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MILITARY SPECIFICATION

ELECTRONIC EQUIPMENT, AEROSPACE, EXTENDED SPACE ENVIRONMENT, GENERAL SPECIFICATION FOR

This specification is approved for use by all departments and agencies of the Department of Defense

1. SCOPE

1.1 Purpose. This specification sets forth the general requirements for the design and manufacture of electronic components and equipment for space vehicles. The detailed performance and individual test requirements shall be as specified in the equipment specification or the contract.

Beneficial comments (recommendations, additions, deletions), and any pertinent data which may be of use in improving this document should be addressed to:

SAMSO/AW
P.O. Box 92960, Worldway Postal Center,
Los Angeles, CA 90009

Use the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or comment by letter.

FSC 1820

1.2 Application. The requirements covered by this specification are applicable to electronic components and equipment to be used on space vehicles (see 6.1). This specification may also be used as a reference document to specify general requirements for electronic components to be used on launch vehicles, intercontinental ballistic missiles, or other vehicles. For those applications the term "space vehicle" is to be interpreted as the applicable vehicle.

2. APPLICABLE DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of the specification to the extent specified herein.

Federal Specifications

QQ-M-56	Magnesium Alloy, Sand Castings
QQ-N-290	Nickel Plating (Electrodeposited)
QQ-C-320	Chromium Plating (Electrodeposited)

Military Specifications

MIL-M-3171	Magnesium Alloy, Processes for Pretreatment and Prevention of Corrosion on
MIL-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-I-6866	Inspection, Penetrant Method of
MIL-F-7179	Finishes and Coatings; Protection of Aerospace Weapon Systems, Structures and Parts; General Specification for
MIL-N-7513	Nomenclature Assignment, Contractors Method for Obtaining
MIL-S-7742	Screw Threads, Standard, Optimum Selected Series: General Specification for

MIL-A-8625	Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-S-8879	Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specifications for
MIL-S-13282	Silver and Silver Alloy
MIL-S-13572	Spring, Helical, Compression and Extension
MIL-P-13949	Plastic Sheet, Laminated, Metal Clad (for Printed Wiring), General Specification for
MIL-F-14072	Finishes for Ground Electronic Equipment
MIL-N-18307	Nomenclature and Identification for Electronic, Aeronautical and Aeronautical Support Equipment Including Ground Support Equipment
MIL-S-19500	Semiconductor Devices, General Specification for
MIL-A-21180	Aluminum-Alloy Castings, High Strength
MIL-C-24308	Connectors, Electric, Rectangular, Miniature Polarized Shell, Rack and Panel, General Specification for
MIL-M-38510	Microcircuits, General Specification for
MIL-C-38999	Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect, Environment Resistant, Removable Crimp Contacts, General Specification for
MIL-C-39012	Connectors, Coaxial, Radio Frequency, General Specification for
MIL-M-45202	Magnesium Alloys, Anodic Treatment of
MIL-M-45207	Magnesium Alloy (K1A), Sand Castings
MIL-S-45743	Soldering, Manual Type, High Reliability, Electrical and Electronic Equipment

MIL-I-46058	Insulating Compound, Electrical (for Coating Printed Circuit Assemblies)
MIL-M-46062	Magnesium Alloy Castings, High Strength
MIL-S-46844	Solder Bath Soldering of Printed Wiring Assemblies
MIL-C-55544	Connectors, Electrical, Environment Resistant, for Use with Flexible Flat Conductor Cable and Round Wire, 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 Polimide Insulated, Copper and Copper Alloy
DOD-W-83575	Wiring Harness, Space Vehicle, Design and Testing
MIL-C-83723	Connectors, Electric, Circular, (Environment Resisting), Receptacles and Plugs, General specification for
MIL-C-83733	Connectors, Electrical, Miniature, Rectangular Type, Rack to Panel, Environment Resisting, 200 Degrees C Total Continuous Operating Temperature, General Specification for

Military Standards

MIL-STD-29	Springs, Mechanical; Drawing Requirements for
MIL-STD-198	Capacitors, Selection and Use of
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-889	Dissimilar Metals
MIL-STD-1512	Electroexplosive Subsystems, Electrically

	Initiated, Design Requirements and Test Methods
MIL-STD-1515	Fasteners used in the Design and Construction of Aerospace Mechanical Systems
MIL-STD-1540	Test Requirements for Space Vehicles
MS-33540	Safety Wiring and Cotter Pinning, General Practices for

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

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS

IEEE-STD-200 (1975)	Reference Designations for Electrical and Electronics Parts and Equipment (with ANSI Y32.16-1975)

(Application for copies should be addressed to the Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, New York 10017.)

3. REQUIREMENTS

3.1 Order of precedence. In the event of conflicts between any of the documents referenced herein and the contents of this specification, the contents of this specification shall be considered the superseding requirements.

3.2 Supplementary specifications and standards. When this specification and the documents referenced herein fail to provide a suitable specification or standard, other appropriate specifications or standards may be used. If the documents referenced in this specification do not provide the contractually required reliability, quality level, or technical performance, they should be interpreted as being referenced to limit the variety of the physical and functional parameters to the extent practicable. In those cases, the referenced specifications should be the basis of contractor specifications that would add, delete, or change specific requirements. When a detail or general military specification exists for the class of material required, the contractor's specification shall reference the existing military specification and set forth only the needed new requirements and deviations. If required by the contract, the supplementary specifications that are prepared by the contractor shall be submitted to the contracting officer for review or approval prior to their use. When required by the contracting officer, the contractor shall provide data substantiating the supplementary requirements and shall provide samples for testing. The use of contractor's specifications shall not constitute waiver of Government inspections requirements.

3.3 General design requirements

3.3.1 Selection of parts, materials, and processes. Unless otherwise specified in the contract, the parts, materials, and processes shall be selected and controlled in accordance with contractor established and documented procedures to satisfy the specified requirements. The selection and control procedures shall emphasize quality and reliability to meet the mission requirements and to minimize total life cycle costs for the applicable vehicles. An additional objective in the selection of parts, materials, and processes shall be to maximize commonality and thereby minimize the variety of parts, related tools, and test equipment required in the fabrication, installation, and maintenance of the vehicle. Whenever a selected specification provides more than one characteristic or tolerance for an item, the equipment manufacturer shall use items of broadest characteristics in the equipment and of the greatest allowable tolerances that will fulfill the performance requirement of the equipment. When acceptable items of higher than minimum quality are readily available, the utilization of which would not increase the life cycle costs, they may be used. When maximum physical dimensions of an item are indicated in the selected specification for the item, all new equipment shall be designed to accommodate the maximum physical size specified so that all parts having the same type designation will be physically interchangeable in the equipment.

3.3.1.1 Equipment performance. The requirements of this specification with regard to parts, materials, and processes shall not relieve the contractor of the responsibility for complying with all equipment performance and other requirements set forth in the equipment specification or the contract.

3.3.1.2 Parts to meet reliability requirements. When the contract or equipment specification includes a reliability requirement that is based on a previous calculation and demonstration of the equipment reliability, the parts used shall be equal to or more reliable than those used in the demonstration equipment.

3.3.1.3 Derating. A documented derating policy shall be uniformly applied in the selection and application of parts and materials. This derating policy shall address application and environmental factors such as voltage, current, power, temperature, vibration, shock, acceleration, radiation, and duty cycles. The part application shall consider the maximum rating variation expected over the stated mission life including derating due to extended storage or other possible service conditions that may be applicable. Parts and materials shall not be subjected to any conditions exceeding the applicable derated values.

3.3.2 Materials

3.3.2.1 Restricted materials. Mercury, compounds containing mercury, zinc parts, zinc plating, cadmium parts, and cadmium plated parts shall not be used except as may be required for the internal functioning of batteries or other devices. Corrosive (acetic acid evolving) silicone sealants, adhesives, and coatings shall not be used. Wood shall not be used. Pure tin or tin electroplate shall not be used except when refused, reflowed, or alloyed with lead, antimony, or bismuth.

3.3.2.2 Dissimilar metals. Protection of dissimilar metal combinations shall be in accordance with MIL-STD-889. The worst case environment anticipated for the equipment, including storage environment, shall be considered.

3.3.2.3 Castings. Castings shall be in accordance with MIL-STD-454, Requirement 21, except aluminum alloy castings shall be in accordance with MIL-A-21180 and magnesium alloy castings shall be in accordance with QQ-M-56 or MIL-M-46062. For high vibration damping applications, magnesium castings shall be in accordance with MIL-M-45207. For applications where minimum outgassing is permitted in space vacuum or where hermeticity in space vacuum is required, castings shall not be impregnated to seal porosity.

3.3.2.4 Aluminum alloy for bonding or grounding. Where bonding or grounding is necessary, aluminum 1100, alloys 3003, 5052, 6053, 6061, 6063, 7072, or equally corrosion-resistant alloys, shall be used. They may be used without other surface treatment.

3.3.2.5 Ferrous alloys. Ferrous alloys shall be in accordance with MIL-STD-454, Requirement 15.

3.3.2.6 Magnesium and magnesium alloys. Although other materials are generally preferable, magnesium that is finished in accordance with the requirements of this specification may be used to achieve a weight reduction or for the damping characteristics it provides. Care shall be taken to avoid corrosion or electrolytic action.

3.3.2.7 Fungus-inert material. Where practicable, fungus-inert materials that are in accordance with MIL-STD-454, Requirement 4 shall be used. In those cases where other materials are required, they shall be selected based upon substantiated data concerning their resistance to fungus growth in the anticipated usage environment.

3.3.2.8 Insulators, insulating materials, and dielectric materials. Insulators, insulating materials, and dielectric materials shall be in accordance with MIL-STD-454, Requirement 11. For space vehicles that will operate at altitudes above 1000 kilometers, insulating materials or finishes having a resistivity greater than 10 megohm-meters shall not be used except in applications where charge buildup will not be excessive.

3.3.2.9 Arc-resistant materials. Arc-resistant materials shall be in accordance with MIL-STD-454, Requirement 26.

3.3.2.10 Flammable materials. Flammable materials shall be in accordance with MIL-STD-454, Requirement 3.

3.3.2.11 Explosive fumes. Parts and materials shall not liberate gases which produce an explosive atmosphere under specified service conditions.

3.3.2.12 Organic fibrous material. The selection and application of organic fibrous material shall be in accordance with MIL-STD-454, Requirement 44.

3.3.3 Finishes. The finishes used shall be such that completed components and hardware items not covered by subsidiary specifications shall be resistant to corrosion. The design goal should be that there would be no destructive corrosion of the completed component when exposed to moderately corrosive environments such as industrial environments or exposure to sea coast fog. Destructive corrosion shall be construed as being any type of corrosion which interferes with meeting the specified mechanical, thermal, or electrical performance of the equipment or its associated parts. Parts and components shall have finishes providing suitable thermal characteristics. Protective methods and materials for cleaning, surface treatment, and applications of finishes and protective coating shall be in accordance with MIL-F-7179. Finishes of bleached chromates shall not be used.

3.3.3.1 Finishes for fasteners and assembly screws. Exposed surfaces of external fasteners and assembly screws which are manipulated, loosened, or removed in the normal processes of servicing and installing the equipment, should be preferably in a noncorrosive black or bright finish, so as to provide strong contrast with the color of the surface upon which they are used. Other external fasteners and assembly screws used for securing the internal parts to the chassis shall be similar in color to the surface upon which they are used.

3.3.3.2 Finishes for aluminum alloy surfaces. The surface of parts fabricated from wrought aluminum 1100; or wrought aluminum alloys 3003, 5052, 6053, 6061, 6063 or 7072; or cast aluminum alloys 356, A356, 357, and A357 after a suitable deoxidizing treatment do not require an anodize or conversion coating. The surfaces of parts fabricated of other wrought or cast aluminum alloys which contain more than one percent (nominal) copper or magnesium or both shall be anodized in accordance with MIL-A-8625 or conversion coated in accordance with MIL-C-5541. Where bonding or grounding is not necessary and exposure to repeated high tensile stress will not occur, hard anodic finishes conforming to number E514 of MIL-F-14072 may be applied to obtain extremely wear-resistant surfaces under Type II (sheltered) exposure.

3.3.3.3 Finishes for magnesium and magnesium alloys. Magnesium and magnesium alloys shall be finished in accordance with MIL-M-3171 or MIL-M-45202. Magnesium and its alloys shall be subsequently painted.

3.3.3.4 Plating and special materials. Chromium plating shall be in accordance with QQ-C-320. Nickel plating shall be in accordance with QQ-N-290. Gold, nickel, chromium, rhodium, tin, lead-tin alloys, or platings of these materials are satisfactory without additional protection or treatment, other than buffing or cleaning. In applications requiring gold, rhodium, or chromium plated finishes, these platings shall be applied over at least 1.3 micrometers (μm) of low stress nickel underplate, except for applications in which the base metal is nickel.

3.3.3.5 Finishes for bonding and grounds. The surface finish for electrical bonding shall be bare metal or a qualified conductive finish such as Iridite 14 or Alodine 1000. Nonconductive coatings such as anodized aluminum shall not be used. If abrasives or scrapers are used to remove any protective finish, they shall be the kind that produces a clean smooth surface without removing excessive materials under the finish. Abrasives that would cause corrosion if embedded in the metal shall not be used.

3.3.4 Enclosures. Enclosures for all electronic equipment shall be electrically conducting and shall be designed to minimize electromagnetic propagation and pickup from external sources. The provisions for installation shall be such that there will be a continuous, low-impedance path from the equipment enclosure to the basic structure of the space vehicle to permit bonding of the equipment. The direct current resistance from enclosure to structure shall not exceed 2.5 milliohms. Mechanical discontinuities in the enclosure, such as covers, inspection plates, and joints, shall be kept to a minimum. Covers shall be secured by methods that prevent conductive metal particles generated from screw threads or EMI gaskets becoming mobile within the enclosure. A low-impedance current path shall be provided across the interface of each discontinuity so as not to degrade the electromagnetic shielding effectiveness of the enclosure. Positive, self-locking fasteners, sized appropriately for the weight of the equipment, shall be used. Shock mounts or vibration isolators shall not be used.

3.3.5 Fabrication related requirements.

3.3.5.1 Structural welding. Structural welding shall be in accordance with MIL-STD-454, Requirement 13.

3.3.5.2 Brazing. Brazing shall be in accordance with MIL-STD-454, Requirement 59.

3.3.5.3 Fasteners and locking. Fastening systems shall be in accordance with MIL-STD-1515. Positive locking devices shall be used on all fasteners. Acceptable positive locking devices are bent tab washers, cotter pins, safety wire, self-locking threads, or self-locking provisions by means of plastic material contained in the nut, bolt, or screw. Self-locking nuts are preferred to bolts or screws that contain plastic material for use as a locking device. Locking compounds shall not be used on threads to provide locking. Where practicable, self-locking devices which depend upon an interference fit between metallic threads shall be avoided in applications where particulate contamination may cause damage or degradation to the equipment or vehicle. Safety wiring and cotter pins shall be in accordance with MS-33540. Drawings shall clearly depict the safety wiring method and configuration used. Through bolts or screws with locknuts are preferred to threaded inserts and should be used where practicable. Threaded inserts shall be used in applications that require tapped holes in aluminum, magnesium, plastic, or other materials that are susceptible to galling or thread damage. When self-locking features are used, the screw length shall be sufficient to fully engage the locking device. When self-locking features are used, the minimum run-in torque shall be specified or the maximum number of reuses that will assure an adequate lock shall be specified. Spring type or star type lock washers shall not be used. Adjustable fittings or mounting plates which use oversized holes or slotted holes to provide adjustment shall not be dependent upon friction between the fitting or mounting plate and the mounting surface to provide locking. Serrated surfaces or other positive indexing techniques shall be used to index and prevent motion of the contacting surfaces. Diamond type serrations shall not be used. When the shaft of a bolt is used as a rotating element in a rotating joint, a castle nut with cotter pin shall be used for retention of the bolt. The grip length of the rotating bolt shall ensure that sufficient end play is provided to preclude binding. When the shaft of a bolt is used as a fixed pivotal element in a rotating joint, the bolt shall either be a shoulder bolt or the bolt shall pass through a spacer. The grip length of the shoulder bolt or the length of the spacer shall ensure that sufficient end play is provided to preclude binding when the self-locking nut is tightened. Split or rolled spring-action pins shall not be used as pivots for rotating joints. Where split or rolled spring-action pins are used in other applications, a positive means of retaining the pin, such as staking the edges of the hole, shall be utilized. Locking compounds shall not be used as the retention method for pivot pins. Snap rings shall be avoided where a more positive means of retention can be used. Snap rings shall not be used to retain pins in linkages or other applications where there is a possibility that moment loads may be imposed on the snap ring. Where snap rings are used in the presence of dry film lubrication, care shall be taken to ensure that no dry film lubricant is deposited in the groove for the snap ring. New snap rings shall be used each time the assembly, or portion thereof which includes the snap ring, is disassembled and reassembled.

3.3.5.4 Threaded parts. Threaded parts shall be in accordance with MIL-S-7742 or MIL-S-8879. A minimum engagement of five full threads is required for threaded attachments; or for through bolts, the threaded ends shall protrude a minimum of two full threads beyond the end of the nut. Screw sizes smaller than 3.5 millimeters (mm) in diameter shall be avoided where practicable.

3.3.5.5 Adhesives. Adhesives shall be in accordance with MIL-STD-454, Requirement 23. The adhesives shall be selected based on their strength in the appropriate failure mode (i.e., shear, peel, flatwise, or tensile) at the maximum and minimum temperature extremes and maximum and minimum cooling rates predicted in operational use or during testing.

3.3.5.6 Encapsulation and embedment (potting). Encapsulation and embedment (potting) materials and their application shall be in accordance with MIL-STD-454, Requirement 47.

3.3.5.7 Conformal coating. Conformal coating for printed wiring boards shall be in accordance with MIL-I-46058 except type UR and type SR coatings may be applied up to a thickness of 0.6 mm, provided the coating material exhibits a durometer hardness of 60 Shore A or less at -50 deg C and a modulus of elasticity less than 69 megapascals at -50 deg C. Where applicable, the selection of coating materials shall consider outgassing that could cause contamination of optical and thermal control surfaces.

3.3.5.8 Lubricants. Lubrication may be provided by greases, liquids, solid film lubricants, or a combination of either grease or liquid with solid film lubricants. The selection of lubricants shall be based on the following considerations: (a) coefficient of friction, (b) lubrication property changes in a vacuum environment, (c) depletion and wearout, (d) operating temperature limits, (e) creep properties, (f) viscosity vs temperature properties, (g) pressure coefficient of viscosity, (h) outgassing that could cause contamination such as on optical or thermal control surfaces, (i) corrosion protection, (j) possibility of polymerization, (k) cleanliness, (l) run-in requirements such as rate of speed, load, and time duration, (m) any requirements for demonstration of the suitability of the lubricant in a simulated space environment, (n) any requirements of other environments such as humidity, and (o) compatibility of the lubricant with other materials, particularly other lubricants if used. Suitable lubricants that are amenable to accelerated testing are preferred for applications requiring long term demonstration of lubricant adequacy. The lubricant chosen shall not cause detrimental effects on the assembly during or after operation at ambient conditions. Selection of the lubricants for assemblies unavoidably subjected to stray electrical currents, shall be such that there are no detrimental effects on the lubricants caused by the passage of maximum current through the lubricated interfaces. In the selection of lubricants for a particular application, priority shall be given those that have been successfully used in equivalent applications. Graphite shall not be used as a lubricant under vacuum conditions.

3.3.5.9 Soldering. Soldering shall be in accordance with MIL-STD-454, Requirement 5, except that manual soldering shall be in accordance with MIL-S-45743. No assembly shall depend solely on soft solder for mechanical strength, except relatively light parts that have, by actual use, proved to be suitable in similar applications when soldered. Solder bath soldering shall not result in electronic parts temperatures that exceed 149 deg C and the solder joints shall meet the workmanship requirements of MIL-S-46844. Active solder fluxes may be used provided the application does not damage the assembly and permits a thorough removal of all unreacted flux and flux residues without depositing contamination on other parts of the assembly. To avoid gold contamination of solder joints, all goldplated electronic hardware, including leads of electronic parts which require soldering, shall be pretinned to remove excess gold; except tinning shall not be required for solder bath soldering if the goldplating thickness is no greater than 1.3 µm.

3.3.5.10 Welds (electrical interconnections). Electrical interconnection resistance welds shall be in accordance with MIL-STD-454, Requirement 24, except the minimum weld strength for any type of electronic welding (modules, stitchwelding) shall be greater than 13 newtons in either shear or peel mode. Weld strengths need not be based on parent metal breaking strength.

3.3.5.11 Tape (electrical). Glass cloth, teflon-glass, and polyimide film tapes may be used. If the application requires pressure-sensitive adhesive tapes, the adhesive shall provide appropriate bond strengths at the maximum temperature to which the equipment may be subjected. Fabric (textile) pressure-sensitive (adhesive or friction) tape shall not be used.

3.3.6 Connectors on equipment enclosures. Electrical connectors to which external wiring harnesses will be attached shall be suitable for the application. Connectors shall be selected consistent with the circuit categories and related requirements of DOD-W-83575. Wire harness connectors shall be of the rear insertable removeable crimp contact and quick disconnect type where feasible. Except as modified herein, connectors shall be in accordance with MIL-C-24308, MIL-C-38999, MIL-C-55544, MIL-C-83723, or MIL-C-83733. Coaxial connectors shall be suitable for the application and be in accordance with MIL-C-39012. Connector shells shall have a conductive finish; however, cadmium plating shall not be used. Connectors for use in an EMP or high level rf environment shall be capable of incorporating rf finger stock at the connector-receptacle interface to provide for shield continuity and shall be mechanically capable of being subjected to the required coupling nut torquing. Pin-type (male) contact connectors shall be used for input power or input signals. Socket (female) contact connectors shall be used for output power.

3.3.6.1 Connector mounting. Connectors shall be mounted so as to provide a ground path through the enclosure to the structure of the vehicle. The dc resistance measured from the connector shell to the vehicle structure shall not exceed 2.5 milliohms. Connectors that are not self-locking shall be safety wired.

3.3.6.2 Connector locations. Connectors shall be located near the middle of the enclosure side or face with a minimum of 25 mm clearance between connector shells to allow access during mating and demating. Connectors for electroexplosive device circuits shall be located 50 mm from other connectors. Where practicable, connectors located on the same equipment enclosure shall have different shell sizes to preclude connector mismating. Connectors located on the same equipment enclosure and having the same shell sizes shall have multiple keyways, with the master keyways on each connector rotated to different positions. Provisions for different keying arrangements shall also be provided to further preclude mismating should similar equipment or connectors be physically located in adjacent areas of the same vehicle. Where redundant equipment is housed in a single enclosure, separate connectors shall be provided for each of the redundant equipments.

3.3.6.3 Power. A minimum of two connector contacts shall be provided each power input and power return. Where practicable, each of the connector contacts shall be rated to carry the maximum load. Where the contact rating is such that two (or more) contacts are required to carry the maximum load, the minimum number of connector contacts for each power input and power return shall be four (or twice the number required based upon the contact rating).

3.3.6.4 Shielded wire. For electroexplosive device circuits, and for all categories of circuits in equipment subjected to an electromagnetic pulse (EMP) environment, the external harness wire shields shall be bonded around the circumference, and preferably within the backshell, of the connectors, and shall not be carried to ground through connector pins or contacts. When the external wiring harness is not exposed to an EMP environment, the harness wire shields may be designed to be connected to connector pins or contacts. In that case, the connector shall have the shield connection on a contact adjacent to the signal contact. The single end or multipoint shield grounding criteria in DOD-W-83575 shall determine whether the shield contact in the equipment connector is grounded in the equipment or not.

3.3.6.5 Circuit isolation. Circuit isolation criteria shall be in accordance with DOD-W-83575. When wires from circuits in different categories use the same connector, the pin assignments and layout shall stress isolation between different categories, and grounded "spare" pins may be utilized to provide such isolation.

3.3.6.6 Twisted wire contacts. Contacts for twisted wires shall be adjacent to each other.

3.3.6.7 Spare contacts. Spare contacts shall be located on the outer periphery of the connector and shall be ungrounded. Connectors with less than 25 contacts shall have a minimum of two spare contacts. Where practicable, at least 10 percent of the contacts in connectors with more than 25 contacts shall be spare. Contacts that are grounded to provide signal isolation shall not be counted as spare contacts. Empty holes shall not be left in connectors where there are unused contacts. In such cases, the connector insert shall be filled with a full complement of contacts and unused contact holes in the connector grommet shall be filled with sealing plugs.

3.3.6.8 Grounding connector contacts. A size American Wire Gauge (AWG) 22 or larger wire shall be used for terminating connector contacts to ground within the equipment enclosures. The dc resistance from the connector contact to the vehicle structure shall be less than 2.5 milliohms.

3.3.6.9 Protective caps. Connector receptacles shall be provided with protective caps whenever the mating connector is not installed, such as during equipment storage or installation.

3.3.7 Cables, waveguide, antennas, and RF devices. Cables and wiring external to enclosures shall be in accordance with DOD-W-83575. Waveguides and related equipment shall be in accordance with MIL-STD-454, Requirement 53 and the requirements stated herein.

3.3.7.1 Materials for waveguide and related equipment. Aluminum or magnesium alloys or castings are preferred for waveguide and related equipment due to its light weight. If castings are utilized, the castings shall exhibit no porosity or gas holes when penetrant tested in accordance with MIL-I-6866. If the application requires the minimum attentuation at frequencies above 12 gigahertz, the waveguide or waveguide component may be constructed of coin silver (90 percent silver, 10 percent copper) conforming to Grade C of MIL-S-13282 with a Rockwell B hardness between 45.0 and 80.0. Aluminum or magnesium waveguides and coin silver waveguides shall not be mated unless the aluminum or magnesium waveguide is silver-plated or both are plated with a common metal. Silver plating shall be electrodeposited using a periodic reverse process to minimize porosity and the mimimum silver plate thickness shall be 5 µm. Silver plating snall be overplated with rhodium, palladium, or gold to a thickness of 0.5 µm plus or minus 0.25 µm.

3.3.7.2 Waveguide assemblies. The face of assembled flanges for waveguides with a cross section of 25 mm by 10 mm or larger shall make an angle of 90 deg plus or minus 0.50 deg with the internal waveguide surfaces. For smaller waveguides, the face of the flange shall make an angle of 90 deg plus or minus 0.25 deg with the internal surfaces. The centers of openings of assembled waveguide sections shall be in axial alignment within 2 percent of the maximum waveguide cross-sectional dimension. Where practicable, grooves shall be oriented downward to prevent moisture accumulation. The smallest practicable number of waveguide couplings and flexible assemblies shall be used, such as by the use of preformed bends, to minimize system voltage standing wave ratio. Long waveguide runs shall be strain-relieved by suitable clamping devices spaced along the length of the waveguide. Flexible waveguide shall not be forced to bend beyond its natural "stop" position and repeated flexing shall be minimized. Waveguide assemblies including choke flanges and couplings shall be free of dirt, metal filings, loose solder particles, and other contamination. The open ends of assemblies shall be suitably sealed to prevent ingress of moisture and contamination.

3.3.7.3 Stripline transmission assemblies. Stripline transmission material shall be in accordance with MIL-P-13949, Type GT, GX, or LX. Bonded stripline circuit boards are preferred to boards assembled by eyelets or screws. The unclad surfaces of the dielectric materials of circuit boards to be laminated into a stripline device shall be chemically etched or otherwise primed for bonding. The design of stripline microwave equipment shall be such that stresses on solder joints are in shear and the shear stress shall be no greater than 6800 newtons per square meter at the highest temperature to which the equipment will be subjected. Connections between stripline assemblies and coaxial lines shall be designed to accommodate the maximum predicted thermal expansion and contraction of the coax center conductor.

3.3.7.4 Surface acoustic wave (SAW) devices. SAW crystals shall be controlled by applicable performance and material properties such as elastic, piezoelectric, and dielectric constants; electromechanical coupling coefficient; temperature coefficient; coefficient of velocity; and delay. The mechanical design of a SAW package shall ensure that the SAW crystal is attached to a substrate carrier by a flexible adhesive material to absorb stresses resulting from the different thermal expansion coefficients of the SAW crystal and the substrate and to absorb the acoustic wave which overlaps to the edges of the SAW crystal and would otherwise be reflected back to the interdigited transducers. The durometer of the adhesive shall be no greater than 65 Shore A, measured at room temperature. Electrical connections to the SAW device shall be made by ultrasonic aluminum bonds or equivalent room temperature bonds. Thermal compression bonds which have the potential to cause microfractures of the SAW crystal shall not be utilized. Discrete electronic parts shall not be attached to the substrate of a SAW package by soldering to circumvent the possibility of contaminating the SAW crystal surface with flux residues or solder. SAW device process operations shall include a thorough cleaning of completed SAW packages.

Prior to package sealing the devices shall be vacuum-baked for 24 hours at 150 deg C or equivalent to dry the device and to allow gases from the adhesives to escape.

3.3.7.5 Antennas. Radiating elements intended to operate over a ground plane shall be designed for installation on a homogeneous counterpoise or ground plane of negligible impedance within the operating frequency range of the electronic equipment involved. The ground plane or counterpoise shall be of adequate dimensions to ensure satisfactory radiation patterns. When coaxial antenna transmission lines are used, provisions shall be made for circumferential rf continuity between the outer conductor and the ground plane of the antenna. For antennas where efficient operation depends upon a low-resistance return current path from the ground plane to metal portions of the antenna, the design shall provide for a low-impedance, homogeneous external surface as the ground plane, with a minimum length connection to the appropriate portion of the antenna. All antennas, whether using a ground plane or not, shall be designed to provide satisfactory radiation patterns in the presence of all spacecraft components for all spacecraft configurations and attitudes to be encountered during operation of the antenna.

3.3.8 Electromechanical subassemblies.

3.3.8.1 Controls. External adjustment, alignment, or calibration controls shall not be provided on electronic enclosures used in space vehicles.

3.3.8.2 Rotary servo devices. Rotary servo devices shall be in accordance with MIL-STD-454, Requirement 56.

3.3.8.3 Batteries. Batteries shall be in accordance with MIL-STD-454, Requirement 27.

3.3.8.4 Electroexplosive devices. Electroexplosive devices shall be in accordance with MIL-STD-1512.

3.3.8.5 Motors. Motors, dynamotors, rotary power converters, and motor generators shall be in accordance with MIL-STD-454, Requirement 46. Motors shall have a minimum driving torque equal to two times the maximum load which must be driven based on combining worst case tolerances, frictional load, and voltages under worst case environmental conditions.

3.3.8.6 Springs. Helical springs shall be in accordance with MIL-S-13572 and MIL-STD-29. Helical compression springs are preferred to helical tension springs. Helical compression springs shall be enclosed, or otherwise captivated, where practicable, to provide motive power even if broken, and to prevent buckling. The attachments for retaining leaf springs shall be designed to reduce stress concentrations by such features as rounding of sharp corners or keeping mounting holes away from highly stressed areas. Spring design shall consider fatigue life and the effects of temperature on spring performance. To reduce the possibility of a reduction of potential energy due to creep, springs shall be designed to maintain stress levels below the material proportional limit. Redundant springs shall be used in all applications where practicable. Springs shall have a minimum force or torque margin of safety of 100 percent based on combining worst case tolerances and frictional load under worst case environmental conditions. All springs shall be dry film lubricated to minimize friction.

3.3.9 Electromagnetic compatibility. Electromagnetic compatibility shall be in accordance with the requirements of the detailed specification.

3.3.10 Antijamming. The electronic components or equipment shall be designed to obtain the maximum inherent protection against possible interferring signals caused by intentional and unintentional jamming. The contractor shall obtain the approval of the contracting officer for the basic antijamming concepts before proceeding with design of the system.

3.3.11 Operational checkout provisions. The test points and operational checkout provisions shall accommodate a continuity of critical test parameter measurements from box acceptance test through subsystem test, vehicle acceptance test, prelaunch checkout, and on-orbit test measurements as applicable. The test parameters shall be chosen to provide assurance of satisfactory equipment performance and to isolate faults should they occur. Where practicable, test points shall be provided as telemetry points on connector pins at the face of the equipment. The test equipment used shall assure that the critical performance parameters can be measured to the required accuracy. The parameter test limits shall be established such that the measurements are made to an expanding accuracy tolerance that avoids the possible rejection of equipment which has passed tests conducted at lower levels of assembly.

3.3.12 Pressurization. Avoid using pressurization of units to meet the requirements of this specification. Where pressurization is necessary, the equipment shall be designed to maintain the specified minimum pressure level for at least four times the mission duration. Whenever pressurization is utilized to meet the requirements of this specification, the following provisions for the enclosure shall be met:

a. Proof pressure equal to or greater than 1.5 times the maximum absolute operating pressure

b. Burst pressure equal to or greater than 2.0 times the maximum absolute operating pressure

3.3.13 Electrical overload protection. Electrical overload protection shall not be provided in individual boxes or components receiving power. Overload protection, when required, shall be a part of the space vehicle electrical power control subsystems.

3.3.14 Electrical power. The equipment shall operate satisfactorily over a range of input voltage from 22.0 volts (V) dc to 34.0 V dc as measured at the input power terminal of the equipment.

3.3.14.1 Ripple voltage. The equipment shall operate satisfactorily when the dc input voltage has a sinusoidal ripple voltage superimposed on the mean level as measured at the input power terminal to the equipment. The design level for the ripple voltage shall be 2.8 V rms in the frequency range between 0.1 hertz and 15 kilohertz. In the frequency range between 40 kilohertz and 400 megahertz the design level shall be 1.0 V rms. The design level of the ripple voltage shall transition from 2.8 V to 1.0 V in the frequency range between 15 kilohertz and 40 kilohertz.

3.3.14.2 Transients. The equipment shall operate satisfactorily when the dc input voltage has a voltage transient superimposed on the mean dc level. For design purposes, the transient voltage shall not exceed ±56 V peak as measured at the input power terminals to the equipment. The integrated area under the assumed transient voltage-time function can be as large as 0.0003 volt-seconds.

3.3.14.3 Power outage. When the input electrical power is removed from the equipment or is less than 22 V dc, the equipment may have a loss of function or performance degradation; however, when normal electric power is restored, the equipment shall recover automatically or be capable of a command reset to full functional operation without performance degradation. The equipment shall be designed to operate without performance degradation or to recover automatically without a command reset should the power interruption be less than 500 microseconds in duration.

3.3.14.4 Warmup time. The warmup time is the time period required to reach the specified operational performance capability from a nonoperational standby condition and environment. The warmup time shall be as specified by the equipment specification.

3.3.15 Corona and rf electrical breakdown prevention. Where practicable, the design of high voltage circuits shall use low dielectric constant insulation material (below 3.5) that are corona resistant. Designs without discontinuities or air gaps in the dielectric material are preferred. Sharp edges in microwave cavities and voids and bubbles in encapsulants shall be avoided to minimize high voltage field stress. When the frequency distance product is greater than 0.7 megahertz-meters, multipacting shall be a design consideration. In that case, (a) the use of encapsulation should be considered to raise the voltage required to start electrons resonating, (b) the area should be vented to allow any gas generated by multipacting to escape and thereby reduce corona, and (c) the use of an electrical or magnetic bias should be considered to sweep away ions.

3.3.16 Explosion-proofing. The equipment shall be made explosion-proof. Equipment or units thereof which do not cause ignition of an ambient explosive gaseous mixture with air or other specified oxidizing atmosphere, when operated in such an atmosphere long enough to be permeated by the atmosphere, shall be considered explosion-proof.

3.4 Automated design and production

3.4.1 Circuit selection. In the selection and layout of circuits, the contractor shall attempt to use circuits and methods of construction which will permit use of the same subassemblies in other equipment having similar circuits and functions. To permit flexibility in the arrangement or assembly of modules and subassemblies, interconnecting leads involving circuits considered susceptible of radiated interference or capable of radiating interferences shall be shielded and have low impedance. All other connections (such as power) shall be well shielded or bypassed internally to prevent radiation or pickup of extraneous fields.

3.4.2 Detailed mechanical and electrical design. The design layout and assembly of the units and their components parts shall be such as to facilitate production based on the quantity of the order, and to result in optimum size and weight consistent with the specified requirements. If redundant components, circuits, or equipments are housed in a single enclosure, the design shall be such that a failure in one of the units does not propagate to the other unit. When designing new equipment, contractors shall consider, where practicable, computer aided designs and designs that have been or can be reproduced by mechanized or semimechanized production facilities consistent with the state of the art. The contracting officer shall be kept informed of the types of circuits selected and the type of facility required to produce such circuits. The following types of mechanized or semimechanized construction shall be considered:

a. Subassemblies using printed circuits upon which the parts are printed or placed and electrically connected.

b. Construction in which several ceramic or plastic wafers are placed one above the other and parts printed or mounted thereon.

c. Three-dimensional or folded-type construction in which the parts are mechanically placed and electrically connected.

d. Microcircuits using deposited or printed techniques, including circuits employing combinations of these processes and discrete parts.

3.4.2.1 Large assemblies. Large assemblies shall be capable of repair by either replacement of subassembly or detail part, whichever is the most practical.

3.4.2.2 Nonrepairable subassemblies. Nonrepairable subassemblies shall be approved by the contracting officer. The approval request shall be based upon the construction and mechanical details, the electrical schematic, and the environmental, performance, and test data for the subassembly considered as a single nonstandard part. Detail parts in the subassembly need not be submitted for approval.

3.5 Detailed requirements for internal subassemblies.

3.5.1 Internal electrical connections. Printed circuit board connectors and other connectors mounted within enclosures shall be in accordance with the applicable sections of MIL-STD-454, Requirement 10. Removeable printed wiring boards shall be connected into the equipment by means of connectors. Printed wiring boards utilizing the conductor pattern as the direct contact with the mating connector shall not be used. Terminals shall be in accordance with MIL-STD-454, Requirement 19. When the mounting of terminals on printed circuit boards is required, the terminals shall not be mounted on active circuit traces or in active plated through holes of the printed circuit board.

3.5.2 Sockets, shields, and clamps. Sockets, shields, and clamps shall be in accordance with MIL-STD-454, Requirement 60.

3.5.3 Printed wiring. Printed wiring shall be in accordance with MIL-STD-454, Requirement 17 and the following controls:

a. Part mounting shall allow visual inspection of all solder joints on both sides of the board.

b. All printed circuit boards shall have plated through holes with pads on both sides. All holes on double sided printed circuit boards used only for interfacial connections shall be filled with wire and solder.

c. Multilayer printed circuit wiring boards, having three or more circuit layers, shall be avoided if practicable. When multilayer printed circuit wiring boards are used, the surfaces of the copper on all inner layers to be laminated shall be treated or primed prior to lamination to increase the laminate bonding. A copper oxidation technique is an acceptable treatment prior to lamination. Etchback shall be used in the holes prior to plating to ensure reliable connections to the circuit traces. Preferred etchback limits are between 5 μm minimum and 40 μm maximum. Multilayer printed wiring boards shall be configured so as to equalize, to the extent practicable, the distribution of conductive areas in a layer and the distribution of conductive areas among layers. Large conductive areas such as ground planes should be positioned close to the board midpoint thickness. When more than one ground plane is required, they should be in layers that are equidistant from the midpoint.

3.5.4 Wiring (internal). Internal wiring practices shall be in accordance with MIL-STD-454, Requirement 69.

3.5.4.1 Wire (hookup). Hookup wire shall be in accordance with MIL-W-81044, MIL-W-81381, or be an equivalent type with insulation that has at least equal to or greater resistance to cold flow than those types. Adequate controls shall be included in the designs, and procedures implemented during assembly, to avoid cold flow failure mechanisms. The size of wire leads supplied with parts shall be controlled by the applicable part specification.

3.5.4.2 Metallic shielding. Shielding and grounding criteria shall be consistent with the circuit categories and external harness interface requirements of DOD-W-83575.

3.5.4.3 Coaxial cable (rf). Coaxial cable (rf) shall be in accordance with MIL-STD-454, Requirement 65.

3.5.5 Capacitors. Capacitors shall be selected and applied in accordance with MIL-STD-198. Capacitors shall be in accordance with specifications which carry an exended reliability (ER) designator. Capacitors shall be selected from the lowest established failure rate group available.

3.5.5.1 Type constraints. Use of air gap capacitors, mechanically variable capacitors, or nonsolid electrolyte tantalum capacitors (wet slug capacitors) requires contracting officer approval.

3.5.5.2 Mounting of fixed capacitors. Fixed capacitors shall be securely mounted. Stress relief loops or other provisions shall be made in mounting to accommodate environmentally caused variations such as that due to temperature changes. Capacitors shall not be mounted by their wire leads without providing other mechanical support for the body of the capacitor. Capacitors weighing 15 grams or less may be secured by only their leads and syntactic foam, adhesive, or conformal coating if the mounting satisfies the thermal and mechanical requirements of the subassembly. The total length of both leads, measured between the points on the capacitor from which the leads egress and the midpoints of the lead attachment terminals, should not exceed 25 mm. In no case shall the wire leads be less than 6 mm in length for capacitors with axial leads.

3.5.6 Resistors. Resistors shall be in accordance with MIL-STD-454, Requirement 33. Resistors shall be in accordance with specifications which carry an extended reliability (ER) designator. Resistors shall be selected from the lowest established failure rate group available. The rating and placement of a resistor in a particular equipment shall be such that the permitted maximum temperature at any point on the surface of the resistor shall not be exceeded under the highest ambient temperature or lowest absolute pressure under service conditions for the complete equipment.

3.5.6.1 Tapped resistors. Use of resistors having fixed or variable taps requires contracting officer approval.

3.5.6.2 Mounting of resistors. Resistors shall be securely mounted. Stress relief loops or other provisions shall be made in mounting to accommodate environmentally caused variations such as that due to temperature changes. Resistors shall not be mounted by their wire leads without providing other mechanical support for the body of the resistor. Resistors weighing 15 grams or less may be secured by only their leads and syntactic foam, adhesive, or conformal coating if the mounting satisfies the thermal and mechanical requirements of the subassembly. The length of both leads, measured between the points on the resistor from which the leads egress and the midpoints of the lead attachment terminals, should not exceed a total of 25 mm. In no case shall the wire leads be less than 6 mm in length.

3.5.7 Solid state devices and electron tubes. Solid state devices, such as microelectronic and semiconductor devices, are preferred to electron tubes wherever practicable. Microcircuits shall be in accordance with MIL-M-38510 Class S. Semiconductors shall be in accordance with MIL-S-19500 Class JAN S. Solid state devices shall be selected from the lowest established failure rate group available.

3.5.8 Transformers and inductors. Transformers and inductors shall be in accordance with MIL-STD-454, Requirement 14.

3.5.9 Filters. Electrical filters shall be in accordance with MIL-STD-454, Requirement 70.

3.5.10 Relays. Relays shall be in accordance with MIL-STD-454, Requirement 57; however, only hermetically sealed relays shall be used.

3.5.11 Switches. Switches shall be in accordance with MIL-STD-454, Requirement 58. Manually positioned switches shall not be used. Insulation materials used in switches shall be arc-resistant.

3.5.12 Circuit breakers. Circuit breakers shall be of the automatic reset or remote control (command) reset type.

3.5.13 Quartz crystal units. Quartz crystal units shall be in accordance with MIL-STD-454, Requirement 38.

3.6 Environmental design. To provide a design factor of safety or margin, the equipment shall be designed to function within performance specifications when exposed to environmental levels that exceed the maximum predicted levels expected during its service life. The maximum predicted environments shall be determined as indicated herein or in accordance with MIL-STD-1540.

3.6.1 Vibration and acoustic noise. The electronic equipment shall be designed to operate satisfactorily at vibration and acoustic noise amplitudes twice the spectral envelope of the maximum anticipated during launch, injection, on-orbit, and reentry conditions as appropriate. The maximum environment shall be considered to persist for three times the exposure duration associated with the environmental amplitudes that are greater than one half the maximum predicted amplitude, or for three minutes, whichever is greater. Microphonic effects, if any, shall not be detrimental to equipment performance.

3.6.2 Shock. The electronic equipment shall be designed to operate satisfactorily during handling and with operational shocks that have amplitudes twice the spectral envelope of the maximum anticipated during launch, injection, and on-orbit operations.

3.6.3 Acceleration. The electronic equipment shall be designed to operate satisfactorily under steady accelerations of 20 g applied in any direction, or to twice the maximum predicted accelerations, whichever is greater.

3.6.4 Orientation. Normal installation position or range of positions shall be as specified in the equipment specification. The equipment shall operate within prescribed limits in any position and under conditions of zero gravity unless otherwise specified in the equipment specification or the contract.

3.6.5 Thermal vacuum design. The electronic equipment shall be designed to operate continuously at ambient temperatures between -34 degrees (deg) C and +71 deg C and at ambient pressures between sea level and deep space. The equipment shall operate satisfactorily when exposed to 24 thermal cycles where the ambient temperature varies at a rate of 3 deg C per minute from one extreme to the other. The equipment shall operate satisfactorily when the ambient pressure drops from sea level to 65,000 meters (m) equivalent in ten minutes. The application of thermal controls or thermal coating to achieve the desired operating temperature range in the space environment shall be based upon a thermal analysis of the particular space vehicle under planned operating conditions. This analysis shall include vehicle checkout, launch conditions, and on-orbit conditions including various load groups cycled on or off, both sunlight and eclipse conditions, high and low electrical bus voltage, various orientations of the space vehicle, and other predictable operating conditions. Should the detailed thermal analysis and associated test verifications indicate that the "on-orbit" operating range for the equipment will exceed a -24 deg C to +61 deg C range, then the specific vehicle equipment shall be designed to operate with the 10 deg C thermal margin beyond the actual calculated or anticipated limits.

3.7 Identification and marking. Items shall be marked in accordance with MIL-STD-454, Requirement 67. Marking shall not adversely affect the leakage path between conductors or any other factor of equipment performance.

3.7.1 Reference designators. Reference designators shall be assigned and marked in accordance with IEEE 200. Reference designators need not be marked on subminiaturized assemblies, such as printed or etched boards or other forms of assembly where space is at a premium. In lieu thereof, location of parts and their reference designators shall be shown by pictorial diagrams, line drawings, photographs, or other media in the equipment handbooks to provide for circuit identification. Parts in nonrepairable subassemblies need not be marked with reference designators.

3.7.2 Wiring marking. Color coding or physical marking of individual conductors used for internal wiring of electronic equipment is not required. Coding or physical marking shall only be used to the extent needed to facilitate assembly, inspection, and possible later modification of the wiring. Marking shall not be used on wires where the dielectric capability of the wire is reduced by such marking. Hot and cold stamping shall be allowed only on insulated wire which will not accept ink marking. All external wiring shall be marked in accordance with DOD-W-83575.

3.7.3 Connector marking. Each connector shall be physically marked with its reference designator. The identification markings shall be located on the side of the panel or enclosure adjacent to the connector, in a manner that assures legibility when connecting the mating wiring harness connectors. The marking may also include a function identifier or color coding for the mating wiring harness.

3.7.4 Nomenclature assignment. Nomenclature assignment shall be in accordance with MIL-N-18307 for the Navy and MIL-N-7513 for the Air Force.

3.8 Operability

3.8.1 Accessibility. Accessibility shall be in accordance with MIL-STD-454, Requirement 36.

3.8.2 Human engineering. Human engineering shall be in accordance with MIL-STD-454, Requirement 62.

3.8.3 Maintainability. The equipment shall be designed so as not to require any scheduled maintenance or repair during its service life.

3.8.4 Durability. The equipment shall be so designed and constructed that no fixed part or assembly shall become loose, no movable part or assembly shall become undesirably free or sluggish, and no degradation shall be caused in the performance beyond that specified for the particular equipment during operation or after storage in the conditions specified.

3.8.5 Reliability. Reliability shall be estimated based upon realistic failure rates and failure modes for each part during each operating condition throughout the service life of the equipment. The reliability goal shall be based upon an allocation of overall mission reliability. The reliability goal shall assure that the overall vehicle reliability requirements are met under the most severe extremes of acceptance testing, storage, transportation, preflight testing, and operational environments. Reliability practices and procedures shall assure mission success with a probability of success equal or greater than that assumed in life cycle cost estimates.

3.8.6 Safety. The design shall be such that a safety hazard to personnel and surrounding equipment shall not be created during installation, maintenance, and ground test of the equipment.

3.8.7 Service life. The combined operational and non-operational service life of the equipment shall exceed the service life of the space vehicle in which it is mounted. The service life includes all operational and nonoperational time required or allowed after successful completion of acceptance tests.

3.8.8 Interchangeability. Any two or more items bearing the same part number or identification shall possess such functional and physical characteristics as to be equivalent in performance and durability and shall be capable of being changed, one for another, without alteration of the items themselves or of adjoining items except for alignment adjustments.

3.8.9 Workmanship. The equipment shall be manufactured, processed, tested, and installed in accordance with the requirements of this specification such that the finished items are of sufficient quality to ensure reliable operation, safety, and service life. To the unaided eye, the equipment shall be free of burrs, sharp edges, nicks, contamination, and defects of any sort.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspections and tests. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection and test requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection and test requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Classification of tests and inspections. The tests and inspection of electronic equipment shall be classified as follows:

a. Parts, materials, and processes controls (4.3)

b. Qualification tests (4.4)

c. Physical configuration audit (4.5)

d. Acceptance tests (4.6)

4.3 Parts, materials, and process controls. To ensure that reliable electronic equipment is fabricated, all parts and materials shall be adequately controlled and inspected prior to assembly. During fabrication the tools and processes, as well as parts and materials, shall be adequately controlled and inspected. Each item of equipment shall have inspection records and test records maintained by serial number to provide traceability. Traceability records shall be provided for parts, materials, and subassemblies: (a) where lot control has been established, (b) where the application might be considered an initial usage, and (c) where required by the contract. Complete records shall be maintained and be available for review during the service life of the equipment. The records shall indicate all reworks and modifications, and all installations and removals for whatever reason. To the extent that it is cost effective, in-process tests and inspections shall be used to detect defective equipment at the lowest level of assembly practicable. The configuration and workmanship of the completed hardware shall be verified by inspection.

4.4 Qualification tests. Qualification tests shall consist of all tests deemed necessary to determine that the equipment meets all requirements of this specification and the contract. These tests shall be in accordance with the applicable qualification test requirements of MIL-STD-1540 and the requirements of the equipment specification on the contract. The 10 deg C, factor of two, or other design factors of safety or margins specified herein include test condition tolerances that are those allowed in MIL-STD-1540. When the actual qualification or acceptance test tolerances can be shown to be less than those specified in MIL-STD-1540, the qualification test levels may be appropriately reduced in accordance with provisions specified in MIL-STD-1540. Qualification tests shall verify the ability of the equipment to perform satisfactorily under all specified operating conditions including all adverse combinations of environments and operating conditions that may be encountered during the service life of the space vehicle. Applications having constraints on allowable outgassing shall qualify to that requirement either by test, or by an analysis using applicable materials test data, to determine the estimated total mass loss and the estimated loss of volatile condensible materials. Qualification tests shall be performed on one unit of equipment (more than one if required by the equipment specification or the contract) representative of the equipment to be supplied under the contract in accordance with the approved test procedures. Tests shall be performed at the contractor's facility, or a commercial testing laboratory satisfactory to the contracting officer, under the responsibility of the contractor.

4.5 Physical configuration audit. A physical configuration audit of the first equipment produced with production tooling and procedures shall be conducted by the contractor at a time and location acceptable to the contracting officer. A quality audit of the first equipment is usually conducted with the physical configuration audit. There shall be no discrepancies among the equipment, the fabrication tooling used, the released drawings, the test data, the inspection records, and the specification requirements. First article approval is valid only on the contract under which it is granted, unless extended by the contracting officer to other contracts.

4.6 Acceptance tests. Acceptance tests shall consist of all tests deemed necessary to determine that the equipment is equivalent in performance and construction to the approved first article or preproduction equipment. These tests should identify any workmanship or quality deficiencies that may exist. Acceptance tests shall be performed on each unit of equipment submitted for acceptance under the contract. These tests shall be in accordance with the applicable acceptance test requirements of MIL-STD-1540 and the requirements of the equipment specifications on the contract. Contact retention tests and contact separation force tests equivalent to those specified in DOD-W-83575 shall be performed on each connector.

4.7 Test procedures. The contractor shall establish written procedures for performing all tests specified.

4.8 Modifications, rework, and retest. Completed electronic equipment shall be modified and reworked with the same high quality assurance provisions and criteria as on original equipment. Unless specifically limited by the approved change proposal, the inspection and retesting requirements following modification shall not be limited to the changes or modifications but the complete equipment must be retested including the changes. Inspection and retesting requirements following rework shall be consistent with the type and extent of the rework, the location where the rework is accomplished, and the inspection and testing criteria for the original equipment. Before resubmitting reworked equipment for acceptance, full particulars concerning previous rejection and the action taken to correct the defects found in the original shall be furnished the Government representatives. Units rejected after retest shall not be resubmitted without the specific approval of the contracting officer.

5. PACKAGING. (Not applicable)

6. NOTES

6.1 Tailored application. This specification is intended for use in equipment specifications or contracts to incorporate those requirements which are common to most space vehicle electronic equipment. The requirements stated are a composite of those that have been found to be cost effective for high reliability space vehicle applications. This specification therefore establishes the minimum requirements for most space vehicle applications. Where possible, the requirements are stated in ways that are self-tailoring to each application. However, tailoring of the requirements should be considered throughout the acquisition process within the constraints of the high priority program elements. These elements typically include performance, reliability, schedules, production costs, operating costs, maintenance costs, and other high cost drivers in the projected life cycle. Some requirements, such as the input voltage range of 22 V dc to 34 V dc and the minimum operating thermal range of -24 deg C to +61 deg C, have been specified based upon typical program and multiple program considerations. These requirements do not generally result in vehicle design complexity, vehicle weight increases, or vehicle power increases because they generally simplify the electrical power subsystem, the thermal control subsystems, or other equipment on a particular vehicle. In addition, they provide a basis for developing commonality within a program or among programs.

The cost savings and reliability benefits that this commonality of design requirements and commonality of testing may achieve for a contractor or for the Government is, of course, subject to evaluation for each application or group of applications. Requirements that are not appropriate, or clearly increase program life cycle costs, should be changed. Contractors are encouraged to identify to the contracting officer, for program office review and reconsideration, any requirements imposed by this specification that are believed excessive. However, contractors are reminded that deviations from contractually imposed requirements can be granted only by the contracting officer. Because of the similarity of requirements, this specification may be used to specify requirements for electronic equipment for use on launch vehicles, intercontinental ballistic missiles, reentry vehicles, or other vehicles. For those applications the term "space vehicle" is to be interpreted as the applicable vehicle.

6.2 Ordering data. The contract should specify:

a. Title, number, and date of the equipment specification relating to the electronic equipment to be furnished.

b. Criteria for tailoring requirements.

c. Requirements for qualification.

d. Items of 6.3 not covered in the detailed equipment specification.

6.3 Detail equipment specifications. This specificiation covers only the general requirements for design and construction. The detailed equipment specification, or the contract, should state specific detail requirements that may include, but are not limited to, the following items:

a. Parts, materials, and processes selection and control requirements

b. Derating requirements

c. Specific finish requirements

d. Electromagnetic compatibility and EMP

e. Equipment pressurization

f. Electrical power, if different than specified herein

g. Warmup time

h. Human engineering

i. Vibration design levels

j. Equipment orientation

k. Thermal design levels

l. Accessibility

m. Maintainability

n. Reliability

o. Safety plan requirements

p. Environmental conditions for qualification tests

q. Environmental conditions for acceptance tests

r. Packaging requirements

6.4 Definitions.

6.4.1 Electronic equipment. Electronic equipment is a general term characterizing the broad category of items including subassemblies, components, and subsystems that use electron devices. Electronic equipment includes the "black boxes" and associated electromechanical components of communications or signal equipment, radio, radar, radiation, photographic, meteorological, fire control, bombing, flight, and navigational equipment, powerplant controls, synchronizers, and test instrumentation when such items employ circuits which utilize a combination of electrical or electronic devices to generate, control, indicate, or record any form of alternating or direct currents, or both.

6.4.2 Equipment specification. The equipment specification is the statement of requirements that establishes or defines a specific item. It may be a military specification, a configuration item specification, or a contractor specification.

6.4.3 Item levels. The item levels from the simplest division to the more complex are: part, subassembly, component, subsystem, system segment, and system. Examples of systems are the launch system, the on-orbit system, and the reentry system. Examples of a system segment are a space vehicle or a launch vehicle. The electronic equipment addressed by this specification are at the subassembly or component levels of assembly. Each of the item levels is defined in MIL-STD-1540.

6.5 Design guidance. In the design of electronic equipment, consideration should be given to the information contained in the following documents:

MIL-HDBK-216	RF Transmission Lines and Fittings
AFSC DH 1-4	Design Handbook, Electromagnetic Compatibility
AFSC DH 1-8	Design Handbook, Microelectronics
NAVAER-16-1-519	NAVAER Handbook, Vol 2, Preferred Circuits, Navy Aeronautical Electronic Equipment

6.6 Supersession data. This issue of DOD-E-8983 is a complete revision of MIL-E-8983B that supersedes all previous issues for new designs. The previous issues of MIL-E-8983 remain in effect to cover the procurement of previously designed equipment.

Custodians:
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Air Force - 19

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INDEX

INDEX	Page
Acceleration criteria	28
Acceptance tests	33
Accessibility	30
Acoustic noise	28
Adhesives	12
Aluminum alloys for bonding	8
Aluminum alloy finishes	9
Altitude design requirements	28
Antennas	19
Antijamming	20
Applicable documents	2
Arc-resistant materials	8
Automated design and production	23
Batteries	19
Bonding of enclosures	10
Bonding and grounds	8,10
Brazing	11
Cables, coaxial (rf)	17,25
Cables, external	17
Capacitors	25
Castings	7
Circuit breakers	27
Circuit isolation in external connectors	16
Circuit selection	23
Clamps	24
Classification of tests and inspections	31
Coaxial cable	17,25
Conformal coating	13
Connectors, external	14
Connectors, internal	24
Connectors, marking	29
Controls	19
Corona prevention	22
Corrosion prevention	9
Definitions	36
Derating of parts and materials	7
Design	6,23
Design guidance	37
Detailed equipment specifications	35
Dielectric materials	8
Dissimilar metals	7
Durability	30

INDEX (Continued)

	Page
Electrical power	21
Electrical overload protection	21
Electroexplosive devices	16,19
Electromagnetic compatibility	20
Electromechanical subassemblies	19
Electron tubes	27
Encapsulation and embedment	13
Enclosures	10
Environmental design	27
Equipment specifications	35,36
Explosion-proofing	22
Explosive fumes	9
Fabrication related requirements	11
Fasteners	11
Fastener finishes	9
Ferrous alloys	8
Filters	27
Finishes	9
Flammable materials	9
Fungus inert materials	8
Generators	19
Grounding connector contacts	16
Grounding criteria	10,15
Hookup wire	25
Human engineering	30
Identification	29
Inductors	27
Inspections, classification of	31
Insulators and insulating materials	8
Interchangeability	31
Internal subassemblies	24
Internal electrical connections	24
Item levels	37
Large assemblies	24
Location of external connectors	15
Locking	11
Lubricants	13
Magnesium	8
Magnesium finishes	10
Maintainability	30
Marking	29
Materials	7
Materials for waveguide	17

INDEX (Continued)

	Page
Mechanized production	23
Microelectronic devices	27
Microphonic effects	28
Modifications	33
Motors	19
Mounting of external connectors	15
Mounting of capacitors	26
Mounting of resistors	26
Multipacting prevention	22
Nomenclature assignment	30
Nonrepairable subassemblies	24
Notes	34
Operability	30
Operational checkout provisions	20
Ordering data	35
Order of precedence	5
Organic fibrous material	9
Orientation of equipment	28
Overload protection	21
Packaging	34
Parts, materials, and process controls	32
Parts, materials, and process selection	6
Patent information (marking)	29
Performance responsibility	7
Physical configuration audit	33
Plating	10
Potting	13
Power contacts in connectors	15
Power outage	22
Power requirements, electrical	21
Pressurization of equipment	21
Printed wiring	24
Protective connector caps	17
Qualification tests	32
Quality assurance provisions	31
Quartz crystal units	27
Redundant components	15,23
Reference designators	29
Rejection and retest	33
Relays	27
Reliability	7,30
Reliability requirements, parts	7
Responsibility for inspections and tests	31

INDEX (Continued)

	Page
Resistors	26
Restricted materials	7
Rework and retest	33
Ripple voltage	21
Rotary servo devices	19
Safety	30
Safety wiring	11
Selection of parts, materials, and processes	6
Semiconductor devices	27
Service life	31
Shielding	16,24,25
Shield grounding	16
Shields	16,24,25
Shock	28
Sockets	24
Soldering	14
Solid state devices	27
Snap rings	12
Spare contacts in external connectors	16
Special materials	10
Specification, supplementary	5
Springs	20
Stripline transmission assemblies	18
Supersession data	37
Supplementary specificatins	5
Surface acoustic wave (SAW) devices	18
Switches	27
Tailored application	34
Tape, electrical	14
Tapped resistors	26
Terminals	24
Test, acceptance	33
Test equipment	6,20
Test points	20
Test procedures	33
Test, qualification	32
Test responsibilities	31
Thermal design	28
Threaded parts	12
Tools, special	6
Transformers	27
Transients	21
Tubes, electron	27

INDEX (Continued)

	Page
Twisted wire contacts, external connectors	16
Vibration	28
Warmup time	22
Waveguide	17
Waveguide assemblies	17
Welding-structural	11
Welds-electrical resistance	14
Wire, external	17
Wire, hookup	25
Wire, internal	25
Wire marking	29
Workmanship	31

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