-HDBK-781	Reliability Test Methods, Plans, and Environments for Engineering Development, Qualification, and Production.
MIL-HDBK-217	Reliability Prediction of Electronic Equipment.

3. Definitions. This section not applicable to this guideline.

4. General guidelines. This section not applicable to this guideline.

5. Detail guidelines.

5.1 Reliability program. Reliability engineering and accounting tasks aimed at preventing, detecting, and correcting reliability design deficiencies, weak parts, and workmanship defects and providing reliability related information essential to acquisition, operation, and support management should be included in contract requirements with the objective of establishing and maintaining an efficient reliability program according to life cycle phase. MIL-HDBK-781 and MIL-HDBK-217 provide additional guidance.

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

GUIDELINE 36

ACCESSIBILITY

1. Purpose. This guideline establishes criteria for accessibility.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-STD-1472	Human Engineering.
MIL-HDBK-505	Definition of Item Levels, Item Exchangeability, Models, and Related Terms.

3. Definitions.

3.1 Part, subassembly, and assembly. Part, subassembly, and assembly are as defined in MIL-HDBK-505.

4. General guidelines.

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

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

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

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

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

5. Detail guidelines.

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

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

GUIDELINE 37

CIRCUIT BREAKERS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-PRF-39019	Circuit Breakers, Magnetic, Low-Power Sealed, Trip-Free, General Specification for.
MIL-PRF-55629	Circuit Breakers, Magnetic, Unsealed or Panel Seal, Trip-Free, General Specification for.
MIL-PRF-83383	Circuit Breakers, Remote Control, Thermal, Trip Free, General Specification for.
MIL-HDBK-217	Reliability Prediction of Electronic Equipment.

3. Definitions.

3.1 Overcurrent protection. There are two main purposes for overcurrent protective devices: (1) The protection of components and equipment from overcurrent damage; and (2) To isolate sub-systems from a main system when a fault occurs.

3.2 Circuit breaker. A circuit breaker is a device that opens a circuit automatically, without damaging itself, when the current exceeds a predetermined value.

4. General guidelines.

4.1 Selection and application. Trip-free circuit breakers should be used. Nontrip-free circuit breakers should be used only when the application requires overriding of the tripping mechanism for emergency use.

4.2 Manual operation. Circuit breakers should be capable of being manually operated to the ON and OFF positions. Circuit breakers should 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 should 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 should operate when permanently inclined in any direction up to 30 from the normal vertical or normal horizontal position. The trip point of an inclined unit should not vary more than +5 percent of the current specified for normal position mounting. Circuit breakers used on flight equipment and portable test equipment should operate within the limits of the detail specification when the equipment is in any position or rotation about its three principal axes.

4.5 Reliability. MIL-HDBK-217 provides reliability prediction models for circuit breakers.

5. Detail guidelines.

5.1 Type and configuration. Circuit breakers are available in various sizes and configurations including thermal, magnetic, thermal-magnetic, and solid state types. The size and configuration of the package are dependent on the electrical characteristics, power dissipation, and the environmental requirements. There are many types available. To obtain further information on configuration, interface requirements, and testing, consult an individual military specification listed in section 2 of this guideline.

GUIDELINE 38

QUARTZ CRYSTALS AND OSCILLATOR UNITS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-PRF-3098	Crystal Units, Quartz, General Specification for.
MIL-PRF-55310	Oscillators, Crystal Controlled, General Specification for.
MIL-HDBK-217	Reliability Prediction of Electronic Equipment.

3. Definitions.

3.1 Crystal. A solid in which the constituent atoms or molecules are arranged with a degree of geometric regularity.

3.2. Crystal oscillator. An oscillator in which a piezoelectric crystal controls the frequency of oscillation.

3.3. Piezoelectric. A property of some crystals that produce a voltage when subjected to a mechanical stress; or, that when voltage is applied, undergo a mechanical stress.

4. General guidelines.

4.1 Crystal units and crystal oscillators units. Crystal units and crystal oscillators units should conform to MIL-PRF-3098 and MIL-PRF-55310 respectively.

4.2 Reliability. MIL-HDBK-217 provides reliability prediction models for quartz crystal units.

5. Detail guidelines:

5.1 Type and configuration. Crystal-controlled oscillators have many applications in electronic equipment. Oscillator types are designated as crystal oscillators (XO), voltage-controlled crystal oscillators (VCXO), temperature-compensated crystal oscillators (TCXO), oven-controlled crystal oscillators (OCXO), temperature-compensated/voltage-controlled crystal oscillators (TCVCXO), oven-controlled/voltage-controlled crystal oscillators (OCVCXO), microcomputer-compensated crystal oscillators (MCXO), and rubidium-crystal oscillators (RbXO). Definitions of the various oscillator types along with information on configuration, interface requirements and testing, can be found in MIL-PRF-55310. Details on quartz crystal units can be found in MIL-PRF-3098.

GUIDELINE 39

FUSES AND FUSE HOLDERS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-PRF-15160	Fuses, Instrument, Power, and Telephone, General Specification for.
MIL-PRF-19207	Fuseholders, Extractor Post Type, Blown Fuse, Indicating and Nonindicating, General Specification for.
MIL-PRF-23419	Fuse, Cartridge, Instrument Type, General Specification for.
MIL-HDBK-217	Reliability Prediction of Electronic Equipment.
SAE-ARP 1199	Selection, Application, and Inspection of Electric Overcurrent Protective Devices.

3. Definitions.

3.1 Overcurrent protection. There are two main purposes for overcurrent protective devices: (1) The protection of components and equipment from overcurrent damage; and (2) To isolate sub-systems from a main system when a fault occurs.

3.2 Fuse. A fuse is a protective device with a fusable link, or link, that will break the current when the current exceeds the capacity of the fuse. When potentially harmful overcurrents occur the link will melt rapidly to protect circuit components.

4. General guidelines.

4.1 Selection and application. Fuses, fuseholders, and associated hardware should be selected from SAE-ARP 1199.

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

4.3 Reliability. MIL-HDBK-217 provides reliability prediction models for fuses.

5. Detail guidelines.

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

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

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

5.4 Type and configuration. Fuses are available in a variety of configurations and sizes (e.g., surface mount, wire leads, blade type, fuse clips, and large cartridges). The size and configuration of the package are dependent on the electrical characteristics, power dissipation and the environmental requirements. There are many military types available. To obtain further information on configuration, interface requirements, and testing, consult an individual military specification listed i section 2 of this guideline.

GUIDELINE 40

SHUNTS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-I-1361	Instrument Auxiliaries, Electrical Measuring: Shunts, Resistors, and Transformers.
A-A-55524	Shunt, Instrument (External, 50 millivolt, Lightweight Type).

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 External meter shunts. External meter shunts should conform to A-A-55524 or MIL-I-1361, as applicable.

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 41

SPRINGS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-S-46049	Strip, Metal, Carbon Steel, Cold Rolled, Hardened and Tempered, Spring Quality.
ASTM A29/A29M	General Specification for, Steel Bars, Carbon and Alloy, Hot Wrought.
ASTM A228/A228M	General Specification for, Steel Wire, Music Spring Quality.
ASTM A313/A313M	General Specification for, Stainless Steel Spring Wire.
ASTM A682/A682M	General Specification for, Steel, Strip, High-Carbon, Cold Rolled.
ASTM A684/A684M	General Specification for, Steel, Strip, High-Carbon, Cold Rolled.
ASTM B122/B122M	General Specification for, Copper-Nickel-Tin Alloy, Copper-Nickel-Zinc Alloy (Nickel Silver),and Copper-Nickel Alloy Plate, Sheet, Strip, and Rolled Bar.
ASTM B139/B139M	General Specification for, Phosphor Bronze Rod, Bar, and Shapes.
ASTM B151/B151M	General Specification for, Copper-Nickel-Zinc Alloy (Nickel Silver) and Copper-Nickel Rod and Bar.
ASTM B194	General Specification for, Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar.
ASTM B196/B196M	General Specification for, Copper-Beryllium Alloy Rod and Bar.
ASTM B197/B197M	General Specification fo,r Copper-Beryllium Alloy Wire.
ASTM B206/B206M	General Specification for, Copper-Nickel-Zinc Nickel Silver Wire and Copper-Nickel Alloy Wire.
ASTM B522	General Specification for, Gold-Silver-Platinum Electrical Contact Alloy.
SAE/AMS 5121	Sheet and Strip, Steel (0.90-1.04) (SAE1095).
SAE/AMS 5122	Steel Strip (0.90-1.04) (SAE1095) Hard Temper.
SAE AS 13572	Springs, Helical, Compression and Extension.
SAE AS 81021	Copper-Beryllium Alloy (Copper Alloy Numbers C17500 and C17510), Strip.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Helical springs. Helical springs should conform to SAE AS 13572.

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

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

5. Detail guidelines.

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

5.2 Fatigue limits. Fatigue limits of the springs should not be adversely affected by corrosion, operating temperature, and other environmental conditions in service. Fatigue limits should be consistent with the maximum specified operating cycles for the respective part or equipment or, if such is not specified, with the maximum duty cycle to be expected during the equipment service life.

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

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

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

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

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

TABLE 41-I. Materials for electrical spring application.

Material	Form	Material specification
Copper-nickel-zinc alloy	Plate, sheet, strip, and rolled bar	ASTM B122/B122M
	Rod, shapes, and flat products with finished edges (flat wire, strip, and bar)	ASTM B122/B122M ASTM B151/B151M ASTM B206/B206M
Copper-beryllium alloy	Bars and rod	ASTM B196/B196M
	Wire	ASTM B197/B197M
	Strip	ASTM B194
Copper-cobalt-beryllium alloy	Strip	SAE AS 81021
Phosphor bronze	Bar, rod, plate, sheet, strip, and flat wire	ASTM B139/B139M
Platinum-iridium alloy	Strip	ASTM B522
Palladium-copper alloy		Metals Handbook,Vol I

TABLE 41-II. Corrosion resisting steel for springs.

Material	Form	Material Specification
Steel, CRES	Wire	ASTM A313/A313M

GUIDELINE 41

TABLE 41-III. Carbon steel for springs.

Material	Form	Material specification
Steel, high carbon	Wire, spring, music	ASTM 228/A228M
Steel, carbon and alloy (for springs)	Strip, cold rolled untempered spring	ASTM 682/A682M ASTM 684/A684M
Steel, carbon and alloy (for springs)	Bars, round, square and flat	ASTM A29/A29M
Steel, carbon, strip and tempered spring	Cold rolled, hardened	MIL-S-46049
Steel, carbon (1095)	Sheet and strip A-annealed (condition 1) H-hard temper (condition 3) cold finished	SAE AMS 5121 SAE AMS 5122

GUIDELINE 42

TUNING DIAL MECHANISMS

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

2. Applicable documents. This section not applicable to this guideline.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

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

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

4.3 Flexible control shafts. Flexible shaft assemblies should be used when a flexible mechanical connection is required between the tuning knob and the tuned device.

5. Detail guidelines.

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

GUIDELINE 43

LUBRICANTS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-L-3918	Lubricating Oil, Instrument, Jewel Bearings.
MIL-PRF-3150	Lubricating Oil, Preservative, Medium.
MIL-PRF-6085	Lubricating Oil, Instrument, Aircraft, Low Volatility.
MIL-PRF-6086	Lubricating Oil, Gear, Petroleum Base.
MIL-L-15719	Lubricating Grease, (High-Temperature, Electric Motor, Ball and Roller Bearings).
MIL-PRF-17331	Lubricating Oil, Steam Turbine, and Gear, Moderate Service.
MIL-PRF-17672	Hydraulic Fluid, Petroleum, Inhibited.
MIL-L-23398	Lubricant, Solid Film, Air-Cured, Corrosion Inhibiting, NATO Code Number S-749.
MIL-PRF-23827	Grease, Aircraft and Instrument, Gear and Actuator Screw.
MIL-PRF-24139	Grease, Multi Purpose, Water Resistant.
DOD-G-24508	Grease, High Performance, Multi-Purpose (Metric).
MIL-PRF-46010	Lubricant, Solid Film, Heat Cured, Corrosion Inhibiting.
MIL-PRF-81322	Grease, Aircraft, General Purpose, Wide Temperature Range, NATO Code Number G-395.
MIL-PRF-81329	Lubricant, Solid Film, Extreme Environment, NATO Code Number S-1737.
29 CFR 1910	Code of Federal Regulations, Title 29, Chapter XVII, Part 1910.
SAE J2360	Lubricating Oil, Gear Multipurpose (Metric) Military Use.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

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

MIL-PRF-3150	MIL-PRF-17331	DOD-G-24508
MIL-L-3918	MIL-PRF-17672	MIL-PRF-46010
MIL-PRF-6085	MIL-L-23398	MIL-PRF-81322
MIL-PRF-6086	MIL-PRF-23827	MIL-PRF-81329
MIL-L-15719	MIL-PRF-24139	SAE J2360

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

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

5. Detail guidelines

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

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

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

5.4 Carcinogens. Certain chemicals have been identified in the occupational Safety and Health Act (OSHA) as cancer-producing substances (carcinogens). Before using any materials which might contain these chemicals, they should be evaluated in accordance with 29 CFR 1910. Consideration of the toxicity of a substance should be given prior to material selection.

GUIDELINE 44

FIBROUS MATERIALS, ORGANIC

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-DTL-32072	Thread, Polyester.
V-T-295	Thread, Nylon.
MIL-W-530	Webbing, Textile, Cotton, General Purpose, Natural or in Colors.
MIL-C-572	Cords, Yarns, and Monofilaments, Organic Synthetic Fiber.
MIL-T-3530	Thread and Twine, Mildew Resistant or Water Repellent Treated.
MIL-W-4088	Webbing, Textile, Woven Nylon.
MIL-C-9074	Cloth, Laminated, Sateen, Rubberized.
MIL-W-27265	Webbing, Textile, Woven Nylon Impregnated.
A-A-50197	Thread, Linen .
A-A-52094	Thread, Cotton.
29 CFR 1910	Code of Federal Regulations, Title 29, Chapter XVII, Part 1910.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Webbing.

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

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

4.2 Cotton duck. Medium texture number 4 should be used for heavy-duty service and hard texture number 12 should be used for services requiring light weight.

4.3 Thread. Thread should conform to A-A-52094, MIL-DTL-32072, A-A-50197, or V-T-295.

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

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

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

5. Detail guidelines

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

5.2 Carcinogens. Certain chemicals have been identified in the Occupational Safety and Health Act (OSHA) as cancer producing substances (carcinogens). Before using any materials which might contain these chemicals, they should be evaluated in accordance with 29 CFR 1910. Consideration of the toxicity of a substance should be given prior to material selection.

GUIDELINE 45

CORONA AND ELECTRICAL BREAKDOWN PREVENTION

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

ASTM D 149	Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D 1868	Standard Test Method for Detection and Measurement of Partial Discharge (Corona) Pulses in Evaluation of Insulation Systems

3. Definitions.

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

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

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

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

4. General guidelines.

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

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

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

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

4.2 Electrical breakdown prevention. The equipment should be designed and manufactured with electrical clearance spacing, leakage (creepage) distances, and insulation characteristics adequate to prevent electrical breakdown. This guideline applies under all specified environmental service conditions including service life and using the specified operating voltages (including transients). Liquid dielectrics, gases other than air, or pressurization to prevent electrical breakdown should not be used unless approved by the procuring activity.

5. Detail guidelines.

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

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

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

5.4 Corona testing. There are many factors which determine whether or not corona will occur, including temperature, humidity, ambient pressure, test specimen shape, rate of voltage change, and the previous history of the applied voltage. Test methods such as ASTM D 1868 may be used but the test results lack accuracy and repeatability and require great care due to the personnel hazards involved.

5.5 Electrical breakdown testing. The breakdown voltage of a given insulating material is dependent upon electrode size and shape, insulator thickness, temperature, humidity, rate of voltage application, voltage waveform, and voltage frequency. When testing, care must be exercised to ensure that the insulating material is evaluated under the actual environmental conditions which apply to the equipment and that the occurrence of corona, or localized heating, does not mask the true breakdown voltage. Provides a test usable at power frequencies, 25 to 800 Hz in accordance with ASTM D 149.

GUIDELINE 46

MOTORS AND ROTARY POWER CONVERTERS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-M-17059	Motor, 60 Cycle, Alternating Current, Fractional H.P. (Shipboard Use).
MIL-M-17060	Motors, 60 Hertz, Alternating Current, Integral-Horsepower, Shipboard Use.
MIL-B-23071	Blowers, Miniature, for Cooling Electronic Equipment, General Specification for.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

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

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 47

ENCAPSULATION AND EMBEDMENT (POTTING)

1. Purpose. This guideline 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 guideline.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-PRF-8516	Sealing Compound, Synthetic Rubber, Electric Connectors and Electric Systems, Chemically Cured.
A-A-59877	Insulating Compound, Electrical, Embedding.
MIL-PRF-23586	Sealing Compound, (with Accelerator), Silicone Rubber, Electrical.
MIL-M-24041	Molding and Potting Compound, Chemically Cured Polyurethane.
SAE AS81822	Insulating Compound, Electrical, Embedding, Reversion Resistant Silicone.
29 CFR 1910	Code of Federal Regulations, Title 29, Chapter XVII, Part 1910.

3. Definitions.

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

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

4. General guidelines.

4.1 Encapsulation and embedment materials. Encapsulation and embedment materials should be of a non-reversion type and should be selected from the following specifications: MIL-S-8516, A-A-59877, SAE AS81822. The materials selected should 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 SAE AS81822, should be requested through the procuring activity.

5. Detail guidelines.

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, combined with random vibration screening, should be performed to verify adequacy of the design. Design considerations should address thermal coefficent of expansion mismatches between potting material and components and stress relief techniques. Wherever economically feasible, the module to be encapsulated or embedded should be designed as a throw-away unit.

5.3 Carcinogens. Certain chemicals have been identified in the Occupational Safety and Health Act (OSHA) as cancer-producing substances (carcinogens). Before using any materials which might contain these chemicals, they should be evaluated in accordance with 29 CFR 1910. Consideration of the toxicity of a substance should be given prior to material selection. Consideration of hazards should address all stages of the equipment lifecycle from fabrication to assembly, to installation, use maintenance, and decomposition during failure analysis and troubleshooting.

GUIDELINE 48

GEARS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

American Gear Manufacturers Association (AGMA), Standards & Information Sheets

3. Definitions. Not applicable.

4. General guidelines.

4.1 Gears. Gears not operating in a lubricant bath should be made of corrosion resistant materials. Gears operating in a lubricant bath containing a corrosion inhibiting additive may be made of noncorrosion resistant materials.

5. Detail guidelines.

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

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

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

GUIDELINE 49

HYDRAULICS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

NFPA B93.3	Fluid Power Systems and Products - Cylinder Bores and Piston Rod Diameters - Inch Series.
NFPA B93.8	Bore and Rod Size Combinations and Rod End Configurations for. Cataloged Square Head Industrial Fluid Power Cylinders.
NFPA B93.9M	Symbols for Marking Electrical Leads and Ports on Fluid Power Valves.
NFPA B93.10	Static Pressure Rating Methods of Square Head Fluid Power Cylinders.
SAE J514	Hydraulic Tube Fittings.
SAE J518	Hydraulic Flanged Tube, Pipe, and Hose Connections, Four-Bolt, Split Flanged Type.
ISO 3019-2	Hydraulic fluid power Dimensions and identification code for mounting flanges and shaft ends of displacement pumps and motors.
ISO 5598	Fluid Power Systems and Components – Vocabulaty.
ISO 6099	Fluid Power Systems and Components - Cylinders - Indentification Code for Mounting Dimensions and Mounting Types.
ISO 10763	Hydraulic Fluid Power - Plain-End, Seamless and Welded Precision Steel Tubes - Dimensions and Nominal Working Pressures.
NFPA T2.13.1	Recommended Practice - Hydraulic Fluid Power - Use of Fire-Resistant Fluids in Industrial Systems.
NFPA T3.5.1	Hydraulic Fluid Power - Valves - Mounting Surfaces.
SAE AS 5440	Hydraulic Systems, Aircraft, Design and Installation, Requirements for.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Aircraft or manned flight vehicles. The design and installation of hydraulic systems for aircraft or manned flight vehicles should conform to the applicable type and class or system described in SAE AS 5440.

5. Detail guidelines. The following documents contain additional information on hydraulic design:

NFPA B93.3	ISO 3019-2
NFPA B93.8	ISO 5598
NFPA B93.9	ISO 6099
NFPA B93.10	ISO 10763
SAE J514	NFPA T2.13.1
SAE J518	NFPA T3.5.1

GUIDELINE 50

INDICATOR LIGHTS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-DTL -3661	Lampholders, Indicator Lights, Indicator Light Housings, and Indicator Light Lenses, General Specification for.
MIL-DTL-6363	Lamps, Incandescent, Aircraft Service, General Specification for.
MIL-DTL -7961	Lights, Indicators, Press to Test.
MIL-L-15098	Lamp, Glow, General Specification for.
MIL-PRF-19500	Semiconductor Devices, General Specification for.
MIL-STD-1472	Human Engineering.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

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

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

4.3 Light emitting diodes (LEDs). LEDs when used as indicator lights should conform to the applicable specification sheets of MIL-PRF-19500.

4.4 Night vision goggles. Night vision goggle compatibility considerations for cockpit indicator lights should be considered where use of night vision goggles by cockpit crews is possible.

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 50

TABLE 50-I. Indicator lights and associated items.

	MIL-DTL-3661	MIL-DTL-6363	MIL-DTL-7961	MIL-L-15098	MIL-PRF-19500
Indicator lights	X		X		X
Indicator light housings	X				
Lamp holders	X				
Lenses	X				
Incandescent lamps, general purpose		X			
Incandescent lamps, severe environment		X			
Neon lamps				X	

GUIDELINE 51

METERS, ELECTRICAL INDICATING

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-M-7793	Meter, Time Totalizing.
MIL-PRF-10304	Meters, Electrical Indicating, Panel Type, Ruggedized, General Specification for.
MIL-M-16034	Meters, Electrical-Indicating (Switchboard and Portable Types).
MIL-M-16125	Meters, Electrical, Frequency.

3. Definitions. This section not applicable to this guideline.

4. General Guidelines.

4.1 Meters. Meters should conform to one of the following specifications: MIL-M-7793, MIL-M-16034, MIL-M-16125, or MIL-PRF-10304.

5. Detail guidelines.

5.1 Analog meters. For analog meters, the normal operating value of the quantity to be indicated should be between 0.3 and 0.8 of full-scale deflection, wherever practicable.

GUIDELINE 52

THERMAL DESIGN

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-PRF-16552	Filter, Air Environmental Control System, Cleanable, Impingement (High Velocity Type).
MIL-B-23071	Blowers, Miniature, for Cooling Electronic Equipment, General Specification for.
MIL-HDBK-251	Reliability/Design, Thermal Applications.
ASTM F 1040	Filter Units, Air Conditioning: Viscous-Impingement Types, and Dry Types, Replaceable.

3. Definitions.

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

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

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

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

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

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

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

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

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

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

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

4. General guidelines.

4.1 Forced air cooling. Forced air cooling should be used only when natural cooling is not adequate. Exhaust and recirculating fans and blowers should be driven by ac brushless motors or by properly shielded dc motors. Miniature blowers should conform to MIL-B-23071. Air filters should be provided for air intakes for fan and blower cooled units when required to protect internal parts. Filters, when used, should conform to ASTM F 1040 or MIL-PRF-16552, and should be removable for cleaning without disassembly of the equipment. All ventilation openings should be designed and located to comply with electromagnetic interference, undesired radiation and enclosure guidelines. Air exhaust should be directed away from operating personnel.

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

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

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

5. Detail guidelines.

5.1 Fan and blower characteristics. The design factors which should be considered in determining the required fan or blower characteristics include such factors as amount of heat to be dissipated, the quantity of air to be delivered at the pressure drop of the enclosed equipment, the allowable noise level, the permissible level of heat that may be exhausted into the surrounding environment, and other pertinent factors affecting the cooling requirements of the equipment. Induced drafts and ventilation by means of baffles and internal vents should be used to the greatest practicable extent. When practicable, ventilation and air exhaust openings should not be located in the top of enclosures or in front panels. When it is impractical to avoid direct impingement on internal parts and circuitry by channeling or use of heat exchangers, the water and contaminants should be removed from the cooling air by suitable water and contaminant removal devices.

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

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

GUIDELINE 53

WAVEGUIDES AND RELATED DEVICES

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

EIA-979	RF Transmission Line and Connector Selection Guide
MIL-DTL-85	Waveguides, Rigid, Rectangular, General Specification for.
MIL-DTL-287	Waveguide, Assemblies, Flexible, Twistable and Non-Twistable, General Specification for.
MIL-DTL-3922	Flanges, Waveguide, General Purpose, General Specification for.
MIL-DTL-3928	Switches, Radio-Frequency Transmission Line (Coaxial and miicrostrip), General Specification for.
MIL-DTL-3933	Attenuators, Fixed, General Specification for.
MIL-D-3954	Dummy Loads, Electrical, Waveguide, General Specification for.
MIL-DTL-3970	Waveguide Assemblies, Rigid, General Specification for.
MIL-DTL-15370	Couplers, Directional, General Specification for.
MIL-DTL-22641	Adapters, Coaxial to Waveguide, General Specification for.
MIL-DTL-23971	Power Dividers, Power Combiners, and Power Divider/Combiners, General Specification for.
MIL-DTL-24044	Flange, Coaxial Line, Rigid, Air Dielectric, General Specification for.
MIL-DTL-24211	Gasket, Waveguide Flange, General Specification for.
MIL-DTL-25879	Switch, Radio Frequency Transmission Line, Coaxial Type SA-521 A/A.
MIL-DTL-28791	Isolators and Circulators, Radio Frequency, General Specification for.
MIL-DTL-28837	Mixer Stages, Radio-Frequency, General Specification for.
MIL-DTL-28875	Amplifiers, Radio Frequency and Microwave, Solid-State, General Specification for.
MIL-DTL-39030	Dummy Loads, Electrical, Coaxial and Stripeline, General Specification for.
MIL-DTL-55041	Switches, Waveguide, General Specification for.
MIL-HDBK-660	Fabrication of Rigid Waveguide Assemblies (Sweep Bends and Twists).

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

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

5. Detail guidelines.

5.1 RF transmission lines and fittings. EIA-979 should be used as a technical information guide for RF transmission lines and fittings.

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

TABLE 53-I. Waveguides and related devices.

Item description		Applicable document
Amplifier, RF and microwave	DIP, coaxial, TO, and flatpack	MIL-DTL-28875
Attenuators	Fixed and variable coaxial and waveguide	MIL-DTL-3933
Circulators	RF-SMA and waveguide	MIL-DTL-28791
Couplers	Directional coaxial waveguide and t printed circuit	MIL-C-15370
Coupling assemblies	Quick-disconnect for subminiature waveguide flanges	MIL-D-3954
Dummy loads	Waveguide, coaxial and stripline	MIL-DTL-39030
Flanges	Waveguide and coaxial	MIL-DTL-3922 MIL-DTL-24044
Gaskets	Pressure sealing for use with cover flanges and flat face	MIL-DTL-24211
Isolators	RF-SMA and stripline	MIL-DTL-28791
Mixer stages	RF-DIP, flatpack, TO and connector	MIL-DTL-28837
Power dividers, combiners and divider/combiners	Solder terminals, plug-in, flatpack, TO and connector	MIL-DTL-23971
Switches	Waveguide to waveguide manual and electro mechanically operated RF coaxial	MIL-DTL-55041 MIL-DTL-25879 MIL-DTL-3928
Waveguide assemblies	Flexible and rigid	MIL-DTL-287 MIL-DTL-3970 MIL-HDBK-660
Waveguides	Rigid rectangular, rigid circular, single, and double ridge	MIL-DTL-85 MIL-DTL-22641

GUIDELINE 54

MAINTAINABILITY

1. Purpose. This guideline offers guidance as to maintainability which may be considered when preparing contractual documents. Maintainability program tasks, quantitative requirements, and verification or demonstration requirements may be directly specified in the contract or the system/equipment specification, as appropriate.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-HDBK -470	Designing and Developing Maintainable Products and Systems.
MIL-HDBK-472	Maintainability Prediction.

3. Definitions. This section not applicable to this guideline.

4. General Guidelines. This section not applicable to this guideline.

5. Detail Guidelines.

5.1 Maintainability program. Maintainability engineering and accounting tasks aimed at preventing, detecting, and correcting maintainability design deficiencies and providing maintainability related information essential to acquisition, operation, and support management should be included in contract requirements with the objective of establishing and maintaining an efficient maintainability program according to life cycle phase. MIL-HDBK-470 is the overall program document for the area. MIL-HDBK-472 provides additional guidance.

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

GUIDELINE 55

ENCLOSURES

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-F-85731	Fastener, Positive Locking, Electronic Equipment, General Specification for.
MIL-STD-108	Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment.
EIA/ECA-310	Cabinets, Racks, Panels, and Associated Equipment.

3. Definitions.

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

4. General Guidelines.

4.1. Cases and mounting bases for airborne equipment. Materials, bonding, shielding, and performance requirements of MIL-F-85731 should apply to all cases. Mounting bases should conform to MIL-F-85731, as applicable.

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

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

4.4. Racks and panels. The internal clearance and the equipment mounting holes of racks and panels should be in accordance with EIA/ECA-310.

4.5. Test guidelines. Enclosures should be tested as specified in MIL-STD-108.

5. Detail Guidelines.

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

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

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

GUIDELINE 56

ROTARY SERVO DEVICES

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-S-22432	Servomotor, General Specification.
MIL-S-22820	Servomotor-Tachometer Generator, AC; General Specification for.
MIL-T-22821	Tachometer Generator AC; General Specification for.
MIL-S-81746	Servtorq, General Specification for.
MIL-DTL-81963	Servocomponents, Precision Instrument, Rotating, Common Requirements and Tests, General Specification for.
MIL-E-85082	Encoders, Shaft Angle to Digital, General Specification for.
MIL-STD-710	Synchros, 60 and 400 Hz, Selection and Application of.
MIL-HDBK-225	Synchros Description and Operation.
MIL-HDBK-231	Encoders Shaft Angle to Digital.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Rotary servo devices. Rotary servo devices should conform to MIL-DTL-81963 as applicable.

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

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

4.4 Tachometer generators. Tachometer generators should conform to MIL-T-22821.

4.5 Encoders. Encoders should conform to MIL-E-85082 for general application.

4.6 Servomotor-tachometer generators. Servomotor-tachometer generators should conform to MIL-S-22820.

4.7 Servtorqs. Servtorqs should conform to MIL-S-81746.

4.8 Application Information. The following documents contain additional information for application: MIL-HDBK-225 and MIL-HDBK-231.

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 57

RELAYS

1. Purpose. This document is intended to be a general guide to aid the designer in the appropriate selection of a relay for the intended application.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-R-5757 Relays, Electromagnetic, General Specification for
MIL-PRF-6106 Relays, Electromagnetic, General Specification for.
MIL-PRF-28750 Relays, Solid State, General Specification for.
MIL-PRF-28776 Relays, Hybrid, Established Reliability, General Specification for.
MIL-PRF-32085 Relays, Electromagnetic, 270 V DC, Established Reliability, General Specification for
MIL-PRF-32140 Relays, Electromagnetic, Radio Frequency, Established Reliability, General Specification for
MIL-PRF-39016 Relays, Electromagnetic, Established Reliability, General Specification for.
MIL-PRF-83536 Relays, Electromagnetic, Established Reliability 25 amperes and below, General Specification for.
MIL-PRF-83726 Relays, Hybrid and Solid State, Time Delay, General Specification for.

3. Definitions.

3.1 Relay. A relay is defined as an electrically controlled device that opens and closes electrical contacts or activates and deactivates operation of other devices in the same or another electrical circuit. Two types of relay technology are available, mechanical and solid state. A mechanical relay is essentially a combination of an inductor and a switch, where the electromagnetic force of the inductor causes a switch to change position. A solid state relay accomplishes the same function with semiconductor devices changing impedance to effectively activate or deactivate a circuit open or closure

3.2 Type. Relays are classified into four general application categories, dependent on the load levels they are designed to switch. A definition of each follows:

3.2.1 Low level. Relays intended for switching low currents, typically in the milliampere range. In these circuits, only the mechanical force between the contacts affects the physical condition of the contact interface. There are no thermal or electrical effects, such as arcing.

3.2.2 Intermediate level. Relays used in load applications where there is insufficient contact arcing to effectively remove surface residue from the organic vapor deposits on the contact surface. However, there may be sufficient energy to cause melting of the contact material.

3.2.3 Power. Relays intended for switching high current loads, typically in excess of 25 A. Significant arcing occurs and the relay is designed with sufficient design margin to withstand the continuous arcing for a given number of cycles.

3.2.4 Special purpose. Sensor, hybrid, and time delay relays are classified as special purpose relays intended for specific applications. A sensor relay is designed to detect specific functions, such as frequency drift, out of phase conditions, voltage level, etc., and produce the appropriate switching response. A hybrid relay has an isolated input and output. This is accomplished through a solid state device, which controls the electromagnetic output. A mechanical time delay relay incorporates a conductive slug, or sleeve, on the core, which produces a counter-magnetomotive force and results in a switching delay. For solid state time delay relays, a separate circuit is incorporated within the device to produce the time delay.

4. General guidelines. Standardized military relays are segregated by the specifications listed on Table 57-1. Relays can further be segregated by sensitivity, or how much current is necessary to switch the relay. Increased sensitivity in non-solid state relays is accomplished by increasing the number of inductive windings inside the relay, which increases resistance.

Table 57-1 Military relay specifications

Military specification	Description
MIL-R-5757	Relays, Electromagnetic, General Specification for
MIL-PRF-6106	Relays, Electromagnetic, General Specification for
MIL-PRF-28776	Relays, Hybrid, Established Reliability, General Specification for
MIL-PRF-32085	Relays, Electromagnetic, 270 V DC, Established Reliability, General Specification for
MIL-PRF-32140	Relays, Electromagnetic, Radio Frequency, Established Reliability, General Specification for
MIL-PRF-39016	Relays, Electromagnetic, Established Reliability, General Specification for
MIL-PRF-28750	Relays, Solid State, General Specification for
MIL-PRF-83726	Relays, Hybrid and Solid State, Time Delay, General Specification for
MIL-PRF-83536	Relays, Electromagnetic, Established Reliability 5 amperes and below

4.1 Selection. Quality and reliability levels of relays may be expressed as the number of switch cycles before wear-out rather than the more traditional failure rate. Vendors consider rated number of switch cycles to be the guaranteed minimum number of cycles the relay can withstand under normal operating conditions before failure (intermittent or constant). Quality is further dependent on the ruggedness of the package and how well the internal switching elements are sealed against influences of the outside environment. Commercial grade relays and relays found in COTS equipment are not routinely acceptable for use in Military environments. Some relay vendors will advertise ISO 9000 quality systems or state they are ISO 9000 certified. Many manufacturers will then give a higher vendor rating (or increased preference) to the ISO 9000 certified vendor. While acceptable, care should be taken to also account for the fundamental design aspects of the relay. For example, a commercial-grade relay designed to withstand a sufficient number of switch cycles to operate 3 to 5 years in a particular application, should not be used in a system with an anticipated life of 15 years, even if the vendor for the commercial relay is ISO 9000 certified.

5. Detail guidelines.

5.1 Interface and physical dimensions. Relays are available in a variety of unique package styles. The size and mass of the package are dependent on the electrical characteristics, power dissipation, and the environmental requirements. Relays are generally the larger size components of a system, where increased attention should be paid to clearances and mounting, especially in high vibration level environments. Many package styles initially developed for unique applications have since gained wide acceptance.

5.2 Failure mechanisms and anomalies.

5.2.1 Failure modes. Table 57-II shows the relative probability of the three principal failure modes for relays. Relays most commonly fail in the "stuck open" position where the mechanical switching element fails to close and the relay fails to carry a current. Relays are less likely to unintentionally close or remain closed after the switching current is released. For this reason, the reliability of relay circuits can be improved by using parallel redundancy. Unlike most of the other electrical parts, relays (with the exception of solid state relays) contain a switching element that physically moves to make electrical contact. This makes them less likely to follow a constant failure rate or traditional "bathtub" curve profile. Instead, they are more prone to follow the failure rate curve for a mechanical part, with an increasing failure rate with age. Except for special high voltage and high temperature applications, solid-state relays are inherently more reliable and predictable for long life applications.

Table 57-II Normalized failure mode distribution for relays

Failure Mode	Relative Probability
Failure to Trip	55%
Spurious Trip	26%
Short	19%

5.2.2 Failure mechanisms. The two most common failure mechanisms of relays are contamination and mechanical wear of the internal switching elements discussed as follows:

a. Contamination. Contamination is a major cause of early life failures. Sources of contamination are numerous, but they are often from the various chemicals used in the manufacturing operation (e.g., soldering fluxes and cleaning agents). Types of contamination can be divided into two categories: Metallic and non-metallic. Metallic contamination causes shorted conditions or blocks the physical movement of mechanical elements. Non-metallic, or gaseous, contamination creates open circuits when it periodically deposits itself on contacts.

b. Mechanical wear. A second major cause of early life failures in relays is mechanical wear of internal switching elements. In fact, the life of a relay is essentially determined by the life of its contacts. Degradation of contacts is caused from high inrush currents, high-sustained currents, and from high voltage spikes. The source of high currents and voltages, in turn, are determined by the type of load. Inductive loads create the highest voltage and current spikes because they have lowest starting resistance compared to operating resistance. This is especially true for lamp filaments and motors, which is why derating is more severe for these types of loads. The life of a contact can be further degraded if contamination or pitting is present on the contact. Physical wear can also occur to other elements within the relay. Some relays contain springs to provide a mechanical resistance against electrical contact when a switching current is not applied. Springs will lose resiliency with time. Relays can also fail due to poor contact alignment and open coils.

5.3 Design and reliability. Selection of the proper relay type for a given application is the most significant factor affecting relay reliability. Many poor design practices are used when designing them into circuits. This is because relays are a relatively uncommon circuit element and often receive little attention during the design process. Whereas most designs will use hundreds each of microcircuits, resistors, etc.; relays typically number in the single digits. Therefore, designers are often less familiar with the intricacies of selecting the proper relay type and rating for a particular application. Some of the more common poor design practices are listed as follows:

a. Paralleling contacts. Paralleling contacting is when two relays are placed in parallel to handle the current that one of them cannot handle alone. The problem with this type of design is that mechanical switching occurs at relatively slow switching speeds. Therefore, for a brief instant, only one relay carries the full current load. Further, switching speeds tend to slow with age, amplifying the affect over time. The preferred method is to use a single relay of sufficient current handling capability. If dual relays are used in parallel in increase reliability, each relay should be capable of handling the full current load.

b. Circuit transient surges. Surge currents are often difficult to measure and predict, especially when switching inductive loads. It is not uncommon for surge current to reach ten times steady state current. Protective devices should be used to limit surge current. The simplest solution is to use a relay with a substantially higher rated surge current than anticipated.

c. High lamp currents. A cold filament lamp draws between 3 and 10 times the steady-state current until warmed up. Relay contacts used for switching lamps should be able to withstand such current surges without the possibility of welded contacts.

d. Load Transferring. Relays are sometimes used in applications where they switch a redundant circuit element, or an additional power supply current, into a circuit. High surges occur in ac applications when the redundant current is not in synchronization with the original current.

e. Polyphase Circuits. A typical misapplication is the use of small multipole relays in 112/200 volt 3-phase ac applications. Phase-to-phase shorting at rated loads is a strong possibility, with potentially catastrophic results.

f. Using relays without motor ratings to switch motor loads. Caution must be applied when using relays to reverse motors, particularly where the motor can be reversed while running (commonly called "plugging"). This results in a condition where both voltage and current can greatly exceed nominal. Only power relays rated for "plugging" and reversing service should be utilized in these applications.

g. Relay race. A relay race condition occurs when one relay must operate prior to another from a separate drive circuit, but fails to do so. The problem usually occurs after the equipment ages or temperatures rise. Potential race circuits should be avoided. Where they must be used, extra consideration must be given to wear considerations, coil suppression circuitry, ambient temperature, drive power, and operate and release times.

h. Slow rate of rise currents. A slowly rising triggering current has an increased likelihood of causing chattering conditions. A problem occurs because back electromotive forces (EMFs) are produced when the armature closes to the pole face. This voltage is opposite in polarity to the driving voltage and can cause the relay to release immediately after initial contact. This process repeats and causes a chatter condition until a sufficient amount of drive current is available to overcome the back EMF.

5.4 Derating.

5.4.1 Continuous current. Derating of continuous current is dependent upon the load type and is shown on Table 57-III. Derating is more severe for inductive and filament loads, due to high current demands upon initial startup and increased propensity of voltage spikes. If a relay is used to switch a combination of loads, the most dominant load should be used for derating purposes. Some relay specifications will contain individual current limitations for capacitive, inductive, motor, and filament loads. For such specifications, limit current to either the current derived through Table 57-I or the maximum current rating for the particular load type given in the specification, whichever is less.

5.4.2 Coil energizing voltage. The voltage to energize or trigger the relay should be at least 110% of the minimum rated energizing voltage. Coil energizing voltage is not derated in the traditional sense of the term because operation of a relay at less than nominal ratings can result in switching failures or increased switching times. The latter condition introduces contact damage and can reduce relay reliability.

5.4.3 Coil dropout voltage. The voltage to dropout or un-trigger a relay should be less than 90% of the maximum rated coil dropout voltage.

5.4.4 Temperature. Limit ambient temperature to maximum rated ambient temperature as shown in Table 57-III.

Note: Relay ratings may be given under the assumption that the relay case will be grounded. If such relays are used in applications where the case is not grounded, additional derating should be considered because the relay may lack arc barriers and contain smaller internal spacings.

Table 57-III Derating factors for relays

Part Type	Derating Parameter	% of Resistive Load Rated Value in Environment		
		Category 1 Protected	Category 2 Normal	Category 3 Severe
Relay	Continuous Current	70 -- Resistive Load 70 -- Capacitive Load 50 -- Inductive Load 30 -- Motor 20 -- Filament (Lamp)	60 -- Resistive Load 60 -- Capacitive Load 40 -- Inductive Load 20 -- Motor 10 -- Filament (Lamp)	50 -- Resistive Load 50 -- Capacitive Load 30 -- Inductive Load 20 -- Motor 10 -- Filament (Lamp)
	Coil Energize Voltage	110, Maximum	110, Maximum	110, Maximum
	Coil Dropout Voltage	90, Minimum	90, Minimum	90, Minimum
	Ambient Temperature	10°C of Max Rated	20°C of Max Rated	30°C of Max Rated

5.5 Technology and design. The construction methods and materials of each type of relay differ. Considerable differences exist between the materials and processes used to manufacture relays. A relay, in its most basic form, is a combination of a switch and an inductive element. In solid state relays, the inductor is replaced by a semiconductor element. The following lists the major categories available:

a. Reed (or dry reed). A reed relay is operated by an electromagnetic coil or solenoid which, when energized, causes two flat magnetic strips to move laterally to each other. The magnetic reeds serve both as magnetic circuit paths and as contacts. Because of the critical spacing and the frailty of the arrangement, the reeds are usually sealed in a glass tube.

b. Electromagnetic. A electromagnetic relay's operation depends upon the electromagnetic effects of current flowing in an energizing winding.

c. Electromechanical. An electromagnetic relay is an electrical relay in which the designed response is developed by the relative movement of mechanical elements under the action of a current in the input circuits.

d. Solid state. A solid state relay incorporates semiconductor or passive circuit devices. As the name implies, it contains no moving parts, and therefore has low switching noise and essentially no bounce or chatter. Solid state relays also have long life and fast response times. Their main disadvantage is a limited number of applications for which they can be used. Solid state relays are typically not used in high temperature environments.

e. Latching (or magnetic latching). A bistable polarized relay having contacts that latch in either position. A signal of the correct polarity and magnitude will reset or transfer the contacts from one position to the other.

5.6 Shock-vibration. Special mounting considerations are necessary for mechanical relays in high temperature or vibration environments because relays are typically high mass parts and can switch unintentionally when subjected to shock. Particular care is needed in airborne applications. Relays should not unintentionally switch even during absolute worse case operating conditions. In addition, the designer should take into account the wear of springs in long life applications.

5.7 Arc suppression. Arc suppression techniques should be used to protect relay contacts of intermediate and power level devices to increase long term reliability. Arc suppression usually consists of external circuitry (e.g., diodes) to limit current surge.

5.8 Parallel redundancy. To increase reliability, relays can be designed into circuits with parallel redundancy. The relative probably of a relay failing in the open position is substantially higher than failure in a closed position (see Table 57-II), thereby improving reliability in parallel redundant configurations. However, parallel redundancy should only be used to increase reliability, not to increase the current handling capabilities of a relay circuit.

5.9 Wide operating temperatures. For relays used over a wide temperature range, account for increased switching current demand at higher temperatures. As a general rule of thumb, coil resistance increases with temperature at a rate of 0.004 Ω/°C.

5.10 Grounded case. If a relay is rated under grounded case conditions, the relay should only be used in applications where the case will be grounded. Use in an ungrounded application may cause a personnel hazard.

5.11 Plugging. When using relays to reverse motor loads while running, use only relays specifically rated to reverse switch motor loads.

GUIDELINE 58

SWITCHES

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-DTL-15291	Switches, Rotary, Snap Action and Detent/Spring Return Action, General Specification for.
MIL-DTL-15743	Switches, Rotary, Enclosed.
MIL-S-16032	Switches and Detectors, Shipboard Alarm Systems.
MIL-S-18396	Switches, Meter and Control, Naval Shipboard.
MIL-DTL-21604	Switches, Rotary, Mulitpole and Selectors; General Specification for.
MIL-PRF-22710	Switches, Code Indicating Wheel (Printed Circuit), Thumbwheel and Pushbutton General Specification for.
MIL-PRF-22885	Switches, Push Button, Illuminated, General Specification for.
MIL-PRF-24236	Switches, Thermostatic, (Metallic and Bimetallic), General Specification for.
MIL-DTL-3786	Switches, Rotary (Circuit Selector, Low-Current Capacity), General Specification for.
MIL-DTL-3950	Switches, Toggle, Environmentally Sealed, General Specification for.
MIL-DTL-6807	Switches, Rotary, Selector Power, General Specification for.
MIL-PRF-83504	Switches, Dual In-line Package (DIP), General Specification for.
MIL-DTL-83731	Switches, Toggle, Unsealed and Sealed, General Specification for.
MIL-PRF-8805	Switches and Switch Assemblies, Sensitive, Snap Action (Basic, Limit, Push Button and Toggle Switches), General Specification for.
MIL-DTL-9395	Switches, Pressure, (Absolute, Gage, and Differential), General Specification for.
MIL-DTL-9419	Switch, Toggle, Momentary, Four-Position On, Center Off, General Specification for.
W-S-896	Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification) for.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Selection and application. Switches should conform to one of the following specifications.

MIL-DTL-15291	MIL-DTL-15743	MIL-S-16032	MIL-S-18396	MIL-DTL-21604
MIL-PRF-22710	MIL-PRF-22885	MIL-PRF-24236	MIL-DTL-3786	MIL-DTL-3950
MIL-DTL-6807	MIL-PRF-83504	MIL-DTL-83731	MIL-PRF-8805	MIL-DTL-9395
MIL-DTL-9419	W-S-896.			

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 59

BRAZING

1. Purpose. This guideline establishes criteria for brazing.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

AWS C3.4	Specification for Torch Brazing.
AWS C3.5	Specification for Induction Brazing.
AWS C3.6	Specification for Furnace Brazing.
AWS C3.7M/3.7	Specification for Aluminum Brazing.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Torch brazing. Torch brazing of steel, copper, copper alloys, and nickel alloys, should be in accordance with AWS C3.4.

4.2 Induction brazing. Induction brazing of steel, copper, copper alloys, and nickel alloys, should be in accordance with AWS C3.5.

4.3 Furnace brazing. Furnace brazing of steel, copper, copper alloys, and nickel alloys, should be in accordance with AWS C3.6.

4.4 Aluminum and aluminum alloy brazing. Brazing of aluminum and aluminum alloys should be in accordance with AWS C3.7M/C3.7.

5. Detail guidelines.

5.1 Stranded or insulated wire connections. Electrical connections of stranded or insulated wire, or those having construction which may entrap fluxes, should not be brazed.

5.2 Resistance brazing. The current and electrode size for resistance brazing should be selected so that the heat will be distributed over a large enough area to allow the brazing alloy to flow freely, but not large enough to cause overheating.

GUIDELINE 60

SOCKETS AND ACCESSORIES

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-DTL-12883	Sockets and Accessories for Plug-In Electronic Components, General Specification for.
MIL-DTL-24251	Shields, Retainers (Bases), and Adapters, Electron Tube, Heat Dissipating, General Specification for.
MIL-DTL-83502	Sockets, Plug-In Electronic Components, Round Style, General Specification for.
MIL-DTL-83505	Sockets, (Lead, Electronic Components) General Specification for.
MIL-DTL-83734	Sockets, Plug-in Electronic Components, Dual-in-Line (DIPs) and Single-in-Line Packages (SIPs), General Specification for.
A-A-55485	Mounting Pads, Electrical-Electronic Component, General Requirements for.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Sockets. Sockets for plug-in electronic parts should be of the single unit type and should conform to MIL-DTL-12883, MIL-DTL-83502, MIL-DTL-83505 or MIL-DTL-83734. The use of sockets for microcircuits requires approval of the procuring activity.

4.2 Shields. Heat dissipating tube shields should conform to MIL-DTL-24251.

4.3 Mounting pads. Where mounting pads are required for use with small electrical or electronic devices, they should conform to A-A-55485.

5. Detail guidelines.

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

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

GUIDELINE 61

ELECTROMAGNETIC INTERFERENCE CONTROL

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-STD-464	Electromagnetic Environmental Effects Requirements for Systems.
MIL-STD-469	Radar Engineering Interface Requirements, Electromagnetic Compatibility.
NTIA Manual	National Telecommunications and Information Administration Manual of Regulations and Procedures for Radio Frequency Management.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 General. Electromagnetic interference requirements should be as specified in MIL-STD-464.

4.2 Radar equipment. Radar systems and equipment should also conform to the provisions of section 5.3 of the NTIA Manual as specified in the contract and to MIL-STD-469. MIL-STD-469 should not be used for Air Force applications. In the event of conflict, the following descending order of precedence should prevail: NTIA Manual, MIL-STD-469 then MIL-STD-464.

4.3 Tests. Tests and test methods should be as specified in MIL-STD-464. For other than Air Force applications, MIL-STD-469 should also apply for radar equipment and systems.

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 62

HUMAN ENGINEERING

1. Purpose. This guideline establishes human engineering criteria which may be considered when preparing contractual documents. Human engineering, and related test and evaluation guidelines, may be directly specified in the contract or the system/equipment specification, as appropriate.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-STD-1472 Human Engineering.

3. Definitions. This section not applicable to this guideline.

4. General guidelines. This section not applicable to this guideline.

5. Detail guidelines.

5.1 Human engineering. Human engineering applied during development and acquisition of military systems, equipment, and facilities serves to achieve the effective integration of personnel into the design of the system. The objective of a human engineering effort is to develop or improve the crew/equipment/software interface and to achieve required effectiveness of human performance during system operation, maintenance and control, and to make economical demands upon personnel resources, skills, training, and costs. MIL-STD-1472 provides design criteria which may be selectively applied as guidance.

GUIDELINE 63

SPECIAL TOOLS

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

3. Definitions.

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

4. General Guidelines.

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

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

5. Detail Guidelines.

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

GUIDELINE 64

MICROELECTRONIC DEVICES

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-PRF-38534	Hybrid Microcircuits, General Specification for.
MIL-PRF-38535	Integrated Circuits (Microcircuits) Manufacturing, General Specification for.
MIL-HDBK-103	List of Standard Microcircuit Drawings.
QML-38534	Qualified Manufacturers List of Hybrid Microcircuits.
QML-38535	Qualified Manufacturers List of Integrated Circuits (Microcircuits) Manufacturing.
SD-18	Program Guide for Parts Requirement and Application.

3. Definitions.

3.1 Microelectronic devices: Monolithic, hybrid, radio frequency, and microwave (hybrid/monolithic) circuits, multichip microcircuits, and microcircuit modules.

3.2 Qualified device (microcircuit): Any device or microcircuit which has met the requirements of MIL-PRF-38535 (monolithic) and MIL-PRF-38534 (hybrid) and is listed on the associated Qualified Manufacturers Listing (QML).

3.3 Reliability. The probability of a part performing its specified purpose for the period intended under the operating conditions encountered.

3.4 Derating. The method of reducing stress and making quantitative allowances for a part's functional degradation. Consequently, derating is a means to reduce failures and extending part life. In addition, derating helps protect parts from unforeseen application anomalies and overstresses. (See guideline 18).

4. General Guidelines.

4.1 General. At each stage in new and re-engineered system designs, (e.g., concept studies, demonstration and validation, and full scale development) the advanced microcircuit technologies which meet reliability, performance, and cost requirements of the application should be evaluated for use in the production phase. Standard parts should be used to the maximum extent possible.

4.2 General guidelines. The use of microelectronic devices should be qualified and monitored to the application and environment they are used in. The "Parts Requirement and Application Guide", SD-18, is recommended to be used as guidance.

4.3 Parts standardization. Parts standardization is encouraged. Standardization positively affects logistic supportability, the overall life cycle costs, obsolete part issues, as well as the quality and reliability of the devices. Standard microcircuit devices are listed in QML-38535 (qualified monolithic parts), QML-38534 (qualified hybrid parts), MIL-HDBK-103 (all standard parts covered on Standard Microcircuit Drawings), and in electronic format on the DSCC web site, https://landandmarititmeapps.dla.mil.

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 65

CABLE, COAXIAL (RF)

1. Purpose. This guideline establishes criteria for the selection and application of coaxial Radio Frequency (rf) cable.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

EIA-979	RF Transmission Line and Connector Selection Guide
MIL-DTL-17	Cables, Radio Frequency, Flexible and Semirigid, General Specification for.
MIL-DTL-3890	Lines, Radio Frequency Transmission (Coaxial, Air Dielectric), General Specification for.
MIL-DTL-22931	Cables, Radio Frequency, Semirigid, Coaxial, Semi-Air-Dielectric, General Specification for.
MIL-DTL-23806	Cable, Radio Frequency, Coaxial, Semirigid, Foam Dielectric, General Specification for.
MIL-DTL-28830	Cable, Radio Frequency, Coaxial, Semirigid, Corrugated Outer Conductor, General Specification for.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Cable selection. Selection of coaxial cable should be in accordance with MIL-DTL-17, MIL-DTL-3890, MIL-DTL-22931, MIL-DTL-23806 or MIL-DTL-28830. Other types of cable may be used provided they are selected from specifications acceptable for the specific application and approved by the procuring activity.

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

5. Detail Guidelines.

5.1 Application guidance. EIA-979 may be used as a technical information guide to applications of transmission lines and fittings.

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

GUIDELINE 66

CABLE, MULTICONDUCTOR

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

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

QQ-W-343	Wire, Electrical, Copper (Uninsulated).
MIL-DTL-17	Cables, Radio Frequency, Flexible and Semirigid, General Specification for.
MIL-DTL 3432	Cables (Power and Special Purpose) and Wire, Electrical (300 and 600 Volts).
MIL-DTL-16878	Wire, Electrical, Insulated, General Specification for.
SAE-AS22759	Wire, Electric, Fluoropolymer-Insulated, Copper or Copper Alloy.
MIL-DTL-24640	Cables, Light-weight, Electric, for Shipboard Use, General Specification for.
MIL-DTL-27072	Cable, Power, Electrical and Cable, Special Purpose Electrical, Multiconductor and Single Shielded, General Specification for.
MIL-DTL-55021	Cable, Electrical, Shielded Singles, Shielded and Jacketed Singles, Twisted Pairs and Triples, Internal Hookup, General Specification for.
MIL-DTL-5846	Chromel and Alumel, Thermocouple Electrical WIre
SAE-AS81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-Imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy.
ASTM B 298	Standard Specification for, Silver-Coated Soft or Annealed Copper Wire.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

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

4.2 Solid or stranded. Either solid or stranded conductors may be used (within the restrictions of the particular wire or cable specification) except that: (1) with the exception of thermocouple and flat cable wire, only stranded wire should be used in aerospace applications; and (2) for other applications, stranded wire should be used when so indicated by the equipment application. Specifically, with the exception of flat multi-conductor flexible cable, stranded wire should be used for wires and cables which are normally flexed in use and servicing of the equipment, such as cables attached to the movable half of detachable connectors.

4.3 Application restrictions.

4.3.1 MIL-DTL-16878 usage. Cable containing MIL-DTL-16878 wire should not be used for Air Force or Navy aerospace applications.

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

4.3.3 Single polytetrafluoroethylene insulation. Wire with only single polytetrafluoroethylene insulation I accordance with SAE-AS22759 used in Air Force space and missile applications requires the approval of the procuring activity.

4.3.4 Silver plated copper wire. Silver plated copper wire should not be used in applications involving Army missile systems without certification by the wire manufacturer that it passes the sodium polysulfide test in accordance with ASTM B 298. Silver plated copper wire should not be used in conjunction with water-soluble solder fluxes. Wire should be stored and handled in such a way so as to minimize exposure to moisture.

5. Detail Guidelines.

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

5.2 Stranded copper conductor test. The following test procedure should be used for stranded conductors since the ASTM B 298 test procedure covers only a single, round conductor.

5.2.1 Sodium polysulfide test. The stranded samples of annealed copper, or copper alloy base material, should be tested in accordance with ASTM B 298 with the following exceptions:

NOTE: The ASTM test applies to single-end wires "taken before stranding". The applicability of the polysulfide test is thus restricted by the ASTM in recognition of the abrasion to the wire inherent in the stranding process.

The following exceptions and criteria should be applied when testing stranded product:

a. Examination of the samples to occur immediately after the solution cycle.

b. Samples to be immersed into the solutions in the as-stranded condition.

(1) Unilay constructions to be tested as the whole conductor.

(2) Concentric constructions to be tested as whole conductor.

(3) Two members from each layer of rope construction to be tested after they have been carefully removed from the finished rope.

TABLE 66-I. Cable, multiconductor.

			Conductor			Shield braid 3/			Jacket 3/	
Specification number	Title	Basic wire specifications	Number of conductors	Volts RMS	Temp 2/	Strand material	Strand coating	% Coverage	Material 1/	Type
MIL-DTL-3432	Cable (Power and Special Purpose) and Wire, Electrical (300 & 600V)	QQ-W-343& Insulation	Unlimited and mixed sizes 4/ 5/	300 and 600	-40°C to +65°C or -55°C to +75°C	None or Copper	Tin	85	Styrene butadiene rubber, chloroprene rubber, ethylene-propylene -dinne, rubber, polyurethan thermoplastic elastomer, or natural rubber	Extruded & vulcanized
MIL-DTL-24640	Cable, Electrical, Light-weight, for shipboard use	SAE-AS81044	2-77 pair	600	150°C	Copper tape	Tinned	85	Crosslinked, polyalkene, crosslinked alkaneimid, polymer, or polyarylene	Extruded
MIL-DTL-27072 See NOTE.	Cable Special Purpose, Electrical, Multi-conductor	MIL-DTL-17 MIL-DTL-5846 M16878/1 M16878/2 M16878/3 M16878/4 M16878/5 M16878/6 M16878/10 M16878/13	2-36	Various Various 600 1000 3000 600 1000 250 600 250	Not Spec Not Spec 105°C 105°C 105°C 200°C 200°C 200°C 75°C 200°C	Copper	Tin, Silver	85	Sheath of PVC, Polyethylene, Polychloroprene, polyamide, TFE-Teflon, or FEP-Teflon	
						Note: MIL-DTL-27072 applicable detail specification sheets control Materials for each specific cable configuration				
MIL-DTL-55021	Cable, Twisted Pairs & Triples, Internal Hookup, General Specification for	MIL-W-16878	2-3	600 to 1000°	-40°C to +105°C or -65°C to +200°C	None or Copper	Tin, Silver or Nickel	90	None PVC, Nylon TFE-Teflon	Extruded Extruded or tape

NOTE: Flexible mulit-conductor cable for use in protected areas: tunnels, wire ways, instrument racks, and conduit. Polyethylene jacketed cable suitable for underwater or direct burial applications only. M16878/6 and /13 not for aerospace applications

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

2/ See applicable detail specification sheet for temperature limitation.

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

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

5/ Available in three classifications:

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

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

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

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

7/ For use under abusive mechanical conditions and resistance to weather, oil and ozone are requirements.

GUIDELINE 67

MARKING

1. Purpose. This guideline establishes criteria for external and internal markings on equipment, assemblies and component parts. Marking for safety, shipping and handling is not within the scope of this guideline.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-DTL-15024	Plates, Tags, and Bands for Identification of Equipment.
MIL-DTL-18307	Nomenclature and Identification for, Aeronautical Systems Including Joint Electronics .Type Designated Systems and Associated Support Systems.
MIL-DTL-81963	Servocomponents, Precision Instrument, Rotating, Common Requirements and Tests, General Specification for.
MIL-STD-130	Identification Marking of U.S. Military Property.
MIL-STD-196	Joint Electronics Type Designation System.
MIL-STD-411	Aircrew Station Alerting Systems.
JSSG-2010	Crew Systems.
MIL-STD-1285	Marking of Electrical and Electronic Parts.
MIL-STD-13231	Marking of Electronic Items.
MIL-HDBK-505	Definitions of Item Levels, Item Exchangeability, Models, and Related Terms.
AIM BC1	Uniform Symbology Specification - Code 39.
ASME Y14.38	Abbreviations and Acronyms.
ASTM D 4956	Standard Specification for Retro reflective Sheeting for Traffic Control.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Patent information. At the manufacturer's option, patent information may be included on equipment, subject to the following restrictions:

a. The identification plate may contain patent information when approved by the procuring activity.

b. The location of, and method used to mark, patent information should not conflict with any specified equipment guidelines, such as marking, enclosure integrity, control, and indicator locations, etc.

c. Patent information should not be located on, or in, equipment having a security classification of confidential or higher, with the exception that patented items used in security classified equipment, when marked, should be marked in such a manner that patent information should be visible only when the item is removed or disassembled for repair or replacement.

4.2 Symbology.

4.2.1 Reference designations. Except for external connectors and cables, reference designations should be employed to identify the location of each item for its particular circuit application. The identification and marking of reference designators for parts and equipment should be in accordance with IEEE 200. On subminiaturized assemblies, such as printed or etched boards or other forms of assembly where space is at a premium, the reference designations need not be marked. In lieu thereof, reference designation marking should be shown by means of pictorial diagrams, line drawings, photographs, or other media to provide for circuit identification (by means of reference designations) in the appropriate handbooks for the equipment. It should not be mandatory to mark the reference designations of parts in nonrepairable subassemblies. Connectors may be further identified on that side of the panel to which the mating connector attaches, by a name denoting the function of the cable attached thereto. External cables should be assigned reference designations W1, W2, etc., for identification. The numerical portions of the reference designations should be consecutive, where practicable.

4.2.2 Abbreviations and legends. Abbreviations and legends should conform to MIL-STD-411, or JSSG-2010 as applicable.

4.3 Marking methods. Equipment, parts and assemblies should be permanently marked or identified. Permanency and legibility should be as required in MIL-STD-130.

4.3.1 Direct marking. Markings may be applied directly to a part, or an assembly, by die or rubber stamping, etching, engraving, molding, casting, forging, decalcomania transfer, stenciling, or silk screening.

4.3.2 Plates. Information and identification plates should conform to, and should be marked, in accordance with MIL-DTL-15024.

4.3.2.1 Identification (ID) plates. The ID plate should be fastened in such a manner as to remain firmly affixed throughout the normal life expectancy of the item to which it is attached. Type G, adhesive-backed metal, ID plates should be used on hermetically sealed items, magnesium cases, or other items where mounting of a plate by mechanical fasteners is impractical.

4.3.2.2 ID plate location. Plates should be located so that they are not obscured by other parts.

4.3.3 Marking cables, cords, and wires. The following methods should be used to mark cables, cords, and wires:

a. Molded on the cable or cord.

b. Stamped on the cable, cord, or wire.

c. Bands in accordance with MIL-P-15024, securely attached or captivated.

d. Adhesive tag or tape that should withstand the applicable environmental guidelines.

NOTE: Hot stamp marking has been determined to damage the wire insulation. Therefore hot stamp marking should not be used for direct marking on wire and cable intended for aerospace vehicle equipment.

4.4 Bar codes. Bar codes should conform to AIM-BC1.

4.5 Type designated items. Each item which is type designated in accordance with MIL-STD-196 should contain an identification marking in accordance with MIL-DTL-18307 for Navy and Air Force or MIL-STD-13231 for Army. These items are systems (electrical-electronic), sets, groups, and some units and assemblies, as defined in MIL-HDBK-505.

4.6 Fuse holders. The current rating of fuses should be marked adjacent to the fuse holder. In addition, "SPARE" should be marked adjacent to each spare fuse holder.

4.7 Connections. Marking adjacent to plugs, jacks, and other electrical connectors should identify the connected circuits to preclude cross connections. The connections to electrical parts such as motors, generators, and transformers should be marked.

4.8 Servo-component connections and markings. Servo-component marking and connection identification should conform to MIL-DTL-81963.

4.9 Controls and indicating devices. Markings should be provided on the front of each exterior and interior panel and panel door, also on control mounting surfaces of each chassis, subpanel, etc., to clearly (though necessarily briefly) designate the functions and operations of all controls, fuses, and indicating devices mounted thereon, protruding through, or available through, access holes therein. All markings should be located on the panel or chassis in correct relationship to the respective designated items.

4.10 Sockets. The chassis should be marked to identify both sockets and parts, modules, or assemblies to be plugged into the sockets. The side of the chassis upon which items are plugged into sockets should be marked, adjacent to each socket, with the reference designation for the item. The reverse side of the chassis should be marked, adjacent to each socket, with the reference designation used in the circuit diagram and table of parts to identify the socket itself. If space does not permit marking of reference designations for sockets and parts, modules, or assemblies mounted in sockets, a location diagram should be placed where it is visible when viewing the chassis, and should display the markings described herein.

4.11 Cables, cords, and wires. All cables, cords, and wires which require disconnection to remove units for servicing and maintenance should be uniquely identified.

4.12 Printed wiring boards. Markings on printed wiring boards should not interfere with electrical operation. When ink is used, it should be nonconductive. Markings should be considered when leakage (creepage) distances are determined.

4.13 Replaceable parts and assemblies. Replaceable parts and assemblies should be marked for identification in accordance with MIL-STD-1285 or MIL-STD-130, as applicable.

4.14 Programmable items. Equipments which are software programmable should indicate the identifying number and revision of the software program which has been loaded into memory. The preferred method is to provide either a local or a remote display which is under the control of the software program. However, when the use of a display is not practical, the equipment enclosure should be marked with the information as follows.

4.14.1 Preproduction and production equipment. Preproduction and production equipment should be marked with the identifying number and revision of the software program. The identifying number should be preceded by the words "software program".

4.14.2 Development equipment. Development equipment should be marked in a manner similar to preproduction and production equipment, except that means should be provided to easily change the revision letter by the use of a matte surface for hand marking or by using self-adhesive labels. The use of the revision letter, or number, and a patch letter, or number, is permissible.

4.14.3 Certain hardware changes. The marking guideline does not apply when changes to the software program are accomplished by making a hardware change (for example, when the software program resides in fusible link devices such as PROMs). In such cases, the marking guidelines applicable to a hardware change should apply.

5. Detail Guidelines.

5.1 Reflective markers. Where reflective markers are required, reflective polyester tape in accordance with ASTM D 4956 may be used.

GUIDELINE 68

READOUTS AND DISPLAYS

1. Purpose. This guideline establishes criteria for the selection of readouts and displays.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-DTL-28803	Display, Optoelectronic, Readouts, Back Lighted Segmented, General Specification for.
MIL-PRF-19500/708	Displays, Diode, Light Emitting, Solid State, Red, Numeric and Hexadecimal, with On Board Decoder/Driver Types 4N51, 4N52, 4N53 and 4N54 JAN and JANTX.

3. Definitions.

3.1 Readouts and displays. Readouts and displays are devices which are designed primarily to convert electrical information into alphanumeric or symbolic presentations. These devices may contain integrated circuitry to function as decoders or drivers.

4. General guidelines.

4.1 Optoelectronic type readouts. Optoelectronic type readouts should conform to MIL-DTL-28803.

4.2 Light emitting diode displays. Visible light emitting diode displays should conform to MIL-PRF-19500/708.

4.3 Night vision goggles. Night Vision Goggle compatibility considerations for cockpit readouts and displays should be considered where use of night vision goggles by cockpit crews is possible.

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 69

INTERNAL WIRING PRACTICES

1. Purpose. This guideline establishes criteria for internal wiring practices.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-T-152	Treatment, Moisture and Fungus Resistant, of Communications, Electronic and Associated Electrical 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-I-22076	Insulation Tubing, Electrical, Non rigid, Vinyl, Very Low Temperature Grade.
MIL-STD-108	Definitions of and Basic Requirements for Enclosure for Electric and Electronic Equipment.
SAE AS 7928	Terminals, Lug: Splices, Conductor: Crimp Style, Copper, General Specification for.
SAE AS 23190	Straps, Clamps, and Mounting Hardware, Plastic and Metal for Cable Harness Tying and Support.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Clearance and leakage (creepage) distances. Clearance between solder connections or bare conductors, such as on terminal strips, standoffs, or similar connections, should 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 should be equipped with suitable mechanical protection (grommet) of insulation. Panels 3 mm or more in thickness either should have grommets or should have the hole edges rounded to a minimum radius of 1.5 mm.

a. 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.

b. 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.

c. 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.

d. 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).

e. Enclosure II. Enclosure II is any equipment enclosure which affords less protection than enclosure I.

TABLE 69-I. Electrical clearance and leakage (creepage) distances.

Voltage ac (rms) or dc	Condition	Clearance (mm)	Leakage distances (mm)	
			Enclosure I	Enclosure II
Up to 150	A	1.5	1.5	1.5
	B	3	3	6
	C	6	9.5	19
150 to 300	A	1.5	1.5	1.5
	B	3	3	6
	C	6	12.5	19
300 to 600	A	1.5	3	3
	B	3	6	6
	C	6	12.5	19
600 to 1000	A	3	9.5	12.5
	B	6	19	25
	C	12.5	38	50

4.3 Wiring arrangement. Wiring should be arranged to permit bundling by one or more of the following methods or permanently mounted in cable ducts.

4.3.1 Lacing. Twine should be in accordance with Type P of MIL-T-713. Cordage should be in accordance with type SR-4.5 of MIL-I-3158.

4.3.2 Sleeving insulation. Sleeving insulation should conform to MIL-I-631, MIL-I-3190, or MIL-I-22076.

4.3.3 Wrapping and tying. Plastic devices for wrapping and tying of wires should conform to SAE AS 23190.

4.4 Clamped connections. In no case should 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 should be clamped between metal members, preferably, such as an assembly of two nuts, two washers and a machine screw.

4.5 Connectors, insulation sleeving. Unpotted connectors furnished as integral wired in parts of articles of equipment should have a piece of insulating tubing placed over each wire in the connector. The tubing should 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 should 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 should fit tightly over the contact or be tied securely enough so that it will not slide off. If bare wire is used, the tubing should be long enough to extend at least 6 mm beyond the contact, metal shell or clamp, whichever projects the farthest. This section does not apply to connectors with body insulated crimp-on contacts, to insulation displacement connectors, or mass soldered flat cable connectors.

5. Detail guidelines.

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; 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.

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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; (e.g., 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 noncrossmating guidelines, and circuit and spare considerations.

5.11 Solderless crimp connections. Solderless crimp connections should meet the following guidelines:

a. Insulated, solderless lugs are preferred and should conform to SAE AS 7928.

b. Where thermal or other considerations prevent the use of insulated lugs, noninsulated solderless lugs conforming to SAE AS 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 in accordance with MIL-T-152.

GUIDELINE 70

ELECTRICAL FILTERS

1. Purpose. This guideline establishes criteria for the selection and application of electrical filters.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-PRF-15733	Filters and Capacitors, Radio Frequency Interference, General Specification for.
MIL-PRF-28861	Filters and Capacitors, Radio Frequency/Electromagnetic Interference Suppression, General Specification for.

3. Definitions. This section not applicable to this guideline.

4. General Guidelines. Electrical filters should be selected and applied in accordance with MIL-PRF-15733 and MIL-PRF-28861.

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 71

CABLE AND WIRE, INTERCONNECTION

1. Purpose. This guideline establishes criteria for the selection and application of electric cable and wire used for interconnection between units.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

A-A-59551	Wire, Electrical, Copper (Uninsulated)
MIL-DTL-17	Cables, Radio Frequency, Flexible and Semi rigid, General Specification for
MIL-DTL-3432	Cables (Power and Special Purpose) and Wire, Electrical (300 and 600 Volts)
MIL-DTL-8777	Wire, Electrical, Silicone-Insulated, Copper, 600 Volt, 200 C
MIL-C-13777	Cable, Special Purpose, Electrical, General Specification for
MIL-DTL-16878	Wire, Electrical, Insulated, General Specification for
SAE-AS22759	Wire, Electric, Fluoropolymer-Insulated, Copper or Copper Alloy
MIL-DTL-24640	Cables, Light-weight, Electric, for Shipboard Use, General Specification for
MIL-DTL-24643	Cables and Cords, Electric, Low Smoke, for Shipboard Use, General Specification for
MIL-DTL-25038	Wire, Electrical, High Temp, Fire Resistant and Flight Critical
MIL-DTL-27072	Standard for Aerospace and Industrial Electrical Cable
NEMA WC 27500	Cable, Power, Electrical, and Cable Special Purpose, Electrical Shielded and Unshielded, General Specification for
MIL-DTL-55021	Cable, Electrical, Shielded Singles, Shielded and Jacketed Singles, Twisted Pairs and Triples, Internal Hookup, General Specification for
SAE-AS81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-Imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy
MIL-DTL-81381	Wire, Electric, Polyimide-Insulated, Copper or Copper Alloy
MS25471	Wire, Electrical, Silicone-Insulated, Copper, 600 Volt, 200 C, Polyester Jacket
MS27110	Wire, Electrical Silicone Insulated, Copper, 600 Volt, 200 C, FEP Jacket
ASTM A 580/A 580M	Standard Specification for Stainless Steel Wire
ASTM B33	Standard Specification for Wire, Tinned Soft or Annealed Copper Wire for Electrical Purposes
ASTM B298	Standard Specification for Silver-Coated Soft or Annealed Copper Wire
ASTM A 580	Standard Specification for Stainless Steel Wire
SAE AS 50861	Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy

3. Definitions.

3.1 Interconnecting wire. Insulated, single-conductor wire used to carry electric current between units.

3.2 Interconnecting cable. Two or more insulated conductors contained in a common covering, or one or more insulated conductors with a gross metallic shield outer conductor used to carry electrical current between units.

4. General guidelines.

4.1 Wire selection. Selection of wire for interconnection between units should be in accordance with table 71-I.

4.2 Multiconductor cable selection. Selection of multiconductor cable for interconnection between units should be in accordance with table 71-II.

4.3 Application restrictions.

4.3.1 MIL-DTL-16878 usage. MIL-DTL-16878 should not be used for Air Force or Navy aerospace applications.

4.3.2 Insulation restriction. Cable or wire with polyvinyl chloride insulation should not be used in aerospace applications. Use of these wires or cables in any other application requires prior approval of the procuring activity.

4.3.3 SAE-AS 22759 usage. SAE-AS 22759 wire with only single polytetra-fluoroethylene insulation used in Air Force space and missile applications will require the approval of the procuring activity.

4.3.4 Aluminum wire. Use of aluminum wire may need specific approval by the procuring activity.

4.3.5 Silver plated copper wire. Silver plated copper wire should not be used in applications involving Army missile systems without certification by the wire manufacturer that it passes the sodium polysulfide test in accordance with ASTM B 298. Silver-plated copper wire should not be used in conjunction with water-soluble solder fluxes. Wire should be stored and handled in such a way so as to minimize exposure to moisture.

5. Detail Guidelines.

5.1 Pulsed or RF signals. All interconnecting cables carrying pulsed or RF signals should be coaxial cables or waveguides and should be terminated, when possible, in the characteristic impedance of the transmitting media.

5.2 Stranded copper conductor test. The following test procedure should be used for stranded conductors since the ASTM B 298 procedure covers only a single, round conductor.

5.2.1 Sodium polysulfide test. The stranded samples of annealed copper or copper alloy base material should be tested in accordance with the ASTM B 298, with the following exceptions:

NOTE: The ASTM test applies to single-end wires "taken before stranding". The applicability of the polysulfide test is thus restricted by the ASTM in recognition of the abrasion to the wire inherent in the stranding process. The following exceptions and criteria should be applied when testing stranded product.

a. Examination of the samples to occur immediately after the solution cycle.

b. Samples to be immersed into the solutions in the as-stranded condition.

(1) Unilay constructions to be tested as the whole conductor.

(2) Concentric constructions to be tested as whole conductor.

(3) Two members from each layer of rope constructions to be tested after they have been carefully removed from the finished rope.

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

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

5.5 Stranded copper conductor test. The following test procedure should be used for stranded conductors since the ASTM B 298 procedure covers only a single, round conductor.

5.5.1 Sodium polysulfide test. Stranded samples of annealed copper or copper alloy conductors should be tested in accordance with ASTM B 298. When this test is performed, one factor which should be taken in to consideration is that the ASTM test applies to single end wires taken before stranding. Thus, the applicability of the polysulfide test is restricted by the ASTM in recognition of the abrasion to the wire inherent in the stranding process. As a result, the following exceptions and criteria apply when testing stranded product.

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a. Examination of the samples to occur immediately after the solution cycle.

b. Samples to be immersed into the solution in the as-stranded condition.

(1) Unilay constructions to be tested as the whole conductor.

(2) Concentric constructions to be tested as whole conductor.

(3) Two members from each layer of rope constructions to be tested after they have been carefully removed from the finished rope.

Specification Number.	Title	Spec Type or class	Construction: Conductor 1/ Material	Construction: Conductor 1/ Coating	Construction: Conductor 1/ Type	Construction: Insulation 2/ Primary	Construction: Insulation 2/ Primary Cover	Construction: Insulation 2/ Jacket/ topcoat	Max Cond Temp ^{0}C	Max rms volts	Remarks
SAE AS 50861	Wire, Electric, PVC Insulated, Copper or Copper Alloy	M5086/1	Cu/A	Sn	Str	1		8	105	600	Medium weight See Note 4
		M5086/2					13A	8, 11			
		M5086/3									
		M5086/4						8		3000	
		M5086/5						9A	110	600	
		M5086/6	HSA	Ag							
		M5086/7	Cu/A	Sn				8	105		
MIL-DTL-8777	Wire, Electrical, Silicone Insulated, Copper, 600 V 200^{0}C'	MS25471	Cu/A	Ag	Str	6	13A	12	200	600	
		M27110						4A			
MIL-W-16878	Wire, electrical Insulated, High Temperature	M6878/1	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		3/, 3A, 3B, 4A 13B	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									
		M16878/13								250	
		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		3/, 3A,3B,4A 13B	200	250	
		M16878/21								600	
		M16878/22								1000	
		M16878/23		Ni		3A			260	250	
		M16878/24				3B					
		M16878/25				3A				600	
		M16878/26				3B					
		M16878/27				3A				1000	
		M16878/28				3B					
		M16878/29								600	

Table 71-I Wire, electrical, interconnection.

Specification Number.	Title	Spec Type or class	Construction: Conductor 1/ Material	Conductor 1/ Coating	Conductor 1/ Type	Insulation 2/ Primary	Insulation 2/ Primary Cover	Insulation 2/ Jacket/ topcoat	Max Cond Temp ^{0}C	Max rms volts	Remarks
		M16878/30	Cu/A	Sn	Str	6			150	1000	
		M16878/31									
		M16878/32		Ag					200		
		M16878/33	Cu/A,CCW	Sn	S,Str	2A			75	600	
		M16878/34	Cu/A	Ag	Str	3B			200	1000	
		M16878/35		Ni					260		
SAE AS 22759	Wire, Electric, Fluoropolymer - insulated, Copper or Copper Alloy	M22759/1		Ag		3A,3B, 3D		13B	200	600	
		M22759/2		Ni					260		
		M22759/3				3B,3D	13B	3B			
		M22759/4		Ag				4A	200		
		M22759/5				3C					
		M22759/6		Ni					260		
		M22759/7	CuA	Ag					200		Medium weight
		M22759/8		Ni					260		Medium weight
		M22759/9		Ag		3A			200	1000	
		M22759/10		Ni					260	1000	
		M22759/11		Ag					200	600	
		M22759/12		Ni					260		
		M22759/13		Sn					135		Medium weight
		M22759/14				4A		9A			Light weight
		M22759/15	HSA	Ag		18					Light weight
		M22759/16	Cu/A	Sn							Medium weight
		M22759/17	HSA	Ag	Str				150		Medium weight
		M22759/18	Cu/A	Sn							Light weight
		M22759/19	HSA	Ag							Light weight
		M22759/20				3A		3A	200	1000	
		M22759/21		Ni					260		
		M22759/22		Ag					200	600	
		M22759/23	Cu/A	Ni					260		
		M22759/28		Ag				7B	200		
		M22759/29		Ni					260		
		M22759/30	HSA	Ag					200		
		M22759/31		Ni							
		M22759/32	Cu/A	Sn		20		20	150		
		M22759/33	HSA	Ag					200		
		M22759/34	Cu/A	Sn					150		
		M22759/35	HSA	Ag							
		M22759/41	Cu/A	Ni							
		M22759/42	HSA						200		

Specification Number.	Title	Spec Type or class	Construction: Conductor 1/ Material	Construction: Conductor 1/ Coating	Construction: Conductor 1/ Type	Construction: Insulation 2/ Primary	Construction: Insulation 2/ Primary Cover	Construction: Insulation 2/ Jacket/ topcoat	Max Cond Temp ^{0}C	Max rms volts	Remarks
		M22759/43	Cu/A	Ag							
MIL-DTL-25038	Wire, Electrical High Temperature and Fire Resistant	M25038/1	Cu/A	Ni clad	Str	15	3B	13B	288	600	Critical circuits where electrical integrity must be maintained during fire (1093 C flame/5 min)
SAE-AS81044	Wire, Electric, Crosslinked Polyalkene Cross-linked Alkaneimide Polymer, etc Insulated, Copper or Copper Alloy	AS81044/6	Cu/A	Sn	Str	2B		9B	150	600	Sheets /12 & /13 light weight - See Note 4
		AS81044/7	HSA	Ag							Sheets /9 & /10 medium weight. See application temp limitation stipulated on detail specification sheet
		AS81044/9	Cu/A	Sn							
		AS81044/10	HSA	Ag							
		AS81044/12	Cu/A	Sn							
		AS81044/13	HSA	Ag							
MIL-DTL-81381	Wire, Electric Polyimide Insulated Copper or Copper Alloy	M81381/7	Cu/A	Ag	Str	7A		17	200	600	Sheets /7 through /10 light weight Sheets /11 through /14 medium weight Sheets /17 through /20 light weight, single wrap primary Interconnect wiring where weight, space, and high temperature capability are critical Sheets /7 through /10 & 17/ through /20 - See Note 4 3B jackets in sheets are in sized 8 and larger
		M81381/8		Ni							
		M81381/9	HSA	Ag							
		M81381/10		Ni							
		M81381/11	Cu/A	Ag				15 or 17			
		M81381/12		Ni							
		M81381/13	HSA	Ag							
		M81381/14		Ni							
		M81381/17	Cu/A	Ag							
		M81381/18		Ni				17			
		M81381/19	HSA	Ag							
		M81381/20		Ni							
		M81381/21	Cu/A	Sn					105		
		M81381/22						15 or 17			

Table 71-I Wire, electrical, interconnection.

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
3D	Polytetrafluoroethylene impregnated glass type
4A	Fluorinated-ethylene propylene/extruded (FEP Teflon)
4B	Fluorinated-ethylene propylene/dispersion
5	Monochlorotrifluoroethylene/extruded (Kel-F)
6	Silicone rubber/extruded
7A	FEP/polyimide film (Kapton)
7B	Polymide lacquer (Pure ML)
8	Polymide/extruder (Nylon)
9A	Polyvinylidene fluoride/extruded (Kynar)
9B	Polyvinylidene fluoride/extruded/cross-linked
10	Braid/synthetic yarn/lacquer impregnated
11	Braid/nylon/impregnated
12	Braid/polyester/impregnated
13A	Braid/glass fiber/impregnated
13B	Braid/TFE coated glass fiber/TFE finish
14	Braid/asbestos/TFE impregnated
15	Braid, weave or wrap/inorganic fiber
16	Alkane-imide polymer/extruded/cross-linked
17	Modified aromatic polyimide
18	Ethylene-tetrafluoroethylene/extruded (Tefzel)
19	Polyarylene/extruded
20	Cross-linked, extruded, modified ethylene-tetrafluoroethylene

3/ When specified on purchase order.

4/ Wire intended for use in electronic equipment hook-up applications. It may also be used as an interconnecting wire when an additional jacket or other mechanical protection is provided

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

Specification number.	Basic Title	Basic Wire Specifications	Conductor			Shield braid 3/			Jacket 3/		Remarks
			Number of conductors	Volts RMS	Temp 2/	Strand material	Strand coating	% Coverage	Material 1/	Type	
MIL-DTL-3432	Cable (Power and Special (Purpose)and Wire, Electrical (300& 600V)	A-A-59551 & Insulation	Unlimited and mixed sizes 4/ 5/	300 & 600	-40°C to +65°C or -55°C to +75°C	None or Copper	Tin	85	Styrene butadiene Rubber, chloroprene rubber, ethylene-propylene rubber, ethylene-propylene-diene rubber, polyurethane thermoplastic elestomer or natural rubber	Extruded & Vulcanized	
NEMA WC 27500	Cable, Electric Aero Space Vehicle	M5086/1 M5086/2 M5086/3	2-7 1-7 1-7	600	105°C	Copper Copper	Tin Tin		None Polyamide (Nylon)	Extruded or Impregbaird	(a)
		M22759/12 M22759-23	1-7 1-7		260°C 260°C	Copper Copper	Nickel Nickel	85 85	(a) (b)	Extruded extruded or tape	Fluorinated ethylene propylene (b) Polytetra-fluoroethylene
		AS81044/9	1-7		100°C	Copper	Tin	85	Polyvinylidene fluoride	Extruded	
		M81381/8 /10 and /14	2-7 1-7		200°C 200°C	Copper	Nickel	85	FEP/polyimide	Film Tape	
		M81381/11	2-7		200°C						
		M81381/12 M81381/13	1-7 1-7		150°C 200°C	Copper Copper	Tin Nickel	85 85	FEP/polyimide	Film Tape	
MIL-C-13777	Cable Special Purpose Electrical	MIL-C-17 A-A-59551 ASTM A580 &Insulation	2-78 6/	600	-53°C to +71°C	Copper	Tin	80	Sheath Poly-Chloroprene Primary Insulation Polyethylene	Extruded & vulcanized Extruded	See Note 7
MIL-C-24640	Cable, Electrical, Light weight for ship board use	SAE-AS81044	2-77 pair	600	150°C	Copper Tape Tinned	85	Crosslinked Polyalkene, Crosslinked Alkaneimide polymer, or Polyarylene	Extruded		
MIL-DTL-	Cable Special	MIL-DTL-17	2-36	Various	Not spec	Copper	Tin,	85	Sheath of		Flexible

Table 71-II Wire, electrical, interconnection.

Specification number.	Basic Title	Basic Wire Specifications	Conductor			Shield braid 3/			Jacket 3/		Remarks
			Number of conductors	Volts RMS	Temp 2/	Strand material	Strand coating	% Coverage	Material 1/	Type	
27072	Purpose, Electrical, Multi-conductor	M16878/1 M16878/2 M16878/3 M16878/4 M16878/5 M16878/6 M16878/10 M16878/13		600 1000 3000 600 1000 250 600 250	105°C 105°C 105°C 200°C 200°C 200°C 75°C 200°C		Silver		PVC, polyethylene, polychloropre ne, polyamide,TFE - Teflon, or FEP- Teflon		multicon ductor cable for use in protected, wire ways, instru- ment racks, and conduit, Poly- ethylene jack- eted cable suitable for underwate r or direct burial applicatio ns only. M16878 /6 and /13 not for aerospace applicatio ns
						Note: MIL-DTL-27072 applicable detail specification sheets control materials for each specific cable configuration.					
NEMA WC	Cable,	MIL-DTL-8777	1-7	600	200°C	Various	Various	85	Various	Braided	For general aerospace flight vehicle applicati ons
27500	Electrical, Shielded and	SAE AS 22759	1-7	Various	Various	Various	Various	85	Various	Extruded or Braided	

Specification number.	Basic Title	Basic Wire Specifications	Conductor			Shield braid 3/			Jacket 3/		Remarks
			Number of conductors	Volts RMS	Temp 2/	Strand material	Strand coating	% Coverage	Material 1/	Type	
	Unshielded,										
	Aerospace	MIL-DTL-25038	1-7	600	260°C	Various	Various	85	TFE coated glass fiber	Braided	
		SAE-AS81044 MIL-DTL-81381	1-7 1-7	600 600	150°C Various	Various Various	Various Various	85 85	Various Various	Extruded Tape	
MIL-DTL-55021	Cable, Twisted Pairs & Triples, Internal Hookup, General Specification for	MIL-DTL-16878	2-3	600 to 1000	-40°C to +105°C or -65°C to +200°C	None or Copper	Tin, Silver or Nickel	90	None PVC, Nylon TFE-Teflon	Extruded Extruded or Tape	

Table 71-II Wire, electrical, interconnection.

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

2/ See applicable detail specification sheet for temperature limitations.

3/ See applicable detail specification sheet for materials control of specific cable configurations impact bend, and twist.

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

5/ Available in three classifications:

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

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

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

6/ See applicable detail specification sheet for mechanical test requirements for cold bend torque,

7/ For use under abusive mechanical conditions and where resistance to weather, oil and ozone are requirements.

GUIDELINE 72

SUBSTITUTABILITY

1. Purpose. This guideline establishes criteria for the selection and application of substitute parts.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-HDBK-61	Configuration Management Guidance
EIA-649	Configuration Management

3. Definitions. This section not applicable to this guideline.

4. General Guidelines.

4.1 Military parts. Substitution of parts covered by defense specifications and standards that include substitutability or supersession information is acceptable. This type substitution does not require submission of engineering change proposals, deviations, or waivers in accordance with MIL-HDBK-61.

4.2 Commercial parts. When the equipment design specifies a commercial part, a defense specification part may be substituted when the form, fit, and functional characteristics of the standard part are equal to, or better than, those of the specified commercial part under equivalent environmental conditions. Substitutions are subject to applicable configuration control procedures of MIL-HDBK-61.

4.3 Unavailable parts. When the equipment design specifies a part that is unavailable, a substitute part which meets the form, fit, and functional characteristics of the specified part may be substituted after approval is obtained from the applicable procuring activity. Substitutions are subject to the applicable configuration control procedures of MIL-HDBK-61.

4.4 Initial qualification/reliability demonstration. Substitute parts with quality/reliability characteristics superior to those specified in the parts list should not be used in equipment to be subjected to initial qualification or demonstration tests.

4.5 Other Guidance. Additional information can be found in EIA-649.

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 73

STANDARD ELECTRONIC MODULES

1. Purpose. This guideline establishes criteria for the selection and application of Standard Electronic Modules (SEM).

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-STD-1389	Design Requirements for Standard Electronic Modules.
MIL-HDBK-246	Program Managers Guide for the Standard Electronic Modules Program.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Application. Requirements for the design and application of SEMs should be in accordance with MIL-STD-1389.

5. Detail guidelines.

5.1 Program and acquisition managers. Guidance for program and acquisition managers, as to the applicability of SEMs for specific system/equipment acquisitions, is provided in MIL-HDBK-246.

GUIDELINE 74

GROUNDING, BONDING, AND SHIELDING

1. Purpose. This guideline establishes grounding, bonding, and shielding interface criteria for installation of electronic equipment.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

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-464	Interface Standard for Electromagnetic Environmental Effects Requirements for Systems.
MIL-STD-1310	Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety.
MIL-STD-1542	Electromagnetic Compatibility (EMC) and Grounding Requirements for Space System Facilities.
MIL-HDBK-419	Ground, Bonding, and Shielding for Electronic Equipments and Facilities.
MIL-HDBK-1857	Grounding, Bonding, and Shielding Design Practices.

3. Definitions. This section not applicable to this guideline.

4. General guidelines.

4.1 Provisions. Grounding, bonding, and shielding provisions should 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-STD-464
Aircraft and space vehicles	MIL-STD-464
Ground telecommunications C-E equipment	MIL-STD-188-124
Shipboard equipment	MIL-STD-1310
Ground space systems facilities	MIL-STD-1542
Other Army ground equipment	MIL-HDBK-1857

4.2 Other Guidance. Guidance for grounding, bonding, and shielding may be found in MIL-HDBK-419.

5. Detail guidelines. This section not applicable to this guideline.

GUIDELINE 75

ELECTROSTATIC DISCHARGE CONTROL

1. Purpose. This guideline offers guidance regarding the handling and control of electronic parts and assemblies that are susceptible to damage or degradation from electrostatic discharge. Guidelines for the establishment and implementation of an Electrostatic Discharge (ESD) control program in accordance with MIL-STD-1686 may be directly specified in the contract or equipment specification.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-STD-883	Microcircuits.
MIL-STD-1686	Electrostatic Discharge Control Program for Protection of electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices), Standard Practice for.
ESD TR20.20	Handbook for the Development of an Electrostatic Discharge Control Program for the Protection of Electronic Parts, Assemblies and Equipment.

3. Definitions. Definitions of applicable terminology may be found in MIL-STD-883, MIL-STD-1686, and ESD TR20.20.

4. General guidelines. This section not applicable to this guideline.

5. Detail guidelines.

5.1 ESD control program. MIL-STD-1686 provides the guidelines for the establishment, implementation, and monitoring of an ESD control program, including identification of Electrostatic Discharge Sensitive (ESDS) items, classification of ESD sensitivity levels, control program elements, extent of program element applicability to each acquisition, protective measures to be employed in equipment design, handling, storage, and packaging of ESDS items, protected work areas, personnel training, ESD audits and program reviews, and tailoring. Appendix A of MIL-STD-1686 provides the criteria and procedure for classifying ESDS parts by test. Appendix B of MIL-STD-1686 identifies and classifies ESDS items. ESD TR20.20 provides guidance for the establishment and implementation of an ESD control program in accordance with MIL-STD-1686.

5.2 General guidelines for an ESD control program. Any program designed for the prevention of ESD damage to ESDS parts and assemblies should be based on the following considerations.

a. Identification of ESDS parts and assemblies and determination of sensitivity.

b. Minimization of static charge generation.

c. Reduction of stored charges (grounding).

d. Isolation of ESDS parts (Faraday shielding and line transient protection).

e. Proper handling, storage, and transportation of ESDS parts and assemblies.

f. Personnel training and certification.

g. Protected work areas.

GUIDELINE 76

FIBER OPTICS

1. Purpose. This guideline establishes the criteria for the selection, application, and testing of fiber optic material, devices and accessories.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

SAE AS22520/10	Crimping Tools, Type 2, Terminal, Hand, Wire Termination, for Coaxial, Twinaxial, Triaxial, Shielded Contacts and Ferrules, Terminal Lugs, Splices, and End Caps..
MIL-PRF-24623	Splice, Fiber Optic Cable, General Specification for (Metric).
MIL-DTL-24728	Interconnection Box, Fiber Optic, Metric, General Specification for.
MIL-M-24791	Module, Fiber Optic, Transmitter or Receiver, Digital, General Specification for.
MIL-PRF-24792	Adhesive, Epoxy, Two Part, Fiber Optics.
MIL-PRF-24793	Adhesive, UV Curable, One Part, Fiber Optics.
MIL-PRF-24794	Material, Index Matching, Fiber Optics.
MIL-PRF-28876	Connectors, Fiber Optic, Circular, Plug and Receptacle Style, Multiple Removeable Termini, General Specification for.
MIL-PRF-29504	Termini, Fiber Optic Connector, Removable, General Specification for.
MIL-PRF-49291	Fiber, Optical, (Metric), General Specification for.
MIL-DTL-49292	Cable Assemblies, Nonpressure Proof, Fiber Optic, Metric, General Specification for.
MIL-DTL-83522	Connectors, Fiber Optic, Single Ferrule, General Specification for.
MIL-DTL-83526	Connectors, Fiber Optic, Circular, Environmental Resistant, Hermaphroditic, General Specification for.
MIL-PRF-85045	Cables, Fiber Optics, (Metric), General Specification for.
MIL-STD-188-200	System Design and Engineering Standards for Tactical Communications.
MIL-STD-790	Established Reliability and High Reliability Qualified Products List (QPL) Systems for Electrical, Electronic, and Fiber Optic Parts Specifications.
DOD-STD-1678	Fiber Optics Test Methods and Instrumentation.
MIL-STD-2163	Insert Arrangements for MIL-C-28876 Connectors, Fiber Optic, Circular, Plug and Receptacle Style, Multiple Removable Termini.
MIL-HDBK-415	Design Handbook for Fiber Optic Communications Systems.
TIA-440	Fiber Optic Terminology.
TIA-587	Fiber Optic Graphic Symbols.

3. Definitions.

3.1 Terminology. Definitions of terminology used in fiber optics technology should be as specified in TIA-440.

4. General guidelines.

4.1 Symbology. Graphic symbols for fiber optic parts for use on engineering drawings, specifications, etc, should be as specified in TIA -587.

4.2 Fiber dimensions. Dimensions for optical fibers should be as specified in MIL-DTL-49291.

4.3 System and subsystem design. Fiber optic system and subsystem designs should be in accordance with the criteria specified in MIL-STD-188-200 (see 5.1 of this guideline).

4.4 Test procedures. Standardized test procedures for fiber optic components should be as specified in DOD-STD-1678.

4.5 Splices. Fiber optic splices should conform to MIL-PRF-24623.

4.6 Cable assemblies. Cable assemblies should conform to MIL-PRF-49292.

4.7 Connectors. Fiber optic connectors should conform to MIL-PRF-28876, MIL-DTL-83522,and MIL-DTL-83526. Insert arrangements for MIL-PRF-28876 connectors should conform to MIL-STD-2163. Removable terminals for fiber optic connectors should conform to MIL-PRF-29504.

4.8 Interconnection boxes. Fiber optic interconnection boxes should conform to MIL-DTL-24728.

4.9 Tools and inspection equipment. Fiber optic tools, inspection equipment, and related kits should conform to SAE AS22520/10.

4.10 Transmitters and receivers. Fiber optic transmitters and receivers should conform to MIL-M-24791.

4.11 Adhesives.

4.11.1 Two part epoxy adhesives should conform to MIL-PRF-24792.

4.11.2 UV curable adhesives should conform to MIL-PRF-24793.

4.12 Materials. Index matching materials should conform to MIL-PRF-24794.

4.13 Cables. Fiber optic cables should conform to MIL-PRF-85045.

4.14 Polyvinyl chloride. Polyvinyl chloride insulating materials should not be used in aerospace applications. Their use in other applications requires procuring activity approval.

5. Detail guidelines.

5.1 Design guides. Fiber optic system design guide information is available in MIL-HDBK-415.

5.2 Product assurance program. When a requirement exists for the implementation of a fiber optic product assurance program, refer to MIL-STD-790.

GUIDELINE 77

INTEGRATED DIAGNOSTICS

1. Purpose. This guideline establishes a design process for integrating all elements which constitute a weapon system's diagnostic capability. Engineering analyses, qualitative and quantitative requirements, design analysis, demonstration, and maturation requirements may be specified in the contract or system/equipment specification, as appropriate.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-HDBK-470	Designing and Developing Maintainable Products and Systems
MIL-HDBK-1814	Integrated Diagnostics
MIL-HDBK-2165	Testability Program for Systems and Equipments
AFGS-87256	Integrated Diagnostics
ASTM F 1166	Standard Practices for Human Engineering Design for Marine Systems, Equipment, and Facilities
EIA-632	Processes for Engineering a System

3. Definitions.

3.1 Integrated diagnostics process. Integrated diagnostics is defined as a structured process which maximizes the effectiveness of diagnostics by integrating pertinent elements, such as: testability, automatic and manual testing, training, maintenance aiding, and technical information. Integrated diagnostics provides a cost-effective capability to detect and unambiguously isolate all faults known or expected to occur in weapon systems and equipment, and to satisfy weapon system mission requirements. This emphasis on the design and acquisition of the diagnostic capability is required because this capability tends to become fractionated. MIL-HDBK-2165 is the overall document for testability. However, because it is a multidisciplined process, reference to other portions of military documents that may be invoked or may be cited directly are: MIL-HDBK-470, EIA-IS-632, MIL-HDBK-1814, AFGS-87256, and ASTM F 1166.

4. General guidelines. This section not applicable to this guideline.

5. Detail guidelines.

5.1 Test provisions.

5.1.1 Testability programs. When specified by the procuring activity a testability program should be implemented by guidance found in MIL-HDBK-2165.

5.1.2 Built-in-test devices. Built-in test devices should maintain their accuracy under all operating conditions required by the equipment under test. These devices should be provided with connections or access for their operational check-outs or calibration.

5.1.3 Test provisions. Equipment which is required to be tested by on-line Automatic Test Equipment (ATE) should provide test points.

5.1.4 Test cables. Test cables and extender cards should be provided and fitted with connectors to allow removable subassemblies to be electrically reconnected for maintenance.

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

5.1.6 Failure effect. Provisions for testing should be designed that any failure of built-in test devices will not degrade equipment operation or cause equipment shut down.

5.1.7 Intermittent fault diagnostics. Intermittent faults are defined in Guideline 79 and should be considered as part of any weapon systems diagnostic process/capability

5.2 Safety criteria. Safety criteria should be applied during equipment hardware design, selection, end construction to eliminate or control hazards that could cause injury to personnel during transportation, storage, installation, operation, maintenance or disposal, or damage to equipment or property.

GUIDELINE 78

PRODUCIBILITY

1. Purpose. This guideline establishes criteria for producibility which should be considered when preparing contractual documents. Producibility program tasks, quantitative requirements, verification, or demonstration requirements may be directly specified in the contract, the system, or equipment specification, as appropriate.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

DoDD 4245.7-M	Transition from Development to Production.
NAVSO P-3679	Producibility Measurement Guidelines.
NAVSO P-6071	Best Practices.
MIL-HDBK-727	Design Guidance for Producibility.

3. Definitions. This section not applicable to this guideline.

4. General guidelines. This section not applicable to this guideline.

5. Detail guidelines.

5.1 Producibility program. Producibility engineering and planning tasks aimed at preventing, detecting, and correcting manufacturability design deficiencies and providing producibility related information essential to acquisition, operation, and support management should be included in contract requirements with the objective of establishing and maintaining an efficient producibility program according to program phase. NAVSO P-3679 is the overall program document for the subject. The successful creation and management of a producibility program is detailed in section 2 of NAVSO P-3679.

5.2 Producibility measurement. Producibility measurement and assessment tools are a critical part of insuring a product is ready for production. Sections 3 and 4 of NAVSO P-3679 give two industry examples of measurement and assessment tools.

5.3 Quantitative producibility. Quantitative producibility requirements and verification, or demonstration requirements, should be established as appropriate to program phase. Producibility measurement is an essential part of the design process which can determine the probability of successful production. Minimal tailoring should be required when NAVSO P-3679 is applied to a program. Other producibility documents which may be cited directly as a basis for contract requirements include DoDD 4245.7M, NAVSO P-6071, and MIL-HDBK-727 for guidance only.

GUIDELINE 79

INTERMITTENT FAULT DIAGNOSIS

1. Purpose. This guideline establishes criteria for diagnosing intermittent faults in Electronic Equipment backplane, chassis and wire harness conductive paths.

2. Applicable documents. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

MIL-PRF-32516 Electronic Test Equipment, Intermittent Fault Detection and Isolation for Chassis and Backplane Conductive Paths

MIL-STD-810 Environmental Engineering Considerations and Laboratory Tests.

2.1 Definitions.

2.2 Intermittent faults. Intermittent faults are short duration discontinuities (opens/shorts) that occur in conductive paths in Electronic Equipment chassis/ backplanes and wire harnesses. Intermittent faults occur as a result of various operational environmental stimuli, including, but not limited to, thermal stress, vibrational stress, gravitational G-force loading, moisture and/or contaminant exposure, as well as changes in the material due to age and use, such as the growth of tin whiskers, metal migration and delamination of materials. These faults can occur individually and /or in rapid succession on any chassis, backplane circuit or wire harness. Fault durations range in time from nanoseconds to milliseconds and have variable random impedances. These conductive path disruptions are frequently caused by: cracked solder joints; intermittent coax lines (e.g., shield corrosion, damaged center conductor, etc.); broken, cracked or frayed wires/wire harnesses; loose clamps; improper crimp connections and unsoldered pins. These conductive path disruptions often cause functional failures/faults in Electronic Equipment chassis, backplanes and wire harnesses whose root cause(s) cannot be detected and isolated using traditional automatic test equipment (ATE) and troubleshooting processes. Lacking the ability to detect and isolate intermittent failures and provide environmental stimuli during test and repair process, such assets are commonly reported as no-fault-found (NFF) or as one of the quasi-NFF repair codes (e.g., cannot duplicate (CND), retest OK (RETOK), beyond capability of maintenance (BCM), disassemble-clean-reassemble (DCR), etc.).

3. General Guidelines.

3.1 General. Each type of Electronic Equipment is different in its function, configuration and operational environment. As a result, no single test method or procedure can adequately replicate an intermittent fault occurrence for all Electronic Equipment. A careful review of the nature of the failure and the operational conditions under which the failure occurred is required. The following steps are recommended when by careful analysis it is determined that the failures occur during ground or flight operating conditions, and the operating temperature does not appear to be contributing to the occurrence of the failures.

3.2 Intermittent faults typical resulting effects.

3.2.1 Vibration-induced. The following is a list of typical effects that may occur as a result of vibration (this list is not intended to be all-inclusive):

a. Chafed wiring.
b. Loose fasteners/components
c. Intermittent electrical contacts
d. Electrical shorts.
e. Deformed seals.
f. Failed components.
g. Optical or mechanical misalignment.
h. Cracked and/or broken structures.
i. Migration of particles and failed components.
j. Particles and failed components lodged in circuitry or mechanisms.
k. Excessive electrical noise.
l. Fretting corrosion in bearings.

3.2.2 Temperature-induced. The following is a list of typical effects as a result of temperature and temperature changes (this list is not intended to be all-inclusive):

a. Binding or slackening of moving parts.
b. Deformation or fracture of components.

c. Cracking of surface coatings.
d. Leaking of sealed compartments.
e. Failure of insulation protection.
f. Differential contraction or expansion rates or induced strain rates of dissimilar materials.
g. Intermittent electrical contacts.
h. Electrical shorts/opens.
i. Failed components.
j. Changes in electrical and electronic components.
k. Electronic or mechanical failures due to rapid water or frost formation.
l. Excessive static electricity.

3.2.3 Combined environmental-induced. Temperature, humidity, vibration, and altitude can combine synergistically to produce the following failures. Although altitude is included in the following discussion typically in regard to Electronic Equipment operating environment it mainly impacts cooling and is a function of temperature. Typically Combined Environmental Test facilities do not include altitude test capability. It should be noted that airborne Electronic Equipment may be operated in environments exceeding -55 °C to +120 °C, 40,000 foot altitude and high vibration due to take-off/landing and carrier catapult launches and arrested landings. The following examples are not intended to be comprehensive:

a. Shattering of optical material. (Temperature/Vibration/Altitude)
b. Binding or loosening of moving parts. (Temperature/Vibration)
c. Separation of constituents. (Temperature/Humidity/Vibration/Altitude)
d. Performance degradation in electronic components due to parameter shifts (Temperature/Humidity)
e. Electronic optical (fogging) or mechanical failures due to rapid water or frost formation. (Temperature/Humidity).
f. Differential contraction or expansion of dissimilar materials. (Temperature/Altitude)
g. Deformation or fracture of components. (Temperature/Vibration/Altitude)
h. Cracking of surface coatings. (Temperature/Humidity/ Vibration/Altitude)
i. Leakage of sealed compartments. (Temperature/Vibration//Altitude)
j. Failure due to inadequate heat dissipation. (Temperature/Vibration /Altitude)

3.3 Operational environment. A review should be conducted of technical manuals, operating manuals and any available operating environment information, prior to development of test procedures using the tailoring process in MIL-STD-810 to determine where forcing functions of temperature, humidity, vibration, and altitude are foreseen in the Electronic Equipment operational environment. Use this method only if the proper engineering has been performed such that the environmental stresses associated with the individual test methods are considered. If appropriate, tailor Electronic Equipment testing to include storage thermal environments and include in environmental testing or, perform them as separate tests, using the individual test methods. It is recommended that where the operational temperature and vibration test levels are not known that the qualification temperature and vibration levels during troubleshooting of the Electronic Equipment be reduced in order to not over stress the Electronic Equipment. The intent is to subject the Electronic Equipment to temperature/vibration level low/high enough to stimulate the intermittent fault, but not reduce the operational life of the Electronic Equipment.

4. Detail guidelines. Testing for intermittent faults should be conducted using diagnostic equipment meeting the performance requirements of MIL-PRF-32516. The diagnostic equipment covered by this specification is intended for use in detecting and isolating intermittent faults in Electronic Equipment, chassis, backplanes and their wire harnesses. The diagnostic equipment is intended to be used with the Electronic Equipment (with internal subassemblies removed) being stimulated by temperature, vibration or vibration/temperature to emulate the environment in which the fault originally occurred. MIL-PRF-32516, Appendices A through C, provide recommended guidelines for defining this external stimulation.

5. Integrated diagnostics. See guideline 77.

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CONCLUDING MATERIAL

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(Project SESS-2020-045)

Review activities:
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Navy - EC, OS, SH
Air Force – 19, 85

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil.