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GENERAL GUIDELINES FOR ELECTRONIC EQUIPMENT

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DEPARTMENT OF DEFENSE

Washington DC 20360

General Guidelines for Electronic Equipment

MIL-HDBK-454

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FOREWORD

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 following Government documents are intimately associated with this handbook.

MIL-STD-2036	General Requirements for Electronic Equipment Specifications.
MIL-E-4158	Electronic Equipment, Ground, General Specification for.
MIL-STD-5400	Electronic Equipment, Aerospace, General Standard for.
MIL-E-8189	Electronic Equipment, Missiles, Boosters and Allied Vehicles, General Specification for (Not for New Design).
DOD-E-8983	Electronic Equipment, Aerospace, Extended Space Environment, General Specification for.
MIL-P-11268	Parts, Materials, and Processes Used in Electronic Equipment.
MIL-STD-11991	Electrical, Electronic and Electro-mechanical Equipment, Guided Missile and Associated Weapon Systems, General Standard for.
MIL-F-18870	Fire Control Equipment, Naval Shipboard, General Specification for.
MIL-T-28800	Test Equipment for Use with Electrical and Electronic Equipment, General Specification for.

CONTENTS

Paragraph

1. SCOPE
1.1 Guidelines applicable to electronic equipment
1.2 Revision of guidelines
1.3 Method of reference
1.4 Interrelationship of guidelines
2. APPLICABLE DOCUMENTS
3. DEFINITIONS
4. GENERAL GUIDELINES
4.1 Application
4.2 Use of selection and application standards
5. DETAIL GUIDELINES
6. NOTES

Individual Guidelines

Guideline 1 - Safety Design Criteria - Personnel Hazards
Guideline 2 - Capacitors
Guideline 3 - Flammability
Guideline 4 - Fungus-Inert Materials
Guideline 5 - Soldering
Guideline 6 - Bearings
Guideline 7 - Interchangeability
Guideline 8 - Electrical Overload Protection
Guideline 9 - Workmanship
Guideline 10 - Electrical Connectors
Guideline 11 - Insulating Materials, Electrical
Guideline 12 - Fastener Hardware
Guideline 13 - Structural Welding
Guideline 14 - Transformers, Inductors, and Coils
Guideline 15 - Metals, Corrosion Resistance
Guideline 16 - Dissimilar Metals
Guideline 17 - Printed Wiring
Guideline 18 - Derating of Electronic Parts and Materials
Guideline 19 - Terminations
Guideline 20 - Wire, Hookup, Internal
Guideline 21 - Castings
Guideline 22 - Parts Selection and Control
Guideline 23 - Adhesives
Guideline 24 - Welds, Resistance, Electrical Interconnections
Guideline 25 - Electrical Power
Guideline 26 - Arc-Resistant Materials
Guideline 27 - Batteries
Guideline 28 - Controls
Guideline 29 - Electron Tubes
Guideline 30 - Semiconductor Devices
Guideline 31 - Moisture Pockets
Guideline 32 - Test Provisions
Guideline 33 - Resistors
Guideline 34 - Nomenclature
Guideline 35 - Reliability
Guideline 36 - Accessibility
Guideline 37 - Circuit Breakers
Guideline 38 - Quartz Crystals and Oscillator Units
Guideline 39 - Fuses and Fuse Holders
Guideline 40 - Shunts
Guideline 41 - Springs
Guideline 42 - Tuning Dial Mechanisms

CONTENTS - Continued.

Guideline 43 - Lubricants
Guideline 44 - Fibrous Materials, Organic
Guideline 45 - Corona and Electrical Breakdown Prevention
Guideline 46 - Motors and Rotary Power Converters
Guideline 47 - Encapsulation and Embedment (Potting)
Guideline 48 - Gears
Guideline 49 - Hydraulics
Guideline 50 - Indicator Lights
Guideline 51 - Meters, Electrical Indicating
Guideline 52 - Thermal Design
Guideline 53 - Waveguides and Related Devices
Guideline 54 - Maintainability
Guideline 55 - Enclosures
Guideline 56 - Rotary Servo Devices
Guideline 57 - Relays
Guideline 58 - Switches
Guideline 59 - Brazing
Guideline 60 - Sockets and Accessories
Guideline 61 - Electromagnetic Interference Control
Guideline 62 - Human Engineering
Guideline 63 - Special Tools
Guideline 64 - Microelectronic Devices
Guideline 65 - Cable, Coaxial (RF)
Guideline 66 - Cable, Multiconductor
Guideline 67 - Marking
Guideline 68 - Readouts and Displays
Guideline 69 - Internal Wiring Practices
Guideline 70 - Electrical Filters
Guideline 71 - Cable and Wire, Interconnection
Guideline 72 - Substitutability
Guideline 73 - Standard Electronic Modules
Guideline 74 - Grounding, Bonding, and Shielding
Guideline 75 - Electrostatic Discharge Control
Guideline 76 - Fiber Optics
Guideline 77 - Intergrated Diagnostics
Guideline 78 - Producibility

Tables

Table 1-I Probable effects of shock
Table 1-II Suitable protective measures
Table 4-I Fungi-susceptibility of materials
Table 10-I Abbreviations for thermocouple materials
Table 20-I Wire, electrical
Table 21-I General comparison of metallic casting processes
Table 26-I Arc-resistant materials
Table 41-I Materials for electrical spring application
Table 41-II Corrosion resisting steel for springs
Table 41-III Carbon steel for springs
Table 50-I Indicator lights and associated items
Table 53-I Waveguides and related devices
Table 66-I Cable, multiconductor
Table 69-I Electrical clearance and leakage (creepage) distances
Table 71-I Wire, electrical, interconnection
Table 71-II Cable, multiconductor, interconnection

Indexes

Index I-1 Index of Applicable Documents
Index I-2 Subject Index

GENERAL GUIDELINES FOR ELECTRONIC EQUIPMENT

1. Scope.

1.1 Guidelines applicable to electronic equipment. This handbook covers the common guidelines to be used in military specifications for electronic equipment.

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 in the individual specification by specifying this handbook and the guideline number.

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 invoking or using these guidelines.

2. Applicable documents.

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

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

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

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

AGMA American Gear Manufacturers Association
1901 North Fort Meyer Drive
Suite 1000
Arlington VA 22209

AMS SAE
400 Commonwealth Drive
Warrendale PA 15096

ANSI American National Standards Institute
1430 Broadway
New York NY 10018

ASM American Society for Metals
Metals Park OH 44073

ASTM American Society for Testing and Materials
1916 Race Street
Philadelphia PA19103

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

EIA Electronic Industries Association
2500 Wilson Blvd
Arlington VA 22201-3834

IEEE Institute of Electrical and Electronics Engineers
820 Second Avenue
New York NY 10017

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

NAS National Standards Association
1200 Quince Orchard Boulevard
Gaithersburg MD 20878

NFPA National Fire Protection Association
Batterymarch Park
Quincy MA 02269

UL Underwriters Laboratories, Incorporated
333 Pfingsten Road
Northbrook IL 60062

3. Definitions.

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

3.2 Other terms are defined in the individual 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, and should be incorporated by reference in general equipment specifications. Other documents may reference Guidelines when applicable.

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 follow.

6. Notes.

6.1 Changes from previous issue. The margins of this handbook are marked with asterisks to indicate where changes (additions, modifications, corrections, deletions) from the previous issue were made. This is done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the guidelines of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

6.2 Subject term (key word) listing.

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

CONCLUDING MATERIAL

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

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

Preparing activity:
DLA - ES

Project GDRQ-0162

GUIDELINE 1

SAFETY DESIGN CRITERIA - PERSONNEL HAZARDS

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

2. Documents applicable to guideline 1:

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

3. Definitions.

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

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

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

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

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

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

4. Guidelines.

4.1 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.

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

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

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

4.4.1 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 guidelines. If a main power switch is provided, it should be clearly labeled as such and should cut off all power to the complete equipment.

4.4.2 Ground. The design and construction of equipment, excluding self-powered equipment, should insure that all external parts, surfaces, and shields, exclusive of antenna and transmission line terminals, are at ground potential at all times during normal operation. The design 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.

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

4.4.2.2 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 imposed upon it;

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

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

4.4.2.3 Hinged or slide-mounted panels and doors. Hinges or slides 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 insure that they are at the same ground potential as the equipment in which they are mounted, whether in a closed or open position. A ground 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 insure the reliable and immediate tripping of equipment over-current protection devices.

4.4.2.4 Shielding. Except where a conflict with single-point shield grounding 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.

4.4.3 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.

4.4.3.1 Guards and barriers. All contacts, terminals and like devices having voltages between 70 and 500 volts rms or dc with respect to ground 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.

4.4.3.2 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 nonbypassable interlocks.

4.4.3.3 Voltage measurement. When the operation or maintenance of equipment employing potentials in excess of 300 volts peak could require that these voltages be measured, the equipment 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.

4.4.3.4 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 in the 70 to 500 volt range.

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

4.4.4 Protective devices.

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

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

b. Bypassable interlocks are required when voltages between 70 and 500 volts are exposed as the result of an access door, cover, or plate being opened. Note that these internal voltages are allowed to be unguarded only if they are not exposed during direct support or operator maintenance. The bypass device 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. Nonbypassable interlocks are required when any voltage in excess of 500 volts is exposed as a result of an access door, cover or plate being opened.

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

4.4.4.3 Safety switches. Safety switches which will deactivate associated mechanical drive units 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 nonoverrideable safety switches to allow independent disconnection in the associated equipment.

4.4.5 Discharging devices.

4.4.5.1 Automatic discharge devices. High voltage circuits and capacitors 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 insure 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.

4.4.5.2 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.

4.4.6 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.

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

4.5.1 Microwave and rf radiation. All electronic equipment or electrical devices capable of emitting microwave or rf radiation between 300 kHz and 100 GHz should be so designed, fabricated, shielded and operated as to avoid overexposure of personnel. In areas where unintended radiation levels exist, equipment design and installation in any unrestricted area accessible to personnel should meet the guidelines of ANSI 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 nonbypassable interlocks.

4.5.2 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 one hour and 100 mr in any 7 consecutive days at the operator position or within 5cm from the equipment (whichever is closer) in any unrestricted area accessible to personnel. In addition, these levels 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 per calendar quarter or 500 millirem per 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 1910.96; 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 nonbypassable interlocks.

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

4.6 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.

4.6.1 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.

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

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

4.7 Equipment safety markings. Danger, caution, etc, signs, labels and markings should be used to warn of specific hazards such as voltage, current, thermal, or physical. The signs, labels, and markings should be as permanent as the normal life expectancy of the equipment on which they are affixed. Guards, barriers, and 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 ANSI Z53.1 where applicable to electronic equipment.

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

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

d. Microwave or rf radiation warning signs should be in accordance with ANSI Z35.1 and ANSI 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 4.5.1 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 300 kHz and 100 GHz with intended electromagnetic radiation levels exceeding those in 4.5.1.

e. (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), which reads:

CAUTION

4.14 Fireproof connectors. Fireproof and firewall connectors should be class K and should conform to Section 101 of MIL-STD-1353. Where it is necessary to maintain electrical continuity for a limited time under continuous flame, both the receptacle and mating plug 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. When used, filter pin connectors should conform to MIL-STD-2120.

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

5. Information for guidance only. Not applicable. 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 ANSI Z35.2.

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

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

4.8 Hazardous and restricted materials.

4.8.1 Gases or fumes. The materials, as installed in the equipment and under service conditions specified in the equipment specification, 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.

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

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

4.8.4 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. This does not preclude the use of military specification wire and cable. When maintenance procedures require access to glass fibers, such as insulation, a proper caution note should be provided.

5. Information for guidance only.

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

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

5.2.1 Shock hazards. Current rather than voltage is the most important variable in establishing the criterion for shock intensity. Three factors that determine the severity of electrical shock are: (1) quantity of current flowing through the body; (2) path of current through the body; and (3) duration of time that the current flows through the body. The voltage necessary to produce the fatal current is dependent upon the resistance of the body, contact conditions, and the path through the body. See table 1-I. Sufficient current passing through any part of the body will cause severe burns and hemorrhages. However, relatively small currents can be lethal if the path includes a vital part of the body, such as the heart or lungs. Electrical burns are usually of two types, those produced by heat of the arc which occurs when the body touches a high-voltage circuit, and those caused by passage of electrical current through the skin and tissue. While current is the primary factor which determines shock severity, protection 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	
0-1	0-4	Perception
1-4	4-15	Surprise
4-21	15-80	Reflex action
21-40	80-160	Muscular inhibition
40-100	160-300	Respiratory block
Over 100	Over 300	Usually fatal

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

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

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

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

a. Use of guards and barriers;

b. Sufficient space separation to prevent short circuits;

c. Caution - warning signs.

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

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

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

5.5 Materials. Certain chemicals have been identified in the Occupational Safety and Health Act (OSHA) as cancer-producing substances (carcinogens). Before using any materials which might contain these chemicals, they should be evaluated in accordance with 29 CFR 1910.

TABLE 1-II. Suitable protective measures. 1/

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

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

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

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

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

GUIDELINE 2

CAPACITORS

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

2. Documents applicable to guideline 2:

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

3. Definitions. Not applicable.

4. Guidelines.

4.1 Selection. Capacitors should be selected and applied in accordance with MIL-STD-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-C-39006/22 and MIL-C-39006/25) should be approved by the procuring activity, and silver cased tantalum capacitors should not be used.

GUIDELINE 3

FLAMMABILITY

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

2. Documents applicable to guideline 3:

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

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

4. Guidelines. 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 nonpermanent additives to the basic material.

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

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

5.2 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 nonnutrients of fungus and establishes conditions under which fungus nutrient materials are acceptable.

2. Documents applicable to guideline 4:

MIL-T-152	Treatment, Moisture and Fungus Resistant, of Communications, Electronic, and Associated Electrical Equipment
MIL-V-173	Varnish, Moisture and Fungus Resistant (For Treatment of Communications, Electronic, and Associated Equipment)
MIL-STD-810	Environmental Test Methods and Engineering Guidelines
29 CFR 1910	Code of Federal Regulations

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. 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. Group II materials should be subjected to the fungus test specified in MIL-STD-810, method 508, for a period of 28 days. Certification by a qualified laboratory or by the material producer, based on test data on record that the material meets grade 0 or grade 1 guidelines of table 508-I, method 508, MIL-STD-810, is sufficient evidence of acceptability.

TABLE 4-I. Fungi susceptibility of materials.

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

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

5. Information for guidance only.

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

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

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

GUIDELINE 5

SOLDERING

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

2. Documents applicable to guideline 5:

MIL-STD-2000 Standard Requirements for Soldered Electrical and Electronic Assemblies

DOD-STD-1866 Soldering Process, General (Non-Electrical) (Metric)

3. Definitions. Not applicable.

4. Guidelines.

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

4.2 Structural soldering. Nonelectrical soldered connections should be in accordance with the guidelines of DOD-STD-1866.

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

5.0 Information for guidance only.

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

GUIDELINE 6

BEARINGS

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

2. Documents applicable to guideline 6:

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

3. Definitions. Not applicable.

4. 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.

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

4.2 Lubricant. Adequate lubricant 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 MIL-STD-1334. Barrier coating material should conform to MIL-B-81744.

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 an 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. Information for guidance only.

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

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

GUIDELINE 7

INTERCHANGEABILITY

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

2. Documents applicable to guideline 7:

MIL-STD-280 Definitions of Items Levels, Item Exchangeability, Models, and Related Terms

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

3. Definitions.

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

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

4. 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 supersession information, the design should permit the substitute or superseding parts or materials to be used interchangeably.

GUIDELINE 8

ELECTRICAL OVERLOAD PROTECTION

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

2. Documents applicable to guideline 8:

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

3. Definitions.

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

3.2 Class 2 equipment. Manned aerospace equipment

3.3 Class 3 equipment. Unmanned aerospace equipment

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

4.1 Protection for class 1 equipment.

4.1.1 Current overload protection. Current overload protection 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.

5. Information for guidance only.

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

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

GUIDELINE 9

WORKMANSHIP

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

2. Documents applicable to guideline 9. Not applicable.

3. Definitions. Not applicable.

4. 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. Information for guidance only.

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

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

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

GUIDELINE 10

ELECTRICAL CONNECTORS

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

2. Documents applicable to guideline 10:

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

3. Definitions. Not applicable.

4. Guidelines.

4.1 Selection. Selection and use of electrical connectors should be in accordance with MIL-STD-1353 and as specified herein. 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 MIL-STD-1646 or as specified in the individual connector specifications. However, contractors may use tooling as recommended by the contact or tooling manufacturer provided that the finished crimp meets all of the performance 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-C-10544 or MIL-C-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 nontactical sound equipment, connectors conforming to EIA-297-A 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.

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

4.4 Heavy duty connectors.

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

4.4.2 General purpose and shipboard. Connectors for general purpose heavy duty applications and shipboard power applications should conform to section 102 of MIL-STD-1353. 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.

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

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

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 to section 105 of MIL-STD-1353. 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 section 200 of MIL-STD-1353. Adapters used with rf connectors should conform to MIL-A-55339.

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

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

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

4.11.1 Quantity and location. Unused connector contacts or contact positions for external circuits 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 or 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.

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 moistureproof and vaporproof caps. Connectors on enclosed cabinet mounted equipment need not be provided with protective caps unless an environmental hazard exists.

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

4.14 Fireproof connectors. Fireproof and firewall connectors should be class K and should conform to Section 101 of MIL-STD-1353. Where it is necessary to maintain electrical continuity for a limited time under continuous flame, both the receptacle and mating plug 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. When used, filter pin connectors should conform to MIL-STD-2120.

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

5. Information for guidance only. Not applicable.

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. Documents applicable to guideline 11:

L-P-516	Plastic Sheet and Plastic Rod, Thermosetting, Cast
HH-I-553	Insulation Tape, Electrical (Rubber, Natural and Synthetic)
MIL-I-10	Insulating Compound, Electrical, Ceramic, Class L
MIL-M-14	Molding Plastics and Molded Plastic Parts, Thermosetting
MIL-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-3825	Insulation Tape, Electrical, Self-Fusing: For Use in Electronics, Communications, and Allied Equipment
MIL-I-7444	Insulation Sleeving, Electrical, Flexible
MIL-T-13020	Tape, Rubber, Unvulcanized, Splicing and Molding (Tapes TL-317/U and TL-318/U)
MIL-I-15126	Insulation Tape, Electrical, Pressure Sensitive Adhesive and Pressure Sensitive Thermosetting Adhesive
MIL-I-17205	Insulation Cloth and Tape, Electrical, Glass Fiber, Varnished
MIL-I-18746	Insulation Tape, Nonadhering, Glass Fabric, Polytetrafluoroethylene Coated
MIL-I-19166	Insulation Tape, Electrical, High-Temperature, Glass Fiber, Pressure Sensitive
MIL-I-22076	Insulation Tubing, Electrical, Nonrigid, Vinyl, Very Low Temperature Grade
MIL-I-22129	Insulation Tubing, Electrical, Polytetrafluoroethylene Resin, Nonrigid
MIL-I-23053	Insulation Sleeving, Electrical, Heat-Shrinkable, General Specification for
MIL-I-23264	Insulators, Ceramic, Electrical and Electronic, General Specification for
MIL-I-23594	Insulation Tape, Electrical; High Temperature Polytetra-fluoroethylene, Pressure-Sensitive
MIL-I-24092	Insulating Varnish, Electrical, Impregnating, Solvent Containing
MIL-I-24204	Insulation, Electrical, High Temperature, Bonded, Synthetic Fiber Paper
MIL-I-24391	Insulation Tape, Electrical, Plastic, Pressure Sensitive
MIL-I-24768	Insulation, Plastics, Laminated, Thermosetting, General Specification for
MIL-I-24768/2	Insulation, Plastics, Laminated, Thermosetting, Glass Cloth, Epoxy-Res
MIL-I-24768/3	Insulation, Plastics, Laminated, Thermosetting, Glass Cloth, Epoxy-Res
MIL-I-46852	Insulation Tape, Electrical, Self-Adhering, Unsupported Silicone Rubber
MIL-I-49456	Insulation Sheet, Electrical, Silicone Rubber, Thermally Conductive, Fiberglass Reinforced
MIL-I-81765	Insulating Components, Molded, Electrical, Heat Shrinkable, General Specification for
MIL-I-85080	Insulation Sleeving, Electrical, Shrinkable Without Heat, General Specification for
SAE-AMS 3638	Plastic tubing, Electrical Insulation, Irradiated Polyolefin, 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 D3295	PTFE Tubing, Specification for
29 CFR 1910	Code of Federal Regulations, Title 29, Chapter XVII, Part 1910

3. Definitions. Not applicable.

4. Guidelines.

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

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

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

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

4.5 Plastic, thermosetting, laminated. Materials selected should conform to MIL-P-18177, MIL-I-24768/2 and /3 or MIL-I-24204. The preferred base is glass cloth. Electrical insulators fabricated from laminated thermosetting-plastic sheets, plates, rods and tubes (except transparent plastics) 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. Materials used to mold electrical insulators should conform to MIL-M-14. 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, insulating. Insulating varnish should conform to MIL-I-24092.

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

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

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

5. Information for guidance only.

5.1 Selection criteria. Insulating materials should be selected based upon meeting or exceeding application 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.

GUIDELINE 12

FASTENER HARDWARE

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

2. Documents applicable to guideline 12:

FF-B-575	Bolts, Hexagon and Square
FF-N-836	Nut, Square, Hexagon, Cap, Slotted, Castle Knurled, Welding and Single Ball Seat
FF-R-556	Rivet, Solid, Small; Rivet, Split, Small; Rivet Tubular, Small; Flat Washer (Burr); and Cap, Rivet, General Purpose
FF-S-85	Screw, Cap, Slotted and Hexagon-Head
FF-S-86	Screw, Cap, Socket-Head
FF-S-92	Screw, Machine; Slotted, Cross Recessed or Hexagon Head
FF-S-200	Setscrews; Hexagon Socket and Spline Socket, Headless
FF-S-210	Setscrews, Square Head and Slotted Headless
FF-W-84	Washers, Lock (Spring)
FF-W-92	Washer, Metal, Flat (Plain)
FF-W-100	Washer, Lock (Tooth)
TT-S-1732	Sealing Compound, Pipe Joint and Thread, Lead Free, General Purpose
FED-STD-H28	Screw-Thread Standards for Federal Services
MIL-S-1222	Studs, Bolts, Hex Cap Screws, Socket Head Cap Screws and Nuts
MIL-F-5591	Fasteners, Panel; Nonstructural
MIL-R-5674	Rivets, Structural, Aluminum Alloy, Titanium Columbium Alloy, General Specification for
MIL-B-6812	Bolts, Aircraft
MIL-S-7742	Screw Threads, Standard, Optimum Selected Series; General Specification for
MIL-B-7838	Bolt, Internal Wrenching, 160 KSI FTU
MIL-R-7885	Rivets; Blind, Structural, Pull-Stem and Chemically Expanded
MIL-R-8814	Rivets, Blind, Nonstructural Type
MIL-B-8831	Bolt, Tensile, Steel, 180 KSI FTU, 450°F, External Wrenching, Flanged Head
MIL-S-8879	Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification for
MIL-F-18240	Fastener, Externally Threaded 250°F, Self-Locking, Element for
MIL-T-22361	Thread Compound, Antiseize, Zinc Dust-petrolatum
MIL-S-22473	Sealing, Locking and Retaining Compounds: (Single-Component)
MIL-R-22978	Fastener, Rotary, Quick-Operating, High Strength
MIL-R-24243	Rivet, Blind, Nonstructural, Retained Mandrel, Open-end, Domed Head, Aluminum Alloy, Carbon Steel
MIL-N-25027	Nut, Self-Locking 250°F, 450°F, and 800°F
MIL-R-27384	Rivet, Blind, Drive Type
MIL-S-46163	Sealing, Lubricating, and Wicking Compounds: Thread Locking, Anaerobic, Single Component
MS33522	Rivets, Blind, Structural, Mechanically Locked and Friction Retainer Spindle, (Reliability and Maintainability, Design and Construction Requirements for)
MS33540	Safety Wiring, and Cotter Pinning, General Practices for
MS33557	Nonstructural Rivets for Blind Attachment, Limitations for Design and Usage
NAS498	Bolts, Shear, 95 KSI FSU
NAS547	Fastener, Rotary, Quick-Operating, High Strength
NAS1686	Rivet, Blind, Aluminum Sleeve, Mechanically Locked, Spindle, Bulbed
NAS1687	Rivet, Blind, Monel and Inconel Sleeve, Mechanically Locked Spindle, Bulbed

3. Definitions. Not applicable.

4. Guidelines.

4.1 Threaded fasteners and related parts.

4.1.1 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 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 MIL-S-8879 for applications requiring high strength or high fatigue life.

(Caution should be exercised where a MIL-S-8879 UNJ external thread fastener is used due to its incompatibility with the commonly used UNC, UNF or UNEF threaded nut or tapped hole.)

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

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

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

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

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

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

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

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

b. Bolt studs should conform to MIL-S-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 MIL-B-8831.

f. Shear bolts should conform to NAS498.

4.1.4 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-S-1222.

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

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

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

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

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

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

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

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

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

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

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

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 MIL-R-8814.

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 rivets should conform to MIL-R-5674.

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

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

5. Information for guidance only.

5.1 Threaded fasteners.

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

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

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

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

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

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

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

5.1.3 Fastening of soft materials to hard materials. In addition to the methods outlined in 5.1.1, a self-locking screw or bolt may be used in a hole tapped into the hard material. Self-locking screws or bolts with nonmetallic locking devices should not be used where the specified service conditions or processing, such as baking of paints or soldering, might deteriorate the locking device.

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

5.1.5 Fastening of brittle materials. Brittle castings or parts made of ceramic or other brittle materials should be properly cushioned when necessary to prevent breakage. Washers or gaskets of suitable material and compressibility should be used between the facing surfaces of the brittle part and other brittle or metal parts, when practicable, to prevent breakage or damage to the protected parts during assembly or from severe shock, vibration or temperature changes encountered under the specified service conditions. Lead washers should not be used. Parts that are secured with threaded devices and pliable washers should not use lockwashers as the locking device, and other appropriate locking devices should be considered.

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

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

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

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

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

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

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

5.2 Rivets. Rivets should be used in preference to other hardware for securing parts not requiring removal. Wherever the thickness of metal which accepts the heads of flush rivets is less than the height of the rivet heads, the material should be dimpled rather than countersunk. The distance from the center of rivet holes to the edges of the material in which the rivets are placed should not be less than 1.5 times the rivet diameter. Design and limitations of rivets should be in accordance with MS33522 and MS33557. Rivets for joining magnesium parts should be composition 5056 anodized aluminum alloy or an aluminum alloy having equal galvanic compatibility with the magnesium being used.

5.3 Other fastening methods.

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

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

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

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

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

5.3.3 Screw threaded device applications.

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

a. Lockwashers under the heads of the screws or bolts

b. Self-locking screws

c. Self-locking threaded inserts

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

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

5.3.3.2 Countersunk head screws. Countersunk head screws, when not secured by other locking means, should be secured by the application of a thread-locking compound in accordance with 4.1.10. Staking by means of upsetting metal is acceptable for permanent assemblies when other means are impracticable or unsatisfactory for design reasons.

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

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

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

GUIDELINE 13

STRUCTURAL WELDING

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

2. Documents applicable to guideline 13:

MIL-W-6858	Welding, Resistance, Spot and Seam
MIL-STD-22	Welded Joint Design
MIL-STD-248	Welding and Brazing Procedure and Performance Qualification
MIL-STD-1261	Arc Welding Procedures for Constructional Steels
MIL-STD-1595	Qualification of Aircraft, Missile, and Aerospace Fusion Welders
MIL-STD-2219	Fusion Welding for Aerospace Applications
MIL-HDBK-5	Metallic Materials and Elements for Aerospace Vehicle Structures
MIL-HDBK-730	Materials Joining
AMS 2680	Welding, Electron Beam, for Fatigue Critical Application
AMS 2681	Electron-Beam Welding
ANSI/AWS A2.4	Standard Symbols for Welding, Brazing and Nondestructive Examination
ANSI/AWS A3.0	Standard Welding Terms and Definitions, Including Terms for Brazing, Soldering, Thermal Spraying and Thermal Cutting

3. Definitions. Not applicable.

4. 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 MIL-STD-248 or MIL-STD-1595. Welding of aluminum, magnesium, and steel alloys should conform to MIL-STD-2219.

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

5. Information for guidance only.

5.1 General. The joint areas of all parts to be welded should be cleaned of contaminants and materials which may be detrimental to obtaining satisfactory welds. 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 ANSI/AWS 2.4 for welding symbols, ANSI/AWS A3.0 for welding terms and definitions, and MIL-STD-22 for welded joint designs. MIL-HDBK-730 provides guidance in this field of materials joining and its related processes.

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

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

5.4 Other methods. Other welding methods, such as the electron beam process of AMS 2680 and 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. Documents applicable to guideline 14:

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

3. Definitions. Not applicable.

4. Guidelines.

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

4.1.1 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.

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

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

5. Information for guidance only. Not applicable.

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. Documents applicable to guideline 15:

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

3. Definitions. Not applicable.

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

5. Information for guidance only. The environmental severity to which the equipment will be exposed should be considered in selection of metals. The use of 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. Document applicable to guideline 16:

MIL-STD-889 Dissimilar Metals

3. Definitions. Not applicable.

4. Guidelines. Selection of metals for use in electronic equipment should be made in accordance with the guidelines of MIL-STD-889.

5. Information for guidance only. Where electronic design guidelines 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. Documents applicable to guideline 17:

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

3. Definitions. Not applicable.

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

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

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-STD-1861.

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

4.5 Discrete wiring boards. Discrete wiring boards with plated-through holes should be in accordance with MIL-STD-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. Information for guidance only.

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

GUIDELINE 18

DERATING OF ELECTRONIC PARTS AND MATERIALS

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

2. Document applicable to guideline 18:

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

3. Definitions. Not applicable.

4. 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 assure the required equipment reliability within the specified operating conditions.

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

5. Information for guidance only. Not applicable.

GUIDELINE 19

TERMINATIONS

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

2. Documents applicable to guideline 19:

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

3. Definitions. Not applicable.

4. Guidelines.

4.1 Terminals.

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

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

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

4.1.3 Number of wires per terminal or lug. The number of wires terminated in an individual terminal or lug 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 is required than those specified herein, approval of the procuring activity should be obtained.

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

4.2.1 Number of lugs per terminal. The maximum number of lugs to be connected to any one terminal on a terminal board should be two for screw-type terminal boards covered by MIL-T-55164 and as specified in the detail specification sheets for stud-type terminal boards. Not more than four lugs should be connected to any one terminal of a board covered by MS27212. 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-STD-1277.

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

GUIDELINE 20

WIRE, HOOKUP, INTERNAL

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

2. Documents applicable to guideline 20:

QQ-W-343	Wire, Electrical, Copper (Uninsulated)
MIL-W-76	Wire and Cable, Hookup, Electrical, Insulated
MIL-W-5086	Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy
MIL-W-5846	Wire, Electrical, Chromel and/or Alumel, Thermocouple
MIL-W-16878	Wire, Electrical, Insulated, General Specification for
MIL-W-19150	Wire, Insulated, Hard Drawn Copper
MIL-W-22759	Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy
MIL-W-81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-Imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy
MIL-W-81381	Wire, Electric, Polyimide Insulated, Copper or Copper Alloy
MIL-W-81822	Wire, Electrical, Solderless Wrap, Insulated and Uninsulated, General Specification for
MIL-STD-681	Identification Coding and Application of Hook-Up and Lead Wire
ASTM B298	Wire, Copper, Silver-Coated, Soft or Annealed

3. Definitions. Not applicable.

4. 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-W-76 usage. MIL-W-76 should be used for Army applications only.

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

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

4.1.4 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.

4.1.5 Silver plated copper wire. Silver plated copper wire shall 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 B298. Wire which fails this test will be rejected. Silver plated copper wire shall not be used in conjunction with water-soluble solder fluxes. Wire shall 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 shall conform to QQ-W-343. Bare hookup wire shall not be used unless insulated wire is impractical because of circuit characteristics or shortness of wire run.

5. Information for guidance only.

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

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

5.3 Thermocouple wire. Selection of thermocouple wire should be in accordance with MIL-W-5846.

5.4 Stranded copper conductor test. The following test procedure should be used for stranded conductors since the ASTM B298 procedure covers only a single, round conductor.

5.4.1 Sodium polysulfide test. The stranded samples of annealed copper or copper alloy base material shall be tested per ASTM B298 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 are to 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 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.

TABLE 20-I. Wire, electrical.

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

TABLE 20-I. Wire, electrical - Continued.

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

TABLE 20-I. Wire, electrical - Continued.

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

TABLE 20-I. Wire, electrical - Continued.

Spec no.	Title	Spec type or class	Construction						Max cond temp °C	Max rms volts	Remarks
			1/ Conductor			2/ Insulation					
			Material	Coating	Type	Primary	Primary cover	Jacket/ topcoat			
MIL-W-81381	Wire, Electric, Polyimide Insulated, Copper or Copper Alloy	M81381/7	Cu/A	Ag	Str	19		20	200	600	/11,/12, and /22 have a bright aromatic polyamide braid with clear finisher coatings on 8 AWG and larger
		M81381/8		Ni			4B				
		M81391/9	HSA	Ag							
		M81381/10		Ni							
		M81381/11	Cu/A	Ag							
		M81381/12		Ni							
		M81381/13	HSA	Ag							
		M81381/14		Ni							
		M81381/17	Cu/A	Ag							
		M81381/18		Ni							
		M81381/19	HSA	Ag							
		M81381/20		Ni					150		
		M81381/21	Cu/A	Sn							
		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
	HSA	High strength copper alloy
	Al	Aluminum
Coating	Sn	Tin
	Ag	Silver
	Ni	Nickel
Type	S	Solid
	Str	Stranded

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

3/ When specified on purchase order

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

GUIDELINE 21

CASTINGS

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

2. Documents applicable to guideline 21:

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

3. Definitions. Not applicable.

4. 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 MIL-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. Information for guidance only.

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

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

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

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

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

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

2. Documents applicable to guideline 22:

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

3. Definitions. Not applicable.

4. Guidelines. Not applicable.

5. Information for guidance only.

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

5.2 Parts control program for spacecraft and launch vehicles. (Not applicable to NASA programs) MIL-STD-1546 establishes the criteria and 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: (1) assure total, integrated, and coordinated management of the selection, application, procurement, control and standardization of parts, materials and processes (PMP), (2) reduce program costs, (3) improve the standardization and reliability of program parts, materials, and processes and (4) assure long term availability of parts.

GUIDELINE 23

ADHESIVES

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

2. Documents applicable to guideline 23:

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

3. Definitions.

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

4. Guidelines. Not applicable.

5. Information for guidance only.

5.1 Design of joint. The joint should be designed to minimize concentrations of stress. The basic stress should be in shear. The weakest design is where the basic stress is in cleavage or peel and 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	MMM-A-1617	MIL-A-25463	MIL-A-48611
MMM-A-130	MMM-A-1931	MIL-A-46050	MIL-A-52194
MMM-A-132	MIL-A-3920	MIL-A-46146	MIL-A-81236
MMM-A-134	MIL-A-5540	MIL-A-47089	MIL-A-81253
MMM-A-138	MIL-A-8576	MIL-A-47315	MIL-A-83377
MMM-A-181	MIL-A-22397	MIL-A-47317	MIL-A-87135
MMM-A-189	MIL-A-24179	MIL-A-47318	MIL-HDBK-691

Many of these specifications have no guidelines 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. Documents applicable to guideline 24:

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

3. Definitions. Not applicable.

4. Guidelines. Welds and welding processes should be in accordance with MIL-W-8939.

5. Information for guidance only.

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

5.2 Electrical connections. Except where needed to meet electromagnetic interference or system compatibility 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. Documents applicable to guideline 25:

MIL-STD-205	Frequencies for Electric Power
MIL-STD-255	Electric Voltages, Alternating and Direct Current
MIL-STD-704	Aircraft Electric Power Characteristics
MIL-STD-1275	Characteristics of 28 Volt DC Electrical Systems in Military Vehicles
MIL-STD-1399	Interface Standard for Shipboard Systems
MIL-STD-1539	Electrical Power, Direct Current, Space Vehicle Design Requirements
MIL-HDBK-411	

3. Definitions. Not applicable.

4. Guidelines.

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

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

4.3 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.

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

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

5. Information for guidance only. Not applicable.

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

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. Documents applicable to guideline 26:

L-P-516	Plastic Sheet and Plastic Rod, Thermosetting, Cast
ZZ-R-765	Rubber, Silicone
MIL-I-10	Insulating Compound, Electrical, Ceramic, Class L
MIL-M-14	Molding Plastics and Molded Plastic Parts, Thermosetting
MIL-I-24768	Insulation, Plastic, Laminated, Thermosetting, General Specification for
MIL-M-24325	Molding Material, Plastic, Epoxy Compounds, Thermosetting
MIL-P-25518	Plastic Material, Silicone Resin, Glass Fiber Base, Low-Pressure Laminated
MIL-P-46112	Plastic Sheet and Strip, Polyimide
FED-STD-406	Plastics: Methods of Testing
ASTM D495-73	Standard Method of Test for High-Voltage, Low-Current Dry Arc Resistance of Solid Electrical Insulation Materials
29 CFR 1910	Code of Federal Regulations

3. Definitions. Not applicable.

4. Guidelines. 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 D495 or method 4011 of FED-STD-406, and are listed in approximate order of arc resistance.

5. Information for guidance only.

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

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

TABLE 26-I. Arc-resistant materials.

Materials	Specification	Types
Ceramic	MIL-I-10	All
Plastic(s), thermosetting, molding	MIL-M-14	CMI-5, GDI-30, GDI-30F, MAG, MAI-30, MAI-60, MAI-100, MAT-30, MDG, MME, MMI-5, MMI-30, MSG MSI-30, SDG, SDG-F, SDI-30
Molding, epoxy compounds	MIL-M-24325	MEE
Laminated rods and tubes	MIL-I-24768	GMG
Laminated sheets		
Glass cloth, melamine resin	MIL-P-15037	GME
Glass cloth, polytetra-fluoroethylene resin	MIL-P-19161	GTE
Glass cloth, silicone resin	MIL-I-24768	GSG
Low pressure laminate, silicone resin, glass fiber base	MIL-P-25518	All
Sheet and rod, cast	L-P-516	E-2
Sheet and strip, polyimide	MIL-P-46112	All
Silicone rubber	ZZ-R-765	All

GUIDELINE 27

BATTERIES

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

2. Documents applicable to guideline 27:

MIL-B-18	Batteries, Non-Rechargeable, Dry
MIL-B-10154	Batteries, Primary, Water-Activated (Dunk Type)
MIL-B-11188	Batteries, Storage, Lead-Acid
DOD-B-15072	Batteries, Storage, Lead-Acid, Portable, General Specification for (Metric)
MIL-B-49030	Batteries, Dry (Alkaline)
MIL-B-49430	Batteries, Non-Rechargeable, Lithium Sulfur Dioxide
MIL-B-49436	Batteries, Rechargeable, Nickel-Cadmium, Sealed
MIL-B-49458	Batteries, Non-Rechargeable, Lithium Manganese Dioxide
MIL-B-49461	Batteries, Non-Rechargeable, Lithium Thionyl Chloride
MIL-B-55118	Batteries, Storage, (Cells), Vented, Nickel-Cadmium
MIL-B-55130	Batteries, Rechargeable, Nickel-Cadmium, Sealed
MIL-B-55252	Batteries, Magnesium, Dry
MIL-B-81757	Batteries and Cells, Storage, Nickel-Cadmium, Aircraft, General Specification for
MIL-B-83769	Batteries, Storage, Lead-Acid, General Specification for
DOD-STD-1578	Nickel-Cadmium Battery Usage Practices for Space Vehicles Regulation 700-83, Army Material Command

3. Definitions. Not applicable.

4. 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 Army Material Command Regulation 700-83.

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

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

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

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

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

4.4 Installation marking. Connections, polarity, minimum acceptable voltage for equipment operation, nominal voltage, and type(s) of batteries required 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. Information for guidance only. The battery compartment should be provided with devices to firmly secure the batteries. Adequate room should be provided for battery installation, maintenance, testing, and removal without disassembly of the equipment. The battery compartment should prevent pressure build-up from heat, gases, liquids, or chemicals released during battery operation, charging, deterioration, or rupture, and should also prevent such materials from entering the electronic compartment. When magnesium dry batteries are used, extra precautions should be observed since these batteries give off heat at high rates of discharge (less than 10 hours) and evolve hydrogen.

GUIDELINE 28

CONTROLS

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

2. Documents applicable to guideline 28:

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

3. Definitions.

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

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

4. 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 conforming to MIL-K-3926 or MIL-K-25049 should be used wherever suitable. For knobs not covered by a military specification, color, tactile information, and flammability guidelines should be in accordance with MIL-K-3926. 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 MIL-D-28728.

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. Information for guidance only.

5.1 Arrangement and location. Controls should be arranged to facilitate smooth and rapid operation. All controls which have sequential relations, which are related to a particular function or operation, or which are operated together should be grouped together along with their associated displays. Controls should be conveniently located with respect to associated visual displays. Controls should be of such size and so spaced that the manipulation 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 set screws 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 for the selection and application of electron tubes.

2. Document applicable to guideline 29:

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

3. Definitions. Not applicable.

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

5. Information for guidance only. Not applicable.

GUIDELINE 30

SEMICONDUCTOR DEVICES

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

2. Documents applicable to guideline 30:

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

3. Definitions. Not applicable.

4. Guidelines.

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

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

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

4.1.2.1 For packaged devices:

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

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

c. Active DESC drawings subject to procuring activity approval.

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

4.1.2.2 For dice:

a. MIL-S-19500 JAN C program (see 1.2.1.2, appendix H, and detailed specifications).

b. Other semiconductor documents subject to procuring activity approval.

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

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

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

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

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

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

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

GUIDELINE 31

MOISTURE POCKETS

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

2. Documents applicable to guideline 31. Not applicable.

3. Definitions. Not applicable.

4. Guidelines. 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. Information for guidance only.

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

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

GUIDELINE 32

TEST PROVISIONS

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

2. Documents applicable to guideline 32:

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

3. Definitions. Not applicable.

4. 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 checkout 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.

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

5. Information for guidance only.

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

GUIDELINE 33

RESISTORS

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

2. Documents applicable to guideline 33:

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

3. Definitions. Not applicable.

4. Guidelines.

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

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

5. Information for guidance only. Not applicable.

GUIDELINE 34

NOMENCLATURE

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

2. Document applicable to guideline 34:

MIL-STD-196 Joint Electronics Type Designation System

3. Definitions. Not applicable.

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

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

GUIDELINE 35

RELIABILITY

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

2. Documents applicable to guideline 35:

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

3. Definitions. Not applicable.

4. Guidelines. Not applicable.

5. Information for guidance only.

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

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

GUIDELINE 36

ACCESSIBILITY

1. Purpose. This guideline establishes criteria for accessibility.

2. Documents applicable to guideline 36:

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

3. Definitions.

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

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

4. 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 or 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. Information for guidance only.

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

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. Documents applicable to guideline 37:

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

3. Definitions. Not applicable.

4. Guidelines.

4.1 Selection and application. Circuit breakers should be selected from MIL-STD-1498. 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.

5. Information for guidance only. Not applicable.

GUIDELINE 38

QUARTZ CRYSTALS AND OSCILLATOR UNITS

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

2. Documents applicable to guideline 38:

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

3. Definitions. Not applicable.

4. Guidelines.

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

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

5. Information for guidance only. Not applicable.

GUIDELINE 39

FUSES AND FUSE HOLDERS

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

2. Document applicable to guideline 39:

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

3. Definitions. Not applicable.

4. Guidelines.

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

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

5. Information for guidance only.

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

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

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

GUIDELINE 40

SHUNTS

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

2. Documents applicable to guideline 40:

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

3. Definitions. Not applicable.

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

5. Information for guidance only. Not applicable.

GUIDELINE 41

SPRINGS

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

2. Documents applicable to guideline 41:

QQ-S-766	Steel, Stainless and Heat Resisting, Alloys, Plate, Sheet, and Strip
QQ-W-321	Wire, Copper Alloy
MIL-S-7947	Steel, Sheet and Strip (1095) Aircraft Quality
MIL-S-13282	Silver and Silver Alloy
MIL-S-13572	Spring, Helical, Compression and Extension
MIL-C-19311	Copper-Chromium Alloy Forgings, Wrought Rod, Bar and Strip (Copper Alloy Numbers 182, 184 and 185)
MIL-S-46049	Strip, Metal, Carbon Steel, Cold rolled, Hardened and Tempered, Spring Quality
MIL-C-81021	Copper-Beryllium Alloy (Copper Alloy Numbers C17500 and C17510), Strip
ASTM A29/A29M	Steel Bars, Carbon and Alloy, Hot Wrought and Cold Finished, General Requirements for
ASTM A228/ A228M-83	Steel Wire, Music Spring Quality
ASTM A313	Chromium-Nickel Stainless and Heat Resisting Steel Spring Wire
ASTM A682	Steel, Strip, High Carbon, Cold Rolled, Spring Quality, General Requirements for
ASTM A684/ A684M-86	Steel, Strip, High Carbon, Cold Rolled
ASTM B122	Plate, Sheet, Strip and Roller Bar, Copper Nickel Tin Alloy, Copper Nickezinc (Nickel Silver), and Copper Nickel Alloy
ASTM B139/ B139M-90	Bronze, Rod, Bar
ASTM B151/ B151-11.89	Alloy (Nickel Silver) Copper Nickel Zinc and Copper Nickel Rod and Bar
ASTM B194	Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar
ASTM B196/ B196M-88	Copper-Beryllium Alloy Rod and Bar
ASTM B197/ B197M-89	Copper-Beryllium Alloy Wire
ASTM B206	Copper Nickel Zinc Alloy Wire and Copper Nickel Alloy Wire
ASTM B206M	Copper Nickel Zinc Alloy Wire and Copper Nickel Alloy Wire Metric
ASTM B522	Gold-Silver-Platinum Electrical Contact Alloy, Specification

3. Definitions. Not applicable.

4. Guidelines.

4.1 Helical springs. Helical springs should conform to MIL-S-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. Information for guidance only.

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

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

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

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

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

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

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

TABLE 41-I. Materials for electrical spring application.

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

TABLE 41-II. Corrosion resisting steel for springs.

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

TABLE 41-III. Carbon steel for springs.

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

GUIDELINE 42

TUNING DIAL MECHANISMS

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

2. Documents applicable to guideline 42:

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

3. Definitions. Not applicable.

4. Guidelines.

4.1 Dial. The division marking and lettering on tuning dials should be suitably etched or printed with characters of style MS33558. 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 conforming to MIL-S-3644 should be used when a flexible mechanical connection is required between the tuning knob and the tuned device.

5. Information for guidance only.

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

GUIDELINE 43

LUBRICANTS

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

2. Documents applicable to guideline 43:

VV-L-800	Lubricating Oil, General Purpose, Preservative (Water-Displacing, Low-Temperature)
VV-P-236	Petrolatum, Technical
MIL-L-2105	Lubricating Oil, Gear, Multi-Purpose
MIL-L-3150	Lubricating Oil, Preservative, Medium
MIL-L-3918	Lubricating Oil, Instrument, Jewel Bearing
MIL-L-6085	Lubricating Oil, Instrument, Aircraft, Low Volatility
MIL-L-6086	Lubricating Oil, Gear, Petroleum Base
MIL-L-15719	Lubricating Grease (High-Temperature, Electric Motor, Ball and Roller Bearings)
MIL-L-17331	Lubricating Oil, Steam Turbine (Noncorrosive)
MIL-H-17672	Hydraulic Fluid, Petroleum, Inhibited
MIL-L-23398	Lubricant, Solid Film, Air Cured, Corrosion Inhibiting
MIL-G-23827	Grease, Aircraft and Instrument, Gear and Actuator Screw
MIL-G-24139	Grease, Multi-Purpose, Quiet Service
DOD-G-24508	Grease, High Performance, Multi-Purpose (Metric)
MIL-L-46010	Lubricant, Cleaner, and Preservative
MIL-G-81322	Grease, Aircraft, General Purpose, Wide Temperature Range
MIL-L-81329	Lubricant, Solid Film, Extreme Environment
29 CFR 1910	Code of Federal Regulations

3. Definitions. Not applicable.

4. Guidelines.

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

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

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

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

5. Information for guidance only.

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

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

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

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

GUIDELINE 44

FIBROUS MATERIALS, ORGANIC

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

2. Documents applicable to guideline 44:

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

3. Definitions. Not applicable.

4. 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. Cotton duck used for protective enclosures should conform to type I or type II of CCC-C-428. 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 V-T-276, V-T-285, V-T-291, 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. Information for guidance only.

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

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

GUIDELINE 45

CORONA AND ELECTRICAL BREAKDOWN PREVENTION

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

2. Documents applicable to guideline 45:

ASTM D149	Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D1868	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. 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. Information for guidance only.

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

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

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

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

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

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. Documents applicable to guideline 46:

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

3. Definitions. Not applicable.

4. Guidelines.

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

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

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

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

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

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

5. Information for guidance only. Not applicable.

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. Documents applicable to guideline 47:

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

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. Guidelines. Encapsulation and embedment materials should be of a nonreversion type and should be selected from the following specifications: MIL-S-8516, MIL-I-16923, MIL-S-23586, MIL-M-24041, and MIL-I-81550. The materials selected 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 MIL-I-81550 should be requested through the procuring activity.

5. Information for guidance only.

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

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

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

c. Color or transparency.

d. Dissipation factor.

e. Specific gravity.

f. Shrinkage.

g. Heat distortion parameters.

h. Stresses on parts.

i. Durometer hardness.

j. Adhesion to substrates (and priming).

k. Temperatures of application and curing.

l. Repairability.

m. Dielectric constant.

n. Volume resistivity.

o. Reversion resistance, including hydrolytic stability.

p. Viscosity.

q. Solvent affects.

r. Compatibility with parts or assemblies to which applied.

5.2 Application. The encapsulation or embedment of microelectronic modules and equipment modules should be avoided, except where specifically indicated by the guidelines of a particular application. In such instances, the module design should be completely verified for the particular encapsulation or embedment materials and processes to be employed. Any changes in module design, materials, and processes may require re-evaluation of the modules. In particular, extreme temperature aging and temperature cycling tests should be performed to verify adequacy of the design. Wherever economically feasible, the module to be encapsulated or embedded should be designed as a throw-away unit.

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

GUIDELINE 48

GEARS

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

2. Documents applicable to guideline 48:

Index American Gear Manufacturers Association (AGMA)

3. Definitions. Not applicable.

4. Guidelines. 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. Information for guidance only.

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

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

5.3 Nonmetallic gears. Nonmetallic gears may be used when they meet load, life, and environmental guidelines 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. Documents applicable to guideline 49:

MIL-H-5440	Hydraulic Systems, Aircraft, Types I and II, Design, Installation, and Data Requirements for
MIL-H-8891	Hydraulic Systems, Manned Flight Vehicles, Type III, Design, Installation, and Data Requirements for
MIL-H-25475	Hydraulic Systems, Missile, Design, Installation, Tests, and Data Requirements, General Requirements for
ANSI B93.1	Fluid Power Cylinders, Dimension Identification Code for
ANSI B93.2	Fluid Power, Glossary of Terms for
ANSI B93.3	Cylinder Bore and Piston Rod Sizes for Fluid Power Cylinders
ANSI B93.4	Electric Resistance Welded Mandrel Drawn Hydraulic Line Tubing
ANSI B93.5	Use of Fire-Resistant Fluids for Fluid Power Systems, Practices for the
ANSI B93.6	Mounting Flanges and Shafts for Positive Displacement Fluid Power Pumps and Motors, Dimensions and Identification Code for
ANSI B93.7	Mounting Surfaces of Sub-Plate Type Hydraulic Fluid Power Valves, Dimensions for
ANSI B93.8	Bore and Rod Size Combinations and Rod End Configurations for Cataloged Square Head Industrial Fluid Power Cylinders
ANSI B93.9	Symbols for Marking Electrical Leads and Ports on Fluid Power Valves
ANSI B93.10	Static Pressure Rating Methods of Square Head Fluid Power Cylinders
ANSI B93.11	Seamless Low Carbon Steel Hydraulic Line Tubing
ANSI SAE J514	Hydraulic Tube Fittings
ANSI SAE J518	Hydraulic Flanged Tube and Hose Connections, 4 Bolt, Split Flanged Type

3. Definitions. Not applicable.

4. 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 MIL-H-5440 or MIL-H-8891.

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

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

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

GUIDELINE 50

INDICATOR LIGHTS

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

2. Documents applicable to guideline 50:

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

3. Definitions. Not applicable.

4. 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 guidelines in MIL-STD-1472.

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

5. Information for guidance only. Not applicable.

TABLE 50-I. Indicator lights and associated items.

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

GUIDELINE 51

METERS, ELECTRICAL INDICATING

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

2. Documents applicable to guideline 51:

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

3. Definitions. Not applicable.

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

5. Information for guidance only. For analog meters, the normal operating value of the quantity to be indicated should be between 0.3 and 0.8 of fullscale deflection, wherever practicable.

GUIDELINE 52

THERMAL DESIGN

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

2. Documents applicable to guideline 52:

ASTM F872	Filter, Air Conditioning, Viscous-impingement and Dry Types, Cleanable
MIL-F-16552	Filter, Air Environmental Control System, Cleanable, Impingement (High Velocity Type)
MIL-B-23071	Blowers, Miniature, for Cooling Electronic Equipment, General Specification for
MIL-HDBK-251	Reliability/Design, Thermal Applications

3. Definitions.

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

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

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

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

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

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

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

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

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

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

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

4. 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 F872 or MIL-F-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 guidelines make the use of air for cooling impractical and alternate methods, such as liquid, evaporative, change of phase material, or heat pipes, are required.

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

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

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

GUIDELINE 53

WAVEGUIDES AND RELATED DEVICES

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

2. Documents applicable to guideline 53:

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

3. Definitions. Not applicable.

4. Guidelines. 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. Information for guidance only.

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

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

TABLE 53-I. Waveguides and related devices.

Item description		Applicable document
Adapters	Coaxial to waveguide	MIL-STD-1636
Amplifier, RF and microwave	DIP, coaxial, TO, and flatpack	MIL-STD-2162
Attenuators	Fixed and variable coaxial and waveguide	MIL-STD-1352
Circulators	RF-SMA and waveguide	MIL-STD-2113
Couplers	Directional coaxial waveguide and prtd ckt	MIL-STD-1328
Coupling assemblies	Quick-disconnect for subminiature waveguide flanges	MIL-STD-1327
Dummy loads	Waveguide, coaxial and stripline	MIL-STD-1637
Flanges	Waveguide and coaxial	MIL-STD-1327
Gaskets	Pressure sealing for use with cover flanges and flat face	MIL-G-24211
Isolators	RF-SMA and stripline	MIL-STD-2113
Mixer stages	RF-DIP, flatpack, TO and connector	MIL-STD-1640
Power dividers, combiners and divider/combiners	Solder terminals, plug-in, flatpack, TO and connector	MIL-STD-1639
Switches	Waveguide to waveguide manual and electro mechanically operated	MIL-S-55041
	RF coaxial	MIL-STD-1329
Waveguide assemblies	Flexible and rigid	MIL-STD-1638
Waveguides	Rigid rectangular rigid circular, single and double ridge	MIL-STD-1358

GUIDELINE 54

MAINTAINABILITY

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

2. Documents applicable to guideline 54:

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

3. Definitions. Not applicable.

4. Guidelines. Not applicable.

5. Information for guidance only.

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

5.2 Quantitative guidelines. Quantitative maintainability guidelines and verification or demonstration guidelines 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. Documents applicable to guideline 55:

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

3. Definitions.

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

4. Guidelines.

4.1 Cases and mounting bases for airborne equipment. Materials, bonding, shielding and performance guidelines of MIL-C-172 should apply to all cases. Mounting bases should conform to MIL-C-172 or MIL-M-81288, 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 RS-310-C.

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

5. Information for guidance only.

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

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

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

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. Documents applicable to guideline 56:

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

3. Definitions. Not applicable.

4. Guidelines.

4.1 Rotary servo devices. Rotary servo devices should conform to MIL-S-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 Electrical resolvers. Electrical resolvers should be selected and applied in accordance with MIL-STD-1451.

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

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

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

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

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

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

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

MIL-HDBK-218 (Resolvers)

MIL-HDBK-225 (Synchros)

MIL-HDBK-231 (Encoders)

GUIDELINE 57

RELAYS

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

2. Documents applicable to guideline 57:

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

3. Definitions. Not applicable.

4. Guidelines.

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

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

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

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

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

5. Information for guidance only. Not applicable.

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. Documents applicable to guideline 58:

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

3. Definitions. Not applicable.

4. Guidelines.

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

5. Information for guidance only. Not applicable.

GUIDELINE 59

BRAZING

1. Purpose. This guideline establishes criteria for brazing.

2. Document applicable to guideline 59:

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

3. Definitions. Not applicable.

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

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

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. Documents applicable to guideline 60:

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

3. Definitions. Not applicable.

4. Guidelines.

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

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

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

5. Information for guidance only.

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

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

GUIDELINE 61

ELECTROMAGNETIC INTERFERENCE CONTROL

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

2. Documents applicable to guideline 61:

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

3. Definitions. Not applicable.

4. Guidelines.

4.1 General. Electromagnetic interference guidelines should be as specified in MIL-STD-461.

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 except that 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, MIL-STD-461.

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

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

GUIDELINE 62

HUMAN ENGINEERING

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

2. Documents applicable to guideline 62:

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

3. Definitions. Not applicable.

4. Guidelines. Not applicable.

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

GUIDELINE 63

SPECIAL TOOLS

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

2. Documents applicable to guideline 63. Not applicable.

3. Definitions.

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

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

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. Documents applicable to guideline 64:

MIL-H-38534	Hybrid Microcircuits, General Specification For.
MIL-I-38535	Integrated Circuits (Microcircuits) Manufacturing, General Specification for.
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production.
MIL-STD-883	Test Methods and Procedures for Microelectronics.
MIL-STD-975	NASA Standard Electrical, Electronic and Electromechanical Parts List.
MIL-STD-1547	Electronic Parts, Materials, and Processes for Space and Launch Vehicles, Technical Guidelines For.
MIL-STD-1562	List of Standard Microcircuits.
MIL-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices).
MIL-BUL-103	List of Standardized Military Drawings (SMDs).
MIL-HDBK-217	Reliability Prediction of Electronic Equipment.
ANSI/IEEE 1076	VHSIC Hardware Description Language (VHDL) VHSIC Interoperability Standards. Includes Specifications for the TM-bus, ETM bus, Pi bus, and VHSIC Electrical Specification. (Copies available from Naval Research Laboratory, Code 5305, Wash DC 20375-5000).
ANSI/IEEE 1029	Waveform and Vector Exchange Specification.
MIL-HDBK-179(ER)	Microcircuit Application Handbook.
JEDEC-STD-17	Latch-Up in CMOS Integrated Circuits.
DI-EGDS-80811	VHSIC Hardware Description Language (VHDL) Documentation.

3. Definitions.

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

3.2 Advanced microcircuit module technology. Microcircuit module fabrication and design technology which is newly available for prototype designs and should be available for production in the near future (2 to 5 years). For digital microcircuits, the performance capability can be approximately characterized by the minimum feature size, the clocking frequency, and the functional throughput rate.

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

3.4 Qualified device (microcircuit). Any device or microcircuit which has met the guidelines of MIL-H-38534, or MIL-I-38535 and is listed on the associated QML/QPL listings.

3.5 Waveform and vector exchange specification (WAVES). A high level computer language for describing test vector and waveform stimuli for electronic hardware (chips, modules, and subsystems). The WAVES is compatible with the VHDL simulation language and simulation environments.

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

3.7 VHSIC. Very high speed integrated circuit.

4. Guidelines.

4.1 Selection.

4.1.1 Technology. At each stage in new and re-engineered system designs, i.e., concept studies, demonstration and validation, and engineering and manufacturing development, the advanced microcircuit module technologies which meet reliability, performance, and cost guidelines of the application should be evaluated for use in the production phase.

4.1.2 Reliability. Microelectronic devices in military systems which are in engineering and manufacturing development and production should, as a minimum, conform to the applicable product assurance level of MIL-H-38534 or MIL-I-38535.

4.1.3 Order of precedence. Unless otherwise specified, the order of precedence should be as follows: This guideline should be superseded upon publication and DoD/Industry fully coordinated acceptance of the proposed DoD Microcircuit Application Handbook or Standard. This document should provide guidance on how the DoD and its contractors can select devices based on cost effective performance, designed in high quality, and reliability for a given application.

a. Microcircuits listed in table I of MIL-STD-1562. Microcircuits with dated military specifications, fully compliant to the QML (MIL-H-38535 and MIL-H-38534).

b. Microcircuits listed in table II of MIL-STD-1562. Microcircuits compliant to the Standard Military Drawing Program, and other MIL-H-38534 compliant microcircuits not listed in tables I and II of MIL-STD-1562.

c. Other microcircuits (see 4.1.5), subject to acquiring activity approval.

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

4.1.4.1 Space applications. When qualified devices are not available or cannot be qualified by the manufacturer, the guideline of MIL-STD-975 or MIL-STD-1547 should apply.

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

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

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

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

c. Quality assurance guidelines, including screening and lot quality conformance (acceptance) tests. As a minimum, devices should be procured to all the guidelines of MIL-STD-883 1.2.1. The applicable detail specification, SMD or vendor/contractor document should be specified for electrical performance, mechanical, and final electrical test guidelines.

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

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

4.1.6 Electrostatic sensitive parts. Microcircuits are susceptible to Electrostatic Discharge (ESD) damage. Microcircuit susceptibility is classified in MIL-STD-1686 and test method 3015 of MIL-STD-883. When device susceptibility is not available, it can be determined using test method 3015 or appendix B of MIL-STD-1686. Microcircuits from the ESDS Class necessary to meet ESD guidelines should be selected. ESD susceptibility of microcircuits are listed in the associated QML/QPL listings of MIL-H-38534 or MIL-I-38535 for the individual devices.

4.1.7 Latch-up test. Latch-up testing should be performed on applicable technologies; (i.e., CMOS) in accordance with JEDEC-STD-17 as a minimum.

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

4.3 Fusible link devices. When fusible link devices (PROMs, PALs, PLDs, etc.) are programmed by the user, parametric and functional electrical tests in accordance with MIL-STD-883, method 5005, group A, subgroups 7 and 9 as a minimum, should be performed after programming to verify the specific program configuration and effectiveness of link fusing.

4.4 Packages. Microcircuit devices used in equipment should be hermetically sealed in glass, metal or ceramic (or combinations of these) packages. No organic or polymeric materials such as lacquers, varnishes, coatings, or greases should be used inside the microcircuit package, unless otherwise specified. No desiccants should be contained in the microcircuit package, unless otherwise specified. Organic or polymeric materials; (e.g., adhesives) compliant to MIL-STD-883, test method 5011, are permitted inside the microcircuit package when specified in the appropriate military specification or SMD.

4.4.1 Use of plastic encapsulated microcircuits. Upon specific request and approval by the procuring activity to waive the guidelines of 4.1, plastic encapsulated microcircuits may be considered for use in Ground Fixed (GF) or Ground Benign (GB) environments as defined in MIL-HDBK-217. Temperature and humidity should be completely controlled in transit, storage, and application. This guideline should be superseded upon publication and DoD/Industry fully coordinated acceptance of the proposed DoD Microcircuit Application Handbook or standard. For Army applications, use of MIL-HDBK-179(ER) is recommended.

4.5 Device design and test documentation.

4.5.1 ASIC documentation in VHDL. Digital Application-Specific Integrated Circuits (ASICs) should be documented by means of structural and behavioral VHSIC Hardware Description Language (VHDL) descriptions in accordance with ANSI/IEEE 1076, (see 5.6). Behavioral VHDL descriptions should include function and timing at the ports accurate enough to enable the performance of test generation and determination of fault detection/fault isolation levels at the integrated circuits pins when performing board or subsystem simulations.

4.5.2 Fault coverage. For all digital microcircuits, fault coverage should be documented in accordance with MIL-STD-883 test method 5012 for all manufacturing-level logic tests.

4.5.3 Qualified device documentation in VHDL. Digital qualified devices used in board level applications should be documented by means of behavioral VHDL descriptions in accordance with ANSI-IEEE 1076, (see 5.6). Behavioral VHDL descriptions should include function and timing at the port accurate enough to perform test generation and determine fault detection/fault isolation levels at the integrated circuit pins.

4.5.4 ASIC test stimuli documentation in WAVES. Digital ASICs should have all test vectors and test waveforms documented and delivered to the Government in the WAVES format.

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

5. Information for guidance only.

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

5.2 Reliability.

5.2.1 Reliability prediction. When required, microcircuit reliability predictions should be prepared in accordance with MIL-HDBK-217, or with procuring activity approval by using specific test and/or field rate data.

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

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

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

5.5 Life cycle cost evaluation. The following factors should be considered in estimating life cycle costs associated with selection of microcircuit devices or technologies:

a. Effect of built-in-test on repair, maintainability, operational availability, and reconfigurability.

b. Value of VHDL descriptions of chips, modules, and boards in resupply, multiple source development, and design upgrade.

5.6 ASIC documentation reference. Data item description, DI-EGDS-80811 provides the documentation preparation and delivery instructions for ASIC documentation.

GUIDELINE 65

CABLE, COAXIAL (RF)

1. Purpose. This guideline establishes criteria for the selection and application of coaxial Radio Frequency (rf) cable.

2. Documents applicable to guideline 65:

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

3. Definitions. Not applicable.

4. Guidelines.

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

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

5. Information for guidance only.

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

5.2 Critical circuits. For use above 400 MHz and in critical rf circuits, elements such as environmental guidelines, 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. Documents applicable to guideline 66:

QQ-W-343	Wire, Electrical, Copper (Uninsulated)
MIL-C-17	Cables, Radio Frequency, Flexible and Semirigid, General Specification for
MIL-C-442	Cable (Wire), Two Conductor, Parallel
MIL-C-3432	Cable (Power and Special Purpose) and Wire, Electrical (300 and 600 Volts)
MIL-W-5086	Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy
MIL-W-5846	Wire, Electrical, Chromel and Alumel, Thermocouple
MIL-C-7078	Cable, Electric, Aerospace Vehicle, General Specification for
MIL-W-8777	Wire, Electrical, Silicone-Insulated, Copper, 600 Volt, 200°C
MIL-C-13777	Cable, Special Purpose, Electrical: General Specification for
MIL-W-16878	Wire, Electrical, Insulated, General Specification for
MIL-C-19547	Cable, Electrical, Special Purpose, Shore Use
MIL-W-22759	Wire, Electric, Fluoropolymer-Insulated, Copper or Copper Alloy
MIL-C-23437	Cable, Special Purpose, Electrical"
MIL-C-24640	Cable, Electrical, Lightweight, for Shipboard Use, General Specification for
MIL-C-24643	Cable and Cord, Electrical, Low Smoke, for Shipboard Use, General Specification for
MIL-W-25038	Wire, Electrical, High Temperature and Fire Resistant, Aircraft and Flight Critical General Specification for
MIL-C-27072	Cable, Power, Electrical and Cable, Special Purpose Electrical, Multiconductor and Single Shielded, General Specification for
MIL-C-27500	Cable, Electrical, Shielded and Unshielded, General Specification for
MIL-C-49055	Cable, Electrical (Flexible, Flat, Unshielded) (Round Conductor), General Specification for
MIL-C-55021	Cable, Electrical, Shielded Singles, Shielded and Jacketed Singles, Twisted Pairs and Triples, Internal Hookup, General Specification for
MIL-W-81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy
MIL-W-81381	Wire, Electric, Polyimide-Insulated, Copper or Copper Alloy
ASTM A580	Standard Specification for, Stainless and Heat Resisting, Steel, Wire
ASTM B33	Standard Specification for, Tinned Soft or Annealed Copper Wire for Electrical Purposes
ASTM B298	Wire, Copper, Silver-Coated, Soft or Annealed

3. Definitions. Not applicable.

4. 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 (a) with the exception of thermocouple and flat cable wire, only stranded wire should be used in aerospace applications, and (b) for other applications stranded wire should be used when so indicated by the equipment application. Specifically, with the exception of flat multiconductor 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-W-16878 usage. Cable containing MIL-W-16878 wire shall not be used for Air Force or Navy aerospace applications.

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

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

4.3.4 Silver plated copper wire. Silver plated copper wire shall 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 B298. Wire which fails this test will be rejected. Silver plated copper wire shall not be used in conjunction with water-soluble solder fluxes. Wire shall be stored and handled in such a way so as to minimize exposure to moisture.

5. Information for guidance only. Not applicable.

5.1 Stranded copper conductor test. The following test procedure should be used for stranded conductors since the ASTM B298 test procedure covers only a single, round conductor.

5.1.1 Sodium polysulfide test. The stranded samples of annealed copper or copper alloy base material should be tested in accordance with ASTM B298 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.

Spec no.	Title	Basic wire specs	Conductor			Shield braid 3/			Jacket 3/		Remarks
			No. of cond	Volts RMS	Temp 2/	Strand material	Strand coating	% Cover-age	Material 1/	Type	
MIL-C-442	Cable, (Wire), Two Conductor, Parallel	QQ-W-343 & Insulation	2	300	Flexi-bility at -40°C or -55°C				Vinyl-polymer or synthetic (styrene buta-diene) rubber or natural rubber		Lead wire for firing explosive charges
MIL-C-3432	Cable (Power and Special Purpose) and Wire, Elec-trical (300 & 600V)	QQ-W-343 & Insulation	Unlimited and mixed sizes 4/ 5/	300 & 600	-40°C to +65°C or -55°C to +75°C	None or Copper	Tin	85	Styrene butadiene rubber, chloro-prene rubber, ethylene-propylene -dinne, rubber, polyurethan thermoplastic elastomer, or natural rubber	Extruded & vul-canized	
MIL-C-7078	Cable, Elec-tric, 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 ImpregBraid	(a)Fluorinated ethylene pro-pylene (b) Polytetra-fluoroethylene
		M22759/12 M22759/23	1-7 1-7		260°C 260°C	Copper Copper	Nickel Nickel	85 85	(a) (b)	Extruded Extruded or tape	
		M81044/9	1-7		110°C	Copper	Tin	85	Polyvinylidene fluoride	Extruded	
		M81381/8 /10 and /14	2-7 1-7		200°C 200°C	Copper	Nickel	85	FEP/polyimide	Film Tape	
		M81381/11 M81381/12 M81381/13	2-7 1-7 1-7		200°C 150°C 200°C	Copper Copper	Tin Nickel	85 85	FEP/polyimide	Film Tape	
MIL-C-13777	Cable, Special Purpose, Electrical	MIL-C-17 QQ-W-343 ASTM-A580 & Insulation	2-78 6/	600	-53°C to +71°C	Copper	Tin	80	Sheath Poly-chloroprene Primary Insulata ion Polyethylene	Extruded & vulcanized Extruded	See Note 7

TABLE 66-I. Cable, multiconductor - Continued.

Spec no.	Title	Basic wire specs	Conductor			Shield braid 3/			Jacket 3/		Remarks
			No. of cond	Volts RMS	Temp 2/	Strand material	Strand coating	% Coverage	Material 1/	Type	
MIL-C-19547	Cable, Electrical, Special purpose, Shore Use	ASTM B33-74 & Insulation	Multiple twisted pairs, 6-100 pairs	600	75°C	Corrugated Aluminun		100	Polyethylene	Extruded	For use as telephone & telegraph signal cables in shore communications
MIL-C-23437	Cable, Electrical, Shielded Pairs	MIL-W-16878/1	Shielded & jacketed twisted pairs 1 pair-104 pairs	600	105°	Copper	Tin	90	PVC	Extruded	For use within shore communications stations, not to be used on board ship
						Note: Shield Applied over each pair					
MIL-C-24640	Cable, Electrical, Lightweight, for shipboard use	MIL-W-81044	2-77 pair	600	150°C	Copper tape	Tinned	85%	Crosslinked, polyalkene, crosslinked alkaneimid, polymer, or polyarylene	Extruded	
MIL-C-27072	Cable Special Purpose, Electrical, Multiconductor	MIL-C-17 MIL-W-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 20o°C	Copper	Tin, Silver	85	Sheath of PVC, polyethylene, polychloroprene, polyamide, TFE-Teflon, or FEP-Teflon		Flexible mulitconductor cable for use in protected areas: tunnels, wire ways, instrument racks, and conduit. Polyethylene jacketed cable suitable for underwater or direct burial applications only. M16878/6 and /13 not for aerospace applications
						Note: MIL-C-27072 applicable detail specification sheets control materials for each specific cable configuration.					

TABLE 66-I. Cable, multiconductor - Continued.

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

TABLE 66-I. Cable, multiconductor - Continued.

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

2/ See applicable detail specification sheet for temperature limitation.

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

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

5/ Available in three classifications:

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

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

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

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

7/ For use under abusive mechanical conditions and where resistance to weather, oil and ozone are requirements.

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. Documents applicable to guideline 67:

L-S-300	Sheeting and Tape, Reflecting, Nonexposed Lens, Adhesive Backing
MIL-M-13231	Marking of Electronic Items
MIL-P-15024	Plate, Tags and Bands for Identification of Equipment
MIL-N-18307	Nomenclature and Identification for Electronic, Aeronautical and Aeronautical Support Equipment, Including Ground Support Equipment
MIL-S-81963	Servo-Components Precision Instrument, Rotating, Common Requirements and Tests, General Specification for
MIL-STD-12	Abbreviations for Use on Drawings, Specifications, Standards and in Technical Documents.
MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-195	Marking of Connections for Electrical Assemblies
MIL-STD-196	Joint Electronics Type Designation System
MIL-STD-280	Definitions of Item Levels, Item Exchangeability, Models, and Related Terms
MIL-STD-411	Aircrew Station Signals
MIL-STD-783	Legends for Use in Aircrew Stations and on Airborne Equipment
MIL-STD-1189	Bar Code Symbology Standard
MIL-STD-1285	Marking of Electrical and Electronic Parts
MIL-STD-1812	Type Designation, Assignment and Method for Obtaining
IEEE 200	Electrical and Electronic Parts and Equipments, Reference Designations for

3. Definitions. Not applicable.

4. 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, in accordance with IEEE 200. 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-12, MIL-STD-411, or MIL-STD-783, 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-P-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.

4.4 Bar codes. Bar codes should conform to MIL-STD-1189.

4.5 Type designated items. Each item which is type designated in accordance with MIL-STD-196 or MIL-STD-155 should contain an identification marking in accordance with MIL-N-18307 for Navy and Air Force or MIL-M-13231 for Army. These items are systems (electrical-electronic), sets, groups, and some units and assemblies, as defined in MIL-STD-280.

4.6 Fuse holders. The current rating of fuses 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 transformer should be marked in accordance with MIL-STD-195.

4.8 Servo-component connections and markings. Servo-component marking and connection identification should conform to MIL-S-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. Information for guidance only.

5.1 Reflective markers. Where reflective markers are required reflective polyester tape in accordance with L-S-300 may be used.

GUIDELINE 68

READOUTS AND DISPLAYS

1. Purpose. This guideline establishes criteria for the selection of readouts and displays.

2. Documents applicable to guideline 68:

MIL-D-28803 Display, Optoelectronic, Readouts, Segmented, General Specification for

MIL-D-87157 Displays, Diode, Light Emitting, Solid State, General Specification for

3. Definitions. Readouts and displays are devices which are designed primarily to convert electrical information into alphanumeric or symbolic presentations. These devices may contain integrated circuitry to function as decoders or drivers.

4. Guidelines.

4.1 Optoelectronic type readouts. Optoelectronic type readouts should conform to MIL-D-28803.

4.2 Light emitting diode displays. Visible light emitting diode displays should conform to MIL-D-87157, quality level A or B.

5. Information for guidance only. Not applicable.

GUIDELINE 69

INTERNAL WIRING PRACTICES

1. Purpose. This guideline establishes criteria for internal wiring practices.

2. Documents applicable to guideline 69:

MIL-T-152	Treatment, Moisture and Fungus Resistant, of Communications, Electronic and Associated Electrical Equipment
MIL-V-173	Varnish, Moisture-And-Fungus Resistant (For Treatment of Communications, Electronic, and Associated Equipment)
MIL-I-631	Insulation, Electrical, Synthetic-Resin Composition, Non-Rigid
MIL-T-713	Twine, Fibrous: Impregnated, Lacing and Tying
MIL-I-3158	Insulation Tape, Electrical Glass-Fiber (Resin Filled); and Cord, Fibrous-Glass
MIL-I-3190	Insulation Sleeving, Electrical, Flexible, Coated, General Specification for
MIL-T-7928	Terminals, Lug: Splices, Conductors: Crimp Style, Copper, General Specification for
MIL-I-22076	Insulation Tubing, Electrical, Non-Rigid, Vinyl, Very Low Temperature Grade
MIL-I-23053	Insulation Sleeving, Electrical, Heat Shrinkable, General Specification for
MIL-S-23190	Straps, Clamps, and Mounting Hardware, Plastic and Metal for Cable Harness Tying and Support
MIL-T-43435	Tape, Lacing and Tying
MIL-STD-108	Definition of and Basic Requirements for Enclosure for Electric and Electronic Equipment
MIL-STD-1130	Connections, Electrical, Solderless, Wrapped

3. Definitions. Not applicable.

4. Guidelines.

4.1 Clearance and leakage (creepage) distances. Clearance between solder connections or bare conductors, such as on terminal strips, stand offs 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.

TABLE 69-I. Electrical clearance and leakage (creepage) distances.

Voltage ac (rms) or dc	Condition	Clearance (mm)	Leakage distances (mm)	
			Enclosure I	Enclosure II
To 150	A	1.5	1.5	1.5
	B	3	3	6
	C	6	9.5	19
150-300	A	1.5	1.5	1.5
	B	3	3	6
	C	6	12.5	19
300-600	A	1.5	3	3
	B	3	6	6
	C	6	12.5	19
600-1000	A	3	9.5	12.5
	B	6	19	25
	C	12.5	38	50

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.

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. Tape should conform to MIL-T-43435. Cordage should be in accordance with type SR-4.5 of MIL-I-3158.

4.3.2 Binding. Tape for binding should be as specified in MIL-T-43435.

4.3.3 Sleeving insulation. Sleeving insulation should conform to MIL-I-631, MIL-I-3190, MIL-I-22076, or MIL-I-23053.

4.3.4 Wrapping and tying. Plastic devices for wrapping and tying of wires should conform to MIL-S-23190.

4.4 Solderless wrapped wire connections. Solderless wrapped wire connections should be in accordance with MIL-STD-1130. Procuring activity approval is required for Navy airborne and Army missile applications.

4.5 Clamped connections. In no case 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.

4.6 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, nor does it apply to wire wrapped connectors in accordance with MIL-STD-1130.

5. Information for guidance only.

5.1 Wiring arrangement. All wiring should be arranged in a neat and workmanlike manner. The use of preformed cables and wiring harness is preferred to the point-to-point method of wiring. Wires should be bundled and routed to minimize electrical coupling. Unless suitably protected, wire or cable attached to sensitive circuits should not be placed adjacent to a disturbing circuit.

5.2 Internal wiring. Stranded wire is preferred; however, solid wire may be used in the equipment, provided such wire is so insulated or held in place that it does not fail or show excessive motion likely to result in failure when the equipment is subjected to vibration and shock encountered under the specified service conditions. An uninterrupted wire is preferable to a junction. The following descending order of preference exists when junctions are used, and the choice of the listed junctions should be determined by consideration of reliability factors, maintenance factors, and manufacturing procedures:

a. Permanent splices.

b. Bolted connections.

c. Connectors.

5.3 Wiring protection. The wiring should be secured and protected against chafing due to vibration or movement (such as slide out racks or drawers). For securing of wiring, polyamide clamps or wrapping and tying devices with integral mounting facilities or adhesive bonding are preferred. Metal clamps, if used, should be cushioned. Individual conductors thus secured should lie essentially parallel.

5.4 Cable ducts. Where cable ducts are employed, provisions should be made for the removal of any wire that may become faulty. For example, covers may be employed at intervals to aid in the removal of a faulty wire.

5.5 Bend radius. The bend radius of polyethylene cable should not be less than five times the cable diameter to avoid establishing a permanent set in the cable.

5.6 Sleeving. Flexible plastic sleeving, either nonflammable, self extinguishing, or flame retardant, should be used on cables subject to flexing, such as panel door cables. The sleeving should be secured under cable clamps at each end, and the cable should be formed and secured so that the cable will not be subject to abrasion in its normal flexing motion. In cases where abrasion cannot be avoided, additional protection should be provided.

5.7 Panel door cables. Wiring to parts on a hinged door should be in a single cable if possible, arranged to flex without being damaged when the door is opened and closed.

5.8 Slack. Wires and cable should be as short as practicable, except that sufficient slack should be provided to:

a. Prevent undue stress on cable forms, wires and connections, including connections to resiliently supported parts;

b. Enable parts to be removed and replaced during servicing without disconnecting other parts;

c. Facilitate field repair of broken or cut wires;

d. Permit units in drawers and slide out racks to be pulled out to the limit of the slide or support travel without breaking connections. Units which are difficult to connect when mounted, should be capable of movement to a more convenient position for connecting and disconnecting cables. When drawers or racks are fully extended and rotated, if rotatable, the cable bend radius should not be less than three times the cable assembly diameter. When flat molded cable assemblies are used, the bend radius should not be less than ten times the cable assembly thickness;

e. Permit replacement of the connected part at least twice. Exceptions to this provision are cases where rf leads must be as short as possible for electrical reasons, when fixed path rotating is specified, or the amount of slack is limited by space available;

f. Ensure freedom of motion of lugs or terminals normally intended to have some degree of movement.

5.9 Support. Wire and cable should be properly supported and secured to prevent undue stress on the conductors and terminals and undue change in position of the wire or cable during and after subjection of the equipment to specified service conditions, or after service or repair of the equipment in a normal manner. When shielding on wire or cable is unprotected by an outer insulation, adequate support is necessary to prevent the shielding from coming in contact with exposed terminals or conductors. Twine or tape should not be used for securing wire and cable.

5.10 Cable and harness design. Cables and separable harnesses should be of the two-connector type. The two connectors should be of the same number of contacts and all contacts should be wired point-to-point; (i.e., pin 1 to pin 1, pin A to pin A, or pin 1 to pin A and up in sequence). A minimum number of connector types and contact configurations within a type should be used consistent with 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 MIL-T-7928.

b. Where thermal or other considerations prevent the use of insulated lugs, noninsulated solderless lugs conforming to MIL-T-7928 should be used, provided they are covered with an insulating sleeve.

5.12 Fungus protection. Prior to attachment of terminals to prepared lengths of cables which contain materials that will support fungus, the ends should be protected against entrance of moisture and fungus by treatment with a fungicidal varnish conforming to MIL-V-173 in accordance with MIL-T-152.

GUIDELINE 70

ELECTRICAL FILTERS

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

2. Document applicable to guideline 70:

   MIL-STD-1395 Filters and Networks, Selection and Use of

3. Definitions. Not applicable.

4. Guidelines. Electrical filters should be selected and applied in accordance with MIL-STD-1395.

5. Information for guidance only. Not applicable.

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. Documents applicable to guideline 71:

QQ-W-343	Wire, Electrical, Copper (Uninsulated)
MIL-C-17	Cables, Radio Frequency, Flexible and Semi-rigid, General Specification for
MIL-W-76	Wire and Cable, Hookup, Electrical, Insulated
MIL-C-442	Cable, Two Conductor, Parallel
MIL-C-3432	Cable (Power and Special Purpose) and Wire, Electrical (300 and 600 Volts)
MIL-W-5086	Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy
MIL-W-5845	Wire, Electrical, Iron and Constantan, Thermocouple
MIL-W-5846	Wire, Electrical, Chromel and Alumel, Thermocouple
MIL-W-5908	Wire, Electrical, Copper and Constantan, Thermocouple
MIL-C-7078	Cable, Electric, Aerospace Vehicle, General Specification for
MIL-W-8777	Wire, Electrical, Silicone-Insulated, Copper, 600 Volt, 200°C
MIL-C-13777	Cable, Special Purpose, Electrical: General Specification for
MIL-W-16878	Wire, Electrical, Insulated, General Specification for
MIL-W-19150	Wire, Insulated, Hard Drawn Copper
MIL-C-19547	Cable, Electrical, Special Purpose, Shore Use
MIL-W-22759	Wire, Electric, Fluoropolymer-Insulated, Copper or Copper Alloy
MIL-C-23437	Cable, Electrical, Shielded Pairs
MIL-C-24640	Cable, Electrical, Lightweight, for Shipboard Use, General Specification for
MIL-C-24643	Cable and Cord, Electrical, Low Smoke, for Shipboard Use, General Specification for
MIL-W-25038	Wire, Electrical, High Temperature and Fire Resistant, General Specification for
MIL-C-27072	Cable, Special Purpose, Electrical, Multiconductor
MIL-C-27500	Cable, Electrical, Shielded and Unshielded, Aerospace
MIL-C-55021	Cables, Twisted Pairs and Triples, Internal Hookup, General Specification for
MIL-W-81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy
MIL-W-81381	Wire, Electric, Polyimide-Insulated, Copper or Copper Alloy
MS25471	Wire, Electrical, Silicone Insulated, Copper, 600 Volt, 200°C, Polyester Jacket
MS27110	Wire, Electrical, Silicone Insulated, Copper, 600 Volt, 200°C, FEP Jacket
ASTM B33-74	Tinned Soft or Annealed Copper Wire for Electrical Purposes
ASTM B298	Wire, Copper, Silver-Coated, Soft or Annealed

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. 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-W-76 usage. MIL-W-76 shall be used for Army application only (see 4.3.3).

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

4.3.3 Insulation restriction. Cable or wire with polyvinyl chloride insulation shall not be used in aerospace applications. Use of these wires or cables in any other application requires prior approval of the procuring activity.

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

4.3.5 Aluminum wire. Use of aluminum wire may need specific approval by the procuring activity.

4.3.6 Silver plated copper wire. Silver plated copper wire shall 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 B298. Wire which fails this test will be rejected. Silver-plated, copper wire shall not be used in conjunction with water-soluble solder fluxes. Wire shall be stored and handled in such a way so as to minimize exposure to moisture.

5. Information for guidance only.

5.1 Pulsed or rf signals. All interconnecting cables carrying pulsed or rf signals should be coaxial cables or waveguides and should be terminated, when possible, in the characteristic impedance of the transmitting media.

5.2 Stranded copper conductor test. The following test procedure should be used for stranded conductors since the ASTM B298 procedure covers only a single, round conductor.

5.2.1 Sodium polysulfide test. The stranded samples of annealed copper or copper alloy base material shall be tested in accordance with the ASTM B298, 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 shall 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.

TABLE 71-1. Wire, electrical, interconnection.

Spec no.	Title	Spec type or class	Construction: 1/ Conductor: Material	Construction: 1/ Conductor: Coating	Construction: Type	Construction: 2/ Insulation: Primary	Construction: 2/ Insulation: Primary cover	Construction: 2/ Insulation: Jacket/ topcoat	Max cond Temp °C	Max rms volts	Remarks
MIL-W-76	Wire and Cable, Hookup, Electrical Insulated	LW MH HW HF	Cu/A or CCW	Sn	S, Str	1 2A	8,10, 13A 3/	8,10, 13A 3/	80	300 1000 2500 1000	See Notes 4 and 5. For Army use only
MIL-W-5086	Wire, Electric, PVC Insulated, Copper or Copper Alloy	M5086/1 M5086/2 M5086/3 M5086/4 M5086/5 M5086/6 M5086/7	Cu/A HSA Cu/A	Sn Ag Sn	Str	1	13A	8 8, 11 8 9A 8	105 110 105	600 3000 600	Medium weight See Note 4
MIL-W-8777	Wire, Electrical, Silicone Insulated, Copper, 600 V 200°C	MS25471 MS27110	Cu/A	Ag	Str	6	13A	12 4A	200	600	
MIL-W-16878	Wire, electrical, Insulated, High Temperature	M16878/1 M16878/2 M16878/3 M16878/4 M16878/5 M16878/6 M16878/7 M16878/8 M16878/10 M16878/11 M16878/12 M16878/13 M16878/14 M16878/15	Cu/A, HSA, CCW Cu/A Cu/A, CCW Cu/A	Ag,Sn Ag Sn Ag Ag,Sn Sn	S,Str	1 3A 6 2A 4A 2C	8,10,11 4A,8, 10,11 8,10,11	1,8,10,11 3A,3B,4A 13B 3/ 4A,8,10, 11 4A	105 200 75 200 125	600 1000 3000 600 1000 250 600 1000 600 1000 250 600 1000	See Note 4

TABLE 71-1. Wire, electrical, interconnection. - Continued

Spec no.	Title	Spec type or class	Construction: 1/ Conductor: Material	Construction: 1/ Conductor: Coating	Construction: type	Construction: 2/ Insulation: Primary	Construction: 2/ Insulation: Primary cover	Construction: 2/ Insulation: Jacket/ topcoat	Max cond temp °C	Max rms volts	Remarks
MIL-W-16878 Cont.	Wire, electrical, Insulated, High Temperature	M16878/16								600	See Note 4
		M16878/17	Cu/A, HSA, CCW	Ag,Sn		1		8	105	3000	
		M16878/18								1000	
		M16878/19								3000	
		M16878/20		Ag		3B		3A,3B,4a, 13B 3/	200	250	
		M16878/21								600	
		M16878/22	Cu/A, HSA, CCW							1000	
		M16878/23		Ni		3A		3A,3B,4A 13B 3/	260	250	
		M16878/24				3B				600	
		M16878/25				3A					
		M16878/26				3B				1000	
		M16878/27				3A					
		M16878/28				3B				600	
		M16878/29	Cu/A	Sn	Str	6			150	1000	
		M16878/30									
		M16878/31		Ag					200		
		M16878/32	Cu/A CCW	Sn	S,Str	2A			75	600	
		M16878/33									
		M16878/34	Cu/A	Ag	Str	3B			200	1000	
		M16878/35		Ni					260		
MIL-W-19150	Wire, Insulated, Hard-Drawn Copper		Cu/H			2A		8			
MIL-W-22759	Wire, Electric, Fluoropolymer-insulated, Copper or Coper Alloy	M22759/1		Ag		3A,3B, 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		

TABLE 71-1. Wire, electrical, interconnection - Continued.

Spec no.	Title	Spec type or class	Construction: 1/ Conductor: Material	Construction: 1/ Conductor: Coating	Construction: type	Construction: 2/ Insulation: Primary	Construction: 2/ Insulation: Primary cover	Construction: 2/ Insulation: Jacket/ topcoat	Max cond temp °C	Max rms volts	Remarks
MIL-W-22759 Cont.	Wire, Electric, Fluoropolymer-insulated, Copper or Copper Alloy	M22759/7	CuA	Ag					200		Medium weight
		M22759/8		Ni					260		Medium weight
		M22759/9		Ag					200	1000	
		M22759/10		Ni		3A			260		
		M22759/11		Ag					200		
		M22759/12		Ni					260		
		M22759/13		Sn							
		M22759/14				4A		9A	135		Medium weight
		M22759/15	HSA	Ag						600	Light weight
		M22759/16	Cu/A	Sn							Light weight
		M22759/17	HSA	Ag	Str	18			150		Medium weight
		M22759/18	Cu/A	Sn							Medium weight
		M22759/19		Ag							Light weight
		M22759/20							150		Light weight
		M22759/21	HSA	Ni					200	1000	
		M22759/22		Ag				3A	260		
		M22759/23		Ni					200		
		M22759/28	Cu/A	Ag	Str				260		
		M22759/29		Ni		3A			200		
		M22759/30	HSA	Ag				7B	260		
		M22759/31		Ni					200		
		M22759/32	Cu/A	Sn							
		M22759/33	HSA	Ag					150	600	
		M22759/34	Cu/A	Sn					200		
		M22759/35	HSA	Ag		20		20	150		
		M22759/41	Cu/A	Ni							
		M22759/42	HSA						200		
		M22759/43	Cu/A	Ag							

TABLE 71-1. Wire, electrical, interconnection - Continued.

Spec no.	Title	Spec type or class	Construction: 1/ Conductor: Material	Construction: 1/ Conductor: Coating	Construction: 1/ Conductor: type	Construction: 2/ Insulation: Primary	Construction: 2/ Insulation: Primary cover	Construction: 2/ Insulation: Jacket/ topcoat	Max cond temp °C	Max rms volts	Remarks
MIL-W-25038	Wire, Electrical, High Temperature and Fire Resistant	M25038/1	Cu/A	Ni clad	Str	15	3B	13B	288	600	Critical circuits where electrical integrity must be maintained during fire (1093°C flame/ 5 min)
MIL-W-81044	Wire,Electric,Cross-linked Polyalkene, Cross-linked Alkane-imide Polymer, etc Insulated, Copper or Copper Alloy	M81044/6 M81044/7 M81044/9 M81044/10 M81044/12 M81044/12	Cu/A HSA Cu/A HSA Cu/A HSA	Sn Ag Sn Ag Sn Ag	Str	2B		9B	150	600	Sheets /12 & /13 light weight - See Note 4 Sheets /9 & /10 medium weight. See application temp limitation stipulated on detail specification sheet
MIL-W-81381	Wire, Electric, Polyimide Insulated, Copper or Copper Alloy	M81381/7 M81381/8 M81381/9 M81381/10 M81381/11 M81381/12 M81381/13 M81381/14 M81381/17 M81381/18 M81381/19 M81381/20 M81381/21 M81381/22	Cu/A HSA Cu/A HSA Cu/A HSA Cu/A	Ag Ni Ag Ni Ag Ni Ag Ni Ag Ni Ag Ni Sn	Str	7A		17 15 or 17 17 15 or 17	200 105	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 /11, /12 & /22 are in sized 8 and larger

TABLE 71-1. Wire, electrical, interconnection - Continued.

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.

TABLE 71-II. Cable, multiconductor, interconnection.

Spec no.	Title	Basic wire specs	Conductor			Shield braid 3/			Jacket 3/		Remarks
			No. of cond	Volts RMS	Temp 2/	Strand material	Strand coating	% Cover-age	Material 1/	Type	
MIL-C-442	Cable, (Wire), Two Conductor, Parallel	QQ-W-343 & Insulation	2	300	Flexi-bility at -40°C or -55°C				Vinyl-polymer or synthetic (styrene buta-diene) rubber or natural rubber		Lead wire for firing explosive charges
MIL-C-3432	Cable (Power and Special (Purpose)and Wire, Elec-trical (300 & 600V)	QQ-W-343 & Insulation	Unlimited amd 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, chloro-prene rubber, ethylene-propylene rubber, ethylene-propylene-dienne rubber, polyure-thane thermo-plastic elestomer, or natural rubber	Extruded & Vulcanized	
MIL-C-7078	Cable, Elec-tric, 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) Fluorinated ethylene pro-pylene (b) Polytetra-fluoroethylene
		M22759/12 M22759-23	1-7 1-7		260°C 260°C	Copper Copper	Nickel Nickel	85 85	(a) (b)	Extruded Extruded or tape	
		M81044/9	1-7		110°C	Copper	Tin	85	Polyvinylidene fluoride	Extruded	
		M81381/8 /10 and /14 M81381/11	2-7 1-7 2-7		200°C 200°C 200°C	Copper	Nickel	85	FEP/polyimide	Film Tape	

TABLE 71-II. Cable, multiconductor, interconnection - Continued.

Spec no.	Title	Basic wire specs	Conductor			Shield Braid 3/			Jacket 3/		Remarks
			No. of cond	Volts RMS	Temp 2/	Strand material	Strand coating	% Cover-age	Material 1/	Type	
MIL-C-442 cont.	Cable, (Wire), Two Conductor, Parallel	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 QQ-W-343 ASTM A580 &Insulation	2-78 6/	600	-53°C to	Copper	Tin	80	Sheath Poly-Chloroprene Primary Insula-tion Polyethylene	Extruded & vulcanized Extruded	See Note 7
MIL-C-19547	Cable, Elec-trical, Spec-ial purpose Shore use	ASTM B33-74 &Insulation	Multiple twisted pairs, 6-100 pairs	600	75°C	Corrugated Aluminum		100	Polyethylene	Extruded	For use as tele-phone & tele-graph signal cables in shore communications
MIL-C-23437	Cable, Elec-trical, Shielded Pairs	MIL-W-16878/1	Shielded & Jacketed twisted pairs 1 pair - 104 pairs	600	105°	Copper Note: Shield applied over each pair	Tin	90	PVC	Extruded	For use within shore communi-cations sta-tions, not to be used on board ship
MIL-C-24640	Cable, Elec-trical, Light weight for ship-board use	MIL-W-81044	2-77 pair	600	150°C	Copper Tape	Tinned	85	Crosslinked Poly-alkene, Cross-linked Alkane-imide polymer, or Polyarylene	Extruded	

TABLE 71-II. Cable, multiconductor, interconnection - Continued.

Spec no.	Title	Basic wire specs	Conductor			Shield braid 3/			Jacket 3/		Remarks
			No. of cond	Volts RMS	Temp 2/	Strand material	Strand coating	% Cover-age	Material 1/	Type	
MIL-C-27072	Cable Special Purpose, Electrical, Multi-conductor	MIL-C-17	2-36	Various	Not spec	Copper	Tin, Silver	85	Sheath of PVC, polyethylene, polychloroprene, polyamide, TFE-Teflon, or FEP-Teflon		Flexible multi-conductor cable for use in protected, wire ways, instrument racks, and conduit, Polyethylene jacketed cable suitalbe for underwater or direct burial applications only. M16878/6 and /13 not for aerospace applications.
		MIL-W-5845		Various	Not spec						
		MIL-W-5846		Various	Not spec						
		MIL-W-5908		Various	Not spec						
		M16878/1		600	105°C						
		M16878/2		1000	105°C						
		M16878/3		3000	105°C						
		M16878/4		600	200°C						
		M16878/5		1000	200°C						
		M16878/6		250	200°C						
		M16878/10		600	75°C						
		M16878/13		250	200°C						
						Note: MIL-C-27072 applicable detail specification sheets control materials for each specific cable configuration.					
MIL-C-27500	Cable, Electrical, Shielded and Unshielded, Aerospace	MIL-W-8777	1-7	600	200°C	Various	Various	85	Various	Braided	For general aerospace flight vehicle applications
		MIL-W-22759	1-7	Various	Various	Various	Various	85	Various	Extruded or Braided	
		MIL-W-25038	1-7	600	260°C	Various	Various	85	TFE coated glass fiber	Braided	
		MIL-W-81044	1-7	600	150°C	Various	Various	85	Various	Extruded	
		MIL-W-81381	1-7	600	Various	Various	Various	85	Various	Tape	

TABLE 71-II. Cable, multiconductor, interconnection - Continued.

Spec no.	Title	Basic wire specs	Conductor			Shield Braid 3/			Jacket 3/		Remarks
			No. of cond	Volts RMS	Temp 2/	Strand material	Strand Coating	% Cover-age	Material 1/	Type	
MIL-C-55021	Cable, Twisted Pairs & Triples, Internal Hookup, General Specification for	MIL-W-16878	2-3	600 to 1000	-40°C to +105°C or -65°C to +200°C	None or Copper	Tin, Silver or Nickel	90	None PVC, Nylon TFE-Teflon	Extruded Extruded or Tape	

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

2/ See applicable detail specification sheet for temperature limitations.

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

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

5/ Available in three classifications:

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

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

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

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

7/ For use under abusive mechanical conditions and where resistance to weather, oil and ozone are requirements.

GUIDELINE 72

SUBSTITUTABILITY

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

2. Documents applicable to guideline 72:

MIL-STD-973	Configuration Mangement
MIL-STD-983	Substitution List for Microcircuits

3. Definitions. Not applicable.

4. Guidelines.

4.1 Military parts. Substitution of parts covered by military specifications and standards that include substitutability or supersession information is acceptable. This type substitution does not require submission of engineering change proposals, deviations, or waivers in accordance with MIL-STD-973.

4.2 Commercial parts. When the equipment design specifies a commercial part, a military specification part may be substituted when the form, fit and functional characteristics of the military part are equal to or better than those of the specified commercial part under equivalent environmental conditions. Applicable microcircuits are listed in MIL-STD-983. Other substitutions are subject to applicable configuration control procedures of MIL-STD-973.

4.3 Unavailable parts. When the equipment design specifies a part that is unavailable, a substitute part which meets the form, fit and functional characteristics of the specified part may be substituted after approval is obtained from the applicable procuring activity. Applicable microcircuits are listed in MIL-STD-983. Other substitutions are subject to the applicable configuration control procedures of MIL-STD-973.

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.

5. Information for guidance only. Not applicable.

GUIDELINE 73

STANDARD ELECTRONIC MODULES

1. Purpose. This guideline establishes criteria for the selection and application of Standard Electronic Modules (SEM).

2. Documents applicable to guideline 73:

MIL-M-28787	Modules, Standard Electronic, General Specification for
MIL-STD-1378	Requirements for Employing Standard Electronic Modules
MIL-STD-1389	Design Requirements for Standard Electronic Modules
MIL-HDBK-246	Program Managers Guide for the Standard Electronic Modules Program

3. Definitions. Not applicable.

4. Guidelines. Guidelines for the design and application of standard electronic modules should be in accordance with MIL-STD-1389 and MIL-STD-1378. Standard electronic modules should be in accordance with MIL-M-28787.

5. Information for guidance only. Guidance for program and acquisition managers as to the applicability of SEMs for specific system/equipment acquisitions is provided in MIL-HDBK-246.

GUIDELINE 74

GROUNDING, BONDING, AND SHIELDING

1. Purpose. This guideline establishes grounding, bonding, and shielding interface criteria for installation of electronic equipment.

2. Documents applicable to guideline 74:

MIL-B-5087	Bonding, Electrical, and Lightning Protection, for Aerospace Systems
MIL-STD-188-124	Grounding, Bonding, and Shielding for Common Long Haul/Tactical Communication Systems Including Ground Based Communications-Electronics Facilities and Equipments
MIL-STD-1310	Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety Shielding
MIL-STD-1542	Electromagnetic Compatibility (EMC) and Grounding Requirements for Space System Facilities
MIL-STD-1857	Grounding, Bonding, and Shielding Design Practices
MIL-HDBK-419	Ground, Bonding, and Shielding for Electronic Equipments and Facilities

3. Definitions. Not applicable.

4. Guidelines. 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 guidelines are specified in the following documents:

Aerospace ground support facilities	MIL-B-5087
Aircraft and space vehicles	MIL-B-5087
Ground telecommunications C-E equipment	MIL-STD-188-124
Shipboard equipment	MIL-STD-1310
Ground space systems facilities	MIL-STD-1542
Other Army ground equipment	MIL-STD-1857

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

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. Documents applicable to guideline 75:

MIL-M-38510	Microcircuits, General Specification for
MIL-STD-883	Test Methods and Procedures for Microelectronics
MIL-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (excluding electrically initiated explosive devices)
DOD-HDBK-263	Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (excluding electrically initiated explosive devices)

3. Definitions. Definitions of applicable terminology may be found in MIL-M-38510, MIL-STD-883, MIL-STD-1686, and DOD-HDBK-263.

4. Guidelines. Not applicable.

5. Information for guidance only.

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. DOD-HDBK-263 provides guidelines for the establishment and implementation of an ESD control program in accordance with MIL-STD-1686.

5.2 General guidelines for an ESD control program. Any program designed for the prevention of ESD damage to ESDS parts and assemblies should be based on the following considerations:

a. Identification of ESDS parts and assemblies and determination of sensitivity.

b. Minimization of static charge generation.

c. Reduction of stored charges (grounding).

d. Isolation of ESDS parts (Faraday shielding and line transient protection).

e. Proper handling, storage, and transportation of ESDS parts and assemblies.

f. Personnel training and certification.

g. Protected work areas.

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. Documents applicable to guideline 76:

MIL-STD-188-111	Subsystem Design and Engineering Standards for Common Long Haul and Tactical Fiber Optics Communications
MIL-STD-790	Product Assurance Program Requirements for Electronic and Fiber Optic Parts Specifications
DOD-STD-1678	Fiber Optic Test Methods and Instrumentation
DOD-STD-1863	Interface Designs and Dimensions for Fiber Optic Interconnection Devices
MIL-STD-2163	Insert Arrangements for MIL-C-28876 (Navy) Environment Resisting Fiber Optic Connectors
MIL-STD-2196(SH)	Glossory, Fiber Optics
MIL-C-22520/10	Crimping Tool, Terminal, Hand
DOD-D-24620	Detector, PIN, Fiber Optic (Metric)
MIL-C-24621	Coupler, Passive, Fiber Optic, General Specification for (Metric)
DOD-S-24622	Sources, LED, Fiber Optic (Metric)
MIL-S-24623	Splice, Fiber Optic Cable, General Specification for (Metric)
MIL-H-24626	Harness Assemblies, Cable, Pressure Proof, Fiber Optic
MIL-P-24628	Penetrators, Hull, Connectorized, Connectors, Pressure Proof, Fiber Optic, Submarine
MIL-S-24725	Switches, Fiber Optic, Shipboard, Electrical Nonlatching, Bypass, Multimode Cable, Standalone (Metric)
MIL-A-24726	Attenuators, Fiber Optic, Shipboard, General Specification for
MIL-R-24727	Rotary Joints, Fiber Optic, Shipboard (Metric), General Specification for
MIL-I-24728	Interconnection Box, Fiber Optic, Metric, General Specification for
MIL-M-24731	Multiplexers, Demultiplexers, Multiplexers, Demultiplexers (Muldems), Frequency Division, Fiber Optic, Interfaceable, Shipboard (Metric), General Specification for
MIL-L-24732	Light Sources, Rigid and Flexible, Fiberscope, Fiber Optic (Metric), General Specification for
MIL-C-24733	Controllers, Interface Unit, Fiber Optic (Metric), General Specification for
MIL-F-24734	Fiberscope, Fiber Optic (Metric), General Specification for
MIL-T-24735	Transmitters, Light Signal, Analog, Fiber Optic (Metric), General Specification for
MIL-M-24736	Multiplexers, Demultiplexers, Multiplexers, Demultiplexers (Muldems), Time Division, Fiber Optic, Interfaceable, Shipboard (Metric), General Specification for
MIL-R-24737	Receivers, Light Signal, Analog, Fiber Optic, Shipboard (Metric), General Specification for
MIL-C-28876	Connectors, Fiber Optic, Environment Resisting (for Navy Shipboard Applications)
MIL-T-29504	Termini, Fiber Optic Connector, Removable
MIL-F-49291	Fiber, Optical, General Specification for
MIL-C-49292	Cable Assembly, Nonpressurized, General Specification for
MIL-I-81969	Installing and Removal Tools, Electrical Contact, General Specification for
MIL-C-83522	Connectors, Fiber Optic, Single Terminus, General Specification for
MIL-T-83523	Tools, Fiber Optic, General Specification for
MIL-M-83524	Microscope, Optical, for Field Inspection of Optical Fibers
MIL-K-83525	Kit, Portable Optical Microscope, Militarized, 200X Magnification for Field Inspection of Optical Fibers
MIL-C-83526	Connector, Fiber Optic, Circular, Environment Resisting, Hermaphroditic, General Specification for
MIL-C-83532	Connectors, Fiber Optic
MIL-M-83533	Maintenance Kit, Fiber Optic Components, General Specification for
MIL-C-85045	Cable, Fiber Optic, Environment Resisting (for Navy Shipboard Application), General Specification for
MIL-HDBK-415	Design Handbook for Fiber Optic Communications Systems
EIA/TIA 587	Fibers, Optical Graphic Symbols
IEC-693	Optical Fibers, Dimensions of

3. Definitions.

3.1 Terminology. Definitions of terminology used in fiber optics technology should be as contained in MIL-STD-2196(SH).

4. Guidelines.

4.1 Symbology. Graphic symbols for fiber optic parts for use on engineering drawings, specifications, etc, should be as contained in EIA/TIA 587.

4.2 Dimensions. Dimensions for optical fibers should be as specified in IEC-693 and MIL-F-49291.

4.3 Interface designs and dimensions. Standard interface designs, dimensions and termination types for use in fiber optic connectors and couplers should be as specified in DOD-STD-1863.

4.4 System and subsystem design. Fiber optic system and subsystem designs should be in accordance with the criteria specified in MIL-STD-188-111 (see 5.1 also).

4.5 Test procedures. Standardized test procedures for fiber optic components should be as specified in DOD-STD-1678.

4.6 Light sources.

4.6.1 Light emitting diodes (LEDs). Fiber optic LED sources should conform to DOD-S-24622.

4.6.2 Fiberscope light sources. Fiber optic light sources for rigid and flexible fiberscopes should conform to MIL-L-24732.

4.7 Splices. Fiber optic splices should conform to MIL-S-24623.

4.8 Cables. Fiber optic cables should conform to MIL-C-85045.

4.9 Cable assemblies. Cable assemblies should conform to MIL-C-49292.

4.10 Harness assemblies. Fiber optic harness assemblies should conform to MIL-H-24626.

4.11 Connectors. Fiber optic connectors should conform to MIL-C-28876, MIL-C-83522, MIL-C-83526 or MIL-C-83532. Insert arrangements for MIL-C-28876 connectors should conform to MIL-STD-2163. Removable terminals for fiber optic connectors should conform to MIL-T-29504.

4.12 Penetrators. Fiber optic penetrators (hull or bulkhead) should conform to MIL-P-24628.

4.13 Detectors. Fiber optic detectors should conform to DOD-D-24620.

4.14 Couplers. Fiber optic couplers should conform to MIL-C-24621.

4.15 Rotary joints. Fiber optic rotary joints should conform to MIL-R-24727.

4.16 Interconnection boxes. Fiber optic interconnection boxes should conform to MIL-I-24728.

4.17 Multiplexers and demultiplexers.

4.17.1 Frequency division. Fiber optic frequency division multiplexers and demultiplexers should conform to MIL-M-24731.

4.17.2 Time division. Fiber optic time division multiplexers and demultiplexers should conform to MIL-M-24736.

4.18 Controllers, interface unit. Fiber optic controllers should conform to MIL-C-24733.

4.19 Fiberscopes. Fiber optic fiberscopes should conform to MIL-F-24734.

4.20 Transmitters, analog. Fiber optic analog transmitters should conform to MIL-T-24735.

4.21 Receivers, analog. Fiber optic analog receivers should conform to MIL-R-24737.

4.22 Attenuators. Fiber optic attenuators should conform to MIL-A-24726.

4.23 Switches. Fiber optic switches should conform to MIL-S-24725.

4.24 Tools and inspection equipment. Fiber optic tools, inspection equipment, and related kits should conform to MIL-I-81969, MIL-T-83523, MIL-M-83524, MIL-K-83525, MIL-M-83533 and MIL-C-22520/10.

5. Information for guidance only.

5.1 Design guides. Fiber optic system design guide information is available in MIL-HDBK-415.

5.2 Product assurance program. When a guideline 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 guidelines, design analysis, demonstration and maturation guidelines may be specified in the contract or system/equipment specification, as appropriate.

2. Documents applicable to guideline 77:

MIL-H-46855	Human Engineering Requirement for Military Systems, Equipment and Facilities
MIL-STD-415	Test Provisions for Electronic Systems and Associated Equipment, Design Criteria for
MIL-STD-470	Maintainability Program for Systems and Equipment
MIL-STD-471	Maintainability Verification/Demonstration/Evaluation
MIL-STD-499	Engineering Management
MIL-STD-2165	Testability Program for Electronic Systems and Equipments
MIL-STD-1814	Integrated Diagnostics
MIL-STD-1326	Test Point, Test Point Selection and Interface Requirements for Equipments Monitored by Shipboard On-line Automatic Test Equipment
MIL-STD-1388-1	Logistics Support Analysis
AFGS-87256	AF Guide Specification on Integrated Diagnostics
ASTM-F-1166	Standard Practices for Human Engineering Design for Marine Systems, Equipment, and Facilities

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 as a means for providing 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 guidelines. This emphasis on the design and acquisition of the diagnostic capability is required because this capability tends to become fractionated. MIL-STD-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-STD-470, MIL-STD-471, MIL-STD-499, MIL-STD-1814, MIL-STD-1388-1, MIL-H-46855, AFGS-87256, and ASTM-F-1166.

4. Guidelines. Not applicable.

5. Information for guidance only.

5.1 Test provisions.

5.1.1 Testability programs. When specified by the procuring activity a testability program should be implemented in accordance with MIL-STD-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 checkouts or calibration.

5.1.3 Test provisions. Test provisions should provide means for monitoring performance, calibration, and fault isolation in accordance with MIL-STD-415. Equipment which is required to be tested by on-line Automatic Test Equipment (ATE) should provide test points in accordance with MIL-STD-1326.

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.

5.2 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 offers guidance as to producibility guidelines which should be considered when preparing contractual documents. Producibility program tasks, quantitative guidelines, and verification or demonstration guidelines may be directly specified in the contract or the system and/or equipment specification, as appropriate.

2. Documents applicable to guideline 78:

DoD 4245.7M	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. Not applicable.

4. Guidelines. Not applicable.

5. Information for guidance only.

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 guidelines 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.

a. This section should also reference risk measure and abatement.

b. Response: Producibility engineering is the abatement of producibility risk It does not relate to performance, overall cost, or other nonproduction related risks. The documents referenced handle the production risk issues adequately, so I would recommend against adding anything further.

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 guidelines. Quantitative producibility guidelines and verification or demonstration guidelines 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 guidelines include DoD 4245.7M, NAVSO P-6071, and MIL-HDBK-727.

a. A link to design-to-cost should also be made here.

b. Response: Design-to-cost is a somewhat separate topic with little formal guidance. It is much broader than just produciblity issues. Manufacturing cost is the driver for produciblity and is covered in the referenced documents, so I wouldn't recommend adding a design to cost link at this time.

INDEX OF APPLICABLE DOCUMENTS

Document	Guideline
SPECIFICATIONS	
Federal	
FF-F-300	52
L-P-516	11,26
L-S-300	67
V-T-276	44
V-T-285	44
V-T-291	44
V-T-295	44
FF-B-171	6
FF-B-185	6
FF-B-187	6
FF-B-195	6
FF-B-575	12
FF-N-836	12
FF-R-556	12
FF-S-85	12
FF-S-86	12
FF-S-92	12
FF-S-200	12
FF-S-210	12
FF-W-84	12
FF-W-92	12
FF-W-100	12
HH-I-553	11
QQ-S-766	41
QQ-W-321	41
QQ-W-343	20,66,71
TT-S-1732	12
VV-L-800	43
VV-P-236	43
ZZ-R-765	26
CCC-C-428	44
MMM-A-121	23
MMM-A-130	23
MMM-A-132	23
MMM-A-134	23
MMM-A-138	23
MMM-A-181	23
MMM-A-189	23
MMM-A-1617	23
MMM-A-1931	23
Military	
MIL-I-10	11,26
MIL-M-14	11,26
MIL-C-17	65,66,71
MIL-B-18	27
MIL-D-24	46
MIL-S-61	40
MIL-W-76	20,71
MIL-T-152	4,69
MIL-C-172	55
MIL-V-173	4,69
MIL-C-442	66,71

Document	Guideline
MIL-W-530	44
MIL-C-572	44
MIL-I-631	11,69
MIL-J-641	10
MIL-P-642	10
MIL-T-713	69
MIL-S-1222	12
MIL-I-1361	40
MIL-L-2105	43
MIL-G-3111	46
MIL-G-3124	46
MIL-L-3150	43
MIL-I-3158	11,69
MIL-I-3190	11,69
MIL-C-3432	66,71
MIL-T-3530	44
MIL-S-3644	42
MIL-L-3661	50
MIL-I-3825	11
MIL-L-3890	65
MIL-L-3918	43
MIL-A-3920	23
MIL-K-3926	28
MIL-B-3990	6
MIL-W-4088	44
MIL-M-4820	46
MIL-W-5086	20,66,71
MIL-B-5087	1,74
MIL-H-5440	49
MIL-A-5540	23
MIL-F-5591	12
MIL-R-5674	12
MIL-B-5687	6
MIL-W-5845	66,71
MIL-W-5846	20,66,71
MIL-W-5908	66,71
MIL-L-6085	43
MIL-L-6086	43
MIL-L-6363	50
MIL-B-6812	12
MIL-W-6858	13
MIL-C-7078	66,71
MIL-I-7444	11
MIL-S-7742	12
MIL-M-7793	51
MIL-L-7806	50
MIL-B-7838	12
MIL-B-7883	59
MIL-R-7885	12
MIL-T-7928	19,69
MIL-S-7947	41
MIL-L-7961	50
MIL-M-7969	46
MIL-S-8516	47
MIL-A-8576	23
MIL-M-8609	46
MIL-W-8777	66,71
MIL-R-8814	12
MIL-B-8831	12
MIL-S-8879	12
MIL-H-8891	49
MIL-W-8939	24
MIL-W-8942	6
MIL-B-8943	6
MIL-W-8948	6
MIL-C-9074	44
MIL-F-9397	46
MIL-B-10154	27

Document	Guideline
MIL-C-10544	10
MIL-B-11188	27
MIL-S-12285	58
MIL-C-12520	10
MIL-S-12883	60
MIL-T-13020	11
MIL-M-13231	67
MIL-S-13282	41
MIL-B-13506	6
MIL-S-13572	41
MIL-C-13777	66,71
MIL-P-15024	67
DOD-B-15072	27
MIL-L-15098	50
MIL-I-15126	11
MIL-T-15659	19
MIL-L-15719	43
MIL-S-15743	58
MIL-M-16034	51
MIL-M-16125	51
MIL-F-16552	52
MIL-W-16878	20,66,71
MIL-I-16923	47
MIL-M-17059	46
MIL-M-17060	46
MIL-I-17205	11
MIL-L-17331	43
MIL-B-17380	6
MIL-M-17413	46
MIL-M-17556	46
MIL-H-17672	43
MIL-P-18177	11
MIL-F-18240	12
MIL-N-18307	67
MIL-S-18396	58
MIL-I-18746	11
MIL-M-19097	46
MIL-W-19150	20,71
MIL-M-19160	46
MIL-B-19166	11
MIL-C-19311	41
MIL-S-19500	30,50
MIL-C-19547	66,71
MIL-M-19633	46
MIL-I-22076	11,69
MIL-T-22361	12
MIL-I-22129	11
MIL-A-22397	23
MIL-S-22432	56
MIL-S-22473	12
MIL-C-22520/10	76
MIL-W-22759	20,66,71
MIL-S-22820	56
MIL-T-22821	56
MIL-C-22931	65
MIL-F-22978	12
MIL-I-23053	11,69
MIL-B-23071	46,52
MIL-S-23190	69
MIL-I-23264	11
MIL-L-23398	43
MIL-C-23437	66,71
MIL-S-23586	47

Document	Guideline
MIL-I-23594	11
MIL-T-23648	33
MIL-C-23806	65
MIL-G-23827	43
MIL-M-24041	47
MIL-I-24092	11
MIL-G-24139	43
MIL-A-24179	23
MIL-I-24204	11
MIL-G-24211	53
MIL-R-24243	12
MIL-S-24251	60
MIL-M-24325	26
MIL-I-24391	11
MIL-G-24508	43
DOD-D-24620	76
MIL-C-24621	76
DOD-S-24622	76
MIL-S-24623	76
MIL-H-24626	76
MIL-P-24627	76
MIL-P-24628	76
MIL-C-24640	66,71
MIL-C-24643	66,71
MIL-S-24725	76
MIL-A-24726	76
MIL-R-24727	76
MIL-I-24728	76
MIL-M-24731	76
MIL-L-24732	76
MIL-C-24733	76
MIL-F-24734	76
MIL-T-24735	76
MIL-M-24736	76
MIL-R-24737	76
MIL-I-24768	11,26
MIL-N-25027	12
MIL-W-25038	66,71

Document	Guideline
MIL-K-25049	28
MIL-A-25463	23
MIL-H-25475	49
MIL-P-25518	26
MIL-C-27072	66,71
MIL-W-27265	44
MIL-R-27384	12
MIL-C-27500	66,71
MIL-D-28728	28
MIL-M-28787	73
MIL-D-28803	68
MIL-C-28876	76
MIL-T-29504	76
MIL-M-38510	64,75
MIL-M-38527	60
MIL-C-39006/22	2
MIL-C-39006/25	2
MIL-T-43435	69
MIL-L-46010	43
MIL-S-46049	41
MIL-A-46050	23
MIL-I-46058	17
MIL-P-46112	26
MIL-W-46132	13
MIL-A-46146	23
MIL-S-46163	12
MIL-P-46843	17
MIL-I-46852	11
MIL-H-46855	62
MIL-A-47089	23
MIL-A-47315	23
MIL-A-47317	23
MIL-A-47318	23
MIL-A-48611	23
MIL-B-49030	27
MIL-C-49055	66
MIL-F-49291	76
MIL-F-49291	76

Document	Guideline
MIL-C-49292	76
MIL-B-49430	27
MIL-B-49436	27
MIL-C-49055	66
MIL-I-49456	11
MIL-B-49458	27
MIL-B-49461	27
MIL-R-50781	56
MIL-A-52194	23
MIL-C-55021	66,71
MIL-S-55041	53
MIL-P-55110	17
MIL-C-55116	10
MIL-B-55118	27
MIL-B-55130	27
MIL-T-55156	19
MIL-T-55164	19
MIL-C-55181	10
MIL-B-55252	27
MIL-O-55310	38
MIL-A-55339	10
MIL-T-55631	14
MIL-C-81021	41
MIL-W-81044	20,66,71
MIL-I-81219	51
MIL-A-81236	23
MIL-A-81253	23
MIL-M-81288	55
MIL-G-81322	43
MIL-L-81329	43
MIL-W-81381	20,66,71
MIL-I-81550	47
MIL-B-81744	6
MIL-S-81746	56
MIL-B-81757	27
MIL-I-81765	11
MIL-B-91793	6
MIL-W-81822	20
MIL-B-81934	6
MIL-B-81936	6
MIL-S-81963	56,67
MIL-I-81969	76
MIL-A-83377	23
MIL-S-83502	60
MIL-C-83503	10
MIL-R-83516	57
MIL-C-83522	76
MIL-T-83523	76
MIL-M-83524	76
MIL-K-83525	76
MIL-C-83526	76
MIL-C-83532	76
MIL-M-83533	76
MIL-T-83721	14
MIL-T-83727	56
MIL-S-83731	58
MIL-S-83734	60
MIL-B-83769	27
MIL-C-85045	76
MIL-I-85080	11
MIL-E-85082	56
MIL-A-87135	23
MIL-D-87157	68

STANDARDS

Federal

FED-STD-H28	12
FED-STD-406	26

Document	Guideline
Military	
MIL-STD-12	67
MIL-STD-22	13
MIL-STD-108	55,69
MIL-STD-130	67
MIL-STD-155	67
MIL-STD-188-111	76
MIL-STD-188-124	74
MIL-STD-195	67
MIL-STD-196	34,67
MIL-STD-198	2
MIL-STD-199	33
MIL-STD-200	29
MIL-STD-202	3
MIL-STD-205	25
MIL-STD-248	13
MIL-STD-255	25
MIL-STD-276	21
MIL-STD-280	7,8,36,67
MIL-STD-411	67
MIL-STD-415	32
MIL-STD-461	61
MIL-STD-462	61
MIL-STD-469	61
MIL-STD-470	54
MIL-STD-471	54
MIL-STD-499	77
MIL-STD-681	20
MIL-STD-683	38
MIL-STD-701	30
MIL-STD-704	25
MIL-STD-710	56
MIL-STD-721	35,36,54
MIL-STD-756	35
MIL-STD-781	35
MIL-STD-783	67
MIL-STD-785	35,64
MIL-STD-1547	7,18,30,64
MIL-STD-1546	22
MIL-STD-790	76
MIL-STD-810	4
MIL-STD-883	64,75
MIL-STD-889	15,16
MIL-STD-965	22
MIL-STD-973	72
MIL-STD-975	64
MIL-STD-981	14
MIL-STD-983	72
MIL-STD-1130	69
MIL-STD-1132	58
MIL-STD-1189	67
MIL-STD-1261	13
MIL-STD-1275	25
MIL-STD-1277	19
MIL-STD-1279	51
MIL-STD-1285	67
MIL-STD-1286	14
MIL-STD-1310	1,74
MIL-STD-1326	77
MIL-STD-1327	53
MIL-STD-1328	53
MIL-STD-1329	53
MIL-STD-1334	6
MIL-STD-1346	57
MIL-STD-1352	53
MIL-STD-1353	10
MIL-STD-1358	53
MIL-STD-1360	39
MIL-STD-1378	73
MIL-STD-1388	1,77
MIL-STD-1389	73
MIL-STD-1395	70
MIL-STD-1399	25
MIL-STD-1451	56
MIL-STD-1472	1,36,50,62
MIL-STD-1498	37
MIL-STD-1516	15
MIL-STD-1539	8,25
MIL-STD-1542	74

Document	Guideline
MIL-STD-1562	64
DOD-STD-1578	27
MIL-STD-1595	13
MIL-STD-1629	35
MIL-STD-1636	53
MIL-STD-1637	53
MIL-STD-1638	53
MIL-STD-1639	53
MIL-STD-1640	53
MIL-STD-1646	10
DOD-STD-1678	76
MIL-STD-1686	64,75
MIL-STD-1814	77
MIL-STD-1857	74
DOD-STD-1863	76
MIL-STD-2000	5
MIL-STD-2036	FWD
MIL-STD-2113	53
MIL-STD-2120	10
MIL-STD-2162	53
MIL-STD-2163	76
MIL-STD-2165	32
MIL-STD-2196(SH)	76
MIL-STD-2175	21
MIL-STD-2219	13
MIL-STD-11991	FWD
MS25471	71
MS27110	71
MS27212	19
MS33522	12
MS33540	12
MS33557	12
MS33558	42

HANDBOOKS

Military

Document	Guideline
MIL-HDBK-5	13
MIL-HDBK-179(ER)	64
MIL-HDBK-216	53,65
MIL-HDBK-217	35,64
MIL-HDBK-218	56
MIL-HDBK-246	73
MIL-HDBK-225	56
MIL-HDBK-231	56
MIL-HDBK-251	52
MIL-HDBK-253	61
DOD-HDBK-263	75
MIL-HDBK-278	76
MIL-HDBK-282	76
MIL-HDBK-411	25
MIL-HDBK-415	76
MIL-HDBK-419	74
MIL-HDBK-472	54
MIL-HDBK-600	1
MIL-HDBK-660	53
MIL-HDBK-691	23
MIL-HDBK-727	78
MIL-HDBK-730	13

OTHER GOVT DOCUMENTS

Document	Guideline
AFGS-87256	77
DI-EGDS-80811	64
DOD 4245.7M	78
MIL-BUL-103	64
10 CFR 20	1
21 CFR 1000 - 1050	1
29 CFR 1910	1,4,11,23,26,43,44,47
NTIA Manual	61
NAVSO P-3679	78
NAVSO P-6071	78
Tester Independent Support Software System (TISSS) Specs	64
VHSIC Interoperability Standards	64
Army Regulation 700-83	27

NON-GOVT DOCUMENTS

Document	Guideline
AGMA Specifications	48
AMS 3638E	11
AMS 3653D	11
AMS 3654B	11
AMS 3655A	11

Document	Guideline
ANSI B93.1	49
ANSI B93.2	49
ANSI B93.3	49
ANSI B93.4M	49
ANSI B93.5	49
ANSI B93.6	49
ANSI B93.7	49
ANSI B93.8	49
ANSI B93.9M	49
ANSI B93.10	49
ANSI B93.11M	49
ANSI C95.1	1
ANSI C95.2	1
ANSI N2.1	1
ANSI Z35.1	1
ANSI Z35.2	1
ANSI Z35.4	1
ANSI Z53.1	1
ANSI/AWS A2.4	13
ANSI/AWS A3.0	13
ANSI/IPC-D-322	17
ANSI/SAE J514f	49
ANSI/SAE J518c	49
ASM Metals Hdbk, Vol 1-1978	41
ASTM A29/A29M-88	41
ASTM A228/A228M-83	41
ASTM A313-87	41
ASTM A682-79	41
ASTM A684/A684M-86	41
ASTM B33-74	66,71
ASTM B194-88	41
ASTM B196/B196M-88	41
ASTM B197/B197M-89	41
ASTM B522-80	41
ASTM D149-87	45
ASTM D495-73	26
ASTM D568-77	3
ASTM D635-81	3
ASTM D1000-82	3
ASTM D1868-81	45
ASTM D3295-81	11
ASTM F1166	77
EIA-297-A	10
EIA-310-C	55
IEC-693	76
IEEE 200	67
IEEE 1029	64
IEEE 1076	64
JEDEC-STD-17	64
NAS 498	12
NAS 547	12
NAS 1686	12
NAS 1687	12
NFPA 70	1,8
UL 94-80	3

SUBJECT INDEX

Subject	Guideline
Abbreviations	67
Access devices	12
Accessibility	36
Adapters	
Rf connector	10
Waveguide	53
Adhesives	23
Antiseize compound	12
Arc-resistant materials	26
Attenuators, rf	53
Barriers, electrical	1
Batteries	27
Bearing assemblies	9
Bearings	6
Boards	
Discrete wiring	17
Printed wiring	17
Bolts	12
Bonding	
Adhesive	23
Electrical	1, 74
Brazing	59
Cabinets	55
Cable, coaxial	65
Cable, multiconductor	
Interconnection	71
Internal	66
Capacitors	2
Carcinogens	1, 4, 11, 23, 26, 43, 44, 47
Cases	55
Castings	21
Circuit breakers	8, 37
Cleaning	9
Clearance	9, 69
Coaxial cable	65
COILS	14
Commercial parts	72
Conformal coating	17
Connections	
Accessibility of	36
Clamped	69
Crimp	69
Marking of	67
Soldered	5
Welded	24
Wire Wrap	69
Connectors	
Electrical	1, 10
Filter pin	10
Rf coaxial	10
Containment	9
Controls	28
Insulation of	1
Flexible shafts for	28, 42
Converters, rotary power	46
Cooling	52
Corona prevention	45
Corrosion protection	15, 16
Couplers, directional	53
Creepage distance	69
Crystal units	38
Derating	18
Desiccants	31, 55
Devices, microelectronic	64
Devices, semiconductor	30
Diagnostics, integrated	77
Dial mechanisms, tuning	42
Dials, control	28
Discharging devices	1
Displays	68
Dissimilar metals	16
Dynamotors	46

Subject	Guideline
Electrical	
Breakdown	45
Connections	5, 10, 24, 69
Filters	10, 70
Insulating materials	11
Meters	51
Overload protection	8
Power	25
Electromagnetic interference control	61
Electronic part derating	18
Electron tubes	29
Electrostatic	
Discharge control	75
Sensitive parts	30, 64, 75
Embedment	47
Encapsulation	47
Enclosures	1, 36, 55
Encoders	56
Fabric	44
Fastener hardware	12
Fasteners, threaded	12
Fiber Optics	76
Fibrous material, organic	44
Filters, electrical	10, 70
Finishes	15
Flammability	3
Flanges, waveguide	53
Fungus inert materials	4
Fungus protection	4, 44, 69
Fuse holders	39
Fuses	8, 39
Fusible link devices	64
Gear trains	48
Gears	48
Generators	46
Grounding	1, 6, 74
Guards, electrical	1
Handles, control	28
Hardware, fastener	12
Heating	52
Hookup wire	20
Human engineering	62
Hydraulics	49
Identification marking	20, 67
Indicator lights	50
Inductors	14
Insulating materials, electrical	11
Integrated diagnostics	77
Interchangeability	7
Interference, electromagnetic	61
Interlocks	1
Internal wiring practices	69
Item names, nomenclature	34
Jacks, telephone/test	10
Knobs, control	1, 28
Lacing	9, 69
Lamps	50
Leakage distance	69
Legends	67
Light emitting diodes	50, 68
Lights, indicator	50
Lines, rf transmission	53, 65
Loads, dummy, rf	53
Locking devices	12, 28
Lubricants	6, 43
Lug terminals	19
Maintainability	54
Marking	67
Battery installation	27
Dials	42
Fuse	39, 67
Radioactive material	1
Warning	1
Materials	
Arc-resistant	26
Carcinogens	1, 4, 11, 23, 26, 43, 44, 47
Electrical insulating	11
Fabric	44

Subject	Guideline
Materials (cont)	
Fibrous organic	44
Flammable	3
Fungus inert	4
Glass fibers	1
Potting	47
Toxic	1
Mercury	1
Metal finishes	15
Metals, dissimilar	16
Meters, electrical	51
Microelectronic devices	64
Mildew treatment	44
Modules	
Microcircuit	64
Standard electronic	73
Moisture pockets	31
Motor-generators	46
Motors	46
Multiconductor cable	
Interconnection	71
Internal	66
Nomenclature	34
Nonstandard parts	22
Nuts	12
Obsolescence, microcircuit	64
Organic fibrous material	44
Oscillators, crystal	38
Overload protection, electrica	18
Pads, mounting	60
Panels, enclosure	55
Parts selection and contro	17, 22, 72
Plastic material, insulating	11
Plugs, telephone	10
Potting	10, 47
Power, electrical	1, 25
Printed wiring	17
Marking of	67
Producibility	78
Protection	
Electrical overload	8
High voltage/current	1

Subject	Guideline
PVC	4, 11, 20, 65, 66, 71
Quartz crystal units	38
Racks	36, 55
Radiation (laser, microwave, X-ray)	1
Radioactive material	1
Readouts	68
Reference designations	67
Relays	57
Reliability	35
Microcircuit	64
Prediction	64
Resistance welds	24
Resistors	33
Resolvers	56
Rf connectors	10
Rotary power converters	46
Rotary servo devices	56
Safety (personnel hazard)	1
Screws	12
Semiconductor devices	30
Servo devices	56
Setscrews	12
Shafts, control	12, 28, 42
Shielding	
Electrical	1, 9, 74
Electromagnetic	61, 74
Shields	60
Shock, electrical, effects of	1
Shunts (meter)	40
Signs, accident prevention	1
Sleeving	11, 69
Sockets	60
Soldering	5
Special tools	63
Splices	69
Springs	41
Standard electronic modules	73
Standard items	7
Stops	28
Stress relief	24

Subject	Guideline
Structural welding	13
Substitutability	72
Switches	58
Battleshort	1
Circuit breakers used as	37
Interlock	1
Rf	1, 53
Safety	1
Waveguide	53
Symbology	67
Synchros	56
Tachometers	56
Tape	
Electrical	11
Lacing	69
Reflective	67
Terminal boards, strips	19
Terminal lugs	19
Terminations	1, 19, 69
Test provisions	10, 32
Thermal design	52
Thermistors	33
Thermocouples	10, 20
Thread	44
Threaded devices	12
Threads	12
Tools, special	63
Toxic materials	1
Transformers	14
Transistors	30
Transmission lines, rf	53
Transolvers	56
Tube shields	60
Tubes, electron	29
Tuning dial mechanisms	42
Type designations	34, 67
Varnish, insulating	11
Vehicles, ground	25
VHSIC	64
Warning labels	1, 27
Washers	12
Waveguides	53
Webbing	44
Welding, structural	13
Welds, resistance	13, 24
Wire	
Hookup	20
Interconnection	71
Solid or stranded	20, 66
Thermocouple	20
Wirewrap	20
Wire Identification	20
Wiring	
Arrangement	9, 69
Connector	10
Internal	69
Printed	17
Rigid-flex	17
Workmanship	9

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