MIL-STD-1547A (USAF)
01 DEC 1987

SUPERSEDING
MIL-STD-1547
Dated 31 OCT 1980

MILITARY STANDARD

ELECTRONIC PARTS, MATERIALS, AND PROCESSES FOR SPACE AND LAUNCH VEHICLES

AMSC N/A

FSC 1820

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DEPARTMENT OF THE AIR FORCE
Washington, D.C. 20330

MIL-STD-1547A (USAF)

Electronic Parts, Materials, and Processes for Space and Launch Vehicles

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FOREWORD

The high reliability required of all space equipment is achieved by the designs, design margins, and by the manufacturing process controls imposed at each and every level of assembly. The design and design margins should ensure that the space equipment is capable of performing its mission in the space environment. The manufacturing process controls are intended to ensure that a known quality product is manufactured to meet the design requirements and that any changes required can be made based on a known baseline. To ensure successful operations of space equipment, attention to every detail is required at every level of assembly throughout development, manufacture, qualification, and testing, starting with the parts, materials, and processes used. For space and launch vehicles, if the parts, materials, and processes have defects or lack the required reliability, success may never be achieved.

Analysis of space mission failures and on orbit anomalies by the USAF Space Division revealed that the nonavailability of reliable space quality electronic piece parts was a serious deterrent to achieving space mission success. In responding to this problem, the Space Division Commander initiated a program with the objective of establishing a higher "space quality" level of piece parts for space borne missions. MIL-STD-1547 is intended to document these unique space requirements for electronic parts, materials, and processes . The requirements stated are based upon corrective actions of prior failure problems and are a composite of those that have been found to be cost effective for high reliability space applications. The technical requirements in MIL-STD-1547 are intended to be consistent with space quality requirements in military specifications for specific parts with JAN Class S designations. To the degree possible, commonality with MX and NASA requirements is also a goal of the MIL-STD-1547 requirements.

This standard is applicable to all USAF Space Division contracts for new or modified designs of space and launch vehicles. These technical requirements for the parts, materials, and processes are intended to be imposed in the program peculiar specifications referenced in acquisition contracts.

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SECTION 1

SCOPE

1.1 PURPOSE

This standard establishes the minimum technical requirements for electronic parts, materials, and processes used in the design, development, and fabrication of space and launch vehicles. The term "electronic" is used in a broad sense in this standard and includes electrical, electromagnetic, electromechanical, and electro-optical parts associated with electronic assemblies such as computers, communication equipment, electrical power, guidance, instrumentation, and space vehicles. The following categories of information are provided in the standard for use by the circuit designer, part specialists, material specialists, process specialists, and reliability engineers:

a. Application information

- Derating
- End-of-life design limits
- Part mounting requirements
- Aging sensitivity
- Temperature limits

b. Design and construction information

- Requirements and recommendations
- Reliability suspect items

c. Quality assurance provisions

- In-process controls
- Screening requirements (100 percent testing)
- Lot conformance testing
- Qualification requirements

1.2 APPLICATION OF THE STANDARD

The requirements covered by this standard are intended to:

a. Be the basis for the specification and use of electronic parts, materials, and processes for space applications.

b. Be the basis for preparing detailed part, material, and process specifications for the purchase of parts and materials for use in space and launch vehicles. These detailed specifications include the design, construction, and quality assurance requirements that are necessary for space or launch applications. In addition, these detailed specifications include requirements from this standard that supercede or supplement requirements in existing general military specifications to ensure the necessary performance in the space environment and the necessary quality and reliability for space and launch vehicle use.

SECTION 2

REFERENCED DOCUMENTS

2.1 GOVERNMENT DOCUMENTS

Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this standard to the extent specified herein.

MILITARY SPECIFICATIONS

MIL-C-17	Cables, Radio Frequency, Flexible and Semirigid, General Specification for
MIL-C-20	Capacitors, Fixed, Ceramic Dielectric (Temperature Compensating), Established and Non-Established Reliability, General Specification for
MIL-T-27	Transformer and Inductor (Audio, Power, and High Power Pulse), General Specification for
MIL-C-123	Capacitors, Fixed, Ceramic Dielectric, (Temperature Stable and General Purpose), High Reliability, General Specification for
MIL-C-3098	Crystal Unit, Quartz, General Specification for
MIL-S-3786	Switches, Rotary (Circuit Selector, Low Current Capacity), General Specification for
MIL-S-3950	Switch, Toggle, Environmentally Sealed, General Specification for
MIL-C-5015	Connector, Electrical, Circular Threaded, AN Type, General Specification for
MIL-R-5757	Relays, Electromagnetic, General Specification for
MIL-W-5088	Wiring, Aerospace Vehicle
MIL-S-5594	Switches, Toggle, Electrically Held, Sealed

MIL-R-6106	Relay, Electromagnetic (Including Established Reliability (ER) Types), General Specification for
MIL-S-6807	Switch, Rotary, Selector, General Specification for
MIL-S-8805	Switches and Switch Assemblies, Sensitive and Push (Snap Action), General Specification for
MIL-S-8834	Switches, Toggle, Positive Break, Aircraft, General Specification for
DOD-E-8983	Electronic Equipment, Aerospace, Extended Space Environment, General Specification for
MIL-S-9395	Switches, Pressure, (Absolute, Gage and Differential), General Specification for
MIL-S-15291	Switches, Rotary, Snap Action
MIL-C-15305	Coil, Fixed and Variable, Radio Frequency, General Specification for
MIL-S-19500	Semiconductor Device, General Specification for
MIL-C-19978	Capacitors, Fixed, Plastic (or Paper-plastic) Dielectric, (Hermetically Sealed, in Metal, Ceramic, or Glass Cases) Established and Non-established Reliability, General Specification for
MIL-T-21038	Transformer, Pulse, Low Power, General Specification for
MIL-S-22710	Switch Code, Indicating Wheel (Printed Circuit) (Thumb Wheel and Push-Botton), General Specification for
MIL-W-22759	Wire, Electric, Fluoropolymer-Insulated, Copper or Copper Alloy
MIL-S-22885	Switch, Push Button, Illuminated, General Specification for
MIL-C-23269	Capacitors, Fixed, Glass Dielectric, Established Reliability, General Specification for

MIL-F-23419	Fuse, Instrument Type, General Specification for
MIL-T-23648	Thermistor (Thermally Sensitive Resistor), Insulated, General Specification for
MIL-S-24236	Switches, Thermostatic, (Metallic And Bimetallic), General Specification for
MIL-C-24308	Connector, Electric, Rectangular, Miniature Polarized Shell, Rack and Panel, General Specification for
MIL-S-24317	Switches, Multistation, Pushbutton (Illuminated and Non-Illuminated), General Specification for
MIL-C-26482	Connector, Electrical, (Circular, Minative, Quick Disconnect, Environment Resisting) Receptacles and Plugs, General Specification for
MIL-C-27500	Cable, Electrical Shielded and Unshielded, Aerospace
MIL-F-28861	Filters and Capacitors, Radio Frequency/Electromagnetic Interference Suppression, General Specification for
MIL-M-38510	Microcircuit, General Specification for
MIL-C-38999	Connector, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded, and Breach Coupling), Environment Resistant, Removable Crimp and Hermetic Solder Contacts, General Specification for
MIL-C-39003	Capacitors, Fixed, Electrolytic (Solid Electrolyte), Tantalum, Established Reliability, General Specification for
MIL-R-39005	Resistor, Fixed, Wirewound, (Accurate), Established Reliability, General Specification for
MIL-C-39006	Capacitors, Fixed Electrolytic (Nonsolid Electrolyte), Tantalum, Established Reliability, General Specification for
MIL-R-39007	Resistor, Fixed, Wirewound (Power Type), Established Reliability, General Specification for

MIL-R-39009	Resistor, Fixed, Wirewound (Power Type, Chassis Mounted), Established Reliability, General Specification for
MIL-C-39010	Coil, Fixed, Radio Frequency, Molded, Established Reliability, General Specification for
MIL-C-39012	Connector, Coaxial, Radio Frequency, General Specification for
MIL-C-39014	Capacitors, Fixed, Ceramic Dielectric (General Purpose), Established Reliability, General Specification for
MIL-R-39015	Resistor, Variable, Wirewound (Lead Screw Actuated), Established Reliability, General Specification for
MIL-R-39016	Relay, Electromagnetic, Established Reliability, General Specification for
MIL-R-39017	Resistor, Fixed Film, (Insulated) Established Reliability, General Specification for
MIL-C-39029	Contact, Electrical Connector, General Specification for
MIL-R-39035	Resistor, Variable, Nonwire Wound (Adjustment Type), Established Reliability, General Specification for
MIL-G-45204	Gold Plating, Electrodeposited
MIL-I-46058	Insulating Compound, Electrical (for Coating Printed Circuit Assemblies)
MIL-P-50884	Printed Wiring, Flexible, and Rigid-Flex
MIL-P-55110	Printed Wiring Boards, General Specification for
MIL-R-55182	Resistor, Fixed, Film, Established Reliability, General Specification for
MIL-C-55302	Connector, Printed Circuit Subassembly and Accessories
MIL-R-55342	Resistor, Fixed, Film, Chip, Established Reliability, General Specification for

MIL-C-55365	Capacitor, Chip Fixed Tantalum, Established Reliability
MIL-C-55681	Capacitors, Chip, Multiple Layer, Fixed, Encapsulated, Ceramic Dielectric, Established Reliability, General Specification for
MIL-W-81381	Wire, Electric, Polyimide - Insulated, Copper or Copper Alloy
MIL-R-83401	Resistor Networks, Fixed, Film, General Specification for
MIL-C-83421	Capacitors, Fixed, Supermetallized, Plastic Film Dielectric, (DC, AC, or DC and AC). Hermetically Sealed in Metal Cases, ER
DOD-W-83575	Wiring Harness, Space Vehicle, Design and Testing, General Specification for
MIL-C-83723	Connector, Electrical, (Circular, Environment Resisting), Receptacle and Plugs, General Specification for
MIL-C-83733	Connector, Electrical, Miniature, Rectangular Type, Rack to Panel, Environment Resisting, 200 deg C Total Continuous Operating Temperature, General Specification for
MIL-C-87164	Capacitors, Fixed, Mica Dielectric, High Reliability, General Specification for
MIL-C-87217	Capacitors, Fixed, Supermetallized Plastic Film Dielectric, Direct Current for Low Energy, High Impedance Applications, Hermetically Sealed in Metal Cases, Established Reliability, General Specification for

FEDERAL STANDARDS

FED-STD-209	Clean Room and Work Station Requirements, Controlled Environment

MILITARY STANDARDS

MIL-STD-198	Capacitor, Selection and Use of
MIL-STD-199	Resistor, Selection and Use of
MIL-STD-202	Test Methods for Electronic and Electrical Component Parts

MIL-STD-275	Printed Wiring for Electronic Equipment
MIL-STD-750	Test Methods for Semiconductor Devices
MIL-STD-883	Test Methods and Procedures for Microelectronics
MIL-STD-976	Certification Requirements for JAN Microcircuits
MIL-STD-981	Design, Manufacturing, and Quality Standards for Custom Electromagnetic Devices for Space Applications
MIL-STD-1132	Switches and Associated Hardware, Selection and Use of
MIL-STD-1331	Parameters To Be Controlled for the Specification of Microcircuits
MIL-STD-1346	Relays, Selection and Application
MIL-STD-1353	Electrical Connectors and Associated Hardware, Selection and Use of
MIL-STD-1580	Destructive Physical Analysis for Space Quality Parts
DOD-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) (Metric)
DOD-STD-2000-1	Soldering Technology, High Quality/High Reliability
DOD-STD-2000-2	Part and Component Mounting for High Quality/High Reliability Soldered Electrical and Electronic Assemblies
DOD-STD-2000-3	Criteria for High Quality/High Reliability Soldering Technology
MIL-STD-2118	Flexible and Rigid-Flex Wiring for Electronic Equipment, Design Requirements for

<u>MILITARY HANDBOOKS</u>

MIL-HDBK-217	Reliability Prediction of Electronic Equipment
DOD-HDBK-263	Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies, and Equipment.

MIL-HDBK-279	Total Dose Hardness Assurance Guidelines For Semiconductor Devices and Microcircuits, February 1985.
MIL-HDBK-280	Neutron Hardness Assurance Guidelines For Semiconductor Devices and Microcircuits, February 1985.
MIL-HDBK-339	Custom Large Scale Integrated Circuit Development and Acquisition For Space Vehicles

(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.)

OTHER MILITARY DOCUMENTS

AFSCP 800-27	Part Derating Guidelines; Department of the Air Force, Air Force Systems Command (AFSC) Pamphlet 800-27

Application for copies should be addressed to: Department of the Air Force, Headquarters Air Force Systems Command, Andrews Air Force Base, DC 20334

NASA PUBLICATIONS

TM X-64755	Guidelines for the Selection and Application of Tantalum Electrolytic Capacitors in Highly Reliable Equipment

Application for copies should be addressed to: National Technical Information Service, 5285 Port Royal Rd. Springfield, VA 22161

MSFC-STD-355	Radiographic Inspection of Electronic Parts

Application for copies should be addressed to: Marshall Space Flight Center, Document Repository (AS24D), Huntsville, AL 35812

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

2.2 NONGOVERNMENT DOCUMENTS

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

AMERICAN SOCIETY FOR TESTING MATERIAL

ASTM E 595-84	Standard Test Method for Total Mass Loss and Collected Volatile Condensable Material From Outgassing in a Vacuum Environment

Application for copies should be addressed to: American Society for Testing Materials, 1916 Race Street, Philadelphia, PA 19111

ELECTRONICS INDUSTRIES ASSOCIATION

RS-477	Cultured Quartz

Application for copies should be addressed to: Electronic Industries Association, 2001 I St., N.W., Washington, D.C. 20006

INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC 302	Standard Definitions and Methods of Measurement For Piezoelectric Vibrators Operating Over the Frequency Range Up to 30 Megahertz

Application for copies should be addressed to: Central Bureau of the International Electrotechnical Commission 1, rue de Varembe, Geneve, Suisse

2.3 ORDER OF PRECEDENCE

In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence. Nothing in this standard, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained from the contracting officer.

SECTION 3

DEFINITIONS

Terms are in accordance with the following definitions:

3.1 CONTRACTING OFFICER

Contracting officer means a person with the authority to enter into, administer, or terminate contracts and make related determinations and findings. The term includes authorized representatives of the contracting officer acting within the limits of their authority as delegated by the contracting officer.

3.2 DERATING

Derating of a part is the intentional reduction of its applied stress, with respect to its rated stress, for the purpose of providing a margin between the applied stress and the demonstrated limit of the part's capabilities. Maintaining this derating margin reduces the occurrence of stress-related failures and helps ensure the part's reliability.

3.3 DESTRUCTIVE PHYSICAL ANALYSIS (DPA)

A systematic, detailed examination of a part during physical disassembly, to verify manufacturing processes, materials, and workmanship and to detect anomalies that may impact performance or reliability.

3.4 ELECTRONIC PARTS.

The term "electronic" is used in a broad sense in this standard and includes electrical, electromagnetic, electromechanical, and electro-optical. These parts are associated with electronic assemblies such as computers, communication equipment, electrical power, guidance, instrumentation, and space vehicles. Electronic parts also include connectors.

3.5 END-OF-LIFE DESIGN LIMIT

The end-of-life design limits for an item are the expected variations in its electrical parameters over its period of use in its design environment. The parameter variations are expressed as a percentage change beyond the specified minimum and maximum values. Circuit designs should accommodate these variations over the life of the system.

3.6 MANUFACTURING BASELINE.

The manufacturing baseline is a description, normally in the form of a flow chart, of the sequence of manufacturing operations necessary to produce a specific item, part, or material. The manufacturing baseline includes all associated documentation that is identified or referenced, such as: that pertaining to the procurement and receiving inspection, storage, and inventory control of parts and materials used; the manufacturing processes; the manufacturing facilities, tooling, and test equipment; the in-process manufacturing controls; the operator training and certification; and the inspection and other quality assurance provisions imposed. Each document is identified by title, number, date of issue, applicable revision, and date of revision.

3.7 MATERIAL.

Material is a metallic or nonmetalic element, alloy, mixture, or compound used in a manufacturing operation which becomes either a temporary or permanent portion of the manufactured item.

3.8 MATERIAL LOT.

A lot for material refers to material produced as a single batch or in a single continuous operation or production cycle and offered for acceptance at any one time.

3.9 PART.

A part is one piece, or two or more pieces joined together, which are not normally subjected to disassembly without destruction or impairment of its designed use.

3.10 PROCESS.

A process is an operation, treatment, or procedure used during a step in the manufacture of a material, part, or an assembly.

3.11 PRODUCTION LOT (ELECTRONIC PARTS).

A production lot of electronic parts refers to a group of parts of a single part type; defined by a single design and part number; produced in a single production run by means of the same production processes, the same tools and machinery, and the same manufacturing and quality controls; and tested within the same period of time. All parts in the same lot have the same lot date code.

3.12 RELIABILITY SUSPECT DESIGNS

Reliability suspect designs are those specific designs or constructions that have demonstrated problems which are inherent to the specific part designs, materials, or processes utilized.

3.13 MANUFACTURER SURVEILLANCE

The monitoring of preestablished criteria by the contractor or his designated representative, of the manufacturing, quality control, and test operations of a manufacturer.

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SECTION 4

GENERAL REQUIREMENTS

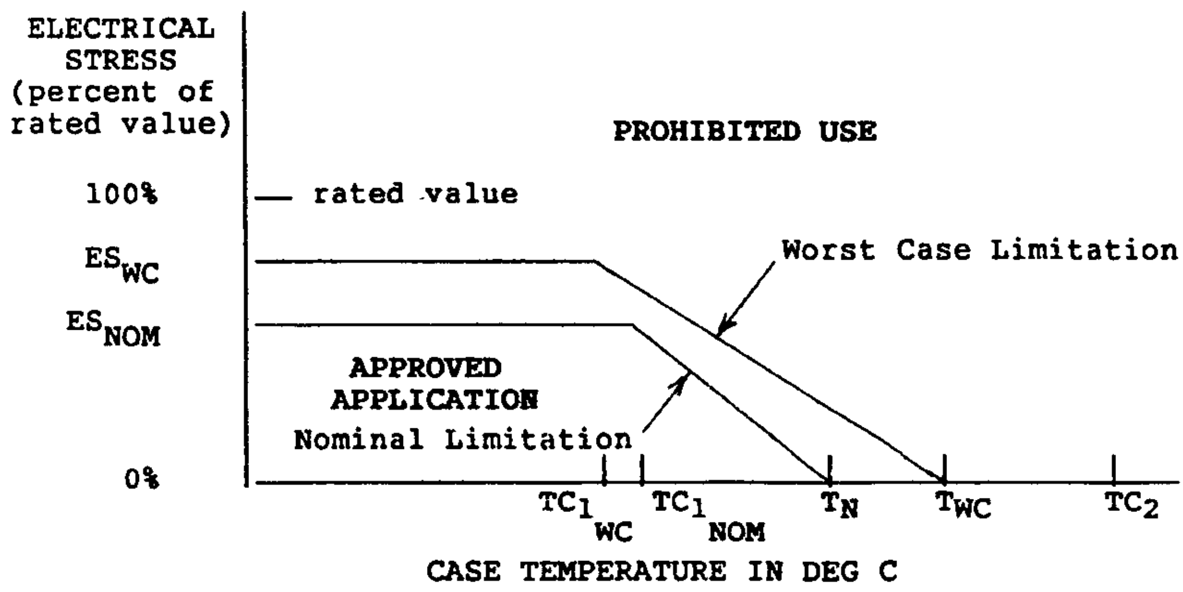
4.1 REQUIREMENT CATEGORIES

The requirements for space quality electronic parts, materials, and processes specified in this document are categorized as application requirements, design and construction requirements, and quality assurance requirements. The application requirements include derating requirements, end-of-life limitations, mounting requirements, and other requirements intended to ensure the high reliability of the parts when used in space equipment and launch vehicle equipment. These application requirements apply to all parts. The design and construction, and the quality assurance requirements included provide requirements that supercede or supplement referenced general military specifications to ensure the necessary performance in the space environment and the necessary quality for space and launch vehicle use. These design, construction, and quality assurance requirements provide the general requirements for customer specifications or contractor specifications for various space quality part types when JAN Class S parts are not available. (A JAN Class S part is an electronic part that is built, tested, qualified, and procured in full accordance with the space quality level requirements as specified in its general and detailed military specification.)

4.2 APPLICATION REQUIREMENTS

4.2.1 Derating. Circuits shall be designed with the parts derated as specified herein. The extent to which electrical stress (e.g., voltage, current, or power) is derated, is dependent upon temperature. The general interrelationship between electrical stress and temperature is shown in Figure 4-1. The approved operating conditions lie within the area below the nominal limitation line (ES_{NOM}). Operation at conditions between the nominal limitation line and the worst case limitation (ES_{WC}) line shall be identified and analyzed to assure meeting system requirements since they result in lower reliability (see MIL-HDBK-217). Operation beyond worst case limitations is not acceptable due to the lowering of part reliability.

To obtain the specific curve for each part type, numerical values are applied to the general curve based on the specified maximum rated values being 100 percent. The applicable derating curve or derating factor is given in the detailed section for



Where:

TC_1 = Case temperature above which applied electrical stress should be reduced. Unless otherwise specified, TC_1 (worst case) is the same as TC_1 (nominal).

TC_2 = Maximum allowable case temperature per detailed specification

T_N = Nominal boundary limitation. Typically: T_N equals (T_{WC} - 10 deg C). Other temperature deltas may be given in the detailed requirements.

T_{WC} = Worst case thermal boundary. Typically: T_{WC} equals (TC_2 - 30 deg C)

ES_{NOM} = Maximum steady state or average operating electrical stress

ES_{WC} = Worst case electrical stress, including electrical transient and radiation effects

100% = Maximum rated value per detailed specification

FIGURE 4-1. Typical Electrical Stress vs Temperature Derating Scheme each part type. The derating factor is to be multiplied times the part rating to obtain the allowed nominal limitation value for specific applications.

4.2.2 End-of-life. Circuits shall be designed such that required functional performance at the component level is maintained even if the performance values of the parts used vary within the identified end-of-life design limits. Except as stated otherwise in the detailed requirements section for each part type, the end-of-life values given are the percentage changes from initial values to be assumed for that part type, during, or at the end of a 10-year period, during which time the parts are in the approved application region (see Fig. 4-1). The end-of-life design limits to be assumed for time periods longer than 10 years require approval of the contracting officer.

4.2.3 Aging Sensitivity. Aging sensitivity for items is measured by the variation of their useful life or of their electrical parameters resulting from:

a. The relaxation of internal stresses, or

b. The operation of deterioration mechanisms, such as oxidation or hydrogen absorption

Aging sensitivity shall be considered in the design and selection of parts and materials. Items with known mechanisms causing degradation as a function of time shall be identified, and monitoring procedures that are approved by the contracting officer shall be established to avoid usage of over age items.

4.2.4 Sealed Packages. The atmospheric environment encountered during space missions range from sea level to hard vacuum. Therefore, only hermetically sealed parts should be selected for use in a space mission environment. When hermetically sealed parts are not available, nonhermetically sealed parts may be selected. When nonhermetically sealed parts are selected, the in-process assembly and cleaning operations used shall not be detrimental to the parts, and the subsequent outgassing, sublimation, moisture penetration, or moisture absorption shall not be detrimental to the part or to the system.

4.2.5 Reliability Suspect Designs. All devices containing desiccants are classified as reliability suspect designs. Other devices or design features are also identified as reliability suspect designs in the detailed requirement sections of this standard. The use of these devices, or other devices identified in the contract as reliability suspect designs, requires the approval of the contracting officer.

4.2.6 Handling. Protection against electrostatic damage to electrostatic sensitive devices shall be provided in accordance with Appendix B. Electrostatic sensitive items shall be packaged, stored, and transported in sealed packages using antistatic wrapping material. The antistatic wrapping material used should not produce nonvolatile residues. The antistatic wrapping material shall be grounded through a resistor prior to removal. The grounding resistor shall have a value between 100,000 ohms and 1 megohm.

4.2.7 Installation and Mounting. The mechanical stresses on parts during environmental changes (e.g., temperature, shock, and vibration) shall be minimized by design and through utilization of the appropriate mounting requirements of Appendix A, as supplemented by mounting requirements for the part type given in the detailed requirements section. The design shall minimize the mechanical stresses on parts arising from different material properties in joined materials.

4.2.8 Conformal Coatings Unless otherwise directed by drawing, all printed wiring board assemblies shall be conformally coated per MIL-STD-275 and the following:

a. To prevent stressing solder joints, a technique of applying conformal coating shall be used to ensure coating the underside of components spaced off the printed wiring board, without bridging between the printed wiring board surface and the parts or part leads.

b. The coated assemblies shall exhibit no blisters, cracking, crazing, peeling, wrinkles, mealing, or evidence of reversion or corrosion. A pin-hole, bubble, or combination thereof may not bridge more than 50 percent of the distance between nonconnecting conductors, while maintaining the minimum dielectric spacing. Bridging of greater than 50 percent shall be reworked to meet this requirement.

c. If rework of a coated assembly is required, only mechanical means may be used to remove other than Type AR (MIL-I-46058) and solvent removable parylene (paraxylene) coatings.

4.2.9 Reuse of Parts and Materials. Parts and materials which have been installed in an assembly, and are then removed from the assembly for any reason, shall not be used again in any item of flight or space hardware.

4.3 PART REQUIREMENTS

The requirements included in this general requirements section (Section 4) are applicable to all part types and are intended to avoid excessive repetition of material in other sections. The requirements for specific part types are stated in subsequent detailed requirement sections of this standard. The applicable military specification requirements are identified in the detailed requirements section for each part type. Therefore, each part used in space or launch vehicles shall comply with the following:

a. The performance and other added requirements specific to a given application, such as outgassing limitations, radiation susceptibility, and corrosion resistance

b. The design, construction, and quality assurance requirements included in the detailed requirements section of this standard for the part type

c. The general design, construction, and quality assurance requirements included in the general requirements section of this standard

d. The referenced requirements of the applicable military specification for the part type

The detailed specifications that are usually prepared for particular parts should incorporate applicable requirements from this standard either by referencing or by copying the applicable requirements to be included.

4.4 PART DESIGN AND CONSTRUCTION

Parts shall be designed and constructed to meet the requirements stated in the detailed requirements section for each part type and the requirements stated herein.

4.4.1 Design. Parts shall be designed for high reliability and long life in storage, in test, and in operational use during the launch environment for both reuseable and for expendable launch vehicles, and during on-orbit operations in the space environment. Where practicable, parts shall be hermetically sealed. When required by system environments, the radiation hardness assurance for piece parts shall be established, implemented, and maintained per the requirements of Appendix C.

4.4.2 Material Hazards. Parts shall be designed and constructed of such materials as to prevent hazardous conditions, such as: arc generation, flammability, outgassing, and toxicity. When hazardous materials are present, they shall be in hermetically sealed packages. Parts shall be designed and constructed of corrosion resistant materials.

4.4.3 Outgassing. The outgassing properties of parts and materials shall be compliance to the requirements of ASTM-E-595-84. The volatile condensible materials shall be less than 0.10 percent and total weight loss shall be less than 1.00 percent. Note that an evaluation is usually required since outgassing may not be controlled by the military specifications.

4.4.4 Processes and Controls. The manufacture of parts shall be accomplished in accordance with processes and controls that ensure the reliability and quality required. These manufacturing processes and controls shall be accomplished in accordance with fully documented procedures. This documentation shall be in a sufficient detail to provide a controlled manufacturing baseline for the manufacturer that ensures that subsequent production items can be manufactured that are equivalent in performance, quality, dimensions, and reliability to initial production items used for qualification or for flight hardware. This documentation shall include the name of each process, each material required, the point it enters the manufacturing flow, and the controlling specification or drawing. The documentation shall indicate required tooling, facilities, and test equipment; the manufacturing check points; the quality assurance verification points; and the verification procedures corresponding to each applicable process or material listed. The specifications, procedures, drawings, and supporting documentation shall reflect the specific revisions in effect at the time the item(s) used for qualification were produced. When approved by the contracting officer, these flow charts and the referenced specifications, procedures, drawings, and supporting documentation become the manufacturing process control baseline and shall be retained by the manufacturer for reference. It is recognized that many factors may warrant making changes to this documented baseline; however, all changes to the baseline processes used, or the baseline documents used, shall be recorded by the manufacturer following the production of the first lot. These changes provide the basis for flight accreditation of subsequent production lots, so the changes should only be made when approved by the contracting officer.

4.4.5 Production Lots. All parts shall be grouped together in individual production lots during the various stages of manufacturing (see 3.11).

4.4.5.1 Serialization. Serial numbers or other unique identification shall be assigned for all items in a production lot at an appropriate point in the manufacturing of the part, usually prior to completion of final assembly, but in all cases prior to 100 percent screening.

4.4.5.2 Traceability Control System for Parts. The manufacturer shall maintain fabrication records capable of providing two-way traceability from the first stages of assembly through final acceptance testing, and in the reverse order. The records shall include traceability of critical materials (including random sampling test records), processes (including destructive testing lot records), and pre-acceptance testing records, and source of supply. The records shall be identifiable to the item serial number.

4.4.6 Manufacturing Workmanship. Workmanship during the assembly of parts shall ensure compliance with the applicable sections of this standard and the following requirements:

a. There shall be no cracks, breaks, chips, spalls, loose or overstressed electrical connections, or any other defect that would make the item unsuitable for use in space and launch vehicles.

b. All surfaces shall be free of any defects that may create adverse effects on reliability, functional characteristics, or shorten the operating life of the part such as excessive scratches, dents, blisters, rough spots, burrs, sharp edges or projections, or inclusions.

c. Items with internal cavities shall be free of particulate contamination.

4.4.7 Rework During Manufacture of Parts. Except as may be allowed by the detailed requirements section for each specific part, rework during manufacturing is not allowed.

4.5 PART QUALITY ASSURANCE PROVISIONS

The quality assurance requirements for each part type are specified in the detailed requirements for that part type. The quality assurance provisions are classified as:

a. In-process controls

b. Screening (100 percent)

c. Lot conformance tests

d. Qualification tests

4.5.1 In-Process Controls. Each production lot shall be subjected to the in-process production controls specified in the detailed requirements section of this standard for that part type. Additional in-process controls shall be imposed as required to achieve the high quality and reliability goals of space and launch vehicle parts. The imposition of appropriate in-process controls is a more cost-effective way of screening out defects than the imposition of tests and inspections on completed units. In fact, the high reliability goals for space quality parts can only be achieved by the imposition of all of the appropriate in-process controls. Nonconforming material or items that do not meet the established tolerance limits set for the in-process production screens shall be removed from the production lot.

4.5.2 Screening (100 Percent). Each item in every production lot shall be subjected to the 100 percent screening requirements specified in the detailed requirements section of this standard for that part type. Nonconforming units that do not meet the established limits set for the 100 percent screens shall be removed from the production lot. Note that many of the tables in this standard list the additions and exceptions to the screening or testing requirements of the referenced military specification. When a blank is shown opposite a specific screen or test, that means that there are no changes to that test method or to the criteria specified in the referenced military specification.

4.5.3 Lot Conformance Tests. Lot conformance testing shall be performed as a basis for final lot acceptance on each production lot of parts. After a production lot has passed all in-process controls and 100 percent screening requirements, the lot conformance tests shall be performed on a randomly selected sample taken from the production lot. The detailed requirements for these lot conformance tests for each production lot are specified in the detailed requirements section of this standard for each part type.

A destructive physical analysis shall be performed as part of lot conformance testing when specified in the detailed requirements section of this standard for that part type. Except as stated otherwise in the detailed requirements for a specific part type, the destructive physical analysis shall be performed in accordance with MIL-STD-1580.

If no failures occur during lot conformance tests, the remaining portion of the production lot is certified as acceptable. Parts that have undergone destructive tests during lot conformance testing shall not be returned to the production lot for flight use; however, other test samples may be shipped as acceptable units. If any of the sample units subjected to the lot conformance tests fail during the testing, the entire lot shall be rejected, unless another disposition of the lot is approved by the contracting officer. In addition, a detailed failure analysis shall be conducted to establish the cause of failure and the corrective actions that would:

a. Establish the recommended disposition of the lot containing the failure that would eliminate the failure (such as 100 percent rescreening for the failure mode).

b. Establish the recommended disposition of subsequent production lots that may contain the identified failure mechanism that would eliminate the failure.

c. Establish the recommended disposition of prior production lots that may contain the identified failure mechanism that would eliminate the failure.

4.5.4 Qualification Tests. All part types shall be qualified in accordance with the requirements stated herein. In all cases, the contracting officer is the agent that approves the satisfactory completion of the part qualification. Part qualification testing requirements in military specifications are normally based upon the maximum functional and environmental limits of the specific part type to ensure the widest possible usage of the part. However, radiation or other environments associated with specific space applications may not be stated in the military specifications for parts, or the expected environments may be more severe than the standard levels specified for qualification testing of that part type. In those cases, qualification testing shall be based on the actual environments associated with the specific space applications, and the qualification test levels shall be raised to levels above the maximum predicted levels to provide an appropriate margin for derating. Qualification of a part type may be by any one of the following methods:

a. Qualification Testing (New Part Types). For part types without any previous space usage, qualification is established by the satisfactory completion of the qualification test requirements stated in the detailed requirements section of this standard for that part type, adjusted to the requirements of the specific application if they are more severe.

b. Qualification Testing (Existing Part Types). For part types with a previous record of high reliability performance in space vehicle applications, separate qualification tests are not required if the new application is identical or less severe. Qualification is established by the completion of the required lot conformance tests stated in the detailed requirements section of this standard for that part type. For part types to be used in more severe applications than in previous space vehicle applications, additional qualification tests are required that are based on the new requirements of the specific application. The qualification levels shall be raised to levels above the maximum predicted levels to provide an appropriate margin for derating.

c. Qualification by Similarity. Qualification by similarity is based upon a previous complete qualification test of a similar part type produced with the same basic raw materials, similar in-process controls, and made by the same manufacturer on the same production line. Satisfactory completion of supplemental analysis and tests shall be required to the extent necessary to substantiate any differences in design, manufacture, screening, or environmental levels with the previously qualified part.

d. Qualification by Contracting Officer Approval. Only the contracting officer may waive qualification requirements. For example, part qualification may be based upon the qualification of higher levels of assembly components or units, or other special qualification procedures may be used, if approved by the contracting officer. Also, part types may be qualified to lower environmental levels than specified in the military specifications if the lower environmental levels still satisfy the requirements of the actual intended application, including the required margin for derating, if approved by the contracting officer.

Parts that have undergone destructive tests during qualification testing shall not be returned to the production lot for flight use.

4.6 PARTS AND MATERIALS DATA RETENTION.

All manufacturing, test, and inspection data and records shall be retained for a minimum of twelve (12) years, or the life of program plus three (3) years, whichever is longer. These include lot travelers, mix or blend records, wafer processing records, test procedures, test data, DPA reports, inspection records, screening records, nondestructive inspection records, and radiographs.

4.7 PACKAGING.

Packaging of individual parts during shipment shall be per the requirements imposed by the associated military specification for the particular part type. Electrostatic sensitive items shall be packaged and sealed using antistatic wrapping material (see Appendix B). The antistatic wrapping material used should not produce nonvolatile residues.

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SECTION 5

DETAILED REQUIREMENTS

The detailed requirements for parts, materials, and processes for use in space and launch vehicles are contained in the following sections of this standard. These detailed requirements are in addition to the general requirements contained in Section 4.

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SECTION 100

BOARDS, PRINTED WIRING

1. SCOPE

This section sets forth detailed requirements for printed wiring boards.

2. APPLICATION

Where practicable, rigid printed wiring boards with plated through holes shall be used to interconnect electronic parts. The mounting of parts shall be in accordance with Appendix A. Part mounting shall allow visual inspection of all solder joints on both sides of the board.

3. DESIGN AND CONSTRUCTION

3.1 Rigid Printed Wiring Boards. All rigid printed wiring boards with plated-through holes shall be in accordance with MIL-P-55110 and MIL-STD-275 and the following:

a. Nonfunctional Lands (Internal Layers): Nonfunctional lands shall be included on internal layers of multi-layer boards whenever clearance requirements permit.

b. Etchback: Etchback or equivalent processes approved by the contracting officer shall be used to ensure complete resin smear removal from the holes prior to plating. The etchback limits shall be between 0.0002 inch minimum and 0.003 inch maximum. The preferred etchback limits are between 0.0005 and 0.002 inch.

c. Flammability: Where practicable, flame-retardant material shall be used.

d. Drill Bit Limit: The number of holes to be plated-thru that are drilled per one drill bit shall be 500 holes maximum.

e. Drill Changes: All drill bit changes shall be documented. Resharpening of drill bits is not permitted.

f. Drilling Roadmap: Drilling of the panel shall be such that drilling begins and ends in a coupon associated with each printed wiring board.

g. Stacking: Stacking of panels is not permitted when drilling holes that are to be plated-through.

h. Tin-lead Plating: Tin-lead plating thickness shall be 0.0003 inch minimum. If the board is to be processed for surface mounting components by reflow soldering, the tin-lead plating thickness on the reflow solderable surface areas shall be between 0.001 and 0.002 inches before fusing. There shall be no solder plate on any surface which is to be laminated to an insulator, metal frame, or stiffener.

i. Fusing: After solder plating and other processes, unless otherwise specified on the master (source control) drawing, the printed wiring board shall be fused, and shall be limited to one fusing operation, whether or not the fusing process heats one or both sides of the board. The fuse time and temperature shall be recorded. After fusing, the solder coating shall be homogeneous and completely cover the conductors without pitting or pinholing and show no non-wet areas. Side walls of the conductors need not be solder coated. Touch-up is permitted.

j. Ductility: Elongation of as-plated copper shall be 12 percent minimum. Pull test samples shall be prepared by the rotating cylinder method, or by any process yielding equivalent results.

k. Process-control Coupons: As many process-control coupons as are necessary to control the processes are required for each panel. The number of in-process coupons is at the manufacturer's option. These process-control coupons shall be included in the shipment of the deliverable boards only if requested by the contracting officer.

l. Solder Plate Coupons: Each board that is to be fused shall require a solder-plate coupon. These solder plate coupons shall be removed from the panel before fusing to verify the solder thickness. These solder-plate coupons shall be included in the shipment of the deliverable boards.

m. Deliverable Coupons: Double-sided and multilayer printed wiring boards require two deliverable coupons per board, or for small board sizes, two deliverable coupons per 150 square centimeters (24 square inches) of panel area, whichever is less. These coupons shall be located on the panel in positions suitable to monitor the processes involved across the diagonal of each board. A single coupon located at the center area common to the inside corners of adjoining boards on a panel may be used as one of the required coupons for each of the adjoining boards. For example, for four large boards on a panel, a coupon at each of the four outside corners and a common coupon at the center, for a total of five coupons, are all that are required. These deliverable coupons are in addition to the process-control coupons required for each panel. All coupons shall be processed with the deliverable boards. The deliverable coupons shall be included in the shipment of the deliverable boards.

n. Coupon Marking: Each coupon shall be suitably marked to achieve traceability. All deliverable coupons shall be serialized.

o. Storage and Retrievability: All deliverable coupons shall be stored and shall be readily retrievable for a period of twelve (12) years, or the life of program plus three (3) years, whichever is longer.

3.2 Multilayer Printed Wiring Boards. When multilayer printed 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. 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 shall be positioned close to the board midpoint thickness. When more than one ground plane is required, they shall be in layers that are equidistant from the midpoint.

3.3 Flexible and Rigid-flex Wiring. Flexible and rigid-flex printed wiring shall conform to MIL-P-50884 and shall be designed in accordance with MIL-STD-2118.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4, the requirements of MIL-P-55110, and the following:.

4.1 In-process Controls. In-process controls shall be monitored to assure compliance with the requirements specified.

a. Elongation of as-plated copper shall be monitored to ensure ductility of 12 percent minimum. An alternate method is to monitor the copper plating bath to maintain the level of bath organics composition within specified limits that are established on the basis of as-plated copper ductility.

b. Solder-plate coupons shall be removed from the panel before fusing, and either sectioned, or a suitable thickness measuring device used, to verify the solder thickness.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the general requirements of Section 4 and other requirements based on guidance provided by MIL-P-55110. 100 percent electrical testing is required at the bare board level.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the general requirements of Section 4 and the requirements of MIL-P-55110. All deliverable coupons shall be sectioned, mounted, and inspected to verify that all applicable requirements have been met.

4.4 Qualification Tests. Qualification testing is based on two steps. First, the manufacturer shall be certified as a qualified manufacturer in accordance with the requirements of MIL-P-55110. The second step is the qualification testing of higher assembly levels (subassemblies or components) that contain the boards. Since qualification is based on these two steps, individual board qualification tests are not required.

SECTION 200

CAPACITORS, GENERAL

1. SCOPE

This section sets forth common requirements for capacitors. Table 200-1 lists, by dielectric type, the capacitor styles included and indicates the applicable section in this standard where additional detailed requirements are set forth.

TABLE 200-1. Capacitor Styles Included in Section 200.

Section Number	Dielectric Material	Ref. Military Specification	Capacitor Style
210	Ceramic	MIL-C-123	CKS
230	Supermetallized Film	MIL-C-83421	CRH
232	Supermetallized Film (Low Energy Applications)	MIL-C-87217	CHS
235	Plastic Film; Metallized and Nonmetallized	MIL-C-19978	CQR
240	Glass	MIL-C-23269	CYR
250	Mica	MIL-C-87164	CMS
260	Tantalum Foil	MIL-C-39006	CLR
270	Solid Tantalum	MIL-C-39003	CSR
272	Solid Tantalum (Low Impedance Applications)	MIL-C-39003/10	CSS
275	Solid Tantalum Chip	MIL-C-55365	CWR
280	Wet Tantalum-Tantalum Case	MIL-C-39006/22	CLR 79

2. APPLICATION

Use of capacitors shall be in accordance with MIL-STD-198 and the requirements contained in the detailed requirements sections of this standard for each capacitor type. For additional tantalum capacitor information see NASA TM X-64755.

2.1 Derating. The longevity, and hence the reliability, of a capacitor is improved by operating below its rated temperature limit and below its rated voltage, both ac and dc. Transient and ripple voltage shall be considered to prevent dielectric breakdown and excessive self-heat. Capacitors for ac applications require proper heat sinking to prevent excessive temperature rises, because, in most cases, the capacitor dissipation factor (DF) and leakage current increase with temperature. The use of derating curves found in each section is described in Paragraph 4.2.1 in Section 4. When capacitors are used in an ac application, the total of the peak ac voltage plus dc bias voltage shall not exceed the derating requirements specified.

2.2 DC Capacitors. Do not subject dc capacitors to ac applications or to high ripple current applications without checking to ensure satisfactory part operation in the particular environment of concern.

3. DESIGN AND CONSTRUCTION

See the detailed requirements section for each capacitor type. Unless otherwise specified, a production lot for capacitors shall consist of all the capacitors of a single capacitance and voltage rating of one design, from the same dielectric material batch, and processed as a single lot through all manufacturing steps on the same equipment, to the same baseline documentation, and identified with the same date and lot code designation. The lot may contain all available capacitance tolerances for the nominal capacitance value.

4. QUALITY ASSURANCE

See the detailed requirements section for each capacitor type.

SECTION 210

CERAMIC CAPACITORS (CKS) (MIL-C-123)

1. SCOPE

This section sets forth detailed requirements for fixed ceramic capacitors (CKS styles).

2. APPLICATION

2.1 Derating. The voltage-derating factor for these capacitors shall be as follows:

ES_{NOM}: 0.50 to +85 deg C, decreasing to 0.30 at +125 deg C

ES_{WC}: 0.70 to +85 deg C, decreasing to 0.50 at +125 deg C

2.2 End-of-life Design Limits.

	General Purpose BX (X7R)	Temperature Compensated BP (NPO)
Capacitance:	± 21 percent	± 1.25 percent or ± 0.75 pF, whichever is greater
Insulation Resistance:	50 percent of initial limit	50 percent of initial limit

2.3 Mounting. Mounting of ceramic capacitors, especially in unencapsulated chip form, is critical and is discussed in Appendix A.

2.3.1 Piezoelectric Concerns. Where avoidance of a significant piezoelectric output is critical to circuit performance, BP-type dielectric product shall be used in place of BX-type dielectric product. Piezoelectric output can also be minimized by mounting chips on their side or on their end on the substrate or by using chips with a reduced length to width ratio.

2.3.2 Conductor Contact. In order to minimize part cracking, do not allow the capacitor termination to directly contact or come within 0.001 inch of contact to the conductor pads on the substrate.

2.3.3 Capacitor Cracking. Ceramic capacitors are easily cracked when exposed to thermal or mechanical stresses. Extreme care shall be taken to avoid excessive thermal stresses when tinning or soldering terminations and leads or when mounting the capacitor on a substrate. When equipment containing ceramic capacitors is to be subjected to a range of temperature, the stresses resulting from a mismatch of coefficients of thermal expansion of all elements involved shall be accommodated.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-C-123 and the requirements of this standard. Where MIL-C-123 does not provide an appropriate basis for the detailed specification, the contractor may substitute MIL-C-20, MIL-C-39014, or MIL-C-55681 on the following basis:

a. The manufacturer is currently on QPL for MIL-C-123 or currently in the process of qualifying to MIL-C-123

b. Manufacturer is manufacturing parts according to a contractor or DESC-approved documentation baseline

c. All chip capacitors shall be from a single chip production lot per MIL-C-123, and all encapsulated devices shall be assembled and tested as a single lot, using chips from a single production lot, per MIL-C-123

d. The lot passes all Group A and B requirement of MIL-C-123

3.2 Reliability Suspect Designs

3.2.1 Maximum Capacitance. 50-volt dc-rated product in the CKS 06 style with a capacitance greater than 0.47 microfarad are reliability suspect.

3.2.2 Thin Dielectric Product. Capacitors containing active dielectric thicknesses of less than 0.0009 inch, absolute, are reliability suspect.

3.2.3 Large Aspect Ratio Product. Capacitors manufactured with a design length-to-width aspect ratio of greater than 2 to 1 are reliability suspect; they are difficult to manufacture without delaminations or distortion.

3.2.4 Conformal-Coated Capacitors. Capacitors that are manufactured with a conformally-coated epoxy case rather than a thicker, molded case are reliability suspect.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-C-123.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements of MIL-C-123.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the requirements of MIL-C-123. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580. Additional lot-sample DPA requirements should be imposed on lots containing active dielectric thicknesses of less than 0.0009 inch, absolute.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-C-123.

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SECTION 230

SUPERMETALLIZED FILM CAPACITORS (CRH) (MIL-C-83421)

1. SCOPE

This section sets forth detailed requirements for fixed supermetallized film capacitors for high-energy circuit applications.

2. APPLICATION

2.1 Low Energy Circuits. Supermetallized film capacitors meeting the requirements of this section shall not be used in circuits with less than 500 microjoules of energy available for clearing and shall not be used in circuits that would be degraded by voltage transients created by part clearing. For capacitor circuits with less than 500 microjoules of energy, or those sensitive to momentary capacitor breakdown, see Section 232.

2.2 Voltage Derating, Polycarbonate Dielectric. The voltage-derating factor for these capacitors shall be as follows:

ES_{NOM}: 0.50 to +85 deg C.

ES_{WC}: 0.65 to +85 deg C.

2.3 Temperature Derating. Polycarbonate dielectric capacitors may be used to a maximum operating temperature of +85 deg C.

2.4 End-of-life Design Limits.

Capacitance: ±2 percent of initial tolerance limits

Insulation Resistance: 70 percent of minimum limit

2.5 Electrical Considerations (Self-healing and Clearing).

2.5.1 Metallized Film. Because the polymeric film used is very thin, pin holes exist. A model of self-healing is when the dielectric strength at a pin hole is not sufficient to withstand the voltage stress, a short develops (10-10,000 ohms range). However, high peak currents at the fault site can then cause a clearing action by vaporizing the metallization from around the hole, thereby, clearing the short.

Two factors shall be considered relative to a clearing action:

a. The energy necessary to accomplish this clearing

b. Short duration transients (voltage drops) during the clearing

For aluminum electrode materials, the energy required for nominal clearing may range up to 100 microjoules. For application purposes, a minimum circuit energy of 500 microjoules (five times the nominal) shall be available before these parts can be used.

2.5.2 Double-Wrap Capacitors. Capacitors made with an extra layer of non-metallized film have a low percentage of parts exhibiting shorting and clearing. Such parts may also have reduced ac current capabilities.

2.5.3 Contamination Shorts. All film types of capacitors (metallized film, single or double-wrap, and extended foil) can behave intermittently when operated under certain conditions. These effects, believed to be caused by ionic conditions or contamination within the capacitor enclosure, can cause spurious, random conduction when the capacitor is operated during temperature changes and where total circuit energy is less than 500 microjoules. The resistance level for polycarbonate capacitors at +125 deg C may vary from 1 to 10,000 megohms for capacitance values below 1.0 microfarad.

2.5.4 AC Applications. Any ac-rated capacitor can be used in an equivalent dc circuit. However, the converse is not true because of:

a. Dielectric heating

b. Pre-corona discharge

c. Resistance heating (Rs)

For high frequency ac applications, the equivalent series resistance (ESR) of each capacitor should be measured either at 100 Khz or at a frequency approximately that of its intended use, whichever is higher. If part ESR readings are greater than twice the standard deviation above the lot average, even though within specified limits, those parts shall not be used in space applications. In addition, the capacitors chosen for a lot acceptance life test shall be those with the highest ESR ratings and shall be tested under accelerated actual use stress conditions.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-C-83421 and the requirements of this standard.

3.1.1 Film Cleaning. Film used in all style capacitors shall be vacuum baked for 48 hours prior to winding to remove all contaminant residues.

3.1.2 Metallization. Deposited metallization shall be a minimum of 99.9 percent aluminum. Aluminum alloys and other materials either have identified problems or unproven reliability.

3.1.3 Winding Installation. Windings installed in cases whose diameter is 0.312 inch or larger shall be wrapped or encapsulated to prevent radial motion during shock or vibration.

3.2 Failure Level. Only failure rate level "S" parts shall be used.

3.3 Reliability Suspect Designs.

a. Parts which have a dc voltage rating less than 50 volts.

b. Parts with a stiff spiral or pigtail type of lead design are relatively prone to lead separation from end metallization. Visual inspection at a minimum of 5X magnification before assembly insertion in a case and lot-sample lead-pull testing shall be used with such part designs.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-C-83421 and the following:

a. Internal visual examination (5X minimum) of the lead attachment to capacitor babbitt (end metallization)

b. Axial push test to verify tight fit between element and case (not required for potted parts or capacitors whose case diameter is less than 0.312 inch)

c. Lot-sample pull test to verify attachment of lead wires to babbitt.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements of Table 230-1.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the requirements listed in Table 230-2. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-C-83421.

TABLE 230-1. 100 Percent Screening Requirements

MIL-C-83421 Screens	Additions and Exceptions to the Methods and Criteria of MIL-C-83421
Thermal Shock	a. MIL-STD-202, Method 107, Condition B, except: -55 deg C to +100 deg C (10 cycles) 5 minute maximum between chamber transfers
DC Burn-In	a. 168 hours minimum at +100 deg C
AC Burn-In	a. Test may be waived if for DC applications only b. 48 hours minimum at +100 deg C c. Max AC Current, 120 percent of I_{AC} rated at 40 kHz d. V_{AC} (RMS) shall not exceed 240 V_{RMS} under any conditions
Seal	
Dielectric Withstanding-Voltage	
Insulation Resistance	
Capacitance	
Dissipation Factor	
ESR	a. Test may be waived if for DC applications only
Visual and Mechanical Examination (External)	
Radiographic Inspection	a. Per MSFC-STD-355; 2 views 90 deg. apart by X-ray, or 360 deg. view by Vidicon. Use of "real-time" X-ray systems capable of viewing through 360 deg rotation is encouraged.
N-Ray (For Potted Parts Only)	a. Verify that no detectable potting voids exist

TABLE 230-2. Lot Conformance Tests for AC and DC Capacitors

MIL-C-83421 Screens	Additions and Exceptions to the Methods and Criteria of MIL-C-83421
<u>Subgroup I</u>	
DC Life (Accelerated)	a. 4 samples b. 2,000 hours
AC Life (Accelerated)	a. 4 samples b. Test may be waived if for DC applications only c. 250 hours d. Max AC current, 120 percent of I_{ac} (RMS); Minimum current shall be three times that of system application current, adjusted for 40 kHz operation. V_{AC} shall not exceed 240 V_{RMS} under any conditions. e. V_{AC} frequency shall be 40 kHz ± 2 percent
CAP, DF, IR, and Seal	a. IR at +25 deg C and +125 deg C
<u>Subgroup II</u>	
Vibration (Random)	a. MIL-STD-202, Method 214, Test Condition II, K b. 2 orthogonal planes, 15 minutes
Vibration (Sine)	
Terminal Strength	
Dielectric Absorption	
Cap, DF, IR, and Seal	
<u>Subgroup III</u>	
Shock	a. 6 samples b. MIL-STD-202, Method 213, Condition D, (500 g)
Solderability	
Temperature Coefficient	
CAP, DF, IR, and Seal	

SECTION 232

SUPERMETALLIZED FILM CAPACITORS (CHS) (MIL-C-87217)

1. SCOPE

This section sets forth detailed requirements for fixed film supermetallized capacitors for low-energy circuits.

2. APPLICATION

2.1 Low Energy Circuits. These capacitors require extensive testing and are intended for use in circuits where the total energy is less than 500 microjoules but more than 100 microjoules. These parts are still subject to momentary shorting and clearing during application. If clearing pulses cannot be tolerated, other capacitor types are recommended.

2.2 Derating. Same as Paragraph 2.2 and 2.3 of Section 230 except parts shall not be used above +85 deg C. or tested above +100 deg C.

2.3 End-of-life Design Limits. Same as Paragraph 2.4 of Section 230.

2.4 Electrical Considerations Same as Paragraph 2.5 of Section 230.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-C-87217 and the requirements of this standard.

3.2 Reliability Suspect Designs. Same as Paragraph 3.2 of Section 230.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-C-87217.

4.2 <u>Screening (100 percent)</u>. Screening (100 percent) shall be in accordance with the Group A test requirements of MIL-C-87217.

4.3 <u>Lot Conformance Tests</u>. Lot conformance tests shall be in accordance with the requirements of MIL-C-87217. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 <u>Qualification Tests</u>. Qualification testing shall be in accordance with the requirements of MIL-C-87217.

SECTION 235

PLASTIC FILM, METALLIZED/NONMETALLIZED (CQR) (MIL-C-19978)

1. SCOPE

This section sets forth detailed requirements for fixed film extended foil capacitors.

2. APPLICATION

Due to their nonclearing failure-to-short characteristic and the general availability of parts of equivalent electrical performance and size in MIL-C-83421, it is recommended that the use of Style CQR capacitors be limited to those applications where capacitors covered by MIL-C-83421 are not available (See Section 230).

2.1 Derating. Same as 2.2 and 2.3 of Section 230 except parts shall not be used or tested above 100 deg C.

2.2 End-of-life Design Limits. Same as 2.4 of Section 230.

2.3 Electrical Consideration. Same as 2.5 of Section 230.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-C-19978 and the requirements of this standard.

3.1.1 Production Lot. A production lot for designated parts shall consist of all the capacitors of a single nominal capacitance and voltage rating of one design, from the same dielectric material batch, and processed as a single lot through all manufacturing steps on the same equipment, to the same baseline document revisions, and identified with the same data and lot code designation. The lot may contain all available capacitance tolerances for the nominal capacitance value. In addition, the lot shall conform to the following:

a. For dielectric material, no more than one vendor lot or batch number shall be used for each of the layers of dielectric (film) material in a manufacturing lot.

b. All film shall be wound on the same machine.

c. Raw material such as capacitor cases, lead material, end seals, and tape shall be traceable to the same lot or batch.

d. A lot number shall be assigned after the capacitor element is wound.

e. All processes such as vacuum bake and screening shall be done on the same equipment without a change in setting within a given lot.

3.1.2 Film. Film shall be selected and processed to an approved procedure.

3.1.3 Winding Installation. Windings installed in cases whose diameters is 0.312 inch or larger shall be wrapped or potted to prevent radial motion during shock or vibration.

3.2 Reliability Suspect Designs. Parts whose DC voltage rating is less than 50 volts.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process controls. In-process controls shall be in accordance with the requirements of MIL-C-19978 and the following:.

a. Internal visual (5X minimum) of lead attachment to capacitor winding

b. Push test (not required for potted parts of where the case diameter is less than 0.312 inch) on element to verify tight fit between element and case

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements of Table 230-1.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the tests listed in Table 230-2.

4.4 Qualification Tests. Qualification testing shall be in accordance with MIL-C-19978.

SECTION 240

GLASS DIELECTRIC CAPACITORS (CYR)
(MIL-C-23269)

1. SCOPE

This section sets forth detailed requirements for fixed glass capacitors.

2. APPLICATION

2.1 Derating. These glass capacitors shall be voltage-derated in accordance with Figure 240-1.

2.2 Temperature. The minimum temperature of use for these parts shall be -55 deg C.

2.3 Temperature Derating. The glass capacitors shall be temperature-derated in accordance with Figure 240-1.

2.4 End-of-life Design Limits.

Capacitance:	+0.5 percent of initial limits or 0.5 pF, whichever is greater
Insulation Resistance:	500,000 megohms at +25 deg C 10,000 megohms at +125 deg C
Dissipation Factor:	0.2 percent maximum

2.5 Electrical Considerations

2.5.1 General. Glass capacitors are relatively expensive, have poor volumetric efficiency, and have a practical capacitance range limited to 10,000 pF. However, the dielectric has near-perfect properties (high IR, high Q, ultrastable capacitance, low dielectric absorption, and fixed TC), and thus these parts are useful in ultrastable and high-frequency circuit applications.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-C-23269 and the requirements of this standard.

3.1.1 Recommended Styles. CYR 10, CYR 15, CYR 20, CYR 30.

3.1.2 Failure Level. Failure rate level "S".

3.2 <u>Reliability Suspect Designs</u>. Lead-to-foil welded devices, radial-leaded capacitors.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 <u>In-process controls</u>. In-process controls shall be in accordance with the requirements of MIL-C-23269.

4.2 <u>Screening (100 percent)</u>. Screening (100 percent) shall be in accordance with the requirements of MIL-C-23269.

4.3 <u>Lot conformance tests</u>. Lot conformance tests shall be in accordance with the requirements of MIL-C-23269.

4.4 <u>Qualification Tests</u>. Qualification testing shall be in accordance with the requirements of MIL-C-23269.

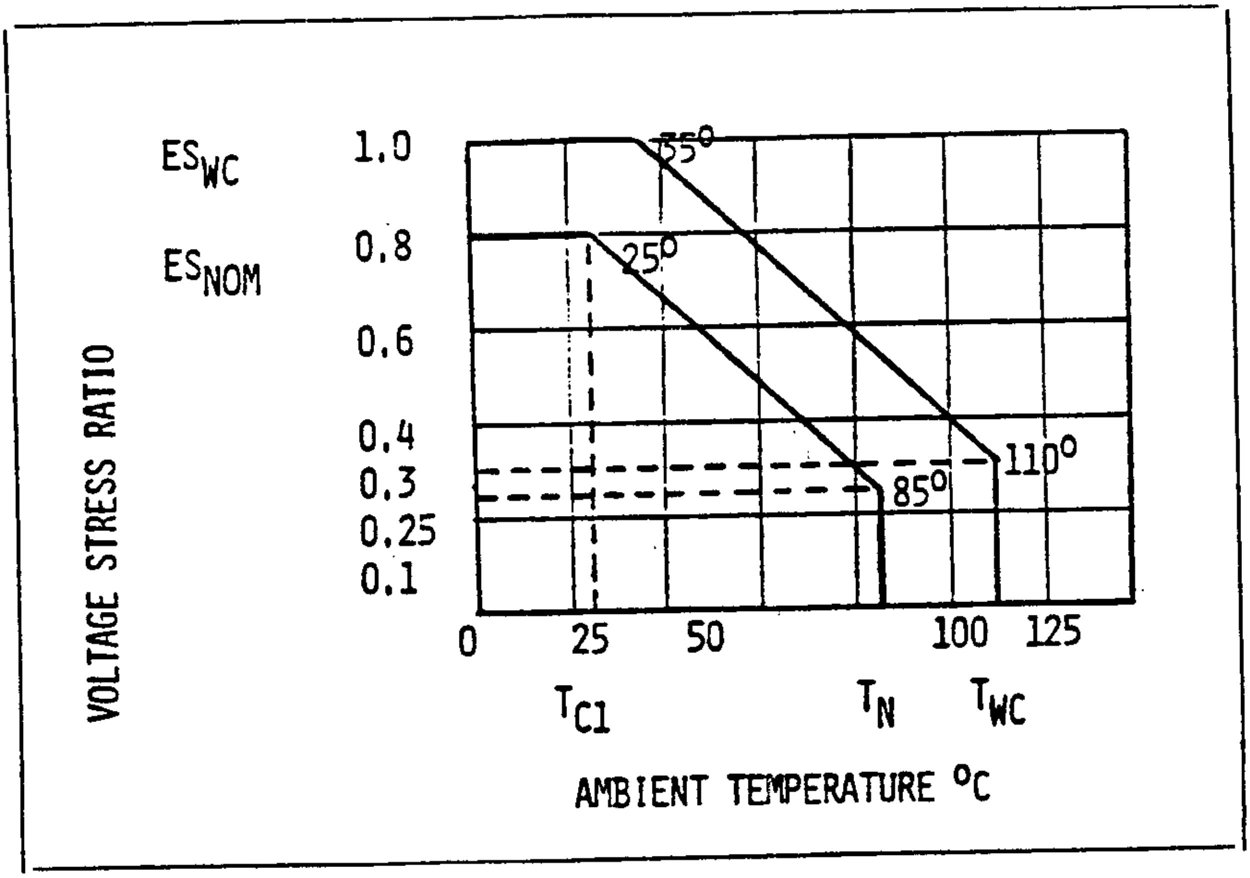

FIGURE 240-1. Voltage Derating for Glass Capacitors

SECTION 250

FIXED MICA CAPACITORS(CMS) (MIL-C-87164)

1. SCOPE

This section sets forth detailed requirements for fixed mica dielectric capacitors.

2. APPLICATION

2.1 Derating. These capacitors shall be voltage-derated in accordance with Figure 250-1.

2.2 End-of-life Design Limits.

Capacitance:	± 0.5 percent of initial limits
Insulation Resistance:	70 percent of initial minimum limit

2.3 Electrical Considerations

This part exhibits electrical characteristics almost identical to those of the CYR style, except that the part is not hermetically sealed.

3. DESIGN AND CONSTRUCTION

Design and construction shall be in accordance with the requirements of MIL-C-87164 and the requirements of this standard.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-C-87164.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the Group A screening requirements of MIL-C-87164.

4.3 <u>Lot Conformance Tests</u>. Lot conformance tests shall be in accordance with the Group B tests requirements of MIL-C-87164. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 <u>Qualification Tests</u>. Qualification testing shall be in accordance with the requirements of MIL-C-87164.

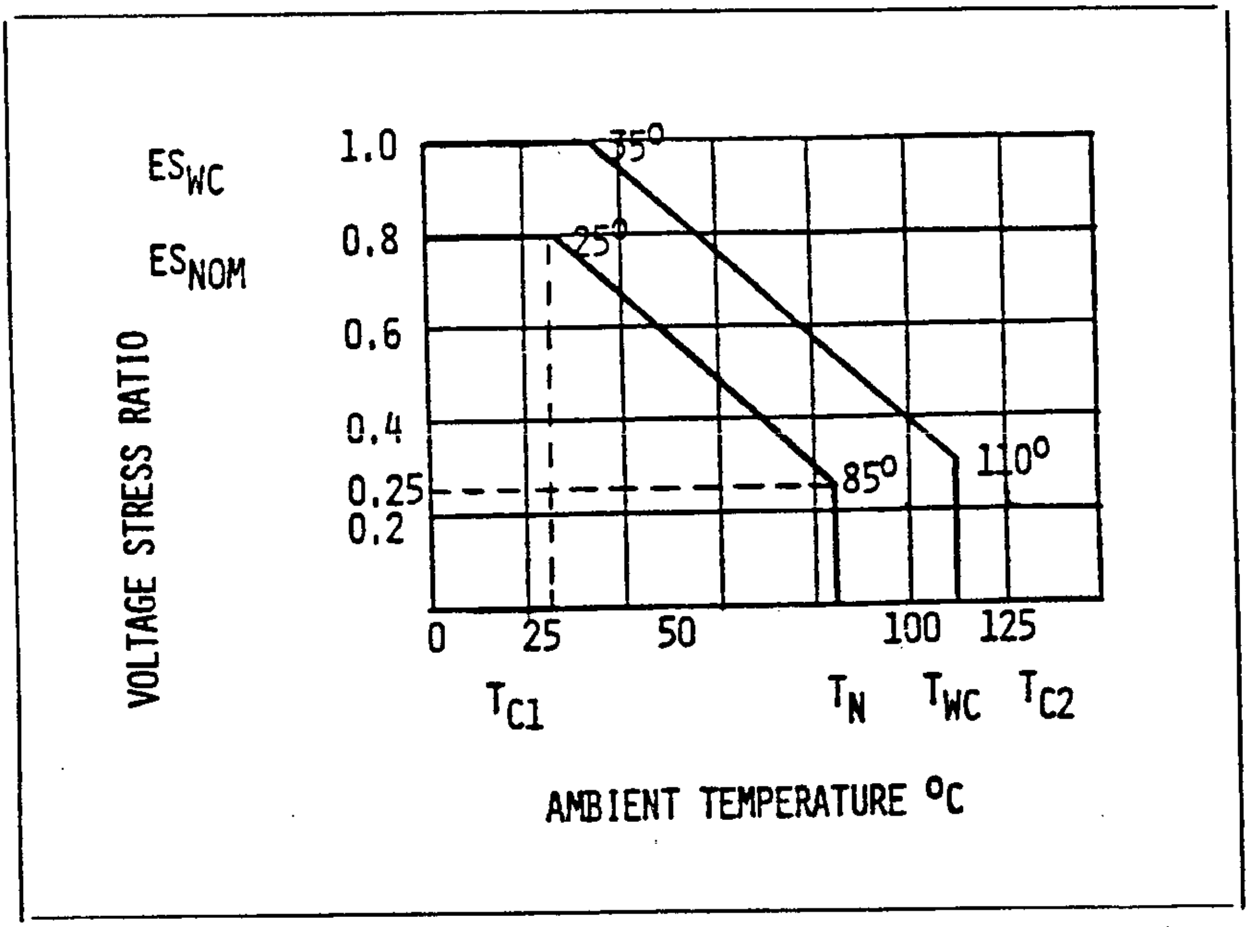

FIGURE 250-1. Voltage Derating for Mica Capacitors

SECTION 260

FIXED TANTALUM FOIL (CLR 25, 27, 35, and 37) (MIL-C-39006)

1. SCOPE

This section sets forth detailed requirements for fixed tantalum-foil capacitors (CLR 25, 27, 35, and 37).

2. APPLICATION

The standard MIL-C-39006 part shall not be used in applications involving shock environments or vibration environments that exceed the requirements of that specification unless qualified for the higher level.

2.1 Derating. These capacitors shall be voltage-derated in accordance with Figure 260-1.

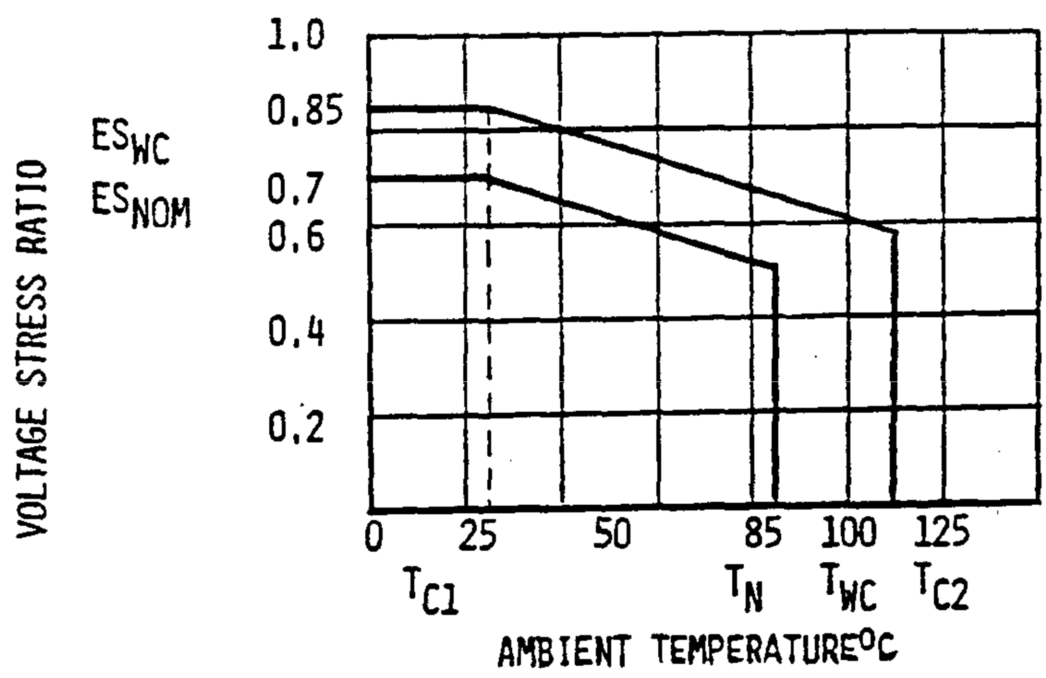

FIGURE 260-1. Voltage Derating for Tantalum-Foil Capacitors

2.2 End-of-life Design Limits.

Capacitance: ± 15 percent of initial limits

Leakage Current: 130 percent of initial maximum limit

2.3 Electrical Considerations. The four capacitor styles listed are constructed with either plain (CLR 35 and 37) or etched-foil (CLR 25 and 27) tantalum dielectric and are either polarized (CLR 25 and 35) or nonpolarized (CLR 27 and 37). These capacitors are recommended for either medium or high voltage applications where high capacitance is required. The etched foil provides as much as 10 times the capacitance per unit area as the plain foil for a given size and is the most widely used. The plain foil is just as reliable as the etched foil, and, in some cases, it may be more desirable because this style can withstand approximately 30 percent higher ripple currents, has better temperature coefficient characteristics, and has a lower dissipation factor.

2.3.1 Reverse Voltage. The polarized capacitor styles can only withstand a maximum of three volts dc reverse voltage at +85 deg C. Under these conditions, the following changes in electrical characteristics are possible:

Capacitance: ±10 percent of initial value

Leakage Current: 125 percent of initial maximum limit

2.3.2 AC Ripple Voltage. The peak ac ripple voltage shall not exceed the dc voltage applied. The sum of the peak ac ripple voltage and any applied dc voltage shall not exceed the maximum dc voltage shown in Figure 260-1. Maximum ripple currents are given in literature of the various manufacturers.

2.3.3 Tantalum Capacitor Packs. (See NASA TM X-64755)

2.3.4 Potted Modules. The glass end seals are designed to withstand high internal pressure. When parts are potted, end seals shall be protected to withstand high external pressures that can result from curing of the encapsulant.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-C-39006 and the requirements of this standard.

3.1.1 Failure Level. Failure rate level "R" or better.

3.1.2 Vibration Environment. When used in shock or vibration environments that exceed the requirements of the military specification, the following additional design requirements shall be met:

a. No internal lead wire welds shall be permitted between internal and external leads.

b. Vibration spacer(s) shall be used to prevent axial motion.

c. The capacitive element shall be wrapped to ensure that it is securely positioned within the case.

3.2 Reliability Suspect Designs. None identified.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-C-39006. Verify that each capacitor element fits snugly within the case and that vibration spacers are installed.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the 100 percent screening requirements listed in Table 260-1.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the test requirements listed in Table 260-2. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-C-39006, Table I,

TABLE 260-1. 100 Percent Screening Requirements for Tantalum Foil Capacitors

MIL-C-39006 Screens	Additions and Exceptions to the Methods and Criteria of MIL-C-39006
Thermal Shock	a. -65 deg C to +125 deg C (5 cycles) b. 5 minute maximum between chamber transfers
Constant Voltage Conditioning	a. Maximum series resistance: 33 ohms b. Burn-in time of 168 hours at +85 deg C
DC Leakage Capacitance DF	
Seal	
Radiographic Inspection	a. Per MSFC-STD-355; 2 views 90 deg. apart by X-ray, or 360 deg. view by Vidicon. Use of "real-time" X-ray systems capable of viewing through 360 deg rotation is encouraged. b. Moderate "telescoping" of roll is acceptable.
Visual and Mechanical Examination	

TABLE 260-2. Lot Conformance Tests
(page 1 of 2 pages)

MIL-C-39006 Screens	Additions and Exceptions to the Methods and Criteria of MIL-C-39006
Subgroup 1	
Thermal Shock	a. During last cycle, monitor capacitance to verify no opens
Surge Voltage	a. Maximum series impedance: 33 ohms
Life	a. At +85 deg C - for 1000 hours
DC Leakage	a. At +25 deg and +85 deg C
Capacitance	
DF	a. At 40 KHz
ESR	a. Test may be waived if for DC applications only
Seal	
Visual and Mechanical Examination (External)	

TABLE 260-2. Lot Conformance Tests
(page 2 of 2 pages)

MIL-C-39006 Screens	Additions and Exceptions to the Methods and Criteria of MIL-C-39006
Subgroup II	
Thermal Shock	a. 20 cycles
Mechanical Shock	a. 500g's
Vibration (Random)	a. MIL-STD-202, Method 214, Test Condition II, K for 15 minutes each axis.
Moisture Resistance	
Reverse Voltage	
DC Leakage	a. At +25 deg and +85 deg C
Capacitance	
DF	
Seal	
Visual and Mechanical Examination (External)	

SECTION 270

SOLID TANTALUM CAPACITORS STYLE CSR 13 and STYLE CSR 33 (MIL-C-39003-/1 and -/6)

1. SCOPE

This section sets forth detailed requirements for fixed solid tantalum capacitors style CSR 13 and CSR 33.

2. APPLICATION

Solid tantalum capacitors covered by this section shall not be used in mission-significant circuits with an impedance of less than 1 ohm per volt. For those applications, see Section 272.

2.1 Derating. These capacitors are voltage derated in accordance with Figure 270-1.

2.2 End-of-life Design Limits.

Capacitance: ±10 percent of initial limits

Leakage Current: 200 percent of initial maximum limit

2.3 Electrical Considerations. This part is recommended where high capacitance in a small area is required and where relatively high temperature coefficients of capacitance can be tolerated. However, only capacitors with a dc working voltage rating of 75 volts or less shall be used. This is because capacitors of this type with a higher voltage rating require thicker dielectrics (containing more impurities) while the lower voltage parts utilize a small tantalum slug (higher ESR) which compensates for external series resistance.

2.4 Mounting. These parts are polarized and care shall be taken to ensure installation with the correct polarity.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-C-39003 -/1 and -/6 and the requirements of this standard.

3.1.1 Recommended Styles. CSR 13 and CSR 33.

3.1.2 Failure Rate Level. Failure rate level "C" or better

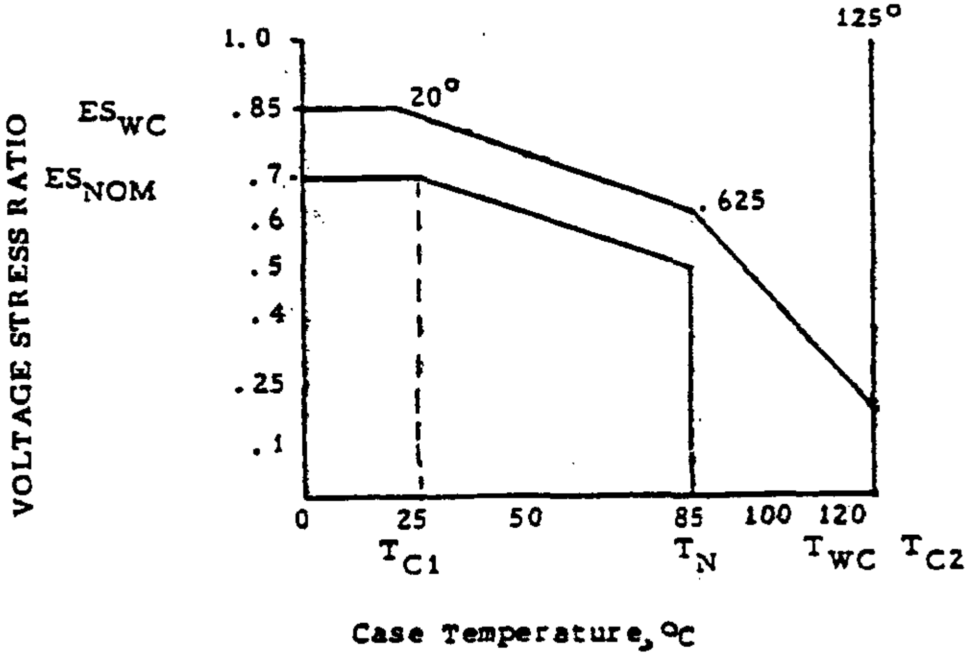

FIGURE 270-1 Voltage Derating for Solid Tantalum Capacitors

3.1.3 Voltage Ratings. These solid tantalum capacitors shall be designed with a dc working voltage of 75 volts or less (Higher voltage ratings require thicker dielectrics, containing more impurities, while the lower voltage parts utilize a small tantalum slug).

3.2 Production Lot. A production lot for solid tantalum capacitors shall be specified in the baseline documentation. As a minimum requirement, the lot shall consist of all the capacitors of a single nominal capacitance and voltage rating of one design, shall be processed as a single lot through manufacturing steps on the same equipment, to the same base line revision, and shall be identified with the same data and lot code designation. The lot may contain all available capacitance tolerances for the nominal capacitance value. In addition, the lot shall conform to the following.

a. Raw materials such as tantalum powder, manganese nitrate, collodial carbon, and case and header materials shall be traceable to the same lot batch and be from the same manufacturer.

b. Lot numbers shall be assigned at anode formation and should provide for traceability to both the anode pressing batch and the tantalum powder batch used.

c. All anodes in a lot shall be pressed in a continuous run on the same pressing machine. Further, the anodes shall be sintered and temperature processed as a complete batch (batches cannot be split during sintering or subsequent temperature conditions).

d. The entire production lot shall be voltage formed at the same time and in the same tank, impregnated, and otherwise processed through final sealing as a complete production lot with all parts receiving identical processing.

e. Cans, headers, seals, and lead wire shall be from a single receiving inspection lot. Each individual item, including solder, shall be from a single vendor.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-C-39003 -/1 and -/6.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the 100 percent screening requirements listed in Table 270-1.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the test requirements listed in Table 270-2. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-C-39003 -/1 and -/6.

TABLE 270-1. 100 Percent Screening Requirements

MIL-C-39003 -/1 and -/6 Screens	Additions and Exceptions to the Methods and Criteria of MIL-C-39003 -/1 and -/6 (Weibull distribution)
Thermal Shock	a. 10 cycles
Surge Current	a. 5 cycles at -55 deg C and +85 deg C b. Maximum impedance in series with each capacitor: 1.0 ohms including a fast blow fuse, wiring, fixturing, and output impedance of power supply c. Minimum peak current to each capacitor: 25 amperes in 5 microseconds
Voltage Aging	a. Maximum series resistance: 1 ohm b. 250 hours with 1.2 times the rated dc working voltage applied at +85 deg C
DC Leakage	a. +25 deg C and +85 deg C
Capacitance	
DF	
Seal	
Radiographic Inspection	a. Per MSFC-STD-355; 2 views 90 deg. apart by X-ray, or 360 deg. view by Vidicon. Use of "real-time" X-ray systems capable of viewing through 360 deg rotation is encouraged.
Visual and Mechanical Examination	

TABLE 270-2. Lot Conformance Tests

MIL-C-39003 -/1 and -/6 Screens	Additions and Exceptions to the Methods and Criteria of MIL-C-39003 -/1 and -/6 (Weibull distribution)
Thermal Shock	a. 20 cycles
Stability at Low and High Temperature	
Surge Voltage	
Life (+85 deg C)	a. Maximum series resistance: 1.0 ohm
DC Leakage	a. At +25 deg C and +85 deg C
Capacitance	
DF	
Seal	
Visual and Mechanical Examination	

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SECTION 272

SOLID TANTALUM CAPACITORS (CSS)
(MIL-C-39003/10)

1. SCOPE

This section sets forth detailed requirements for fixed solid tantalum capacitors, styles CSS13 and CSS33.

2. APPLICATION

These specially screened parts are to be used in those special applications where circuit impedances of 1 ohm per volt cannot be achieved. For applications involving 1 ohm per volt or more, solid tantalum capacitors covered in Section 270 may be used. CSS style capacitors may be directly substituted for CSR style parts of equal capacitance and voltage.

2.1 Derating. These capacitors shall be voltage-derated in accordance with Figure 270-1.

2.2 End-of-life Design Limits.

Capacitance: ±10 percent of initial limits

Leakage Current: 200 percent of initial maximum limit

2.3 Minimum Source Impedance. A source impedance of at least 1 ohm shall be used in all circuits containing these parts to act as a transient suppressor. Source impedance current limiting in circuits shall be included to guarantee that the effective maximum current is not exceeded.

2.4 Mounting. These parts are polarized and care shall be taken to ensure installation with the correct polarity. The parts are marked with a black band on the negative end.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-C-39003/10 and the requirements of this standard.

3.1.1 Failure Level. Failure rate level "C" or better

3.1.2 Voltage Ratings. These solid tantalum capacitors shall be designed with a dc working voltage of 75 volts or less (Higher voltage ratings require thicker dielectrics, containing more impurities, while the lower voltage parts utilize a small tantalum slug).

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-C-39003/10.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements of MIL-C-39003/10.

4.3 Lot Conformance Tests. Lot conformance tests not required.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-C-39003/10.

SECTION 275

SOLID TANTALUM CHIP CAPACITORS (CWR) (MIL-C-55365)

1. SCOPE

This section sets forth detailed requirements for fixed, unencapsulated solid tantalum capacitors with either wrap around or "T-bar" terminations.

2. APPLICATION

These parts are designed for use in hybrids or circuit boards where increased component packaging density is required.

2.1 Voltage Derating. These capacitors shall be voltage derated in accordance with Figure 270-1.

2.2 Surge Voltage Derating. The maximum allowable surge voltage shall be as given in Table 275-1.

TABLE 275-1. Surge Voltage Ratings

Symbol	Voltage (volts, dc)		
	Steady State Voltage Rated (+85 deg C)	Steady State Voltage Derated (+85 deg C)	Maximum Surge Voltage (-55 deg C to +85 deg C)
B	3	2.1	3
C	4	2.8	4
D	6	4.2	6
F	10	7.0	10
H	15	10.5	15
J	20	14.0	20
K	25	17.5	25
L	30	21.0	30
M	35	24.5	35

2.3 Minimum Circuit Impedance. A minimum circuit impedance of 1 ohm per volt or more shall be used in circuits containing solid tantalum chip capacitors.

2.4 End-of-life Design Limits.

Capacitance: ± 10 percent of initial limits

Leakage Current: 200 percent of initial maximum limit

2.5 Electrical Considerations. This part type is recommended where a high capacitance to volume ratio is required and where relatively high temperature coefficients of capacitance can be tolerated. Because the unencapsulated configuration of these parts renders them quite susceptible to damage during circuit manufacturing, it is recommended that they not be used in single-point failure locations or in mission-critical circuits.

2.6 Mounting. Mounting shall be in accordance with Appendix A. Due to high susceptibility to surface damage, it is recommended that these parts be mounted last in the assembly sequence and given a detailed visual examination for surface damage before circuit conformal coating or hybrid sealing. Mounting in a vertical configuration may be required for some capacitance values.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-C-55365 and the requirements of this standard.

3.1.1 Protective Coating. The body of the parts shall be covered by a thin protective coating to provide improved resistance to handling damage.

3.1.2 Failure Rate Level. Failure rate level "R" or better.

3.2 Reliability Suspect Designs.

a. The highest capacitance value in any given case size is suspect.

b. The extended termination designs are more susceptible to handling damage than more compact termination designs.

3.3 Production Lot. A production lot for solid tantalum chip capacitors shall consist of all the capacitors of a single nominal capacitance and voltage rating of one design, shall be processed as a single lot through all manufacturing steps on the same equipment, to the same baseline document revisions, and shall be identified with the same date and lot code designation. The lot may contain all available capacitance tolerances for the nominal capacitance value. In addition, the lot shall conform to the following:

a. Raw materials such as tantalum powder, manganese nitrate, collodial carbon, and termination materials shall be traceable to the same lot batch and be from the same manufacturer.

b. Lot numbers shall be assigned at anode formation but should provide for traceability to the anode pressing batch and tantalum powder batch used.

c. The anode shall be pressed in a continuous run on the same pressing machine. Further, it shall be sintered and temperature-processed as a complete batch (batches cannot be split during sintering or subsequent temperature conditioning).

d. The entire production lot shall be voltage-formed (at the same time and in the same tank), impregnated, and otherwise processed through final sealing as a complete production lot with all parts receiving identical processing at the same time.

e. Termination and lead materials shall each be from a single receiving inspection lot. Each individual item including solder and solder flux shall be from a single vendor.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-C-55365.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements listed in Table 275-2.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the requirements of MIL-C-55365.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-C-55365.

TABLE 275-2. 100 Percent Screening Requirements

MIL-C-55365 Screens	Additions and Exceptions to the Methods and Criteria of MIL-C-55365
Thermal Shock	a. 10 cycles
Surge Current	a. 5 cycles at -55 deg C and +85 deg C b. Maximum impedance in series with each capacitor: 1.0 ohm plus 1 to 3 amperes fast blow fuse c. Minimum peak current to each capacitor: 25 amperes in 5 microseconds
Voltage Aging	a. Maximum series resistance: 1 ohm b. 250 hours with 1.3 times the rated working voltage applied at +85 deg ±5 deg C
DC Leakage	a. +25 deg C and +85 deg C
Capacitance	
DF	
ESR	a. Test may be waived if for DC applications only b. At 40 kHz If the application involves frequencies above 1 MHz, measurement at a minimum frequency of 1 MHz shall be required.
Radiographic Inspection	a. Per MSFC-STD-355; 2 views 90 deg. apart by X-ray, or 360 deg. view by Vidicon. Use of "real-time" X-ray systems capable of viewing through 360 deg rotation is encouraged.
Visual and Mechanical Examination (External)	

SECTION 280

FIXED TANTALUM-TANTALUM CAPACITOR (SINTERED WET SLUG, CLR 79) (MIL-C-39006/22)

1. **SCOPE**

This section sets forth detailed requirements for tantalum-cased, sintered tantalum, wet slug capacitors.

2. **APPLICATION**

These parts are low-impedance, polarized capacitors that are designed for insertion into a circuit with a specific physical orientation. There is some evidence that in circuits active during vibration or shock environments the parts can generate voltage spikes.

2.1 Derating. Parts shall be voltage-derated in accordance with Figure 280-1.

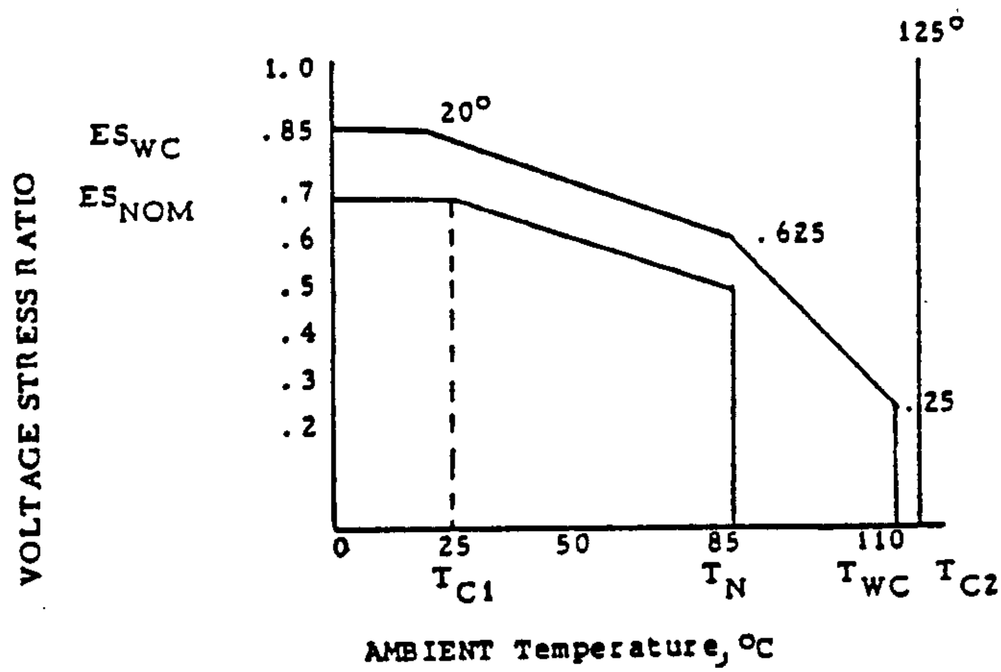

FIGURE 280-1. Voltage Derating for Tantalum-Tantalum (Sintered Wet Slug) Capacitor

2.2 End-of-life Design Limits.

Capacitance: ± 10 percent of initial limits

Leakage Current: 130 percent of initial maximum limit

2.3 Electrical Considerations.

2.3.1 Construction. The CLR 79 device type is assembled into a hermetically sealed, welded metal case and is constructed of four basic materials: tantalum, polytetrafluoroethylene (PTFE), glass, and a gelled sulfuric acid.

2.3.2 ESR versus Frequency. Figure 280-2 is a plot of equivalent series resistance (ESR) versus frequency for various case sizes. When capacitors are to be used in circuits operating between 10 kHz and 100 kHz, equivalent series resistance measurements at 40 kHz shall be taken during 100 percent screening.

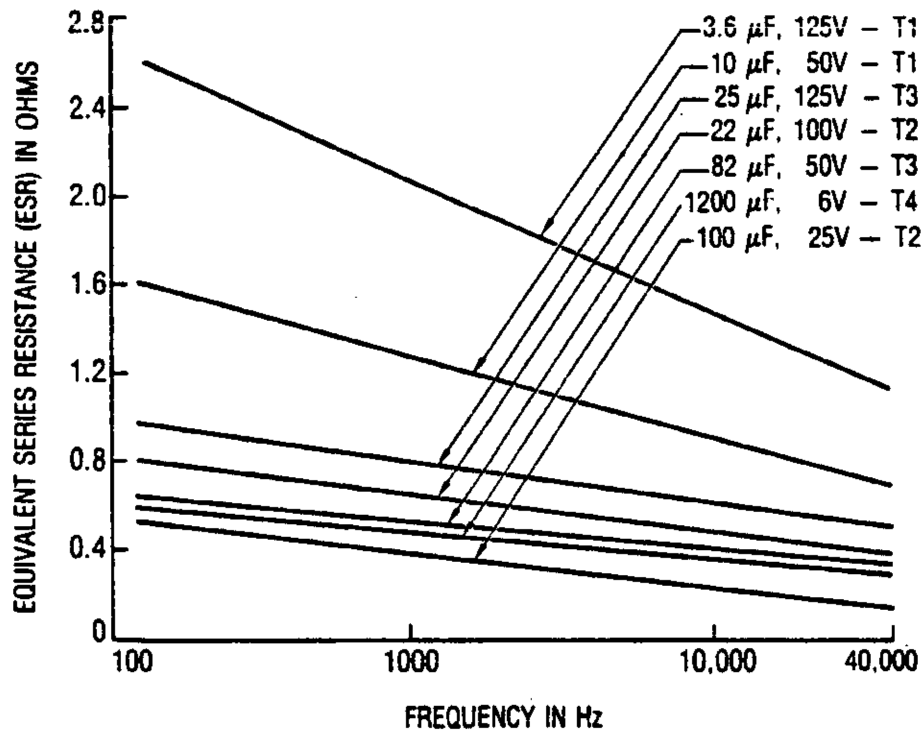

FIGURE 280-2. ESR versus AC Frequency

2.3.3 Vibration and Shock. Parts have been tested to 80 g sine vibration (0.06 double amplitude) from 10 to 2000 Hz for 3 hours in each orthogonal axis. Parts have been shocked to 100 g for 6 milliseconds with a saw tooth pulse. The "H" vibration-screened part option shall be used for all CLR 79s that are used in circuits to be operated in vibration or shock environments. There are indications, however, that even "H" screened parts may be prone to voltage spikes in these environments.

2.3.5 Reverse Voltage. Maximum reverse voltage shall be 3.0 Vdc at +85 deg C or 20 percent of the rated dc voltage, whichever is less.

2.3.6 Other. Detailed mechanical and electrical characteristics are found in MIL-C-39006/22.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-C-39006/22 and the requirements of this standard.

3.2 Reliability Suspect Designs. All single-sealed CLR 79 designs incorporating liquid electrolytes are reliability suspect and constitute a safety hazard.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-C-39006/22. In addition, each capacitor anode assembly shall be inspected at a minimum of 10X magnification. All parts not meeting the following requirements shall be rejected.

a. The tantalum anode (slug) shall be straight, not bent or distorted. All anodes in a given lot shall be of the same size.

b. The anodes shall be of the same uniform color.

c. The anode shall fit snugly and be firmly seated within the top and bottom PTFE vibration spacers.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements of Table 280-1.

4.2.1 Vibration Screening. When vibrational screening is required, the following test conditions shall apply.

4.2.1.1 Direction of Vibration. The direction of vibration shall be perpendicular to the cylindrical axis of the capacitor.

4.2.1.2 Test Potential. The rated voltage of each part shall be applied.

4.2.1.3 Sinusoidal Vibration. All parts shall be tested per MIL-STD-202, Method 204, Test Condition H (80 g).

4.2.1.4 Random Vibration. All parts shall be tested per MIL-STD-202, Method 214, Test Condition II, K (51.1 g rms)

4.2.1.5 Continuous Monitoring. During all vibration tests the dc leakage current shall be continuously monitored across a 10 kilohms resistor connected in series with each part under test.

4.2.1.6 Post-Vibration Measurements. After completion of all testing, parts shall be subjected to dc leakage measurements at +25 deg and +125 deg C and capacitance and dissipation factor measurements at +25 deg C, all per MIL-C-39006/22.

4.2.1.7 Failure Criteria. All parts shall be rejected whose post-vibration electrical measurements are not within the limits specified in MIL-C-39006/22 or who exhibit intermittent voltage spikes of 0.3 millisecond or greater duration, or arcing, open, or short circuiting during vibration testing.

4.2.1.8 Visual and Mechanical Examinations. All parts shall be visually examined per MIL-C-39006/22 after testing. Any part showing evidence of mechanical damage or electrolyte leakage shall be rejected.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the requirements listed in Table 280-2.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-C-39006/22.

TABLE 280-1. 100 Percent Screening Requirements

MIL-C-39006/22 Screens	Additions and Exceptions to the Methods and Criteria of MIL-C-39006/22
Thermal Shock	a. 10 cycles
Constant Voltage Conditioning	a. Maximum series resistance: 33 ohms b. Burn-in time: 168 hours at +85 deg C
DC Leakage	
Capacitance	
DF	
Seal	
Visual and Mechanical Examination	

TABLE 280-2. Lot Conformance Tests

MIL-C-39006/22 Screens	Additions and Exceptions to the Methods and Criteria of MIL-C-39006/22
Subgroup I	
Thermal Shock	a. During last cycle, monitor capacitor to verify no opens
Surge Voltage	
Life	a. At +85 deg C for 240 hours b. Maximum series impedance: 33 ohms
DC Leakage	a. At +25 deg C and +85 deg C
CAP	
DF	
Seal	
Visual and Mechanical Examination	
Subgroup II	
Thermal Shock	a. 100 cycles
Mechanical Shock	a. 500 g, 0.5 sine (1 millisecond duration)
Vibration (Random)	a. MIL-STD-202, Method 214, Test Condition 11K, for 15 minutes each axis
Moisture Resistance	
Reverse Voltage	
DC Leakage	a. At +25 deg C and +85 deg C
CAP	
DF	
Seal	
Visual and Mechanical Examination	

SECTION 300

CONNECTORS

1. SCOPE

This section sets forth detailed requirements for space-qualified connectors which are capable of continuous operation within a temperature range of -65 deg C to +200 deg C. Additional information and guidance for the general use of connectors can be found in MIL-STD-1353.

2. APPLICATION

The selection and use of connectors shall be in accordance with MIL-STD-1353 and the requirements contained herein. Connector selection shall be based on operational requirements of the equipment and the following considerations:

a. Closed-entry-type socket contacts shall be used whenever available.

b. Scoop-proof connectors shall be used whenever there is an awkward or blind installation.

c. Redundant contacts shall be used where critical signal applications are subjected to vibration conditions.

d. Guide devices shall be used for proper axial alignment and orientation. These devices shall not be used to carry current.

e. Strain relief for wires, harnesses, and cables shall be provided, particularly where there may be frequent mating and unmating or where severe shock and vibration environments are anticipated.

f. Protective covers shall be installed at all times until connectors are mated.

g. Rear removable contacts shall be used wherever possible.

h. Connector savers shall be used for those applications subject to frequent mate and demate operations such as during testing.

i. Solder contacts shall be required where hermeticity is necessary and achieved by encapsulation. Crimp contacts shall not be encapsulated.

2.1 Derating. Circular, rectangular rack panel, printed wiring board, and coaxial RF connectors shall be derated in accordance with AFSCP-800-27, Section I, with the following exception: High altitude ratings listed in connector specifications shall be derated 50 percent. When high altitude ratings are not listed, the Voltage Derating at Altitude table in AFSCP-800-27, Section I, shall be used.

2.2 Hot Spot Temperature versus Service Life. No contact shall carry sufficient current to cause a hot spot temperature which reduces the connector's expected service life less than that required for the application. The service life of a connector is dependent on the temperature rating of the insert, the contact resistance of the contacts, the current flowing through the contacts, and other environmental factors. The insert shall have a temperature rating which provides twice the service life of the system requirements (test and operational). The service life versus hot spot temperatures relationship shall be in accordance with Figure 300-1.

2.3 Aging Sensitivity. The shelf life of connector contacts as piece parts or as part of a connector assembly shall be twelve years minimum. Contacts and connector assemblies in storage for three years or more shall undergo visual examination for signs of deterioration prior to release for use. A minimum of 20 percent, but not less than three contacts of each connector, shall be examined. Any sign of contact deterioration which may affect mechanical or electrical performance shall require 100 percent screening or requalification.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of the applicable specifications and the requirements of this standard.

3.1.1 Electrical Connectors. The following criteria shall apply.

a. Electroless nickel plating is preferred in nonhermetic applications. Passivated stainless steel is preferred for hermetic applications.

b. Silver shall not be used as a contact overplate finish or as an underplate.

c. Cadmium or zinc plated connectors shall not be used.

d. All organic materials used in the manufacture of connectors, connector accessories, and protective caps shall have a total maximum loss (TML) of 1.0 percent of the original specimen mass and a maximum volatile condensable material (VCM) content of 0.1 percent of the original specimen mass per ASTM E 595-84.

e. Crimp rear release contacts are preferred for all multi-contact nonhermetic connectors. Solder contacts shall be limited to potted and hermetic applications.

f. Connectors that contain wire wrap contacts shall not be used unless approved by the contracting officer.

g. Flat cable headers shall not be used for external wiring purposes unless approved by the contracting officer.

3.1.2 Coaxial Connectors. Only SC series, TNC - type, and SMA - type connectors shall be used. The following criteria shall apply.

a. Only captivated contacts shall be used.

b. Right-angle connectors shall require contact termination of the cable center conductor.

c. Nickel, ferromagnetic, or ferrimagnetic materials shall not be used where intermodulation of signals would be a problem.

d. Plating or finish shall be gold or passivated stainless steel. When stainless steel is used, verification testing is required to ensure that any intermodulation of signals is acceptable.

3.2 Recommended Physical Configurations. Connectors on equipment enclosures to which typical wiring harnesses interface shall have physical configurations compliant with the physical configurations of the following:

a. MIL-C-24308 Revision B (rack and panel, rectangular)

b. MIL-C-83733 (rack and panel, rectangular)

c. MIL-C-38999 (circular, high density)

d. MIL-C-83723 Series III only (circular, environmental resisting)

e. MIL-C-5015 Series MS345X, Class L (rear release types)

f. MIL-C-55302 (printed circuit boards)

g. MIL-C-39012 (coaxial connectors)

h. MIL-C-39029 (contacts)

i. MIL-C-26482 (circular, minature, quick disconect, environment resisting)

j. NASA Marshall Space Flight Connectors MSFC 40M38277

k. NASA Marshall Space Flight Connectors MSFC 40M38298

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the applicable requirements in the applicable military specifications.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the applicable requirements in the applicable military specifications.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the applicable requirements in the applicable military specifications. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Qualification testing shall be in accordance with the applicable requirements in the applicable military specifications.

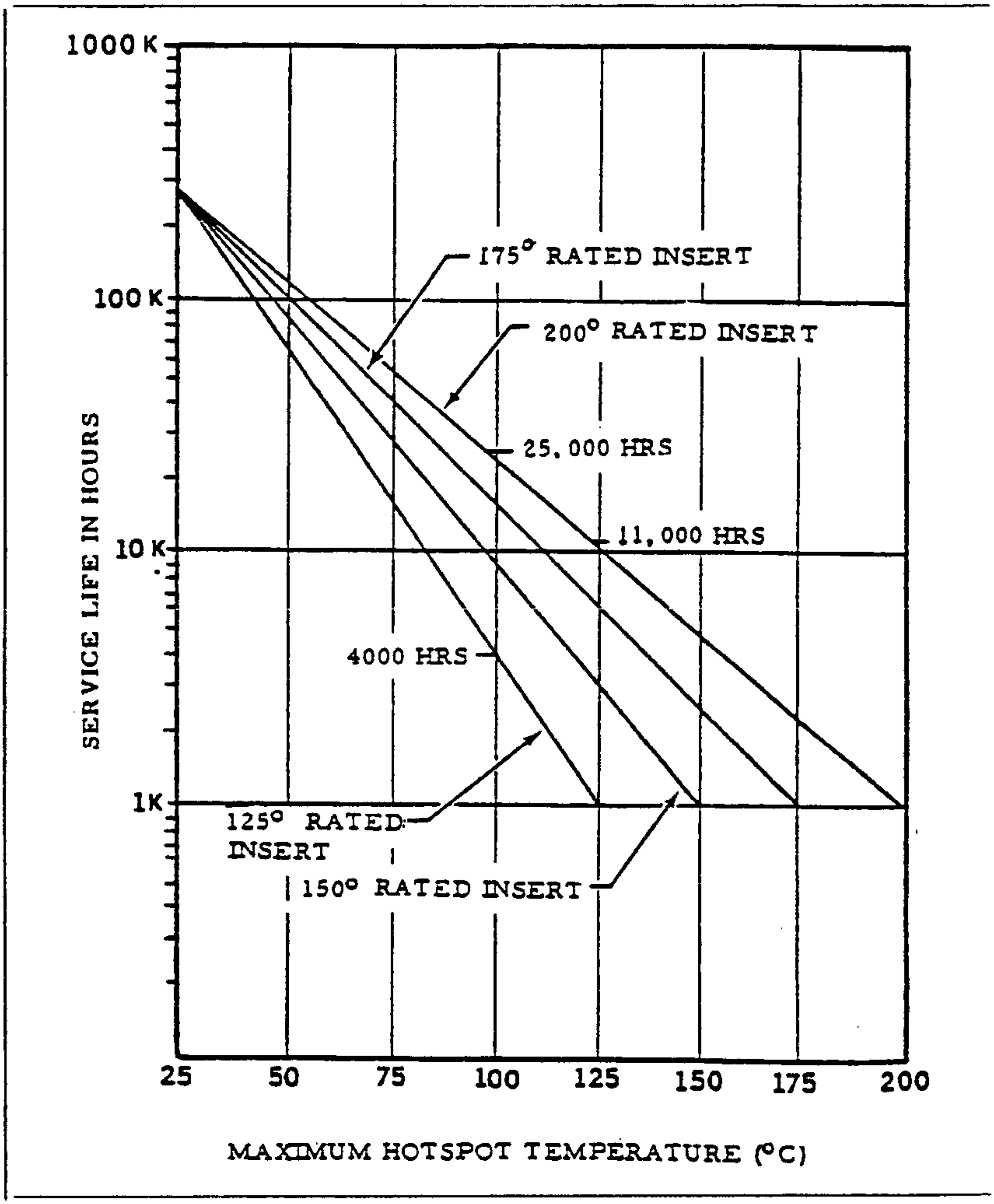

FIGURE 300-1. Maximum Hot Spot Temperature Versus Service Life

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SECTION 400

CRYSTALS
(MIL-C-3098)

1. SCOPE

This section sets forth detailed requirements for quartz crystal units.

2. APPLICATION

2.1 Power Derating. The power-derating factor for these crystals shall be 0.25 of the rated maximum input power (rated drive level) if the crystal cut permits this without frequency drift or start up problems. Drive requirements are generally related to the type of crystals used (cut, mode of operation, and geometry).

2.2 End-of-life Design Limits. None identified.

2.3 Electrical Considerations. Operation at high drive levels may cause degradation of normal aging characteristics, of spectral purity, and of short-term stability. Low drive levels shall be used where these parameters are critical.

2.4 Mounting. Handling and mounting precautions shall be taken to prevent seal damage or excessive mechanical shock or vibration to the crystal. Precautions shall be taken when trimming wire leads to minimize mechanical shock to the resonator. Plug-in type crystals shall not be used in space flight hardware.

2.5 Aging Sensitivity. Aging causes frequency shifts that shall be considered for each application.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-C-3098 and the requirements of this standard. The design of the crystal shall be such that the required frequency stability and drift can be maintained at a 0.25 drive factor (see 2.1 of this section).

3.1.1 Hermetic sealing. Only hermetically sealed crystals shall be used. Nonhermetically-sealed crystals may be used when the crystal filter manufacturer also manufacturers the crystal and provides for controlled transport of the crystal to the filter manufacturing area. In this instance, the filter shall be hermetically sealed. For individual crystal units, either cold-weld or resistance-weld enclosures shall be used.

3.1.2 Metallization. Metallization shall be selected to provide the necessary adhesion of the electrode contacts; e.g., the use of an undercoat such as chromium or tungsten prior to a gold electrode disposition on the quartz is necessary.

3.1.3 Crystal Support. The design and materials employed on the support mechanism for the crystal shall provide adequate reliability under the specified operating and environmental conditions. Crystals shall be supported by a minimum of three positions located about 120 degrees apart.

3.1.4 Type of Quartz. Use of cultured, premium Q quartz per EIA Standard RS-477 is recommended. For use in radiation environments, the quartz shall be electronically swept.

3.1.5 Solder. Solder sealing shall not be used. Cold or resistance welding shall be the package closure method used.

3.1.6 Gold. Gold shall be in accordance with MIL-G-45204.

3.2 Reliability Suspect Designs. Plug-in type crystals shall not be used in space flight hardware.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-C-3098 and the following.

4.1.1 Visual and Mechanical Examinations. A minimum 30X magnification inspection shall be used with the crystal being illuminated with a light source of at least 300 foot-candles intensity and a grazing angle of about 20 degrees. Units exhibiting one or more of the following anomalies shall be rejected.

a. Cracks or holes in the weld contact area where crystal support members are welded to the holder base terminal pins

b. Loose or broken terminal pins or crystal mounting supports

c. Cracks or separations in electrically conductive bonding cement between quartz crystal and support member

d. Fractures of any size and any location in the crystal quartz resonator; or cracked or flaked edges; or fractures, cracks, or peeling of the electrodes

e. Loose weld spatter, bonding cement, or other particulate matter greater than 0.001-inch in its largest dimension

f. Less than 0.005-inch clearance between quartz crystal and its mounting supports

g. Quartz crystal resonator not parallel or perpendicular to crystal holder base within 10 degrees

h. Joining of packages by interference, friction, crimping or similar methods unreinforced by welding.

i. Any surface, including cover, exhibiting contamination (adhering particulate, film, flux residue, or other type of material)

j. Non-uniform quantities of bonding cement at mounting points or bonding cement in areas other than mounting points

k. Adhering weld splatter exceeding 0.03-inch dimension through any plane. Weld splatter shall be considered adherent when it cannot be removed with a 20 psig gas blow of dry, oil-free nitrogen.

l. Base terminal and crystal mounting support exhibiting nicks, misalignment, cuts, cracks, or distortion

m. Quartz crystal not centered within ± 0.030 inch in its mounting with respect to the quartz crystal holder base

4.1.2 Motional capacitance. The motional capacitance, C_1, is defined in accordance with IEC-302. The load resonant frequency (F_R) is measured using two load capacitances connected successively in series with the crystal unit. The results obtained with two load capacitors C_{L1} and C_{L2} can be combined so that:

$$C_1 = \frac{2\,(\text{Delta } C_L)(\text{Delta } F_1)(\text{Delta } F_2)}{(F_R)(\text{Delta } F)}$$

where

C_1 = motional capacitance
Delta C_L = $C_{L2}-C_{L1}$
Delta F = $F_{L1}-F_{L2}$
Delta F_1 = $F_{L1}-F_R$
Delta F_2 = $F_{L2}-F_R$
F_R = load resonant frequency

It is necessary to maintain the current through the crystal unit constant to within 10 percent and the frequencies shall be corrected for temperature variations during the test, if necessary. The two load capacitors C_{L1} and C_{L2} shall be chosen such that Delta F, Delta F_1, and Delta F_2 are large enough with respect to the frequency resolution of the measurement system to deliver the required accuracy.

4.1.3 Quality Factor. The quality factor, Q, is defined by:

$$Q = \frac{1}{2(\text{pi})(F_R)(R_1)(C_1)}$$

where

C_1 = motional capacitance (above)
R_1 = measured value
F_R = load resonant frequency
pi = 3.14159

The quality factor, Q, shall be determined using the largest value of R_1 measured in the temperature range specified. R_L shall be calculated from R_1 using the following equation:

$$R_L = R_1\left(1 + \frac{C_o}{C_L}\right)$$

where

C_o = the crystal unit shunt capacitance
C_L = the load capacitor
R_1 = measured value

4.1.4 Controls. Necessary control measures shall be employed to ensure highly polished surfaces (optically transparent). Additionally, the following tests shall be conducted as required:

a. Fogging test (applicable to devices requiring stability greater than 1 parts per million).

b. Electrical tests for:

F_O (series and parallel resonant frequency)

R_1

C1, motional capacitance. C1 testing may be waived for oscillator circuits.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements listed in Table 400-1 and the following. In oscillators where overtones are used, some crystals may exhibit spurious frequencies caused by mode mixing or combinations of harmonic mixing at specific drive thresholds. A screen may be needed to locate spurious noise below a given drive threshold at specific temperatures. The resistance of any unwanted mode shall be measured in the same manner as the desired mode. The approximate frequency and resistance of any unwanted mode shall be determined first using a sweep transmission system.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the requirements listed in Table 400-2 and the following:

4.3.1 Lot Conformance Subgroup 1 Tests. Subgroup 1 tests shall be in accordance with the requirements of MIL-C-3098 and the following:

4.3.1.1 Solderability and Lead Attachments.

a. Wire-lead Terminals: MIL-STD-202, Method 208

b. Ceramic Package: If parallel-gap welding or thermocompression bonding is used, gold wires shall be attached using the specified method. Each wire or ribbon shall be subjected to Test Condition C, Method 2011, of MIL-STD-883. If soldering is specified, 0.25mm diameter (#30 B & S) copper wire shall be soldered to each terminal. Each wire shall be subjected to Test Condition A and Test Condition B of Method 2005 of MIL-STD-883.

4.3.1.2 Radiation Hardness. Total dose and any other specified radiation testing shall be performed to the specified system level requirements in accordance with appropriate sections of Method 1019 of MIL-STD-883. The crystal units shall be subjected to the specified radiation levels and dose rates. Within 75 minutes following radiation, the frequency and resistance shall be measured. When a neutron fluence is specified, the crystal units shall be subjected to the specified neutron fluence and the frequency shall be measured during irradiation. Proper accounting shall be given in the frequency change for other-than-neutron irradiation effects.

4.3.1.3 Terminal Strength. The appropriate method among those listed below shall be used.

4.3.1.3.1 Method A. Terminal Pull. Crystal units shall be tested in accordance with Method 211 of MIL-STD-202. The following details shall apply:

a. Test Condition: A

b. Applied force: 4 pounds for pin terminals and 2 pounds for wire terminals, applied to each terminal separately.

4.3.1.3.2 Method B. Wire-lead Bend. Applicable to crystal units with wire-lead terminals. Crystal units shall be tested in accordance with Method 211 of MIL-STD-202. The following details shall apply:

a. Test Condition: C

b. Applied load: 1 pound

4.3.1.3.3 Method C. Wire-lead Twist. Applicable to crystal units with wire-lead terminals. Crystal units shall be tested in accordance with Method 211, Test Condition D, of MIL-STD-202.

4.3.2 DPA A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Separate qualification tests are not required. Completion of lot conformance tests in accordance with the requirements listed in Table 400-2 also satisfies the qualification testing requirement.

TABLE 400-1. 100 Percent Screening Requirements for Quartz Crystals (Page 1 of 3)

MIL-C-3098 Screens	Additions and Exceptions to the Methods and Criteria of MIL-C-3098
Pre-Seal Visual Examination (Internal)	a. Paragraph 4.1.1 of this Section
Aging	a. Temperature: +85 deg C; 1000 hours minimum (Actual time shall be determined by program requirements; measure frequency three times weekly except daily during final 168 hours) b. Delta f/f equal or less than 10^{-6} c. Delta R less than 2 ohms or 5 percent
Accelerated Aging	a. Aging or accelerated aging per MIL-C-3098
Electrical Measurements	
Resonant frequency	a. Series and parallel
Resistance versus temperature	
Frequency versus static temperature	
Coupled modes (frequency versus temperature anomalies)	
Resistance nonlinearity	a. (Reduced drive level)

TABLE 400-1. 100 Percent Screening Requirements for Quartz Crystals (Page 2 of 3)

MIL-C-3098 Screens	Additions and Exceptions to the Methods and Criteria of MIL-C-3098
Shock	a. MIL-STD-202, Method 213, Test Condition C.
Vibration	a. 50 g peak 200 to 3,200 Hz b. Sweep rate 0.5 octave per min, one sweep along an axis in the plane of the resonator at an angle 45 deg relative to a line normal to the resonator supports. c. Delta f/f equal or less than 10^{-6} d. Delta R less than 2 ohms or 5 percent
Temperature Cycling	a. -55 deg to +125 deg C b. 10 cycles minimum c. Delta f/f equal or less than 10^{-6} d. Delta R less than 2 ohms or 5 percent
Temperature Run	a. -30 deg to +75 to +30 deg C b. Minimum drive 250 milliwatts, continuously monitor frequency and equivalent resistance (each plot to have a minimum resolution of 1 percent)
Insulation Resistance	a. MIL-STD-202, Method 302 b. 500 megohms minimum, at 50 volts c. Pin to pin, unground pins to case
Seal	a. MIL-STD-202, Method 112. Gross leak per Test Condition A, B, D, or E. Fine leak per Test Condition C, Procedure IIIa or IIIb. b. Leak Rate shall be less than 10^{-8}ATM cc/sec
Electrical Measurements	
Resonant frequency	a. Series and parallel
Resistance versus temperature	

TABLE 400-1. 100 Percent Screening Requirements for Quartz Crystals (Page 3 of 3)

MIL-C-3098 Screens	Additions and Exceptions to the Methods and Criteria of MIL-C-3098
Frequency versus static temperature	
Coupled modes (frequency versus temperature anomalies)	
Resistance nonlinearity	a. (Reduced drive level)
Unwanted Modes	See 4.2 this section.
Capacitance	
Capacitance, Shunt	a. MIL-STD-202, Method 306. Measure terminal to terminal with crystal holder ungrounded
Capacitance, Motional	a. Measure at frequency at which resonator shows no response. See 4.1.2 this section.
Quality Factor	See 4.1.3 this section.
Low Temperature Storage or Application	
Radiographic Inspection	a. Per MSFC-STD-355; 2 views 90 deg. apart by X-ray, or 360 deg. view by Vidicon. Use of "real-time" X-ray systems capable of viewing through 360 deg rotation is encouraged. b. No extraneous material greater than 0.001 inch in any dimension
Visual and Mechanical Examination	a. 10X magnification, minimum

TABLE 400-2. Lot Conformance Tests (Page 1 of 2)

MIL-C-3098 Screens	Additions and Exceptions to the Methods and Criteria of MIL-C-3098
Subgroup 1	In accordance with 4.3 of this section
Particle Impact Noise (PIND)	a. MIL-STD-202, Method 217 Detection
Terminal Pin Pull	a. Two specimens b. Two opposite supports pulled in tension; no pin fracture, bending, lifting, or separation
Subgroup 2	
Vibration	a. 100 g peak 200 to 3,200 Hz b. Sweep rate 0.5 octave per min, one sweep along an axis in the plane of the resonator at an angle 45 deg relative to a line normal to the resonator supports. c. Delta f/f equal or less than 10^{-6} d. Delta R less than 2 ohms or 5 percent
Acceleration	
Acceleration Sensitivity	
Acoustical Noise	
Thermal Shock	a. Thermal time constant b. Frequency overshoot c. Thermal frequency repeatability d. Thermal frequency hysteresis
Mechanical Shock	a. MIL-STD-202, Method 213, Test Condition C. F, 1500 g, 0.5 second shooks each direction b. Delta f/f equal or less than 10^{-6} c. Delta R less than 2 ohms or 5 percent
Temperature Cycling	a. -55 deg to +125 deg C b. 10 cycles minimum c. Delta f/f equal or less than 10^{-6} d. Delta R less than 2 ohms or 5 percent

TABLE 400-2. Lot Conformance Tests (Page 2 of 2)

MIL-C-3098 Screens	Additions and Exceptions to the Methods and Criteria of MIL-C-3098
Seal	a. MIL-STD-202, Method 112. Gross leak per Test Condition A, B, D, or E. Fine leak per Test Condition C, Procedure IIIa or IIIb. b. Leak rate shall be less than 10^{-8} ATM cubic centimeters per second
Frequency and Equivalent Resistance	
Capacitance	
Capacitance, Shunt	a. MIL-STD-202, Method 306. Measure terminal to terminal with crystal holder ungrounded
Capacitance, Motional	a. Measure at frequency at which resonator shows no response. See 4.1.2 this section.
Quality Factor	a. See 4.1.3 this section.
Unwanted Modes	a. See 4.2 this section.
Visual and Mechanical Examination	a. 10X magnification, minimum
<u>Subgroup 3</u>	
Moisture Resistance	
Salt spray	
Short-term Stability	
Aging	a. Temperature: +85 deg C; 2000 hours minimum (Actual time shall be determined by program requirements; measure frequency three times weekly except daily during final 168 hours) b. Delta f/f equal or less than 10^{-6} c. Delta R less than 2 ohms or 5 percent

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SECTION 500

DIODES

1. SCOPE

This section sets forth detailed requirements for the following types of diodes: (a) Light Emitting, (b) Rectifier, (c) Schottky Barrier, (d) Switching, (e) Varactor, (f) Voltage Reference, (g) Voltage Regulator, and (h) Photo.

2. APPLICATION

2.1 Derating. The derating of diodes shall be in accordance with AFSC Pamphlet 800-27, Level I, except as noted in Table 500-1.

TABLE 500-1. Derating Exceptions to AFSC Pamphlet 800-27 for Diodes

DIODE TYPE	PARAMETERS DERATED *	DERATING FACTOR
Axial Lead (all)	Reverse Voltage (factor times rated value) Surge Current (factor times rated value)	0.75 0.50
Rectifiers	Reverse Voltage (factor times rated value) Average Forward Current (factor times rated value) Surge Current (factor times rated value) Power (factor times rated value)	0.75 0.75 0.75 0.65
Transient Suppressor	Transient Current(factor times rated value) Power dissipation(factor times rated value)	0.75 0.75
Varactor	Power (factor times rated value) PIV (factor times rated value) Forward Current (factor times rated value)	0.50 0.75 0.75
Photo	Current (factor times rated value)	0.50

* The maximum junction temperature shall be +105 deg C nominal, +125 deg C worst case, for all diodes.

2.2 Tunnel, Gunn, or Impact Diodes. Adequate heat sinking shall be provided. Adjacent materials shall be analyzed to ensure thermal stability.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of the applicable specifications and the requirements of this standard. Devices shall be metallurgically bonded in solid glass encapsulation, where practicable. All plastic encapsulation shall not be used. Monometallic bonding shall be used. Unglassified semiconductors in which leads cross scribe lines with clearance of less than 0.002 inch shall not be used.

3.2 Reliability Suspect Designs. The following designs are reliability suspect:

a. Diodes in hot-welded cans
b. Nonglassivated semiconductor devices
c. Devices with gold-aluminum bonds
d. Point contact (whisker) diodes

3.3 Diodes in Hot-Welded Cans. A protective coating of internal elements shall be used, provided that adequate thermomechanical evaluation and qualification testing at the part level is performed to ensure that no potential failure mechanisms of a more undesirable type have been introduced into the device for that application.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the JAN S requirements of MIL-S-19500, and the following special in-process screens, tests, or precautions to be used when the identified construction or materials are used.

4.1.1 Glass Die Attach:

a. 100 percent mechanical shock

b. Sample: post shock die shear

4.1.2 Organic Materials. When organic materials are used on the surface of die:

a. 1000 hour burn-in

b. 100 percent "monitored" temperature sweep for bond intermittency

4.1.3 Mesa Construction:

a. Review process controls for assurance of clean surfaces

b. Verify at least 6000 angstroms of glass or oxide passivation over junctions

c. Perform HTRB in accordance with Method 1038, MIL-STD-750, Condition B. Measure I_R at 80 percent of V_{BR} before HTRB and within 16 hours of removal of voltage after HTRB. If the I_R = ± 10 percent of the maximum specified or ± 100 percent of the initial I_R value, whichever is larger, the device is a reject.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the JAN S requirements of MIL-S-19500, and the following:

4.2.1 Burn-in Test. The electrical tests and reject criteria in Figure 500-1 and Table 500-2 shall be used for the burn-in tests.

4.2.2 Diodes in Hot-Welded Cans.

a. Perform 100 percent mechanical shock test (such as MIL-STD-202, Method 213A, Condition F) of each lot followed by particle impact noise detection (PIND) screening per MIL-STD-750, Method 2052.

b. Conduct radiographic (X-ray or vidicon) inspection of each part after completion of screening requirements.

4.2.3 Nonglassivated Semiconductor Devices.

a. Perform 100 percent mechanical shock test (such as MIL-STD-202, Method 213A, Condition F) of each lot followed by particle impact noise detection (PIND) screening per MIL-STD-750, Method 2052. Subject devices to PIND tests until no failures are found on two successive sequences.

b. Conduct radiographic (X-ray or vidicon) inspection of each part after completion of screening requirements.

4.2.4 Nonmetallurgically Bonded Devices. 100 percent screening in accordance with the requirements for instability shock tests (FIST and BIST) per JAN S screening in MIL-S-19500.

4.2.5 Point Contact (Whisker/Schottky) Diode Requirements.

a. Perform 100 percent forward instability shock test (FIST) in accordance with MIL-STD-750, Method 2081. Subject each whisker-type diode to five shock pulses in each of two perpendicular planes at 1500g minimum (approximately 0.5 ms rise time). During shock test, monitor the forward dc voltage continuously on an oscilloscope. Any discontinuity, ringing, or shifting of the oscilloscope trace shall be cause for rejection.

b. Perform 100 percent backward instability vibration test (BIST) in accordance with Method 2082, MIL-STD-750. Subject each whisker-type diode to a vibration of 60 $\pm$ 3 Hz with 0.1 inch minimum displacement for a minimum period of 30 seconds in the X_1 and X_2 orientation planes. During vibration, monitor the reverse current vs voltage characteristics at the maximum reverse voltage on an oscilloscope swept at 60 Hz. Any discontinuity, ringing, flutter, drift, frame instabilities, or shifting of the oscilloscope trace shall be cause for rejection.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group B quality conformance tests for JAN S per MIL-S-19500, and the following:

4.3.1 Nonglassivated Semiconductor Devices.

b. Conduct radiographic (X-ray or vidicon) inspection of each part after completion of screening requirements.

c. Conduct DPA sampling of passed devices, inspect for particles.

4.3.2 Radiation Hardness Assurance. When radiation hardness is specified, wafer lot testing shall be accomplished in accordance with the Group D tests for JANS per MIL-S-19500, and Appendix C of this standard.

4.3.3 DPA. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Qualification testing shall be in accordance with the JAN S requirements of MIL-S-19500.

TABLE 500-2. Required Electrical Tests
(page 1 of 2)

RECTIFIERS

1. Forward voltage, V_F at rated I_F
2. Reverse current, I_R at +25 deg C and maximum rated operating temperature
3. Breakdown voltage, V_{BR} at specified I_R
4. Delta limits, Delta V_F and Delta I_R, after burn-in and after high temperature reverse bias (when applicable)

SWITCHING DIODES

1. Forward voltage, V_F at rated I_F
2. Reverse current, I_R at +25 deg C and maximum rated operating temperature
3. Breakdown voltage, V_{BR} at specified I_R
4. Capacitance C at specified voltage and frequency per MIL-STD-750, Method 4301
5. Delta limits, Delta V_F and Delta I_R, after burn-in and after high temperature reverse bias (when applicable)

VARACTOR

1. Forward voltage, V_F at rated I_F
2. Reverse current, I_R at +25 deg C and maximum rated operating temperature
3. Breakdown voltage, V_{BR} at specified I_R
4. Quality factor Q at specified voltage and frequency per MIL-STD-750, Method 4301
5. Delta limits, Delta V_F and Delta I_R, after burn-in and after high temperature reverse bias (when applicable)

TABLE 500-2. Required Electrical Tests
(page 2 of 2)

HOT CARRIER

1. Forward voltage, V_F at rated I_F and 1 mA dc
2. Reverse current, I_R at +25 deg C and maximum rated operating temperature
3. Reverse recovery time, t_{rr} per MIL-STD-750, Method 4031 at specified V_R, I_R load resistance, load capacitance
4. Capacitance C at specified voltage and frequency per MIL-STD-750, Method 4301
5. Delta limits, Delta V_F and Delta I_R, after burn-in and after high temperature reverse bias (when applicable)

REFERENCE

1. V_Z at I_Z, and Delta V_F after burn-in and after high temperature reverse bias (when applicable)
2. Z_Z
3. I_R at 80 percent of V_Z at 25 percent C
4. V_Z over temperature range to determine α V_Z

LIGHT EMITTING

1. V_F at I_F, and Delta V_F after burn-in and after high temperature reverse bias (when applicable)
2. P_O, and Delta P_O, after burn-in and after high temperature reverse bias (when applicable)

SECTION 600

EMI AND RF FILTERS (FS)
(MIL-F-28861)

1. SCOPES

This section sets forth detailed requirement for low-pass RF and EMI filters.

2. APPLICATIONS

2.1 Derating.

2.1.1 Voltage Derating. Filters shall not be used at more than 50 percent of their rated voltage at the specified temperature (derating factor of 0.50).

2.1.2 Current Derating. The dc current shall be limited to 75 percent of the maximum rated current at the specified temperature (derating factor of 0.75).

2.2 End-of Life Design Limits.

a. Capacitance: (ceramic capacitor designs) ± 20 percent of specification limits for BX dielectric

b. Insulation: Resistance: 50 percent of specification limit

2.3 Electrical Considerations. Under certain conditions, the current parameters of the filter are governed by the transient surge current (I_S). In order to determine whether a filter can withstand a known surge current, the following analysis shall be used. A filter shall not be exposed to a transient current that could damage the device.

a. Transient Current. With no load current flowing:

I_S = Surge current (amperes)
I_R = Rated DC current (amperes)
t_S = Duration of I_S (microseconds)

Then, if t_S multiplied by I_S is less than 1.4 I_R, the filter should not be damaged.

b. Rated Load Current. With rated load current I_R flowing:

Then, if t_S multiplied by I_S is less than $0.4\ I_R$, the filter should not be damaged.

2.4 Mounting.

2.4.1 Installation and Soldering. Installation and soldering shall be in accordance with Appendix A.

2.4.2 Stud Mounting. Stud mounted devices shall not have the mounting nut torqued more than the specified limit. Never hold the filter body (to keep it from turning when the nut is being tightened or loosened) unless the filter is expressly designed for this purpose. Only internal-style tooth lockwasher shall be used to cut through any mounting surface contamination and the lockwasher shall only be inserted between the filter and mounting surface and not between the nut and mounting surface.

2.4.3 Connecting Wires. When connecting wires to the device, always heat sink the filter stud lead.

2.5 Aging Sensitivity. Filters with ceramic disc capacitors using BX or X7R dielectrics can exhibit capacitance decreases of 2.0 to 4.0 percent per decade hour.

3. DESIGN AND CONSTRUCTION

Filters used for EMI are usually L, C, Pi, or T sections made up of toroidal wound inductors and capacitors or of simple feedthrough capacitors. Ceramic capacitors are used in most smaller EMI filters requiring low RF currents.

3.1 Requirements. Design and construction shall be in accordance with the Class S requirements of MIL-F-28861 and the requirements of this standard. Piece parts that are utilized in manufacturing the filters, such as magnetic devices, resistors and capacitors, shall also meet the applicable requirements of their sections in this document.

3.2 Reliability Suspect Designs

3.2.1 Parts. Filters using reliability suspect parts are reliability suspect.

3.2.2 Nonhermetically Sealed Filters. Filters without glass end seals are not hermetically sealed and are both subject to corrosion and may outgas significantly. Gold-plated parts with polymeric end seals are especially subject to moisture penetration and outgassing.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the Class S requirements of MIL-F-28861.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the Group A screening requirements of MIL-F-28861, Class S.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group B tests of MIL-F-28861, Class S requirements. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Qualification testing shall be in accordance with the Class S requirements of MIL-F-28861.

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SECTION 700

FUSES

1. SCOPE

This section sets forth detailed requirements for fixed, high reliability sealed fuses.

2. APPLICATION

Electrical overload protection, when required, is usually considered part of the electrical power control subsystem. When fuses are required, the current ratings of the fuses shall be determined at specified operating conditions. These conditions typically vary for each application and include:

a. Ambient temperature
b. Connections to the circuit
c. Ventilation
d. Vacuum

2.1 Derating. The current ratings of fuses shall be derated depending on the part type and usage. The following derating criteria shall be used:

a. Atmospheric. For atmospheric or nonvacuum conditions, for link type or similar fuses at +25 deg C, use a derating factor of 0.70.

b. Vacuum. For vacuum conditions, for fuses at +25 deg C, derate per Table 700-1. Smaller fuses require greater derating to compensate for loss of cooling due to long term leakage of air from hermetic devices (See Paragraph 3.1 below).

c. Temperature. Above +25 deg C, the derating factor decreases an additional 0.5 percent for each deg C above +25 deg C.

2.2 Electrical Considerations

2.2.1 Fuse Characteristics. Factors to be considered shall include the likely variation of fuse element resistance from fuse to fuse, deterioration of fuse rating resulting from repeated turn-on and turn-off of the fuse, other current surge characteristics, and maximum open circuit voltage tolerance.

TABLE 700-1 Fuse Derating in Vacuum at +25 deg C

Fuse Rating (Amps)	Derating Factor
2	0.50
1	0.45
1/2	0.40
3/8	0.35
1/4	0.30
1/8	0.25

2.2.2 Voltage. Fuses shall not be used in circuit applications when the open circuit voltage exceeds the maximum specified voltage rating for the fuse.

2.3 Mounting. Mounting environments including heat sinking shall be considered. For some miniature fuses, heat sinking is required during the soldering operation when the fuse is installed.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of the applicable specifications and the requirements of this standard. Designs shall be considered for space use only if they can be demonstrated to not alter current ratings more than 10 percent when used under vacuum (i.e., loss of pressure within fuses) or if hermeticity can be demonstrated to provide the above stability over a 10-year period in vacuum. (Extrapolations from leak rate measurements may be used.)

3.2 Reliability Suspect Design. Fuses requiring fuse holders.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-F-23419. Fuse element attachment shall be visually inspected on all items at 10X magnification minimum.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements listed in Table 700-2.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the quality conformance tests, Subgroups 1, 2, and 5 of Group C inspections, of MIL-F-23419.

4.3.1 DPA. A destructive physical analysis shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580. The destructive physical analysis samples may be from the Group IV qualification tests.

4.3.2 Vibration and Shock Test. For critical applications or where more predictable results in alien environments are required, a vibration and shock test shall also be performed as part of the lot conformance tests. The shock level shall be 500 ± 50 g for one-half second sinewave input, and the vibration level shall be per MIL-STD-202, Method 214, Condition IIK (monitor continuity during shock and vibration).

a. Measure resistance by current plots in excess of monitored display for elimination of unusual characteristics

b. Record parameters over various temperatures

c. Thermal vacuum testing

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-F-23419.

TABLE 700-2. 100 Percent Screening Requirements for Fuses

MIL-F-23419 Screens	Additions and Exceptions to the Methods and Criteria of MIL-F-23419
Thermal Shock	a. MIL-STD-202, Method 107, Condition B; during last cycle, monitor for continuity
Seal, Hermetic	a. MIL-STD-202, Method 112. Gross leak per Test Condition A, or equivalent b. Test may be waived if not applicable
Terminal Strength and DC Resistance	a. Simultaneous dc resistance measurement b. Test current used shall be 10 percent of rated value during strength measurement c. +25 deg C d. Resistance data within spec at all times during strength measurement
Burn-in	a. At +85 deg +0 deg - 3 deg C for 168 hours b. Rated DC voltage c. 50 percent rated DC current
DC Resistance	a. +25 deg C b. Test current used shall be 10 percent of rated value c. Resistance data within spec at all times d. Resistance data within ± 8 percent of initial reading at all times
Voltage Drop	a. Measurement taken with rated current b. Measurement taken after 5 minutes c. Accept fuses within ± 2 standard deviation of lot average
Visual and Mechanical Examination (External)	a. Marking and identification b. Defects and damage; i.e., body finish, lead finish, misalignment, cracks
Radiographic Inspection	a. Per MSFC-STD-355; 2 views 90 deg. apart by X-ray, or 360 deg. view by Vidicon. Use of "real-time" X-ray systems capable of viewing through 360 deg rotation is encouraged. b. Test may be waived except for ceramic and molded body devices

SECTION 800

MAGNETIC DEVICES (TRANSFORMERS, INDUCTORS, AND COILS) (MIL-STD-981)

1. SCOPE

This section sets forth detailed requirements for transformers, inductors, and coils.

2. APPLICATION

2.1 Derating.

2.1.1 Temperature Derating. The maximum operating temperature of the device shall be a minimum of +30 deg C lower than the insulation class temperature of the lowest temperature insulation material used in the device. The maximum operating temperature is the same as the allowable hot-spot temperature which is defined as the sum of the ambient temperature and the device temperature rise.

2.1.2 Voltage Derating. Maximum winding-to-winding and winding-to-case voltages shall be derated to a factor of 0.50 of the minimum rated wire insulation voltage.

2.2 End-of-life Design Limits. The operational life of a magnetic device is limited by the various temperatures to which the insulation may be exposed. For organic insulating materials, the design service life shall be reduced 50 percent for each 10 deg C increase in hot-spot temperature.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of the applicable specifications and the requirements of this standard.

3.1.1 Applicable Specifications. The applicable specifications are:

a. MIL-T-27 for Audio, Power, and High-Power Pulse Transformers and Inductors

b. MIL-T-21038 for Low-Power Pulse Transformers

c. MIL-C-15305 and MIL-C-39010 for Fixed and Variable, Radio Frequency Coils

d. MIL-STD-981 for all Custom Magnetic Devices:

3.1.2 Wire Size. Minimum magnetic wire size shall be as defined for Class S parts in Table I of MIL-STD-981, except that for devices rated at 200 volts or higher the minimum wire size shall be AWG size #36.

3.2 Reliability Suspect Design. Variable inductors or variable coils.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the Class S requirements of MIL-STD-981.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the Class S requirements of MIL-STD-981.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Class S requirements of MIL-STD-981. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Separate qualification tests are not required. Completion of lot conformance tests as specified in Paragraph 4.3 of this section satisfies the qualification testing requirement.

SECTION 900

MICROCIRCUITS

1. SCOPE

This section sets forth detailed requirements for monolithic microcircuits (integrated circuits).

2. APPLICATION

2.1 Derating. Derating shall be in accordance with Table 900-1, Table 900-2, and Table 900-3, as applicable.

TABLE 900-1. Derating Guidelines for Digital Microcircuits

Parameter	Derating Factor Nominal	Derating Factor Worst Case
Output load current (total) (1)	0.80	0.90
V_{CC} specified nominal supply voltage	1.1 V_{CC}	1.1 V_{CC}
Transients (2)	1.2 V_{CC}	1.2 V_{CC}
Propagation delay	110 percent	
Fanout	(3)	(3)
Power dissipation, P_D	0.80	0.90
Junction or "hot-spot" temperature, maximum	+105 deg C	+125 deg C
Supply voltage for CMOS	0.70	0.80

NOTES:
(1) Not applicable to single fanout devices.
(2) Transient peaks shall not exceed the specified value.
(3) Derate by one load or to 80 percent of maximum rating (whichever is greater), except where fanout is rated as one.

TABLE 900-2. Derating Guidelines for Linear Microcircuits

Parameter	Derating Factor Nominal	Derating Factor Worst Case
Input signal voltage	0.70	0.80
Output current	0.75	0.85
*Operating frequency (application)	0.75	0.85
Transients (2)	$1.20V_S$	$1.40V_S$
*Gain (application)	0.75	0.85
Power dissipation, P_D	0.75	0.85
Junction or "hot-spot" temperature, maximum	+105 deg C	+125 deg C

NOTES:
(2) Transient peaks shall not exceed the specified value.

TABLE 900-3. Derating Guidelines for Voltage Regulator Microcircuits

Parameter	Derating Factor Nominal	Derating Factor Worst Case
Input current	0.80	0.90
Input voltage	0.80	0.85
Output current	0.75	0.85
Power dissipation, P_D	0.75	0.85
Junction or "hot-spot" temperature, maximum	+105 deg C	+125 deg C

2.2 Power Dissipation. Power dissipation shall be calculated as follows:

For digital logic device application

$$P_D = \frac{I_{CCL} + I_{CCH}}{2} \times V_{CC} + I_{OL} \times V_{OL} + CV^2F$$

where:

C is the load capacitance.

V is the voltage swing on load capacitance.

F is output frequency.

P_D is the actual power dissipated in the circuit application and is the product of the actual measured or calculated voltage and current.

I_{CCL} is the actual supply current drain with inputs in logic "L" state.

I_{CCH} is the actual supply current drain with inputs in logic "H" state.

V_{CC} is the actual power supply voltage.

I_{OL} is the actual output logic "L" state sink current.

V_{OL} is the actual logic "L" state output voltage.

If $(I_{OH} \times V_{OH}) = (I_{OL} \times V_{OL})$ in the equation for P_D, substitute $(I_{OH} \times V_{OH})$ for $(I_{OL} \times V_{OL})$.

I_{OH} is the actual logic "H" stated sink current.

V_{OH} is the actual logic "H" stated output voltage.

For linear device application

$$P_D = V_S^+ \times I_{SS}^+ + V_S^- \times I_{SS}^-$$

where:

V_S is the actual supply voltage (±).
I_{SS} is the actual supply current (±).

2.3 Electrical Considerations. The circuit design shall make allowances for the worst case variations in output voltage or current, and propagation delays.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-M-38510, Class S, and the requirements of this standard. The manufacture of microcircuits on a JAN Class S certified line is encouraged. The guidance provided in MIL-HDBK-339 for custom LSICs should be used to the extent applicable in establishing the requirements for the upgrading process of a specific microcircuit to meet space system requirements. In general, additional screens should be provided as part of the upgrading process based on requirements and test features. Test chips and internal test nodes shall be used where practicable. Independent monitoring of the manufacturing process shall be imposed to help assure product quality.

3.2 Marking. Each microcircuit package shall be marked, where space permits, to include:

a. Orientation mark (NOTE: Device orientation may be designated by a tab or notch in lieu of marking.)

b. Manufacturer's identification

c. Manufacturer's (generic) part number

d. Inspection lot identification code (NOTE: See Paragraph 3.6.3 of MIL-M-38510)

e. Serial number

f. Radiation hardness assurance designator

g. Electrostatic discharge sensitivity per MIL-M-38510

h. Contractors part number

i. Country of origin

3.3 Reliability Suspect Designs. Reliability suspect designs are:

a. Hot welded cases

b. Nonglassivated devices

c. Packages that do not conform to those specified in Appendix C of MIL-M-38510

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the Class S requirements of MIL-M-38510.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the Class S requirements of MIL-M-38510. The interim and post burn-in screening electrical test and reject criteria shall be in accordance with Table 900-4.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group A, Group B, and Group D test requirements for Class S in MIL-M-38510. The Group D tests shall be performed on the initial production lot and on six-month intervals during production of the product.

4.3.1 Radiation Hardness Assurance. When radiation hardness is specified, wafer lot testing shall be accomplished in accordance with the Group E tests for Class S per MIL-M-38510, and Appendix C of this standard.

4.3.2 DPA. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Qualification testing requirements are incorporated in the lot conformance tests so separate qualification tests are not required.

TABLE 900-4. Interim Pre Burn-In and Post Burn-In Screening Electrical Test and Reject Criteria

AMPLIFIER	COMPARATOR	DIGITAL			
X	X		I_{IB},	I_{IB}	± 10 percent
X	X		I_{IO},	I_{IO}	± 10 percent
X	X		V_{IO},	V_{IO}	± 20 percent
		X	V_{OH},	V_{OH}	± 5 percent
		X	V_{OL},	V_{OL}	± 10 percent
		X	I_{IH},	I_{IH}	± 10 percent
		X	I_{IL},	I_{IL}	± 10 percent
X			P_D		
X			CMR		
X			PSRR		
X			Gain		
X			Gain		

SECTION 910

CUSTOM LARGE SCALE INTEGRATED CIRCUITS

1. SCOPE

This section sets forth detailed requirements for custom large scale integrated circuits (LSICs) which have complexities greater than 100 gates. A custom LSIC is one that is designed and fabricated for a specific application.

2. APPLICATION

The "custom" in custom LSICs means that at least some features may be unique and lack successful production or usage experience. This lack of maturity is normally the major problem to be evaluated with regard to the use of a custom LSIC. The selection and evaluation of custom LSICs for space applications shall be in accordance with the guidance provided in MIL-HDBK-339.

2.1 Derating. Same as in Section 900 (Table 900-1, Table 900-2, and Table 900-3, as applicable).

2.2 Electrical Considerations. The circuit design shall make allowances for the worst case variations in output voltage or current, and propagation delays.

3. DESIGN AND CONSTRUCTION

Design and construction shall be in accordance with the baseline requirements of MIL-HDBK-339, Appendix C. In addition, the guidance provided by MIL-HDBK-339 shall be used in establishing other requirements and procedures that may be applicable to a specific device. These include such items as the testability requirements, application of test chips and test structures, radiation hardness requirements, and design and process controls applicable to a specific custom LSIC.

Each custom device wafer shall contain two or more test chips located in positions on the wafer in lieu of active circuits. The test chips shall be located approximately two-thirds of the distance from the center to the edge of the wafer on opposite sides of the center. The test chips shall contain, as a minimum, test structures for evaluating the following:

a. Basic electrical parameters

b. Dielectric strength of each dielectric layer

c. Stability of each dielectric layer under bias-temperature stress

d. Junction and device breakdown voltages

e. Pinholes

f. Step coverage of metal and other conductors over multilayers (if used) and contacts

g. Resistance of diffusions or implants (after activation)

h. Contact integrity

i. Standard cell and other circuit features

j. Control of etched line widths, gaps, and contact openings

k. Metallization and dielectric thicknesses

l. Thermal stability (CV plots)

m. Radiation hardness

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4, the baseline quality assurance provisions of MIL-HDBK-339, Appendix C, and the following:

Other detailed quality assurance requirement and procedures applicable to a specific custom LSIC shall be established based on the documentation resulting from the designer capability audit, from the manufacturer capability audit, and from the product evaluations. The audits and product evaluations shall be in accordance with the descriptions and baseline requirements of MIL-HDBK-339.

4.1 In-process Controls.

4.1.1 Parts, Materials, and Process Controls. Parts, materials, and process controls shall be in accordance with the baseline requirements of MIL-HDBK-339, Appendix C.

4.1.2 Test Chips. Specific tests and limits shall be specified for the test chips from each wafer to assure process control and reliability.

4.1.3 Nichrome PROMS. The following requirements are applicable to Nichrome PROMs:

a. Nichrome PROMs shall have less than 500 parts per million water content at 100 deg C as a condition for Group B testing in Table IIa, Method 5005, MIL-STD-883. This is required for packages with or without desiccants.

b. Burn-in shall be conducted after programming. The burn-in PDA shall be five percent.

c. One pulse per fuse is used.

4.1.4 EPROMS and EAROM. EPROMs and EAROMs shall be burned in after initial programming.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the baseline requirements of MIL-HDBK-339, Appendix C.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the baseline lot conformance test requirements of MIL-HDBK-339, Appendix C.

4.4 Qualification Tests. Qualification testing shall be in accordance with the baseline qualification testing requirements of MIL-HDBK-339, Appendix C.

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SECTION 940

MICROCIRCUIT CHIPS FOR HYBRIDS

1. SCOPE

This section sets forth the detailed requirements for microcircuit chips to be employed as an integral part of hybrid microcircuits.

2. APPLICATION

2.1 Derating. Same as in Section 900 (Table 900-1, Table 900-2, and Table 900-3, as applicable).

2.2 Alternative Derating. When system performance requirements cannot be satisfied with the derating criteria in Section 900 (Table 900-1, Table 900-2, and Table 900-3, as applicable), alternative derating shall be employed using the following constraints:

a. Alternative deratings shall apply to power dissipation, output current, fanout, and propagation delay.

b. Control of junction temperatures below the limits stated in Section 900 (Table 900-1, Table 900-2, and Table 900-3, as applicable) shall be required.

c. Verification of θ_{jc} during fabrication, inspection, or by DPA for each microcircuit lot shall be required.

d. Control of case temperatures in the printed circuit board assemblies shall be required.

Use of alternative derating criteria requires the approval of the contracting officer.

2.3 Electrical Considerations. The circuit design shall make allowances for the worst case variation of the I_{OL}, I_{OH}, propagation delay, gain, offset voltage, and bias current.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-M-38510, Class S, and the requirements of this standard. The manufacture of microcircuit chips on a JAN Class S certified line is encouraged. The guidance provided in MIL-HDBK-339 for custom

LSICs should be used to the extent applicable in establishing the requirements for the upgrading process of a specific microcircuit chips to meet space system requirements. In general, additional screens should be provided as part of the upgrading process based on requirements and test features. Test chips and internal test nodes shall be used where practicable. Independent monitoring of the manufacturing process shall be imposed to help assure product quality.

3.2 Reliability Suspect Designs. None identified.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of Appendix A of MIL-M-38510, Class S.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements of MIL-M-38510, Appendix G, Class S for hybrid elements. The electrical tests and reject criteria are given in Table 900-4. Parameters to be tested shall be in accordance with MIL-STD-1331.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group A, Group B, and Group D test requirements of MIL-M-38510, Class S. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-M-38510, Class S.

SECTION 960

HYBRIDS

1. SCOPE

This section sets forth detailed requirements for hybrid microcircuits.

2. APPLICATION

2.1 Derating. Derating shall be in accordance with the derating requirements for each element of the hybrid microcircuit. See Section 900 (Table 900-1, Table 900-2, and Table 900-3, as applicable).

2.2 End-of-life Design Limits. Per program requirements

2.3 Electrical Considerations. None identified

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-M-38510, Appendix G, Class S, and the requirements of this standard. Particle getters may be used only when approved by the contracting officer. Electronic parts that are utilized in manufacturing the hybrids, such as diodes, transistors, and capacitors, shall also meet the applicable requirements stated in their sections of this document. Cerdip or Cerpack packages shall not be used.

3.2 Reliability Suspect Designs. All.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the Class S requirements of Appendix G of MIL-M-38510.

4.2 Screening (100 Percent). Screening requirements shall be in accordance with MIL-M-38510, Appendix G, Class S.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group A, Group B, and Group D test requirements for Class S in Appendix G of MIL-M-38510. The Group D tests shall be performed on the initial production lot and on six-month intervals during production of the product. A

DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Qualification testing requirements are incorporated in the lot conformance tests so separate qualification tests are not required.

SECTION 1000

RELAYS (CURRENT RATING OF 25 AMPERES OR LESS)

1. SCOPE

This section sets forth detailed requirements for electromechanical relays with current rating of 25 amperes or less.

2. APPLICATION

Selection and application of relays shall be in accordance with MIL-STD-1346 and the requirements contained herein.

2.1 Capacitive Load. Series resistance shall be used with any capacitive load to ensure that currents do not exceed derated levels for resistive loads.

2.2 Suppression Diodes. Internal diodes are recommended for coil suppression. If coil suppression is used, a double diode configuration is preferred, wherein one diode suppresses reverse transients to two times the nominal coil voltage and the second diode provides reverse polarity protection for the primary diode.

2.3 Coil Voltage. The following caution is specified by both MIL-R-6106 and MIL-R-39016:

CAUTION: The use of any coil voltage less than the rated voltage compromises the operation of the relay.

Therefore, normal coil operating voltage should be 100 ± 5 percent of nominal rated value and should not exceed (worst case) 90 percent of the maximum rated coil voltage at +125 deg C.

2.4 Loads. If relay usage is at low or intermediate loads relative to the rated load for the relay, the relay shall also be qualified at the reduced (usage) load.

2.5 Derating.

2.5.1 Contact Current Derating. Contact current derating shall be based on the contact load type in accordance with Table 1000-1, and the operating life of relay. Inrush currents in excess of the rated resistive load may be permitted with a corresponding reduction in life when the following criteria are met:

a. The relay has been qualified to withstand an inrush of "X" times the rated resistive load for "Y" number of cycles.

b. Lot-by-lot conformance tests are performed to verify continued compliance.

c. The actual application shall not require more than an inrush of "X" times the rated resistive load for 50 percent the specified "Y" number of cycles.

TABLE 1000-1 Contact Current Derating.

Contact Load Type	Derating Factor from Rated Resistive Load
Resistive	0.75
Inductive	0.40
Motor	0.20
Filament	0.10
Capacitive	(See 2.1)

2.5.2 Specification Provided Rated Values. When the detail specification provides "rated values" not only for resistive loads, but also for inductive, motor, and lamp loads, the derating factor shall be 0.75. For example, the inductive load shall be derated to 0.75 times the "rated inductive load" provided in the detail specification.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of the applicable specifications and the requirements of this standard. Applicable specifications typically are MIL-R-5757, MIL-R-6106, and MIL-R-39016.

3.1.1 Electronic Parts. Electronic parts that are utilized in manufacturing the relays, such as diodes, transistors, capacitors, and hybrids, shall also meet the applicable requirements stated in their sections of this document.

3.1.2 Critical Processes. The manufacturer shall document the manufacturing flow including the processes and procedures that have critical effect on the fabrication, function, reliability, or service life of the article. As a minimum, these shall include raw material certification and property sample tests, coil assembly, carrier assembly, contact assembly, armature assembly, coil core and pole piece assembly, motor assembly, relay subassembly prior to closure, and final assembly and closure. Inspections and tests associated with each process and assembly operation shall be included in the processes. As a minimum, the following items are considered critical materials: coil assembly, carrier assembly, contact assembly (contacts), armature assembly, coil core, pole piece assembly, motor assembly, wires, and header.

3.1.3 Magnet Wire. Coil wire shall be 44 AWG or larger and use a polyimide (or equivalent) insulation. Wire sizes smaller than 44 AWG require approval of the contracting officer.

3.1.4 Final Assembly. Relays shall be assembled in a Class 100 or cleaner area. After pre-can visual inspections have been completed, the relay can shall be placed on the relay, and the relay sealed (canned) while in the Class 100 or cleaner area. If after pre-can visual inspections have been completed, but prior to sealing, the covers are removed for any reason, pre-can visual inspections shall be repeated. If subassemblies or unsealed relays are removed from the Class 100 clean area for any reason, covers or other provisions shall used to maintain cleanliness. The relays may be remagnetized and stabilized, if applicable.

3.2 Reliability Suspect Designs.

a. Materials that outgas or cause contamination

b. External suppression diodes (instead of internal)

c. Use of silicone, adjunct sealants, or dielectric improvement processes on any external portion of the relay, unless approved by the contracting officer

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of the applicable military specification, and the following:

4.1.1 Vacuum Bake. Relay coil assemblies shall be vacuum baked to ensure no coil outgassing that could cause a film buildup on the contacts that would increase contact resistance.

4.1.2 General Method of Inspection

4.1.2.1 Visual and Mechanical Examinations. A visual examination shall be performed in a Class 100 environment per FED-STD-209 on 100 percent of the relays prior to final cleaning and assembly in the can. The examination shall be performed using a 10-power microscope (or as otherwise specified) except when an abnormality is suggested in a area where greater magnification is required to verify product integrity (20X maximum), or as specified in this procedure. All parts not under immediate inspection shall be stored in covered trays and returned to covered trays immediately after inspection.

4.1.2.2 Initial Inspection. Visually examine the following areas:

a. Contact assembly, contact surfaces, stationary and movable contacts, springs

b. Coil, pole piece, armature, header

4.1.2.3 Final Examination for Contamination. Upon completion of the initial inspection, the entire relay assembly shall be inspected. Any particulate contamination visible at 20X magnification is cause for rejection. During this inspection, the relay shall be rotated in various orientations to utilize all available lighting.

4.1.3 Detailed Explanation of Inspection

4.1.3.1 Moving Contact Assembly and Springs. Inspect the moving contact assembly for proper installation and position. The springs shall clear all adjacent parts for both positions of the armature. Inspect support brackets for the moving contact assembly for cracks and loose fractures (20X).

4.1.3.2 Contact Surfaces (Fixed and Movable). Inspect surfaces for scratches or burrs in contact mating area and cracked or peeling plating. Inspect mating contact surfaces for proper alignment for both positions of the armature.

a. Contact area for fibrous and other contaminants (20X)

b. Underside of contact supports for tool marks (20X)

c. Contact terminals for weld splatter (20X)

4.1.3.3 Coil Inspection. Inspect coil for the following:

a. Poor coil lead welds; inspect for evidence of weld on each coil lead wire, followed by probing weld area to verify that each coil lead wire is attached to the terminal

b. Weld splatter at coil terminals (20X)

c. Proper lead coil dress; ensure clearance to all moving and conductive surfaces (Coil leads shall not be kinked and shall not be stretched tight from coil to coil lead post (10X).)

d. Nicks in the coil wire due to the stripping of the insulation (20X)

e. Coil assembly for loose or frayed teflon insulation

4.1.3.4 Armature and Pole Piece. Inspect armature and pole piece gap for weld splatter and contamination (20X).

4.1.3.5 Header. Inspect header (10X) for the following:

a. Unacceptable tool marks

b. Glass seals

c. Weld splatter

d. Cracked or peeling plating

e. Proper alignment of header and frame

4.1.3.6 Inspection Criteria

4.1.3.6.1 Weld Splatter. Weld splatter or weld expulsion balls observed under 20X magnification shall be acceptable if capable of withstanding a probing force of 150 grams applied using an approved force gage calibrated for a range of 125 to 150 grams pressure force. User may apply a maximum force of 125 grams during pre-cap. Each suspect weld may be probed one time only by the user during pre-cap.

4.1.3.6.2 Scratches. Scratches or tool marks wholly below the surface of the metal are acceptable. Burrs protruding above the surface are not acceptable.

4.1.3.6.3 Cracks. Cracks in the header pin glass seals are not acceptable, if the crack extends from the pin or outer edge more than one-third the radius of the seal. This criterion is not applicable to glass seals less than 0.1 inch diameter.

4.1.3.6.4 Teflon. Teflon strands that are an integral part and extension of the teflon coil wrap or coil lead insulation are acceptable, unless they are of sufficient length or location that they can interfere with the normal actuation and operation of the relay.

4.1.4 Cleaning. Cleaning shall be performed in a Class 100 environment per FED-STD-209. Relays with permanent magnets shall be demagnetized, if they can be remagnetized and stabilized after canning. The relays shall be demagnetized using a Thomas and Skinner Model DM 35 or equivalent equipment.

4.1.4.1 Ultrasonic Cleaning. Ultrasonically clean relay trays and covers. Clean a sufficient quantity of trays and covers for storage and transport of relays, cans, and other parts for the remainder of required cleaning. Store in Class 100 environment per FED-STD-209. Ultrasonically clean relays, cans, and any other parts and subassemblies that constitute the final assembly. Immediately after cleaning, store the parts in covered trays in a Class 100 environment per FED-STD-209.

4.1.4.2 Vacuum Cleaning. Vacuum parts at the laminar flow bench. Using a pressure gun and filtered air flowing through a static eliminator, blow filtered air on the parts, holding the parts in front of a vacuum inlet to trap loosened particles. Immediately store cleaned parts in clean covered trays.

4.1.4.3 Cleaning and Small Particle Pre-seal Inspection. Test relays, cans, and any other parts or subassemblies that constitute the final assaembly using the following procedure, or a procedure approved by the contracting officer. First obtain freon from a pre-filtered supply. Assembly pre-cleaned 1000 milliliter flask, vacuum pump, filter holder, pre-cleaned 0.80 micrometer filter, and pre-cleaned funnel. Fill funnel with pre-filtered freon and turn vacuum pump on. Repeat until flask is filled. Fill a pressurized container with cleaned freon. Clean filter by blowing both surfaces with ionized air. Using the pressurized container, wash both sides of the filter with clean filtered freon. Observe filter under 30X magnification; if any particles 2.5 micrometers (0.001 inches) or larger, or visable particles under 2.5 micrometers (0.001 inches) are observed, repeat the cleaning process until satisfactory results are obtained. Place the filter holder and cleaned filter on a clean empty 1000 milliliter flask under funnel. Air blow all parts to be millipore-cleaned using ionized air. Place parts in funnel. Using 1000 milliliter flask of filtered freon, pour the freon into the funnel, covering the parts to be cleaned. Cover funnel. Turn on vacuum pump. When all the freon has passed through the filter, turn off vacuum pumps. Remove filter and examine under 30X magnification. If one or more particles 2.5 micrometers (0.001 inches) or larger are present, or three or more visable particles under 2.5 micrometers (0.001 inches) are present on the filter, repeat the process until this condition is corrected. Place cleaned parts in cleaned covered trays in preparation for canning the relays.

4.2 Screening (100 percent). Screening (100 percent) of MIL-R-39016 type relays shall be in accordance with the "M" level of the Group A inspections in MIL-R-39016, with the addition and exceptions in Table 1000-2. Screening (100 percent) of MIL-R-6106 type relays shall be in accordance with the ER requirements of the Group A inspections in MIL-R-6106 with the additions and exceptions in Table 1000-2. Screening (100 percent) of other type relays shall be in accordance with Table 1000-2.

4.2.1 Vibration Miss Test. For those relays in which the noise signature is high, and the Particle Impact Noise Detection (PIND) test may not detect particles, a Vibration Miss Test shall be used in place of the PIND test. The Vibration Miss Test requirements are:

a. Vibrate relay with a 10 g peak sine wave at a fixed frequency of 10 Hz for 3 minutes.

b. Axis of vibration shall be perpendicular to the motion of the contacts.

c. Relay shall be operated at 9.9 Hz

d. All contacts shall be monitored for any misses.

e. Relays with misses shall be rejected and removed from the production lot

4.2.2 Electrical Characteristics. The following electrical characteristics shall be determined in accordance with the requirements in MIL-R-39016:

a. Contact Resistance

b. Operate Voltage

c. Release Voltage

d. Hold Voltage

e. Operate and Release Times

f. Contact Bounce

g. Coil Resistance

h. Transient Suppression

i. Reverse Polarity Protection

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group B tests in MIL-R-39016 with the following additions:

a. Random vibration and shock shall conform to the requirements of the specific application.

b. Resistance to solder heat shall be per MIL-R-39016.

c. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580. During DPA, verify no contamination larger than 1 mil and that correct material and workmanship to the manufacturer's detail requirements were used to fabricate the relays.

d. Life testing shall be performed to system level requirements.

e. Internal moisture shall be determined per MIL-R-6106.

4.4 Qualification Tests. Not required.

TABLE 1000-2. 100 Percent Screening Requirements
(Page 1 of 2)

MIL-R-39016 Screens	Additions and Exceptions to the Methods and Criteria of MIL-R-39016
Vibration (Sine)	
Vibration (Random)	a. MIL-STD-202, Method 214, Test Condition II, K (to the requirements of the application) b. 3 orthogonal planes, 3 minutes c. Mounting fixture shall not add or remove energy from relay under test d. Monitored for contact chatter, 10 microseconds maximum per MIL-STD-202, Method 310, Circuit B e. No contact transfer (monitor equipment shall be capable of detecting closures greater than 1 microsecond) f. Energize nonlatch relays during half test time and de-energize during other half g. Latching relays shall be latched in one position for half the test and latched in the other position for the other half (coils de-energized)
Thermal Shock	a. Per MIL-R-6106, Group A, operational reliability requirements b. Five thermal shocks c. Record pickup and dropout voltage d. For relays with coil gauge wire of AWG 44 or smaller, continually monitor coil continuity with 350 microamperes (maximum current) during last temperature cycle e. Miss Test during fifth cycle of thermal shock
Particle Impact Noise (PIND)	a. See requirement in paragraph 4.2.1 of this standard for the Vibration Miss Test b. MIL-STD-202, Method 217 Detection c. If 2 percent of the lot fails, PIND testing may cease; if more than 2 percent fails, the lot shall be retested.

TABLE 1000-2. 100 Percent Screening Requirements
(Continued, Page 2 of 2)

MIL-R-39016 Screens	Additions and Exceptions to the Methods and Criteria of MIL-R-39016
Electrical Characteristics	a. See requirements in paragraph 4.2.2 of this standard
Neutral Screen	
Insulation Resistance	
Dielectric Withstanding-Voltage	a. Sea Level Only
Radiographic Inspection	a. Per MSFC-STD-355; 2 views 90 deg. apart by X-ray, or 360 deg. view by Vidicon. Use of "real-time" X-ray systems capable of viewing through 360 deg rotation is encouraged.
Seal	a. Per MIL-R-6106
Visual and Mechanical Examination (External)	a. Per MIL-R-6106 or MIL-R-39016 (as applicable)

SECTION 1100

RESISTORS

1. SCOPE

This section sets forth detailed requirements for resistors and thermistors. Table 1100-1 lists the types covered and indicates the applicable section in this standard where detailed requirements are set forth.

TABLE 1100-1. Resistor Types

Section Number	Resistor Type	Specification	Style
1120	Fixed Film	MIL-R-39017	RLR
1125	Fixed Film Resistor Chips	MIL-R-55342	RM
1130	Fixed Film	MIL-R-55182	RNC
1140	Variable, Nonwire-wound (Adjustment Type)	MIL-R-39035	RJR
1150	Variable Wire-Wound (Lead Screw-actuated)	MIL-R-39015	RTR
1160	Fixed, Wire-Wound (Accurate)	MIL-R-39005	RBR
1170	Fixed, Wire-Wound (Power Type)	MIL-R-39007	RWR
1180	Fixed, Wire-Wound (Power Type, Chassis-mounted)	MIL-R-39009	RER
1190	Resistance Network	MIL-R-83401	RZ
1195	Thermistor	MIL-T-23648	RTH

2. APPLICATION

Use of resistors shall be in accordance with MIL-STD-199 and with the requirements contained in this standard.

2.1 Derating. Power derating requirements are based on conditions of temperature and stress that are used for testing to establish failure rate levels. Improved part failure rates result when reduced part stress ratios or reduced temperatures are used. Derating requirements given are based on operation in vacuum. The use of derating curves found in each section is described in Paragraph 4.3.1 in Section 4.

2.2 End-of Life Design Limits. End-of-life design limits do not include item tolerances and are therefore additive to values specified in each applicable section.

2.3 Electrical Considerations.

2.3.1 Power Ratings. Selection of resistor types and power ratings shall be based on the intended application and allowable failure rate.

2.3.2 Pulse Applications. In applications where pulse voltages are present, the maximum pulse amplitude (including any steady-state voltage) shall not exceed the value established by derating, regardless of resistance value. For repetitive pulses, the average power shall not exceed the established derated value. Average power is defined by

$$P\ (avg) = P\ (t/T)$$

where P = pulse power, calculated from the equation ($P = E^2/R$)
t = pulse width, and T = cycle width.

For nonrepetitive pulses, the thermal time constant of the resistor in the particular application shall be determined and the pulse power limited to a value that does not result in a temperature rise at the resistor surface which is greater than the temperature rise that would result from the applied derated dc power level. When actual test pulse power data exist, the data shall be listed in the appropriate section.

2.4 Mounting. Mounting shall be in accordance with MIL-STD-199 as modified by Appendix A and requirements provided in the detailed section for each resistor type.

2.5 Aging Sensitivity. See applicable section.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. See the detailed requirements section for each resistor type.

3.2 Reliability Suspect Designs. The following resistor types have failure modes that are not able to be completely removed by existing controls and screens. These types are not approved for mission-significant or critical space applications.

a. Carbon film resistors

b. All types of variable resistors

4. QUALITY ASSURANCE

See the detailed requirements section for each resistor type.

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SECTION 1120

FIXED FILM RESISTORS (RLR)
(MIL-R-39017)

1. SCOPE

This section sets forth detailed requirements for fixed film (thick) resistors.

2. APPLICATION

2.1 Derating.

2.1.1 Power Derating. Steady state power shall be derated in accordance with Figure 1120-1.

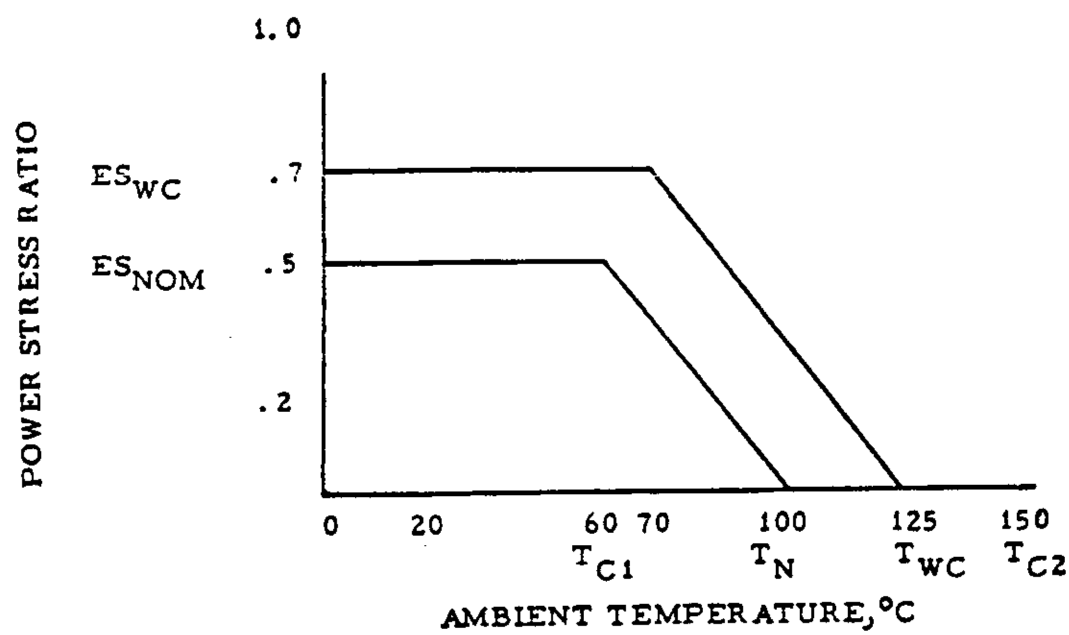

FIGURE 1120-1. Power Derating for Film Resistors

2.1.2 Voltage Derating. Voltage applied to these resistors shall be limited to 0.80 of the maximum continuous working voltages as shown in Table 1120-1.

TABLE 1120-1 Maximum Continuous DC Working Voltage.

Part Type	RLR05	RLR07	RLR20	RLR32
Maximum Continuous W V DC	200V	250V	350V	500V

2.2 End-of-life Design Limits. (Resistance)

a. ± 2 percent for approved application

b. ± 3 percent for worst case application

2.3 Electrical Considerations. The peak power shall be limited as follows:

Type	Peak Power (Watt-seconds)
RLR 05	1
RLR 07	3
RLR 20	15
RLR 32	40

2.4 Outgassing. Due to resistor encapsulation in organic materials, circuit and system sensitivity to moisture and outgassing shall be considered in part application.

3. DESIGN AND CONSTRUCTION

3.1 Recommended. Nichrome film parts on solid ceramic cores are recommended.

3.2 Failure Level. Failure rate level "S" parts shall be used.

3.3 Reliability Suspect Design. Devices constructed with a deposited thin metal film over a solid core that do not have a protective undercoating completely over the metal film shall not be utilized.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-R-39017.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements listed in Table 1120-2.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group B tests in MIL-R-39017. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-R-39017.

TABLE 1120-2. 100 Percent Screening Requirements for Fixed Film (Thick) Resistors

MIL-R-39017 Screens	Additions and Exceptions to the Methods and Criteria of MIL-R-39017
Thermal Shock	a. MIL-STD-202, Method 107, Condition B; in lieu of Method 102
DC Resistance	a. Read and record
Power Conditioning	a. 96 hours minimum at temperature with full rated power; however, either the ambient temperature or the power may be reduced if needed to ensure that the resistor temperature does not exceed +125 deg C.
Overload	a. Minimum 24 hours with 1.5 times rated power applied at +25 deg C ± 5 deg C.
DC Resistance	a. Paragraph 3.9 and 4.7.3 of MIL-R-39017 b. Measurements made at end of overload test may be used if the measurement can, without conversion, be directly related to nominal resistance value and tolerance. Compute delta resistance prior to power conditioning. Delta shall not exceed +0.5 percent +0.05 ohm.
Visual and Mechanical Examination (External)	a. Marking and identification b. Defects and damage; i.e., body finish, lead finish, misalignment, cracks

SECTION 1125

FIXED FILM RESISTOR CHIPS (RM)
(MIL-R-55342)

1. SCOPE

This section sets forth detailed requirements for film resistor chips.

2. APPLICATION

2.1 Derating

2.1.1 Power Derating. Steady-state power applied to these resistors shall be limited at temperatures below +70 deg C. to 0.50 of the power rating values shown in Table 1125-1 for approved applications. Power applied to these resistors shall be limited at temperatures below +70 deg C. to 0.75 of the power rating values shown in Table 1125-1 for worst case applications.

2.1.2 Temperature Derating. Both the steady-state and the worst case power applied to these resistors shall be linearly reduced at temperatures above +70 deg C. to zero power at +125 deg C. For example, steady-state power applied to these resistors at temperatures above +70 deg C. shall be linearly reduced from the value at +70 deg C. (0.50 of the power rating values shown in Table 1125-1) to zero power at +125 deg C.

2.1.3 Voltage Derating. Steady-state voltage applied to these resistors shall be limited to 0.80 of the maximum voltage values shown in Table 1125-1.

2.2 End-of-life Design Limits. (Resistance)

a. ± 4 percent for approved application

b. ± 7 percent for worst case application

2.4 Electrical Considerations. These resistors are suited for high frequency operations. Above 200 MHz, however, effective resistance is reduced as a result of shunt capacity between resistance elements and controlling circuits. Manufacturer's impedance characteristics curves may be used to determine maximum usable frequency for each device style.

2.5 Mounting. The terminations of these chips (usually platinum or gold) are subjected to leaching when exposed to solder at high temperatures. Reflow soldering techniques are recommended in lieu of soldering with a soldering iron. To achieve maximum long term stability, mounting should result in a minimum of compressive or tensile stresses being applied to the parts.

2.6 Electrostatic Discharge Sensitivity. Under relatively low humidity conditions film chip resistors, particularly those of smaller case size with high sheet resistance films, are subject to electrostatic discharge (ESD) and sudden shifts in resistance and the temperature coefficient of resistance. Precautions against ESD are necessary in packaging and handling.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-R-55342 and the requirements of this standard.

3.2 Reliability Suspect Designs

3.2.1 Silver Terminations. Chip resistors with silver or silver and palladium terminations have, in general, greatly reduced resistance to solder leaching and shall not be utilized unless leach resistance barriers such as nickel or copper are utilized between the termination and the solder.

3.2.2 Thin Film Resistors. Designs requiring film thickness of 350 angstroms or less are reliability suspect due to increased susceptibility of these parts to a) mechanical handling damage b) opens resulting from "hot spots" at surface defects, and c) other anomalies.

3.2.3 Noise. Excess noise has been reported in resistors made using copper conductor films.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-R-55342.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements listed in Table 1120-1.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group B tests in MIL-R-55342. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 <u>Qualification Tests</u>. Qualification testing shall be in accordance with the requirements of MIL-R-55342.

TABLE 1125-1. Maximum Allowable Power and Voltage Ratings for Each Characteristic Chip Style

Resistor Chip Style	Characteristics	Power Rating (Milliwatts)	Maximum Voltage DC or AC (RMS)
RM 0502 (M55342/1)	K & M H	20 10	40 40
RM 0505 (M55342/2)	H & Y K & M	25 50	40 40
RM 1005 (M55342/3)	H M & K	50 100	40 40
RM 1505 (M55342/4)	H & Y M & K	100 150	40 40
RM 2208 (M55342/5)	H K & M	200 225	40 40
RM 0705 (M55342/6)	K & M H	100 50	50 50

TABLE 1125-2. 100 Percent Screening Requirements for Fixed Film Resistor Chips

MIL-R-55342 Screens	Additions and Exceptions to the Methods and Criteria of MIL-R-55342
Thermal Shock	
High Temperature Exposure	a. 100 hours at +125 deg C
DC Resistance	
Visual and Mechanical Examination (External)	a. Marking and identification b. Defects and damage; i.e., body finish, lead finish, misalignment, cracks

SECTION 1130

FIXED METAL FILM RESISTORS (RNC)
(MIL-R-55182)

1. **SCOPE**

This section sets forth detailed requirements for fixed metal film resistors.

2. **APPLICATION**

2.1 **Derating**.

2.1.1 **Power Derating**. Power derating shall be in accordance with Figure 1130-1. At temperatures above +70 deg C parts shall be linearly derated to zero power at +120 deg C in accordance with Figure 1130-1.

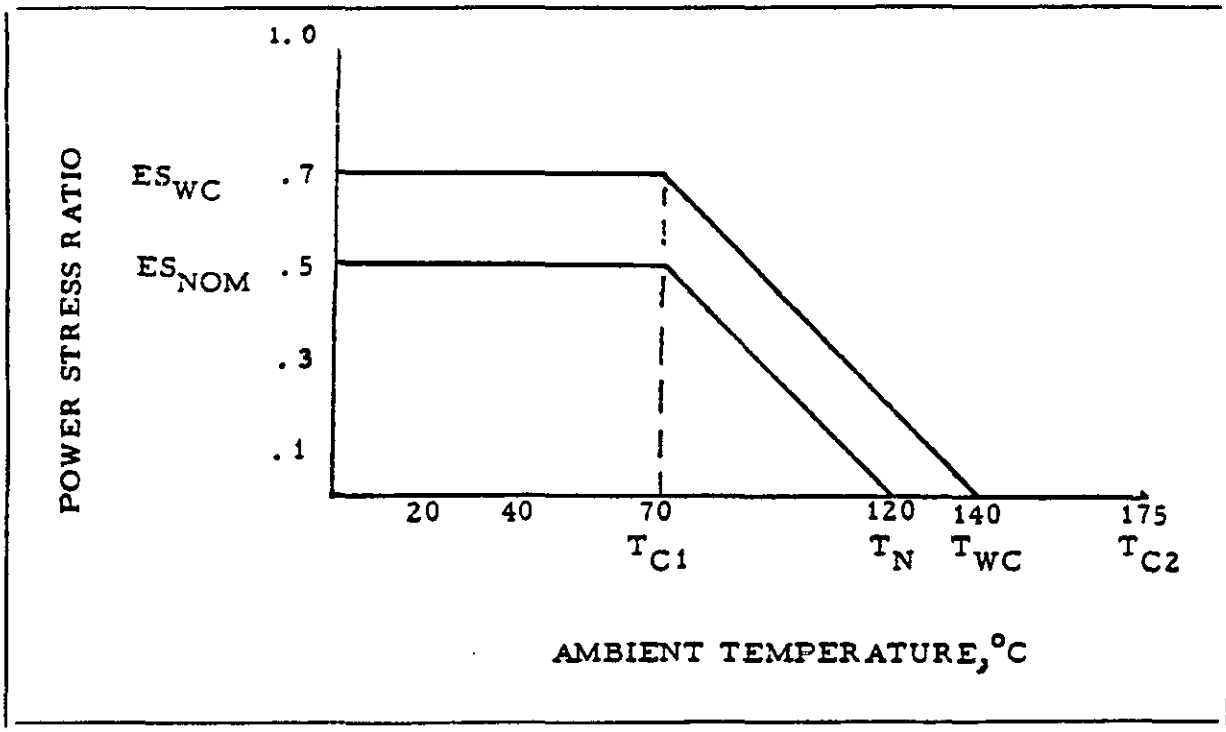

FIGURE 1130-1. Power Derating for Metal Film Resistors

2.1.2 **Voltage Derating**. Steady-state voltage applied to RNC resistors shall be limited to 0.80 of the maximum allowable voltage ratings shown in Table 1130-1 for applications at 71 deg

TABLE 1130-1. Maximum Allowable Voltage Ratings for MIL-R-55182 Fixed Metal Film Resistor Styles at 71 deg C to 125 deg C. Volts DC or AC (RMS)

Resistor Style	MIL-R-55182 PART CHARACTERISTIC				
	C	H	E	J	Y
RNC 50	200 v	200 v	200 v	200 v	N/A
RNC 55	200 v	200 v	200 v	200 v	N/A
RNC 60	250 v	250 v	250 v	250 v	N/A
RNC 65	300 v	300 v	300 v	300 v	N/A
RNC 70	350 v	350 v	350 v	350 v	N/A
RNC 75	N/A	N/A	750 v	750 v	N/A
RNC 90	N/A	N/A	N/A	N/A	300 v

C to 125 deg C. Steady-state voltage applied shall be limited to 0.80 of the voltage ratings shown in Table 1130-2 for applications at 70 deg C and below. (N/A means not available.)

2.2 End-of-life Design Limits. (Resistance)

a. ± 1.0 percent for approved application

b. ± 1.5 percent for worst case application

2.3 Electrical Considerations

2.3.1 Temperature Coefficient. MIL-R-55182 specifies the maximum change (with respect to +25 deg C) as being ± 50 or ± 100 parts per million per deg C depending on part number specified. The temperature in this rating is the temperature of the resistors, not of their environment. This coefficient (TC) is nonlinear but can be approximated by a straight line for small temperature changes. Due to variations in the film thickness, the TC may be either positive or negative and can be ordered with requirements of ± 5 parts per million per deg C when required (RNC 90Y only).

TABLE 1130-2. Maximum Allowable Voltage Ratings for MIL-R-55182 Fixed Metal Film Resistor Styles at 70 deg C and Below. Volts DC or AC (RMS)

Resistor Style	MIL-R-55182 PART CHARACTERISTIC				
	C	H	E	J	Y
RNC 50	200 v	200 v	200 v	200 v	N/A
RNC 55	200 v	200 v	200 v	200 v	N/A
RNC 60	300 v	300 v	300 v	300 v	N/A
RNC 65	350 v	350 v	350 v	350 v	N/A
RNC 70	500 v	500 v	500 v	500 v	N/A
RNC 75	N/A	N/A	750 v	750 v	N/A
RNC 90	N/A	N/A	N/A	N/A	300 v

2.3.2 High Frequency Characteristics. In general, these resistors are the best suited of all types for high frequency operation. This characteristic is not controlled by the military specification, but the curves shown in Figure 1130-2 may be used as a guide.

2.3.3 Circuit Noise. For reduced circuit noise and reduced resistance drift parts shall be thermally stabilized in vacuum during production and voltage conditioned 100 hours at +125 deg C at full rated power.

2.3.4 Electrostatic Discharge. Designs that are subject to degradation by electrostatic discharge of 4000 volts or less shall be subject to the requirements of Appendix B.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-R-55182 and the requirements of this standard. When appropriately processed, all polymeric materials used shall have a total weight loss of not more than 1 percent and a total volatile condensable material of not more than 0.1 percent.

3.2 Recommended. Hermetically-sealed types shall be used. The molded body case is the preferred style, because hollow-core construction has a potential for corrosion due to moisture.

3.3 Reliability Suspect Designs.

a. Resistors not protected from electrostatic charge during shipping and handling may experience permanent damage.

b. Hollow-core types (susceptible to cracking).

c. Resistors using aluminum terminations are very susceptible to moisture penetration; these parts should be used only in a hermetically-sealed configuration.

d. Resistors using a thin film metal construction without a corrosion-resistant organic coating over the metal film (susceptible to corrosion).

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-R-55182 plus precap visual inspections. The precap visual inspections shall be done on representative samples of each lot at 20X minimum magnification using direct and back-lit illumination. If any of the samples exhibit any of the following defects, the entire lot shall be 100 percent screened.

a. Pinholes on the precoat.

b. Precoat not extending into at least one-half of the skirt of the end caps.

c. Misaligned, bent, or cracked end caps.

d. Cracks on the lead weld.

e. Holes on the end caps from welding operations.

f. Contaminants on or trapped under the precoat.

g. Particles on the spiral.

h. Any discoloration on the precoat.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements listed in Table 1130-3.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group B tests in MIL-R-55182. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-R-55182, with the addition that samples of all polymeric materials used when appropriately processed shall pass the outgassing test of ASTM E 595-84.

TABLE 1130-3. 100 Percent Screening Requirements for Metal Film Resistors

MIL-R-55182 Screens	Additions and Exceptions to the Methods and Criteria of MIL-R-55182
DC Resistance	a. Uniquely identify, read and record
Thermal Shock	
Overload	a. No arcing, burning, or charring at 10X magnification
DC Resistance	a. MIL-STD-202, Method 108 b. 0.20 percent maximum change from first reading
Power Conditioning	a. 96 hours minimum at +125 deg C and full-rated power b. No visual evidence of damage
DC Resistance	a. 0.20 percent maximum change from post overload value
Hermetic Seal	
Visual and Mechanical Examination (External)	a. Marking and identification b. Defects and damage; i.e., body finish, lead finish, misalignment, cracks

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SECTION 1140

VARIABLE, NONWIRE-WOUND RESISTORS (RJR) (MIL-R-39035)

1. SCOPE

This section sets forth detailed requirements for variable, nonwire-wound resistors.

2. APPLICATION

Variable resistors shall be avoided whenever possible. They are not recommended for space use. These resistors are not hermetically sealed and are susceptible to degraded performance due to ingestion of soldering flux, cleaning solvents, and conformal coatings during equipment fabrication. These parts are also subject to resistance change during shock and vibration.

2.1 Derating

2.1.1 Power Derating. Power shall be derated in accordance with Figure 1140-1.

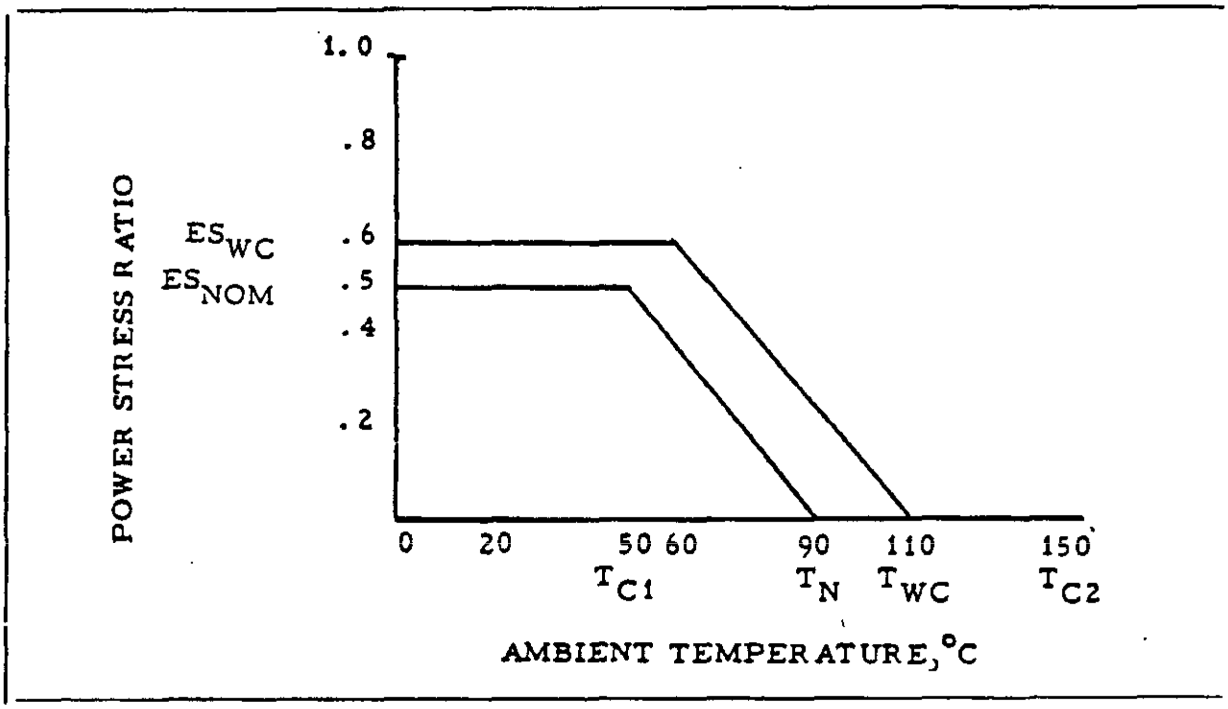

FIGURE 1140-1. Power Derating for Variable, Nonwire-wound Resistors.

2.1.2 Voltage Derating. Steady-state voltage applied to these resistors shall be limited to 0.80 of the values shown in Paragraph 3.3 of Section 402 of MIL-STD-199.

2.2 End-of-life Design Limits. (Resistance)

a. ± 22 percent for approved applications

b. ± 30 percent for worst case application

2.3 Mounting. Mounting brackets shall be used.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-R-39035 and the requirements of this standard.

3.2 Recommended. None identified.

3.3 Reliability Suspect Designs. All variable resistors are reliability suspect.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-R-39035 and the following: An internal visual inspection is required for all parts. A binocular microscope with minimum 30X magnification and an integral light source or fiber optic light ring shall be used. Any resistor exhibiting one or more of the following defects shall be marked and rejected.

a. Foreign material

b. Chips, spalls, cracks, or scratches in the resistor element

c. Element misalignment or improper seating

d. Incorrect or missing element stops

e. Incorrect seating or damage to wiper arm

f. Faulty termination of element or pins

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements listed in Table 1140-1.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group B tests in MIL-R-39035. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-R-39035.

TABLE 1140-1. 100 Percent Screening Requirements for Variable, Nonwire-wound Resistors

MIL-R-39035 Screens	Additions and Exceptions to the Methods and Criteria of MIL-R-39035
Thermal Shock	
Conditioning	a. 168 hours minimum
Contact Resistance Variation	
Immersion	
Vibration (Random)	a. MIL-STD-202, Method 214, Test Condition II, K (to the requirements of the application) b. Two cycles of 10 minutes each in two orthogonal planes c. Vibration mode shall be random
DC Resistance	
Visual and Mechanical Examination (External)	a. Marking and identification b. Defects and damage; i.e., body finish, lead finish, misalignment, cracks

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SECTION 1150

VARIABLE, WIRE-WOUND RESISTORS (RTR) (MIL-R-39015)

1. SCOPE

This section sets forth detailed requirements for variable, wire-wound resistors.

2. APPLICATION

Variable resistors shall be avoided whenever possible. They are not recommended for space use. These resistors are not hermetically sealed and are susceptible to degraded performance due to ingestion of soldering flux, cleaning solvents, and conformal coatings during equipment fabrication. These parts are also subject to resistance changes during shock and vibration or aging.

2.1 Derating

2.1.1 Power Derating. These resistors shall be power-derated in accordance with Figure 1150-1.

2.1.2 Voltage Derating. Steady-state voltage applied to these resistors shall be limited to 0.80 of the values shown in Table 1150-1.

TABLE 1150-1. MIL-STD-199 Rated Voltages

Nominal Resistance Ohms	Maximum Rated Voltage Volts AC (rms) or DC
10	2.7
20	3.8
50	6.1
100	8.7
200	12.3
500	19.4
1000	27.4
2000	38.7
5000	61.3
10000	86.7

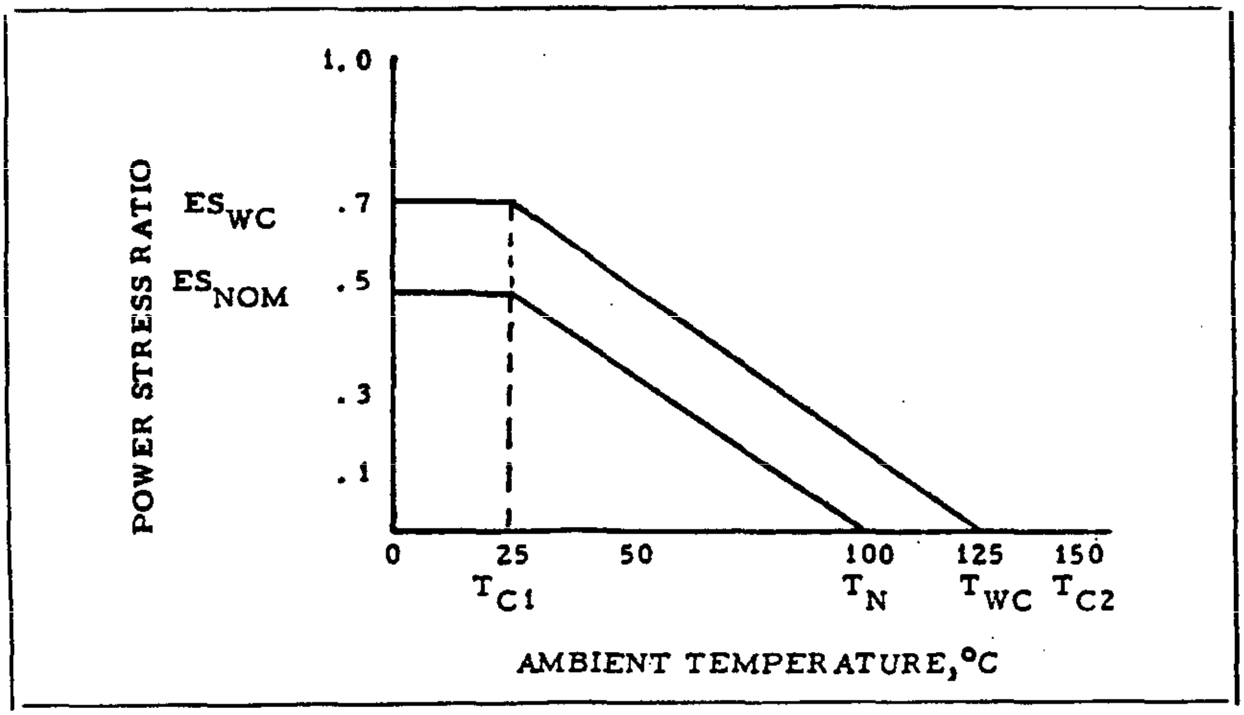

FIGURE 1150-1. Power Derating Requirements for Variable, Wire-Wound Resistors

2.2 End-of-life Design Limits. (Resistance)

a. ± 10 percent for approved applications

b. ± 20 percent for worst case application

2.2.1 Pulse Power. Same requirements as described in Paragraph 2.3.5 of Section 1170, if the wiper position is not less than 70 percent of the maximum setting.

2.3 Mounting. Mounting shall be in accordance with Appendix A. Mounting brackets may be necessary for part typical shock and vibration environments.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-R-39015 and the requirements of this standard.

3.2 Recommended

3.1.1 Wire Size. A minimum wire size of 2.5 micrometers (0.001 inches) absolute shall be used.

3.1.2 Internal Connections. All internal connections shall be welded.

3.3 Reliability Suspect Designs. All variable resistors are reliability suspect.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-R-39015 and the following: An internal visual inspection is required for all parts. A binocular microscope with minimum 30X magnification and an integral light source or fiber optic light ring shall be used. Any resistor exhibiting one or more of the following defects shall be marked and rejected. The entire lot shall be rejected if the percentage of its rejected parts exceeds 7.0 percent.

a. Damage to resistance wire reducing its diameter by one-third or more

b. "Cold," loose, incomplete, or corroded solder joints

c. Loose windings on active portion of resistor

d. Loose wire ends or wraps capable of touching other conductive parts or each other

e. Any lubricant on resistance element

f. Resistance element not secure to resistor body

g. Body and wiper stops cracked, damaged, or distorted

h. Loose welds

i. Burning at weld greater than one-half of tab width

j. Cracks or fractures in welds

k. Loose terminals

l. Foreign material such as weld splatter, solder splatter, flux residue, or metallic particles.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements listed in Table 1150-2.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group B tests in MIL-R-39015. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-R-39015.

TABLE 1150-2. 100 Percent Screening Requirements for Variable, Wire-wound Resistors

MIL-R-39015 Screens	Additions and Exceptions to the Methods and Criteria of MIL-R-39015
Thermal Shock	
Conditioning	a. 168 hours minimum
Peak Noise	
Immersion	
Vibration (Random)	a. MIL-STD-202, Method 214, Test Condition II, K (to the requirements of the application) b. Two cycles of 10 minutes each in two orthogonal planes c. Vibration mode shall be random
Total Resistance	
Continuity Tests	a. Both output leads shall be connected together
Absolute Minimum Resistance	
End Resistance	
Actual Effective Electric Travel	
DWV	
IR	
Torque	
Visual and Mechanical Examination (External)	a. Marking and identification b. Defects and damage; i.e., body finish, lead finish, misalignment, cracks

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SECTION 1160

WIRE WOUND, ACCURATE, RESISTORS (RBR)
(MIL-R-39005)

1. SCOPE

This section sets forth detailed requirements for fixed wire-wound (accurate) resistors.

2. APPLICATIONS

2.1 Derating

2.1.1 Power Derating. Power shall be derated with temperature in accordance with Figure 1160-1.

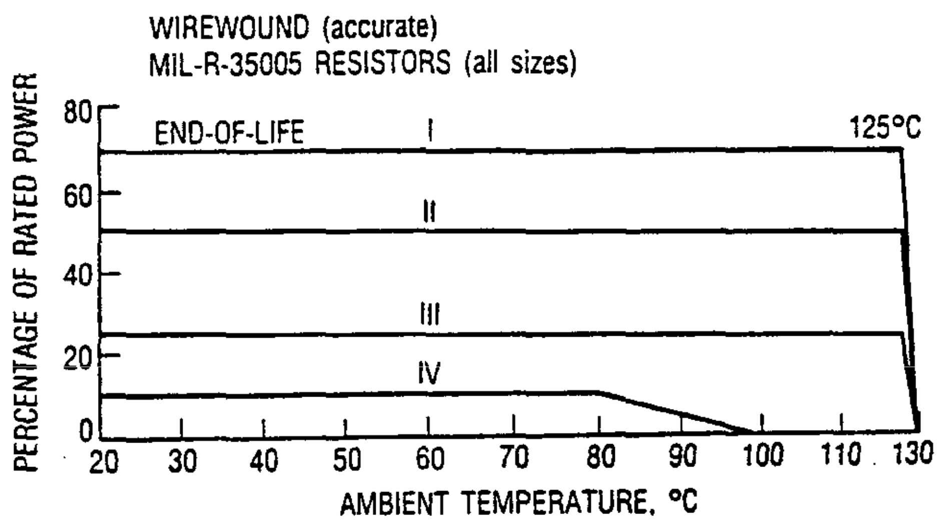

FIGURE 1160-1. High Temperature Derating Curves for Accurate Wire-wound Resistors

2.1.2 Voltage Derating. Steady-state voltages applied to these resistors shall be limited to 0.80 of the values shown as maximum voltages in Table 303-II of MIL-STD-199.

2.1.3 Resistance Tolerances and Wattage Input. Maximum steady-state wattages shall be further derated according to the resistance tolerance of the resistor as listed in Table 1160-1.

TABLE 1160-1 Resistance Tolerance and Required Derating.

Resistance Tolerance	Additional Derating Factor of Nominal Wattage
0.01 percent	0.40
0.05 percent	0.40
0.1 percent	0.40
1.0 percent	0.80

2.2 End-of-life Design Limits. (Resistance). Power derating is for all sizes in MIL-R-39005. The end-of-life (EOL) stabilities are based on power-derating curves of Figure 1160-1.

I. EOL = ± 1.00 percent (plus initial tolerance)

II. EOL = ± 0.51 percent (plus initial tolerance)

III. EOL = ± 0.30 percent (plus initial tolerance)

IV. EOL = ± 0.03 percent (plus initial tolerance)

2.3 Electrical Considerations

2.3.1 Moisture. These resistors are susceptible to absorption of water vapor and can exhibit a positive or negative (usually positive) shift of resistance of 30 to 70 parts per million. The shift in resistance is influenced by the relative humidity, temperature, and the time exposed. The process is completely reversible by baking at a moderate temperature. (Consult with manufacturer for temperature and duration.)

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-R-39005 and the requirements of this standard.

3.2 Recommended

3.2.1 Wire Size. A minimum wire size of 2.5 micrometers (0.001 inches) absolute shall be used.

3.2.2 Internal Connections. All internal connections shall be welded.

3.3 Reliability Suspect Designs. Designs using soldered or crimped internal connections are reliability suspect. Designs using a wire size of less than 2.5 micrometers (0.001 inches) absolute is reliability suspect.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-R-39005 and the following: All exposed inner surfaces of each resistor shall be examined at a minimum of 10X magnification. Any part exhibiting one or more of the following anomalies shall be rejected.

a. Less than 0.025-inch gap between leads

b. Absence of a soft cushion coating over wire winding

c. Burning at weld greater than one-half tab width

d. Lack of indication weld tip indention at welds

e. Cracks, breaks, or partial fracture at welds

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements listed in Table 1160-2.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group B tests in MIL-R-39005. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-R-39005.

TABLE 1160-2 100 Percent Screening Requirements for Fixed, Wirewound, Accurate Resistors

MIL-R-39005 Screens	Additions and Exceptions to the Methods and Criteria of MIL-R-39005
Thermal Shock	
DC Resistance	
Conditioning	a. 168 hours minimum
Short Time Overload	
Peak Noise	
Immersion	
Vibration (Random)	a. MIL-STD-202, Method 214, Test Condition II, K (to the requirements of the application) b. Two cycles of 10 minutes each in two orthogonal planes c. Vibration mode shall be random
Delta DC Resistance	a. R ±(0.01 percent +0.01 ohm)
Radiographic Inspection	a. Per MSFC-STD-355; 2 views 90 deg. apart by X-ray, or 360 deg. view by Vidicon. Use of "real-time" X-ray systems capable of viewing through 360 deg rotation is encouraged. b. Test may be waived if in-process inspection is performed
Visual and Mechanical Examination (External)	a. Marking and identification b. Defects and damage; i.e., body finish, lead finish, misalignment, cracks

SECTION 1170

WIRE-WOUND, POWER-TYPE RESISTORS (RWR) (MIL-R-39007)

1. SCOPE

This section sets forth detailed requirements for wire-wound (power-type) resistors.

2. APPLICATION

2.1 Derating

2.1.1 Power Derating. Power shall be derated in accordance with Figure 1170-1.

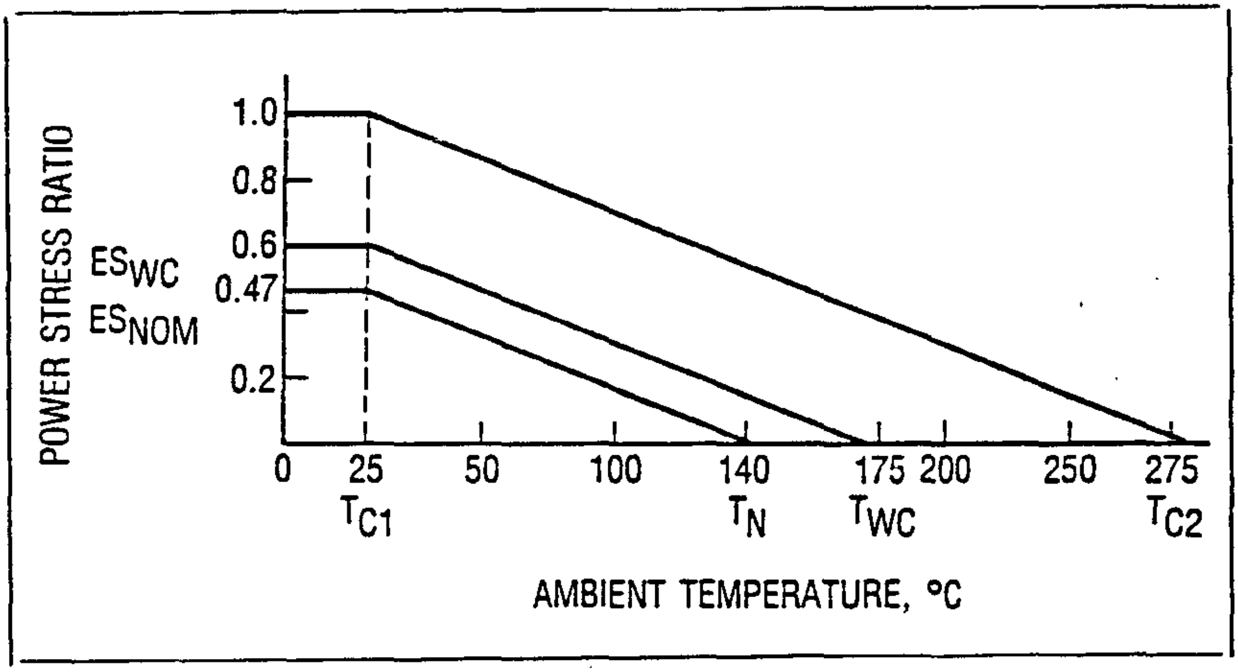

FIGURE 1170-1. Power Derating Requirements for Wire-wound (Power-type) Resistors

2.1.2 Voltage Derating. RWR resistors are relatively low ohmic devices, and voltage derating is normally not required.

2.2 End-of-life Design Limits. (Resistance)

a. ± 1 percent for approved application

b. ± 5 percent for worst case application

2.3 Electrical Considerations

2.3.1 Temperature Coefficient. The temperature coefficient of resistance (due to wire variations) may be either negative or positive, and the values for each style are listed in the applicable MIL-R-39007 slash sheet.

2.3.2 High Frequency Operation. These resistors are not designed for high-frequency circuits where their ac characteristics are important.

2.3.3 Noise. The only source of noise is thermal agitation which can be neglected in most circuit applications.

2.3.4 Voltage Coefficient of Resistance. This parameter is not specified for wire-wound resistors.

2.3.5 Pulse Power. Steady-state power and voltage ratings for wire-wound resistors may not apply to short time constant pulses. Figures 1170-2 through 1170-4 show the maximum power which the resistors are typically capable of enduring for relatively short periods of time without significant changes in resistance or other parameters. Specific curves should be obtained from the manufacturer for each resistor type. The uses and limitations of these curves are as follows:

2.3.5.1 Maximum Pulse Power. Determine the maximum-pulse power rating for:

a. Non repetitive Pulses.

1. Calculate the pulse power: $P = (E^2/R)$

2. The maximum pulse-power rating is not exceeded if the intersection of the pulse-power line and pulse width line is on or below the pulse-power curve for the appropriate part.

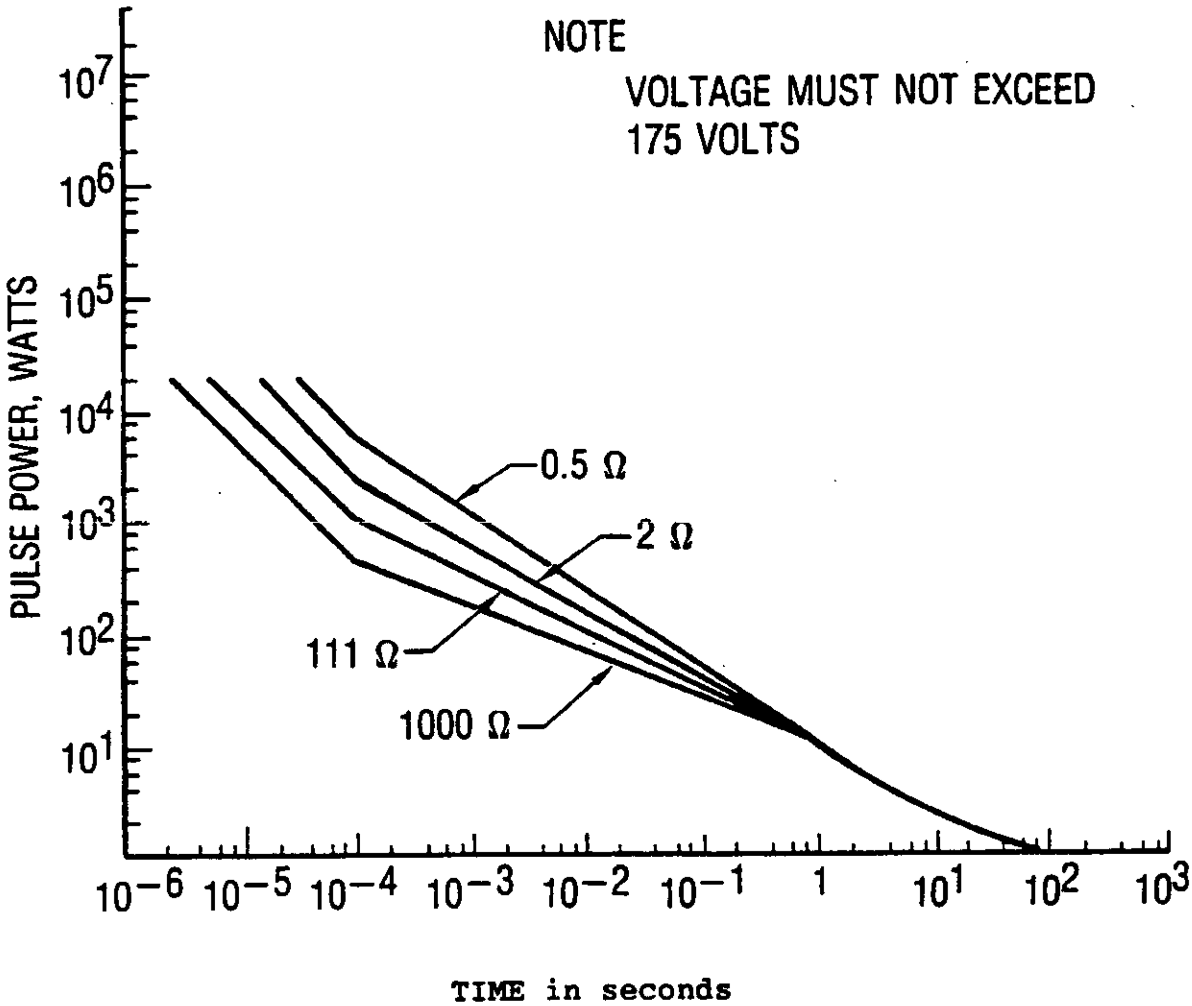

FIGURE 1170-2. Typical Maximum Pulse Power versus Time for RWR 81 (1-watt) Resistors

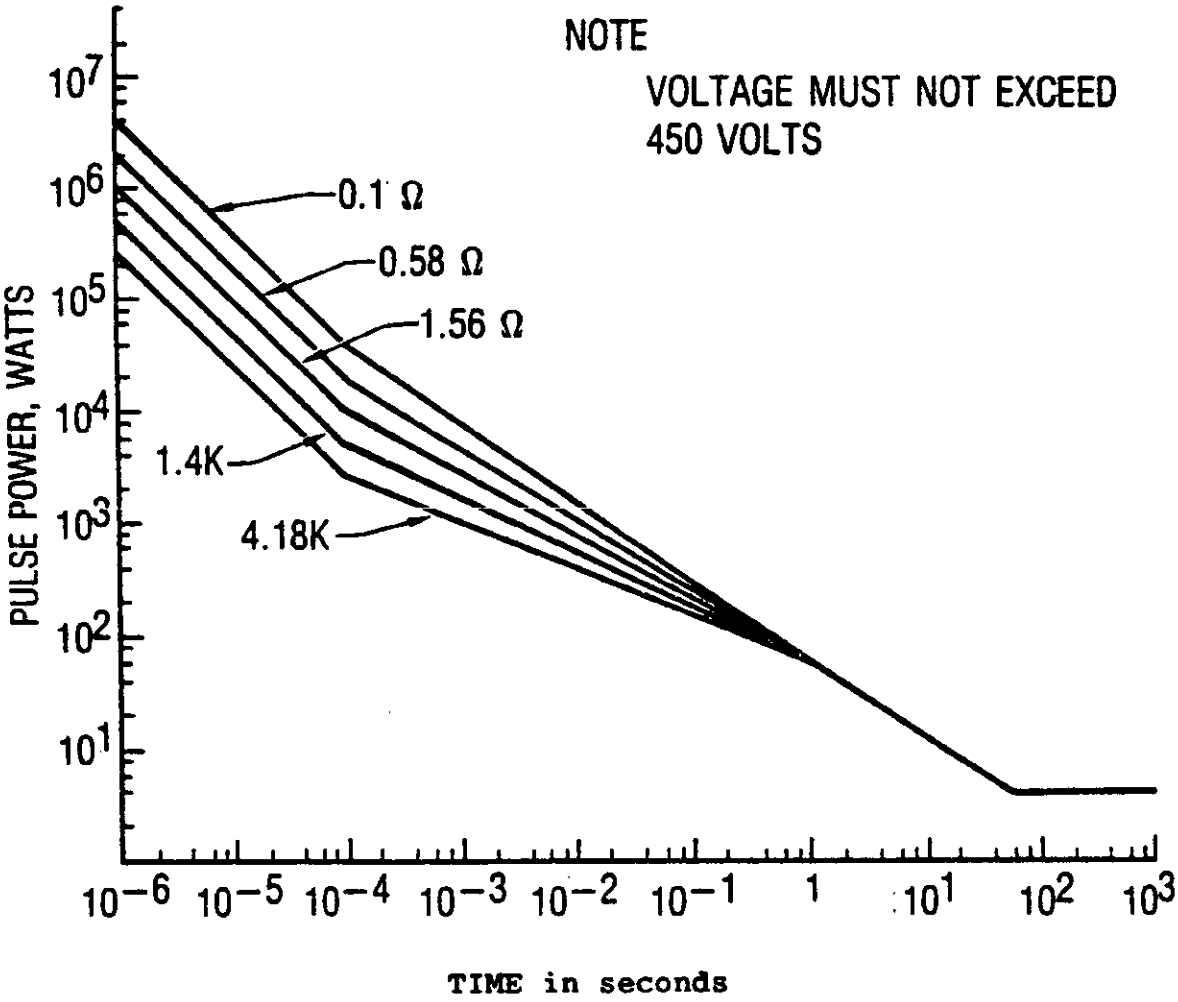

FIGURE 1170-3. Typical Maximum Pulse Power versus Time for RWR 89 (3-watt) Resistors

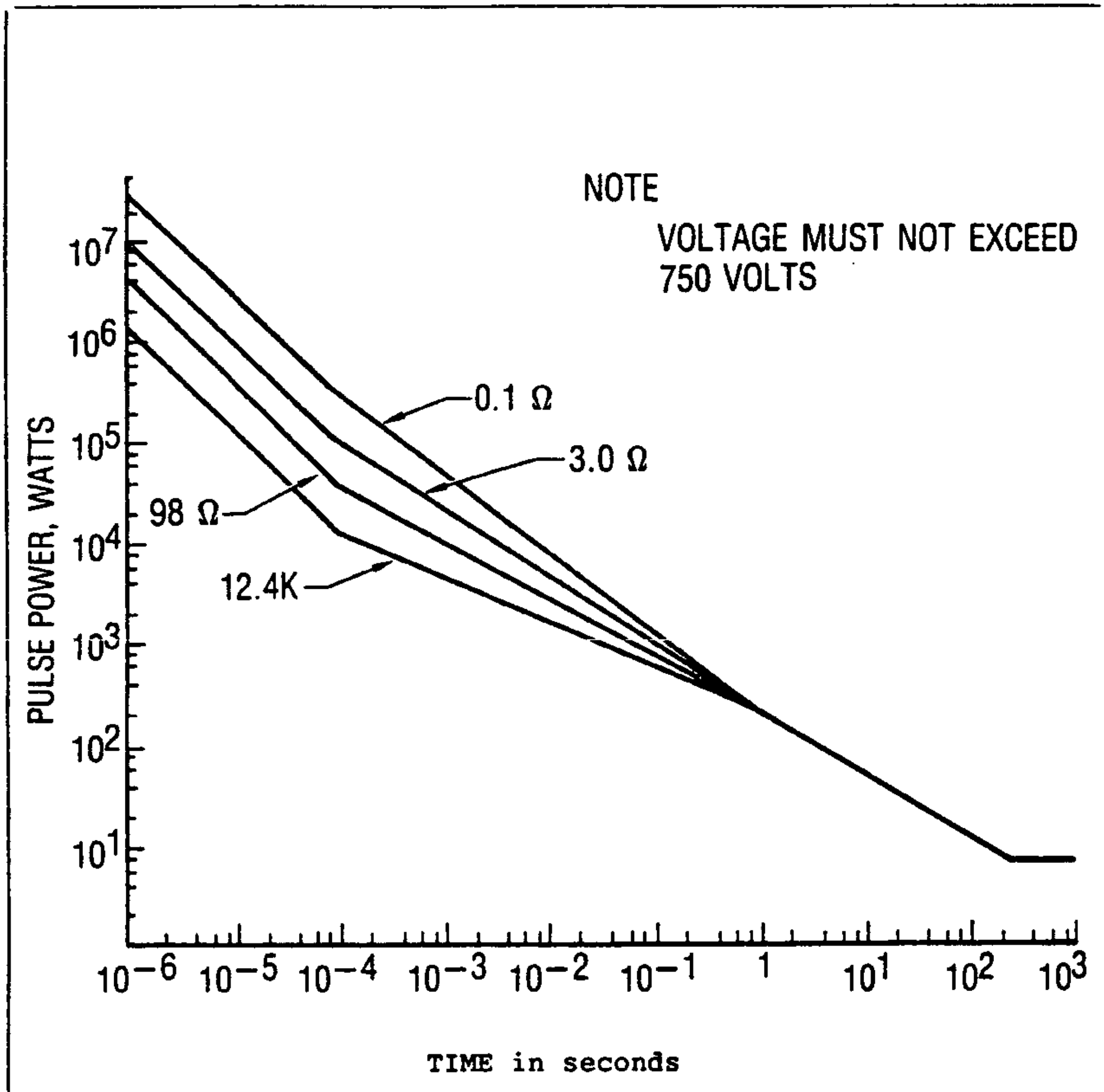

FIGURE 1170-4. Typical Maximum Pulse Power versus Time for RWR 84 (7-watt) Resistors

b. Repetitive Pulses.

1. Calculate the pulse-power and determine the maximum pulse power rating as in (a) above.

2. If the maximum pulse power rating is not exceeded, determine the average pulse power:

$$P_{(avg)} = P(t/T)$$

The average pulse power shall not exceed 50 percent of the steady-state power rating.

2.3.5.2 Maximum Pulse Voltage. The maximum pulse voltage shall be:

Style	Voltage
RWR 81	175 V
RWR 89	450 V
RWR 84	750 V

2.3.5.3 Limitations.

a. Under reduced pressure conditions, the voltage shall not exceed the values shown due to reduced dielectric strength of the air.

b. When the resistors are operated at temperatures above +25 deg C, the pulse power rating shall be derated (see Fig. 1170-1).

c. When the resistors are operating under steady-state conditions and a pulse is applied in addition, the pulse power rating shall be derated so that the sum of the steady-state power plus the pulse power does not exceed the derating requirements of Figure 1170-1.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-R-39007 and the requirements of this standard. Coating material shall be per MIL-STD-199.

3.1.1 Wire Size. A minimum wire size of 2.5 micrometers (0.001 inches) absolute shall be used.

3.1.2 Internal Connections. All internal connections shall be welded.

3.2 Reliability Suspect Designs. Designs using soldered or crimped internal connections are reliability suspect. Designs using a wire size of less than 2.5 micrometers (0.001 inches) absolute is reliability suspect.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-R-39007 and the following: All exposed inner surfaces of each resistor shall be examined at a minimum of 10X magnification. Any part exhibiting one or more of the following anomalies shall be rejected.

a. End cap misalignment greater than 10 degrees

b. Cracks, excessive bends, incomplete wire weld, or loose wire at end cap

c. Split, distorted, or cracked end caps

d. Space between wire turns more than five times the wire diameter, except for values less than 1.0 ohms or for fusible resistors (High resistance values require insulated wire and the wire turns may touch.)

e. Cracks or surface holes in core which exceed 0.025 inch in greatest dimension

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements listed in Table 1170-1.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group B tests in MIL-R-39007 plus the resistance temperature characteristics and moisture resistance tests specified herein.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-R-39007.

TABLE 1170-1. 100 Percent Screening Requirements for Wire-wound (Power Type) Resistors

MIL-R-39007 Screens	Additions and Exceptions to the Methods and Criteria of MIL-R-39007
Thermal Shock	
Conditioning	
Short Time Overload	
Dielectric Withstanding-Voltage	
DC Resistance	
Radiographic Inspection	a. Per MSFC-STD-355; 2 views 90 deg. apart by X-ray, or 360 deg. view by Vidicon. Use of "real-time" X-ray systems capable of viewing through 360 deg rotation is encouraged. b. Test may be waived if in-process inspection is performed
Visual and Mechanical Examination (External)	a. Marking and identification b. Defects and damage; i.e., body finish, lead finish, misalignment, cracks

SECTION 1180

WIRE-WOUND, CHASSIS-MOUNTED RESISTORS (RER) (MIL-R-39009)

1. SCOPE

This section sets forth detailed requirements for fixed, wire-wound, power-type, chassis-mounted resistors.

2. APPLICATION

2.1 Derating

2.1.1 Power Derating. See Paragraph 2.1.1 of Section 1170.

2.1.2 Voltage Derating. See Paragraph 2.1.2 of Section 1170.

2.2 End-of-life Design Limits. See Paragraph 2.2 of Section 1170.

2.3 Electrical Considerations. See Paragraph 2.3 of Section 1170.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-R-39009 and the requirements of this standard.

3.2 Recommended

3.2.1 Wire Size. A minimum wire size of 0.001 inch absolute shall be used.

3.2.2 Internal Connections. All internal connections shall be welded.

3.3 Reliability Suspect Designs. Designs using soldered or crimped internal connections are reliability suspect. Designs using a wire size of less than 0.001 inch absolute is reliability suspect.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-R-39009 and the following: All exposed inner surfaces of each resistor shall be examined at a minimum of 10X magnification. Any part exhibiting one or more of the following anomalies shall be rejected.

a. End cap misalignment greater than 10 degrees

b. Cracks, excessive bends, incomplete wire weld, or loose wire at end cap

c. Split, distorted, or cracked end caps

d. Space between wire turns more than five times the wire diameter, except for values less than 1.0 ohms or for fusible resistors (High resistance values require insulated wire and the wire turns may touch.)

e. Cracks or surface holes in core which exceed 0.025 inch in greatest dimension

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements listed in Table 1180-1.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group B tests in MIL-R-39009.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-R-39009.

TABLE 1180-1. 100 Percent Screening Requirements for Wire-wound, Power-type, Chassis-mounted Resistors.

MIL-R-39009 Screens	Additions and Exceptions to the Methods and Criteria of MIL-R-39009
Thermal Shock	
Conditioning	
Short Time Overload	
Dielectric Withstanding-Voltage	
DC Resistance	
Radiographic Inspection	a. Per MSFC-STD-355; 2 views 90 deg. apart by X-ray, or 360 deg. view by Vidicon. Use of "real-time" X-ray systems capable of viewing through 360 deg rotation is encouraged. b. Test may be waived if in-process inspection is performed
Visual and Mechanical Examination (External)	a. Marking and identification b. Defects and damage; i.e., body finish, lead finish, misalignment, cracks c. Minimum of 10X magnification

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SECTION 1190

FIXED FILM RESISTANCE NETWORK (RZ)
(MIL-R-83401)

1. SCOPE

This section sets forth detailed requirements for a fixed-film resistor network installed in flat pack or dual-in-line packages.

2. APPLICATION

2.1 Derating.

2.1.1 Power Derating. Steady-state power applied to these resistors shall be limited at temperatures below +70 deg C. to 0.50 of the power rating values shown in Table 1190-1 for approved applications. Power applied to these resistors shall be limited at temperatures below +70 deg C. to 0.75 of the power rating values given in Table 1190-1 for worst case applications.

2.1.2 Temperature Derating. Both the steady-state and the worst case power applied to these resistors shall be linearly reduced at temperatures above +70 deg C. to zero power at +125 deg C. For example, steady-state power applied to these resistors at temperatures above +70 deg C. shall be linearly reduced from the value at +70 deg C. (0.50 of the power rating values shown in Table 1190-1) to zero power at +125 deg C.

2.1.3 Voltage Derating. Steady-state voltage applied to these resistors shall be limited to 0.80 of the maximum voltage values shown in Table 1190-1.

2.2 End-of-life Design Limits. (Resistance)

a. ± 1 percent for approved application

b. ± 2 percent for worst case application

2.3 Electrical Considerations. The resistance temperature coefficient (TC) can be either characteristic H (± 50 parts per million per deg C) or characteristic K (± 100 parts per million per deg C). Since all resistors in a network are manufactured from the same batch at the same time, the TCs should be matched within 5 parts per million.

TABLE 1190-1. Manufacturer's Element Power, Network Power, and Voltage Ratings

Resistor Style	Schematic Type*	Element Power Rating at +70 deg C in watts	Network Power Rating at +70 deg C in watts	Maximum Voltage DC or AC (RMS)
RZ 010	A	0.2	1.4	100
RZ 010	B	0.1	1.3	100
RZ 020	A	0.2	1.6	100
RZ 020	B	0.1	1.5	100
RZ 030	A	0.05	0.35	50
RZ 030	B	0.025	0.325	50
RZ 030**	A	0.2	1.0	50
RZ 030**	B	0.1	1.0	50

* Schematics are shown in detail specification of MIL-R-83401.

** RZ 030 ratings are based on case temperature (heat sinked) up to +50 deg C for total network and up to +90 deg C per element. Rating shown here is for thick film.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-R-83401 and the requirements of this standard. The resistance temperature coefficient (TC) shall be either characteristic H (± 50 parts per million per deg C) or characteristic K (± 100 parts per million per deg C). All resistors in a network shall be manufactured from the same batch at the same time.

3.2 Recommended

a. Tantalum nitride, deposited onto substrate, and protected by tantalum pentoxide passivation.

b. The surface should be anodized for moisture protection or laser-trimmed and subsequently glassivated.

c. Welded internal connections

d. Hermetically sealed units

3.3 Reliability Suspect Designs

3.3.1 Thick Film Designs. Resistor networks manufactured by thick film technology are reliability suspect due to the internal solder connections required.

3.3.2 Nichrome. Thin film resistors manufactured with nichrome as the resistive element are reliability suspect due to the potential opening of nichrome traces in the presence of moisture and bias, even in hermetically sealed packages.

3.3.3 Excessively Thin Tantalum Nitride. Designs requiring tantalum nitride thicknesses below 350 Angstroms are reliability suspect due to the increased susceptibility of these parts to (a) mechanical handling damage, (b) opens resulting from "hot spots" at surface defects and (c) nonohmic behavior at low voltages.

3.3.4 Nonhermetically Sealed Packages. Parts in nonhermetically sealed packages are reliability suspect.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-R-83401 and the following:

4.1.1 Precap Visual Inspection. Precap visual inspection is required for all parts. A binocular microscope with minimum 100X magnification and an integral light source or fiber optic light ring shall be used. The resistor side visual inspection shall be performed at 100X minimum magnification, perpendicular to the die surface, with illumination normal to the die surface. Any die exhibiting one or more of the following defects shall be marked and rejected.

4.1.1.1 Metallic Particles.

a. Unattached. There shall be no more than 3 unattached metallic particles. Unattached particles shall be less than 0.005 inch or the width of the width of the spiral cut in dimension, whichever is less. Particles shall not be joined.

b. Attached. Attached metallic particles shall not exceed 0.005 inch in the major dimension. Particles shall not touch nor extend over the metal film. Particles shall be considered attached when they cannot be removed with a 20 psig gas blow of dry nitrogen or dry, oil-free, air.

c. Residue. There shall be no visible spiral residue at 50X magnification within the enclosure.

4.1.1.2 Nonmetallic Particles. Glass, fibers, and other nonmetallic materials within the enclosure shall not exceed 0.005 inch in their major dimension.

4.1.1.3 Metallization Defects. Any of the following anomalies in the active circuit metallization shall be cause for rejection.

a. Metallization Scratches. Any scratch in metallization through which the underlying resistor material also appears to be scratched. Any scratch in the interconnecting metallization which exposes resistive material or oxide anywhere along its length and reduces the width of the scratch-free metallization strip to less than 50 percent of its original width. (see Figure 1130-2). A scratch is defined as any tearing defect that disturbs the original surface of the metallization.

b. Metallization Voids. Any void in the interconnecting metallization which leaves less than 50 percent of the original width undisturbed. A void is defined as any region in the interconnecting metallization where the underlying resistive material or oxide is visible which is not caused by a scratch.

c. Metallization Adherence. Any evidence of metallization lifting, peeling or blistering.

d. Metallization Probing. Probe marks on the interconnecting metallization other than the bonding pads that violate the scratch or void criteria.

e. Metallization Bridging. Bridged metallization defect that reduces the distance between any two metallization areas to less than 0.0003 inch. Bridging between metallization and resistor pattern not intended by design that reduces the distance between the two to less than 0.0001 inch.

f. Metallization Alignment. Any misalignment between the resistor pattern and the metallization such that more than 0.0005 inch of resistor on a side is exposed.

g. Metallization Corrosion. Any evidence of localized heavy stains, metallization corrosion, discoloration or mottle metallization.

4.1.1.4 Resistor Defects. Any of the following anomalies within the active resistor area shall be cause for rejection. The active area of resistor is that part of the resistance pattern which remains in series connection between resistor terminals and is not shorted by metallization.

a. Resistor Scratches. Any scratch within the active resistor area.

b. Resistor Voids. Any void or neckdown in the active resistor path which reduces the width of the stripe by more than 50 percent of the original width. Any void or necking down in the active resistor path for a line width design of less than 0.0002 inch which reduces its original width by 25 percent or more. Any void or chain of voids in the resistor element at the gold termination.

c. Resistor Adherence. Any evidence of resistor film lifting, peeling or blistering.

d. Probe Marks. Any probe mark on the resistor material.

e. Resistor Material Corrosion. Any evidence of localized heavy stains or corrosion of resistor material in the active resistor path; however, discoloration of tantalum-based resistors due to thermal stabilization is not a cause for rejection.

f. Resistor Bridging Defects. Any conductive continuous bridging between active resistance stripes. Partial bridging defect that reduces the distance between adjacent active resistance stripes to less than 0.1 mil or 50 percent of the design separation, whichever is less, when caused by smears, photolithographic defects or other causes. For a partial bridge within lines and spacing of 0.0001 inch design width, visual separation (evident at 400X) is sufficient for acceptance.

4.1.1.5 Laser Trim Faults

a. A partial cut or bridged coarse or mid-range trim link.

b. The remaining width in fine-trim top hat area after laser cut is less than the width of the narrowest line within the same resistor pattern. Uncut material is remaining after a laser scribe due to "skipping" of laser beam. If laser cut is not straight lines, the narrowest remaining width shall be equal to or greater than the width of the narrowest lines within the same resistor pattern.

c. Laser cut scribed to indicate a reject chip when the scribe does not meet the requirements of the individual mask model lists.

d. Oxide voids, cracking or similar damage caused to the SiO_2 underlayer by laser beam where such damage touches active interconnects or resistor path.

e. Laser trim cut where edge of cut touches the active resistor path.

f. Any discolorization or change in surface finish of a resistor stripe by the direct laser beam or by spurious reflections caused by optics of the system. Discoloration of tantalum-based resistors in and around laser kerf is not a cause for rejection.

g. Any chip intended to be laser-trimmed that is not laser-trimmed.

4.1.1.6 Resistor Bonding Pad Defects. Any resistor containing one or more bonding pads with one or more of the following anomalies shall be rejected.

a. Globules A globule is defined as any material with a smooth perimeter extending out from the bonding pad onto the resistor or substrate material. Such globules are usually featureless and of low reflectivity and therefore difficult to focus upon.

b. Missing Metallization. Any indications of missing metallization whether at the perimeter or totally within the bonding pad. Resistor material may be visible in the areas of missing metallization.

c. Metallization Corrosion. Any evidence of localized heavy, diffuse stains, discolored material, or low-density material either on the pad's perimeter or totally within the bonding pad. Any evidence of stains or discoloration extending out onto the resistor or substrate material.

4.1.1.7 Oxide Defects. Any resistor having excessive oxide defects or voids shall be rejected. An oxide void is a fault in the oxide evidenced by localized double or triple colored fringes at the edges of the defect visible at 100X. The following shall be cause for rejection:

a. Any oxide void that bridges any two resistor or metal areas not intended by design.

b. Any oxide void under metallization or resistor geometry.

c. Less than 0.0005 inch oxide visible between active metallization and edge of a die. Excluded from this are any inactive metallization lines.

4.1.1.8 Scribing and Die Defects. Any resistor having the following scribing or die anomalies shall be rejected:

a. Any chipout or crack in the active resistor or metal area.

b. Any crack that exceeds 0.005 inch in length or comes closer than 1.0 mil to an active area on the die.

c. Any crack in a die that exceeds 0.001 inch in length and points towards the active circuit area. (See Fig. 11).

d. A die having an attached portion of an adjacent die which contains metallization or resistor material.

e. A crack or chip in the backside of a die that leaves less than 75 percent of area intact or a crack or chip under a bonding pad.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements listed in Table 1190-2 and the following:

4.2.1 Fail Criteria. Resistor networks that are out of resistance tolerance, or which experience a change in resistance greater than that permitted, shall be removed from the lot. Lots having more than 5 percent total rejects due to resistance tolerance or resistance change shall be rejected.

4.2.2 Power Conditioning.

a. The network shall be mounted to attain the test temperature condition noted below. Leads shall be mounted by means other than soldering or welding to avoid stress or damage to the leads. Networks shall be so arranged that the temperature of one network can not appreciably affect the temperature of any other network.

b. Operating conditions shall be accordance with MIL-R-83401. The supply voltage shall be regulated and controlled to maintain ± 5 percent of the maximum voltage specified.

c. With the dc voltage applied, the ambient temperature shall be adjusted to obtain a case temperature of +70 deg C, +5 deg C, -0 deg C .

d. Initial and final resistance shall be at room ambient temperature

e. Test duration shall be 168 hours, minimum

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group B tests in MIL-R-83401.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-R-83401.

TABLE 1190-2 100 Percent Screening Requirements for Fixed-film Resistor Networks

MIL-R-83401 Screens	Additions and Exceptions to the Methods and Criteria of MIL-R-83401
Precap Visual Inspection	a. Paragraph 4.1 of this section
Thermal Shock	
Power Conditioning	a. Paragraph 4.2.2 of this section
Short Time Overload	
Dielectric Withstanding-Voltage	
Insulation Resistance	
DC Resistance	
Particle Impact Noise (PIND)	a. MIL-STD-202, Method 217 Detection b. If 2 percent of the lot fails, PIND testing may cease; if more than 2 percent fails, the lot shall be retested.
Visual and Mechanical Examination (External)	a. Marking and identification b. Defects and damage; i.e., body finish, lead finish, misalignment, cracks

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SECTION 1195

Thermistors (RTH)
(MIL-T-23648)

1. SCOPE

This section sets forth detailed requirements for thermistors, i.e., temperature-sensitive resistors. There are two classes of thermistors, one with positive temperature coefficients of resistance (PTC) and one with negative coefficients (NTC).

2. APPLICATION

2.1 Derating

2.1.1 Positive Temperature Coefficient (PTC). Positive temperature coefficient thermistors are generally operated in the self-heat mode (heated as a result of current passing through). Such parts should be derated to 50 percent of their rated power at any given temperature as provided in the thermal derating curve of a given slash sheet.

2.1.2 Negative Temperature Coefficient (NTC). Negative coefficient types operated in the self-heat mode shall be derated in accordance with Figure 1195-1 to prevent thermal runaway. Such parts should be derated to a power level causing a maximum increase of 50 times the dissipation constant or a maximum part temperature of 100 deg C, whichever is less. Operation in a heat sunk mode allows greater power levels.

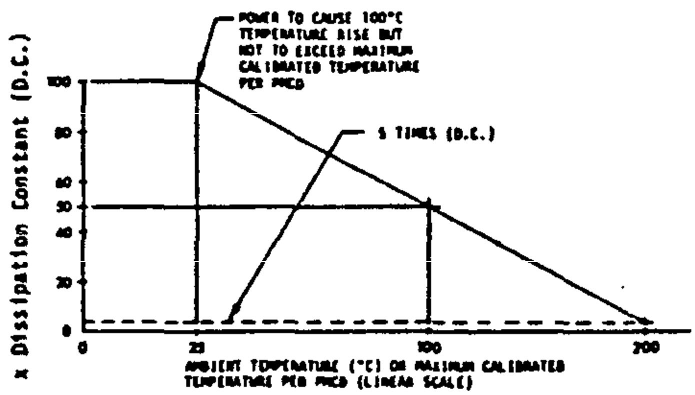

FIGURE 1195-1. Derating Curve for Negative Coefficient Thermistors

2.2 <u>End-of-life (EOL) Design Limits, (for Five Years), Resistance</u>

a. Glass Bead (Negative TC) = ± 1.3 percent + initial tolerance*

b. Bead Encapsulated (Positive TC) = ± 1.8 percent + initial tolerance*

c. Disc (Positive or Negative TC) = ± 5 percent + initial tolerance*

* EOL resistance factor is the total RSS (root sum square) design tolerance:

$$\text{Total design tolerance} = \left[(\text{Aging} + \text{initial tolerance})^2 + (\text{environments})^2 \right]^{\frac{1}{2}}$$

2.3 <u>Electrical Considerations</u>. The following circuit design cautions shall be observed:

a. Use a current limiting resistor or a series circuit design when using a fixed voltage source to prevent the negative coefficient type thermistor from going into thermal runaway.

b. Never exceed the maximum current or power rating, even for short time periods.

c. Never move a thermistor (used in the self-heat mode) into a medium of lower thermal conductivity without careful analysis in order to prevent thermal runaway conditions.

d. Accurate thermistors (± 1 percent) are calibrated for specific temperature test points; operation beyond the test points could result in permanent tolerance changes greater than those allowed for in the calibration.

2.4 <u>Mounting</u>. The following shall be considered when mounting thermistors:

a. The dissipation constant is specified in still air with the thermistor suspended by its leads. Any thermal or mechanical contact with an item acting as a heat sink, or change in surrounding media, changes the resistance of the thermistor.

b. Heat sinks should be used when soldering to thermistor leads.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-T-23648 and the requirements of this standard.

3.2 Recommended.

a. Glass bead style.

a. Hermetically sealed thermistor where appropriate. (The only hermetically sealed thermistor available in MIL-T-23648 is the -/19, a PTC device type.)

3.3 Reliability Suspect Designs. The use of some disc-type thermistors should be avoided because they can absorb water. Other thermistors are mechanical fragile and can easily be broken.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-T-23648.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements listed in Table 1195-1.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the requirement listed in Table 1195-2. A DPA shall be conducted on a representative sample of each production lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-T-23648.

TABLE 1195-1. 100 Percent Screening Requirements for Thermistors

MIL-T-23648 Screens	Additions and Exceptions to the Methods and Criteria of MIL-T-23648
Zero Power Resistance (Initial)	a. At +25 deg C
Thermal Shock	a. For negative TC devices only b. Maximum of 1.0 percent change
Bake (High temperature exposure)	a. 168 hours at maximum specified operating temperature
Burn-in	a. For positive TC devices only b. 168 hours at +25 deg C with 1.5 times rated power
Zero Power Resistance	
Resistance Ratio Characteristic	
Insulation Resistance	a. Minimum of 100 megohms
Visual and Mechanical Examination (External)	a. Marking and identification b. Defects and damage; i.e., body finish, lead finish, misalignment, cracks

TABLE 1195-2. *Lot Conformance Tests for Thermistors*

MIL-T-23648 Screens	Additions and Exceptions to the Methods and Criteria of MIL-T-23648
Short Time Load	a. Maximum delta Zero Power Resistance: 1 percent
Dielectric Withstanding-Voltage	
Low Temperature Storage	a. Maximum delta Zero Power Resistance: 1 percent
Dissipation Constant	
Terminal Strength	a. Minimum 1.0 pound strength b. Maximum delta Zero Power Resistance: 0.5 percent

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SECTION 1200
SWITCHES

1. SCOPE

This section sets forth common requirements for switches. Table 1200-1 lists the military specifications for the general switch types and indicates the applicable section in this standard where detailed requirements are set forth.

TABLE 1200-1. Switch Types

Section Number	Switch Type	Specification Number
1210	Sensitive and push (snap action)	MIL-S-8805
1220	Thermostatic	MIL-S-24236
1230	Pressure	MIL-S-9395

1. APPLICATION

The selection and use of switches and associated hardware shall be in accordance with MIL-STD-1132 and the requirements contained herein. Contact data such as loads, protection, arc suppression, and noise suppression are similar to those for relay contacts of the equivalent type. See Section 1000 of this standard for the applicable information.

2.1 Derating. Use the derating requirements for relay contacts in Section 1000 to derate switch contacts for operation at ambient temperatures.

2.2 Electrical Considerations. Each switch is rated for a specified number of operations at rated current and voltage parameters over a specific temperature range.

2.2.1 Contact Current. Current during make, break, and continuous duty shall be carefully considered. Ratings of contacts are usually given for room temperature. As the ambient temperature increases, switching current ratings are reduced. Typical switch current versus temperature are shown in Figure 1200-1 for a typical switch.

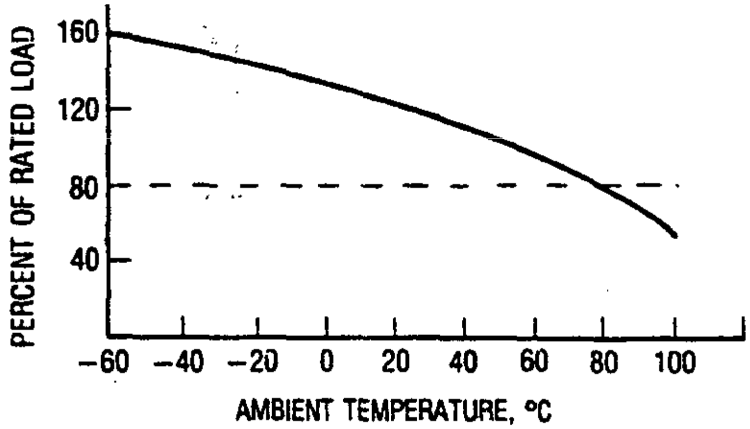

FIGURE 1200-1. Switch Current Rating versus Temperature for a Typical Switch

2.2.2 Cautions

a. Manually Operated Switch. Manually operated switches that are not toggle or snap action can have the contacts damaged or seriously reduce its load handling capabilities can be seriously reduced when the switch is deliberately operated in slow motion.

b. Load Considerations. For inductive loads, low level loads, intermediate range loads, parallel contacts, series contacts, dry circuit switching, transformer switching, transient suppression, and dynamic contact resistance, the requirements of MIL-STD-1132 and MIL-STD-1346 (as applicable) shall apply.

c. Environmental Conditions. The environmental conditions shall be considered when using the leaf type actuator. Uncontrolled forces due to shock, vibration, and acceleration can result in inadvertent plunger actuation.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of the applicable specifications and the requirements of this standard.

3.2 Construction Controls. The following controls shall apply:

a. Each switch not being assembled or inspected shall be kept in a clean dust-free enclosure.

b. Subsequent to final cleaning and assembly, all open switches shall be worked on under a Class 100 environment per FED-STD-209.

c. Pre-closure wash (millipore) shall be accomplished per Section 1000.

3.3 Recommended. Recommended designs and constructions are:

a. Switch shaft and housing of corrosion-resistant material

b. High contact pressures in cold environments

c. Hermetically sealed

d. Snap-action style

e. Positive break

f. Panel seal

3.4 Reliability Suspect Designs. None identified.

4. QUALITY ASSURANCE

The quality assurance requirements for snap action switches, thermal switches, and pressure switches are stated in subsequent sections of the standard. Quality assurance provisions for other switches shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of the applicable specifications, and the following:

4.1.1 Internal Visual Inspection. Inspect 100 percent at 10X minimum for:

a. No contamination particle greater than 0.001 inch in diameter

b. Solder and weld joints

c. Proper alignment

d. Clean feedthroughs

e. Normal contacts

4.1.2 Additional Controls. The following controls shall apply:

a. Inspect seals and encapsulation 100 percent at 10X minimum for cracks

b. Leads and terminals are clean and straight

c. Each switch shall have its contact closure force setting checked.

d. Each switch shall have its critical internal dimensions checked for correctness.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements in the applicable specifications. Unless otherwise specified, the screening shall include 500 cycles of run-in testing with contacts monitored for misses at 6 volts dc, 100 milliamperes maximum.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group B, or equivalent, tests in the applicable specifications.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of the applicable specifications.

SECTION 1210

SENSITIVE AND PUSH (SNAP ACTION) SWITCHES (MIL-S-8805)

1. SCOPE

This section sets forth detailed requirements for hermetically sealed snap-action switches.

2. APPLICATION. See Section 1200.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-S-8805 and the requirements of this standard.

3.2 Recommended. See Section 1200.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-S-8805. Internal visual inspection shall also be in accordance with the requirements of Paragraph 4.1 in Section 1200. In addition, devices shall be inspected at 10X minimum for the following defects:

a. Adhering conductive or nonconductive particles (metal burrs or case flashing)

b. Incomplete swagging or staking of assembly components (not 360 degrees)

c. Scratches or nicks in contact interface surface areas

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements listed in Table 1210-1.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group B tests in MIL-S-8805.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-S-8805.

TABLE 1210-1. 100 Percent Screening Requirements
(Page 1 of 2)

MIL-S-8805 Screens	Additions and Exceptions to the Methods and Criteria of MIL-S-8805
Operating Characteristics	
Dielectric Withstanding-Voltage	
Contact Resistance	
Vibration (Random)	a. MIL-STD-202, Method 214, Test Condition II, K (switch in critical system position and test to the requirements of the application) b. 3 orthogonal planes, 1 minute each c. Mounting fixture shall not add or remove energy from switch under test d. Monitored for contact chatter, 10 microseconds maximum per MIL-STD-202, Method 310, Circuit B e. No contact transfer (monitor equipment shall be capable of detecting closures greater than 1 microsecond) f. If more than one critical system position exists, repeat steps a, b, c, d, and e, with the switch in each critical position.
Thermal Shock	a. During last cycle (5th), measure contact resistance at temperature extremes
Particle Impact Noise (PIND)	a. MIL-STD-202, Method 217 Detection b. If 2 percent of the lot fails, PIND testing may cease; if more than 2 percent fails, the lot shall be retested.
Insulation Resistance	
Mechanical Run-in	a. 500 cycles at 10 cycles per minute at +25 deg C b. Monitor all make and break contacts at 6 VDC 100 mA max.

TABLE 1210-1. 100 Percent Screening Requirements
(Page 2 of 2)

MIL-S-8805 Screens	Additions and Exceptions to the Methods and Criteria of MIL-S-8805
Seal	
Dielectric Withstanding-Voltage	
Insulation Resistance	
Operating Characteristics	
Radiographic Inspection	a. Per MSFC-STD-355; 2 views 90 deg. apart by X-ray, or 360 deg. view by Vidicon. Use of "real-time" X-ray systems capable of viewing through 360 deg rotation is encouraged.
Visual and Mechanical Examination (External)	a. Marking and identification b. Defects and damage; i.e., body finish, lead finish, misalignment, cracks

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SECTION 1220

THERMAL SWITCHES
(MIL-S-24236)

1. SCOPE

This section sets forth detailed requirements for thermal switches.

2. APPLICATION

2.1 Derating. The derating requirements given in Section 1000 for relay contacts shall be used to derate switch contacts.

2.2 Electrical Considerations. Bimetallic disc (BMD) thermal switches have been used for temperature sensing and heater control. They have the advantage of being lightweight, sturdy (withstand high shocks of 750 g and vibration of 60 g rms random), and require no external power.

Some of the anomalous switch behaviors exhibited are drift in both upper and lower switching temperatures. These anomalies are known as "creepage" or "dithering" and have been used interchangeably to describe either of the following two conditions:

a. The failure of an assembled unit to respond to temperature changes with immediate positive snap action of the disc

b. A deviation of the switching temperatures of a unit in service from its original set-temperatures, resulting in a very narrow switching band

The former condition usually results in high rejection rates during acceptance tests. The latter case can be far more consequential, since such events are usually characterized by either a hesitant contact or a series of frequent openings and closings of the contacts and thus may induce excessive arcing or stress cycling; these effects often result in switch malfunction or shortened service life.

To alleviate the possibility of dither, increase the deadband (temperature separation between the thermal switch "on" position and the switch "off" position) to +4 deg C minimum and require a temperature rate-of-change greater than 0.11 deg C per minute. The in-process controls and screens described herein are intended to improve switch reliability.

Thermal switches shall not be used for applications where the temperature rate of change is less than 0.11 deg C per minute, or the thermal deadband is less than +4 deg C. In such applications, solid-state temperature sensing and control is preferred.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-S-24236 and the requirements of this standard.

3.2 Recommended. Snap-action.

a. Contact current rating, 5 amperes maximum

b. Deadband +4 deg C minimum

c. Temperature rate-of-change accommodated, 0.11 deg C per minute.

3.2 Reliability Suspect Designs. See Paragraph 2.2 in this section.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-S-24236 and the following:

4.1.1 Switch Assembly

a. Each switch shall have its contact closure or opening force setting checked.

b. Each switch shall have its critical internal dimensions checked for correctness.

c. Each switch not being assembled or inspected shall be kept in a clean dust-free enclosure.

d. Subsequent to final cleaning and assembly, all open switches shall be worked on under a Class 100 environment per FED-STD-209 or as approved by the contracting officer.

e. All switches that utilize different materials for movable and stationary contacts shall have the contacts identified as + and - and the life verified by tests with voltage applied in the polarity specified.

4.1.2 Precap Visual Inspection (100 percent). 10X magnification minimum under laminar flow benches for:

a. No particle contamination greater than 0.001 inch in maximum dimension

b. No plating defects such as flaking or blistering.

c. No loose oxide film on surface of bimetallic disc

d. No organic compounds or films on contacts or header base

e. Actuator tips free of sharp peaks, cracks, chips, and flakes

f. No radial cracks in the glass seal extending greater than one-half the distance from the center post to outside edge

4.1.3 Cleaning (Pre-Seal) and Small Particle Inspection. Clean thermostatic switches, cans, and any other parts or subassemblies that constitute the final assembly, using the following procedure or a procedure approved by the contracting officer. First obtain freon from pre-filtered supply. Assembly pre-cleaned 1000 milliliter flask, vacuum pump, filter holder, pre-cleaned 0.80 micrometer filter, and pre-cleaned funnel. Fill funnel with pre-filtered freon and turn vacuum pump on. Repeat until flask is filled. Fill a pressurized container with cleaned freon. Clean filter by blowing both surfaces with ionized air. Using the pressurized container, wash both sides of the filter with clean filtered freon. Observe filter under 30X magnification; if any particles 2.5 micrometers (0.001 inches) or larger, or visable particles under 2.5 micrometers (0.001 inches) are observed, repeat the cleaning process until satisfactory results are obtained. Place the filter holder and cleaned filter on a clean empty 1000 milliliter flask under funnel. Air blow all parts to be millipore-cleaned using ionized air. Place parts in funnel. Using 1000 milliliter flask of filtered freon, pour the freon into the funnel, covering the parts to be cleaned. Cover funnel. Turn on vacuum pump. When all the freon has passed through the filter, turn off vacuum pumps. Remove filter and examine under 30X magnification. If one or more particles 2.5 micrometers (0.001 inches) or larger are present, or three or more visable particles under 2.5 micrometers (0.001 inches) are present on the filter, repeat the process until this condition is corrected. Place cleaned parts in cleaned covered trays in preparation for canning the relays.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements listed in Table 1220-1.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group B tests in MIL-S-24236 with the following exceptions:

a. Solderability per MIL-S-24236 or DOD-STD-2000

b. DPA per MIL-STD-1580

c. MIL-S-24236, Group B tests not required on each lot are as follows:

Subgroup 1 --	Moisture Resistance Flame Response Short Circuit
Subgroup 3 --	All
Subgroup 4 --	Sensitivity Response Temperature Anticipation

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-S-24236 with the addition of a test for resistance to soldering heat per Condition B of Method 210 of MIL-STD-202.

TABLE 1220-1. 100 Percent Screening Requirements for Thermal Switches (Page 1 of 2)

MIL-S-24236 Screens	Additions and Exceptions to the Methods and Criteria of MIL-S-24236
Vibration (Sine)	a. MIL-STD-202, Method 204, at 30 g, 10-2000 Hz (switch in critical system position) b. Electrical load of 110 mA maximum at 6 Vdc c. Monitored for contact chatter, 10 microseconds maximum per MIL-STD-202, Method 310, Circuit B d. No contact transfer (monitor equipment shall be capable of detecting closures greater than 1 microsecond) e. Duration of 1 frequency sweep per contact position
Vibration (Random)	a. MIL-STD-202, Method 214, except use the following spectrum: 20 Hz...........0.01 g^2 per Hz 20-90 Hz........+9dB per Octave 90-350 Hz.......0.9 g^2 per Hz 350-2000 Hz.....-6db per Octave b. 3 orthogonal planes c. Duration shall be 1 minute per axis per contact position d. Monitored for contact chatter, 10 microseconds maximum per MIL-STD-202, Method 310, with 110 mA maximum at 6 Vdc e. No contact transfer (monitor equipment shall be capable of detecting closures greater than 1 microsecond)
Calibration	
Mechanical Run-in	a. 500 cycles b. Monitor all make and break contacts at 6 VDC 100 mA max. c. Miss test monitoring equipment to measure contact resistance required.
Calibration	

TABLE 1220-1. 100 Percent Screening Requirements for Thermal Switches (Page 2 of 2)

MIL-S-24236 Screens	Additions and Exceptions to the Methods and Criteria of MIL-S-24236
Particle Impact Noise (PIND)	a. MIL-STD-202, Method 217 Detection b. If 2 percent of the lot fails, PIND testing may cease; if more than 2 percent fails, the lot shall be retested.
Creepage	a. Temperature rate of change shall be 0.11 deg C per minute b. Three runs c. Arc duration of 5 millisecond maximum at 500-600 Vdc with current limited to 1 mA maximum
Seal	Per MIL-S-24236 for hermetic switches
Dielectric Withstanding-Voltage	
Insulation Resistance	
Contact Resistance	
Radiographic Inspection	a. Per MSFC-STD-355; 2 views 90 deg. apart by X-ray, or 360 deg. view by Vidicon. Use of "real-time" X-ray systems capable of viewing through 360 deg rotation is encouraged.
Visual and Mechanical Examination (External)	a. Marking and identification b. Defects and damage; i.e., body finish, lead finish, misalignment, cracks

SECTION 1230

PRESSURE SWITCHES
(MIL-S-9395)

1. <u>SCOPE</u>

This section sets forth detailed requirements for hermetically sealed pressure switches.

2. <u>APPLICATION</u>

See Section 1200.

3. <u>DESIGN AND CONSTRUCTION</u>

3.1 <u>Requirements</u>. Design and construction shall be in accordance with the requirements of MIL-S-9395 and the requirements of this standard. (See the requirements of Section 1200 and Section 300, as applicable.)

4. <u>QUALITY ASSURANCE</u>

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 <u>In-process Controls</u>. In-process controls shall be in accordance with the requirements of MIL-S-9395 and Paragraph 4.1 in Section 1200.

4.2 <u>Screening (100 percent)</u>. Screening (100 percent) shall be in accordance with the requirements listed in Table 1230-1.

4.3 <u>Lot Conformance Tests</u>. Lot conformance tests shall be in accordance with the requirements in Table 1230-2.

4.4 <u>Qualification Tests</u>. Qualification testing shall be in accordance with the requirements of MIL-S-9395.

TABLE 1230-1. 100 Percent Screening Requirements for Pressure Switches (Page 1 of 2)

MIL-S-9395 Screens	Additions and Exceptions to the Methods and Criteria of MIL-S-9395
Vibration (Random)	a. MIL-STD-202, Method 214, Test Condition II, K (switch in critical system position and test to the requirements of the application) b. 3 orthogonal planes, 1 minute each c. Mounting fixture shall not add or remove energy from switch under test d. Monitored for contact chatter, 10 microseconds maximum per MIL-STD-202, Method 310, Circuit B e. No contact transfer (monitor equipment shall be capable of detecting closures greater than 1 microsecond) f. If more than one critical system position exists, repeat steps a, b, c, d, and e, with the switch in each critical position.
High Temperature	
Low Temperature	
Particle Impact Noise (PIND)	a. MIL-STD-202, Method 217 Detection b. If 2 percent of the lot fails, PIND testing may cease; if more than 2 percent fails, the lot shall be retested.
Mechanical Run-in	a. 500 cycles at 10 cycles per minute at +25 deg C b. Monitor all make and break contacts at 6 VDC 100 mA max. c. Miss test monitoring equipment to measure contact resistance required.
Proof Pressure	
Calibration	
Coincidence of Operation	a. Multi-pole only
Contact Resistance	

TABLE 1230-1. 100 Percent Screening Requirements for Pressure Switches (Page 2 of 2)

MIL-S-9395 Screens	Additions and Exceptions to the Methods and Criteria of MIL-S-9395
Dielectric Withstanding-Voltage	
Seal	
Radiographic Inspection	a. Per MSFC-STD-355; 2 views 90 deg. apart by X-ray, or 360 deg. view by Vidicon. Use of "real-time" X-ray systems capable of viewing through 360 deg rotation is encouraged.
Visual and Mechanical Examination (External)	a. Marking and identification b. Defects and damage; i.e., body finish, lead finish, misalignment, cracks

TABLE 1230-2. Lot Conformance Tests
for Pressure Switches

MIL-S-9395 Screens	Additions and Exceptions to the Methods and Criteria of MIL-S-9395
Group I	a. 3 Samples
Solderability	a. If applicable
Shock	
Moisture Resistance	
Overload Cycling	
Seal	
Group II	a. 3 Samples
Mechanical Endurance	
Electrical Endurance	
Contact Resistance	
Seal	
Dielectric Withstanding-Voltage	
Group III	a. 2 Samples
Burst Pressure	
Explosion	a. If applicable

SECTION 1400

TRANSISTORS
(MIL-S-19500)

1. SCOPE

This section sets forth detailed requirements for transistors. The transistor types covered in this section are:

a. Field Effect (FET)
b. General Purpose
c. Microwave
d. Power
e. Switching
f. Unijunction

2. APPLICATION

2.1 Derating. The derating factors for transistors shall be in accordance with AFSC Pamphlet 800-27 except as follows:

a. For bipolar silicon transistors that are low power devices, derate breakdown voltage to 0.75 of rated value.

b. For bipolar silicon transistors that are high power devices, derate safe operating area to 0.75 of rated V_{CE} value and to 0.75 of rated I_C value.

c. For field effect transistors, derate breakdown voltage to 0.75 of rated value.

d. For all transistors, transient peaks shall not exceed the supply voltage by more than the derating factor.

e. For all transistors, voltage deratings apply to V_{CBO}, V_{EBO}, and V_{CEX} ratings. Precautions against secondary breakdown shall be taken.

f. For all transistors, the maximum junction temperature shall be +105 deg C nominal and +125 deg C worst case.

2.2 Electrical Considerations. To ensure a safe operating range, applications in line or relay drivers, power inverters, converters, or amplifiers, and other circuits involving reactive loads, shall be restricted to devices for which the pertinent secondary breakdown characteristics are defined. The locus of the I-V operating point shall fall within the safe operating (including secondary breakdown) area with a safety margin not less than 20 percent for worst-case circuit operating condition.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-S-19500 and the requirements of this standard. Plastic encapsulation shall not be used. Monometallic bonding shall be used. Unglassivated semiconductors in which leads cross scribe lines with clearance of less than 0.002 inch shall not be used.

3.2 Transistors in Hot-welded Cans. If transistors in hot-welded cans are designed, the header design shall include an effective weld-splash barrier ring. In addition, a protective coating of the internal elements shall be used, provided adequate chemical and thermomechanical evaluation and testing at the part level is performed to ensure that no potential failure mechanisms of a more undesirable type have been introduced into the device for that application.

3.3 Reliability Suspect Designs. The following designs are reliability suspect:

a. Hot-welded cases (see Paragraph 4.2.1)
b. Nonglassivated devices (see Paragraph 4.2.2)
c. Gold-aluminum bonds

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-S-19500, JAN S, and the following:

4.1.1 SEM. SEM inspections per Method 2018, MIL-STD-883, shall be used on those devices which have metallization over oxide steps.

4.1.2 Die-shear. Die-shear strength tests shall be in accordance with Table 1400-1.

TABLE 1400-1. Die Shear Strength Criteria
(Minimum Force Versus Die Attach Area)

Die Area ($mils^2$)	Equivalent Square Die Side (Mils)	Maximum Applied Force (grams)	Suspect Shear Limit (grams)
625	25	900	250
900	30	900	360
1600	40	900	640
2500	50	1200	1000
3600	60	1600	1440
4900	70	2500	1960
6400	80	3000	2500
8100	90	3000	2500
10000	100	3000	2500
10000	100	3000	2500

4.1.5 Special Concerns. The special screens, tests, or precautions stated below shall be used when the identified construction or materials are used in semiconductors.

4.1.5.1 Silver Glass Die Attach

a. 100 percent mechanical shock
b. Sample: post-shock die shear

4.1.5.2 Epoxy Materials or Desiccants. Devices containing desiccants, internal epoxy materials, or epoxy materials used for sealing shall have a sample baked at +200 deg C followed by a gas analysis. A maximum of 1000 parts per million of water at +100 deg C shall be allowed.

4.1.5.3 Organic Materials on Surface or Die

a. 1000 hour burn-in
b. 100 percent "monitored" temperature sweep for bond intermittency
c. Residual gas analysis

4.1.5.4 Gallium Arsenide Transistors

a. Adequate heat sinking
b. 100 percent "monitored" temperature

4.1.5.5 **MOS Transistors**. MOS Transistors shall be electrostatically protected.

4.1.5.6 **Optically Coupled Isolators**

a. High Temperature Reverse Bias at +125 deg C, V_{CB} = 20 V, 96 hours minimum
b. Monitored temperature sweep from -55 deg C to +125 deg C for bond integrity

4.1.5.7 **Mesa Construction**

a. Review process controls for assurances of clean surfaces.
b. Require at least 6000 angstroms of glass or oxide passivation over junctions.
c. Perform High Temperature Reverse Bias (HTRB) in accordance with Method 1039, MIL-STD-750, Condition A. Measure I_R at 80 percent of V_{BR} before HTRB and within 16 hours of removal from HTRB. After removal from HTRB, power shall be maintained until the testing is performed. If the variation in I_R is $\pm$ 10 percent of the maximum I_R specified or $\pm$ 100 percent of the initial value, whichever is larger, the device is a reject.

4.2 **Screening (100 percent)**. Screening (100 percent) shall be in accordance with the JAN S Screening requirements of MIL-S-19500. The electrical tests shall be in accordance with the items listed in Table 1400-2. Unless otherwise specified the reject criteria shall be per the detail spec limit.

4.2.1 **Transistors in Hot-welded Cans**. If transistors are in hot-welded cans, perform the following additional tests and inspections:

a. Perform 100 percent mechanical shock test (such as MIL-STD-202, Method 213A, Condition F) of each lot followed by particle impact noise detection screening per MIL-STD-750, Method 2052, Condition A.

b. Conduct radiographic (X-ray or vidicon) inspection of each part after completion of screening requirements

4.1.2 Nonglassivated Transistors. If transistors are nonglassivated, perform the following additional tests and inspections:

a. Perform 100 percent mechanical shock test (such as MIL-STD-202, Method 213A, Condition F) of each lot followed by particle impact noise detection screening per MIL-STD-750, Method 2052. Subject devices to PIND tests until no failures are found on two successive sequences.

b. Conduct radiographic (X-ray or vidicon) inspection of each part after completion of screening requirements.

c. DPA-sample passed devices, inspect for particles.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Group B tests of MIL-S-19500 for JAN S. When radiation hardness is specified, wafer lot testing shall be accomplished in accordance with the Group D tests for JAN S per MIL-S-19500, and Appendix C of this standard.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-S-19500.

TABLE 1400-2. Electrical Test and Reject Criteria
(Page 1 of 3)

Transistor Types							Tests and Criteria
FET (1)	GENPUR (2)	MICRO (3)	UNI (4)	POWER (5)	SWITCH (6)	RF (7)	NOTE: Unless otherwise specified reject criteria shall be per detail spec limit
X							I_{GSS}, Delta I_{GSS} greater than ± 100 percent of initial value or greater than ± 10 percent of spec. limit, whichever is greater
X							V_{GS} (th), V_{DS} (on), Delta V_{GS} (th) or Delta V_{DS} (on) greater than ± 20 percent of initial value
X							I_{DSS}, Delta I_{DSS} greater than ± 100 percent of initial value or greater than ± 10 percent of spec. limit, whichever is greater
	X	X		X	X	X	I_{CBO}, Delta I_{CBO} greater than ± 100 percent of initial value or greater than ± 10 percent of spec. limit, whichever is greater
	X	X		X	X	X	I_{EBO}
	X				X	X	I_{CES}
	X			X	X	X	V_{CE} (sat), Delta V_{CE} (sat) greater than ± 50 mVdc
	X			X	X	X	h_{FE}, Delta h_{FE} greater than ± 15 percent of initial value.
		X					h_{FE}, Delta h_{FE} greater than ± 20 percent of initial value.
			X				I_{EB20}, Delta I_{EB20} greater than ± 100 percent of initial value or greater than ± 10 percent of spec. limit, whichever is greater.

TABLE 1400-2. Electrical Test and Reject Criteria (Continued, Page 2 of 3)

Transistor Types: FET (1)	GEN PUR (2)	MICRO (3)	UNI (4)	POWER (5)	SWITCH (6)	RF (7)	Tests and Criteria. NOTE: Unless otherwise specified reject criteria shall be per detail spec limit
X							y_{fs}, Delta y_{fs} greater than ± 10 percent
X							r_{on}, Delta r_{on} greater than ± 10 percent
			X	X			Delta I_{EBO} greater than ± 100 percent of initial value or greater than ± 10 percent of spec. limit, whichever is greater.
		X					C_{obo}, Delta C_{obo} greater than ± 25 percent
			X				r_{BBO}, Delta r_{BBO} greater than ± 20 percent
						X	Each application shall be tested for 100,000 turn-on and turn-off cycles at a rate not to exceed 1000 cycles per second with no power degradation in output.
	X	X		X	X		$V_{(BR)CBO}$, $V_{(BR)CEO}$, $V_{(BR)EBO}$
	X	X		X	X		V_{BE} (sat)
		X					P_O
			X	X			n, Delta n greater than ± 5 percent of the initial value
			X				NF

TABLE 1400-2 Electrical Test and Reject Criteria
(Continued, Page 3 of 3)

NOTES:

1. FET
   - Drain to source current, source shorted to gate, I_{DSS}
   - Small signal forward transadmittance, y_{fs}
   - On resistance, r_{on}
   - Gate-to-source threshold voltage, $V_{GS\ (th)}$, or gate-to-source cutoff voltage, $V_{GS\ (off)}$, as applicable
   - Gate-to-source leakage current, source shorted to drain, I_{GSS}
   - Drain-to-source voltage (on-state), $V_{DS\ (on)}$

2. General Purposes
   - Collector cutoff current, base shorted to emitter, I_{CES}
   - Collector cutoff current, emitter open, I_{CBO}
   - Emitter cutoff current, collector open, I_{EBO}
   - Base-to-emitter saturation voltage, $V_{BE\ (sat)}$
   - Static value of the forward current transfer ratio (common emitter), h_{FE}
   - Breakdown voltage, collector to base, emitter open, $V_{(BR)CEO}$
   - Breakdown voltage, emitter to base, collector open, $V_{(BR)\ EBO}$

3. Microwave

   Same as General Purposes (except for breakdown voltages) with the following additions:
   - Power output, P_O (or NF for small signal devices)
   - Output capacitance (common base), input open circuited, C_{obo}
   - Noise figure, NF

4. Unijunction
   - Emitter to base two reverse current, I_{EB2O}
   - Interbase resistance, r_{BBO}
   - Intrinsic standoff ratio, n

5. Power

   Same as General Purposes (see Note 2)

6. Switching

   Same as General Purposes (see Note 2)

7. RF

   Same as General Purposes (See Note 2)

SECTION 1500

WIRE AND CABLE

1. SCOPE

This section sets forth requirements for wire and cable for use in space vehicles.

2. APPLICATION

2.1 External. Wiring external to electronic enclosures shall be in accordance with DOD-W-83575.

2.2 Internal. Wiring internal to electronic enclosures should use DOD-W-83575 as guidance; however, the selection and use of wire, cables, and RF coaxial cables is not as restrictive. Wiring internal to electronic enclosures shall be in accordance with MIL-W-22759, MIL-W-81381, MIL-C-27500, MIL-C-17, and the requirements contained herein. Teflon (TFE, FEP, and PFA) shall not be used as the primary insulation on wires. Teflon may be used in combination with other insulation materials that provide suitable cut through resistance for the composite insulation system. Polyvinyl chloride (PVC) insulated conductors and jacketing materials shall not be utilized.

2.3 Derating. Derating factors and wire current ratings shall be based on the wire size, on the insulation used, and on whether it is a single wire or in a bundle. The wire current ratings and deratings listed in MIL-W-5088 shall be used.

2.4 Electrical and Handling Considerations. The characteristics of the insulation used on wire shall be used as an aid in selecting the proper wire type for each application.

Carbon flashover should be considered if applicable. Carbon flashover is a catastrophic failure mechanism brought about by the more vigorous propagation of electrical arcing in a failed wire bundle via carbonization of the insulation. Carbonization of the insulation is a thermal degradation process due to high temperature discharges, particularly in a vacuum, that yields a conducting carbon char residue as contrasted to gaseous products. Wire bundles exposed both to low oxygen environments (vacuum) and to salt spray, electrolytes, surface discharge scintillations, excessive oxidation, repeated maintenance, or ballistic impact have a greater risk of flashover. Some insulation materials, such as Kapton, are at more risk to carbon flashover than are other materials, such as Teflon.

2.4.1 <u>Thermoplastics</u>.

2.4.1.1 <u>Tefzel (ETFE)</u>. Tefzel, a Du Pont trade name, is a copolymer of ethylene and tetrafluoroethylene, has a maximum surface temperature of 150 deg C, and an embrittlement temperature below -100 deg C, with very good electrical characteristics. It is resistant to physical abuse, has good thermal properties and is inert to chemicals. It is slightly stiffer than Teflon, but is quite flexible.

2.4.1.2 <u>Kynar</u>. Kynar, a Pennwalt Corporation trade name, is a crystalline, high molecular weight polymer of vinylidene fluoride with excellent mechanical strength, and higher resistance to abrasion, cut-through, and cold flow than Teflon (TFE, FEP, and PFA) with an operating temperature of -65 deg C to +135 deg C. Kynar is typically used as a jacket over a soft insulation, such as polyalkene, rather than as a primary insulation. The high dielectric constant makes it undesirable as a primary insulation.

This material should be considered especially where wiring is exposed to gamma radiations of up to 10^8 roentgens in vacuum environments. Because of the temperatures at which Kynar is processed, tin coated conductors should not be used with Kynar insulation. However, tin may be suitable under another primary insulation (such as polyalkene) with a Kynar jacket. Nickel can withstand the Kynar processing temperature.

Kynar insulated wires shall not be utilized where it can be exposed to sulfonating agents at high temperatures. This insulation is slightly stiffer than Tefzel and sharp bends, tight installations, and other assembly features may be more of a problem.

2.4.2 <u>Thermosets</u>

2.4.2.1 <u>Kapton</u>. Kapton, a Du Pont trade name, is an aromatic polyimide with excellent thermal and electrical resistance and good cut-through and solvent resistance (except concentrated acids and alkalies) properties. It has an extrapolated life of 10 years at +250 deg C.

Kapton is stiff, hydroscopic, and shall not be exposed to high-moisture environments. It is recommended for harnessing when straight runs or generous bend radii can be achieved. This material can carbonize under some conditions.

2.4.2.2 <u>Crosslinked Polyalkene</u>. Polyalkenes are a thermoplastic copolymer of ethylene and propylene. Crosslinking, either chemically or by irradiation, greatly improves the properties and changes the material to a thermoset plastic. This is a lightweight, tough material that is flexible, has a high dielectric strength with a high resistance to stress cracking, ozone, solvents, cut-through, and solder iron heat. The operating temperature is up to +150 deg C.

2.5 Stripping. Thermal stripping of insulation is recommended for MIL-W-22759 wire and for most wire types and gauges. Thermal stripping shall be in accordance with good workmanship practices. Mechanical stripping is acceptable provided adequate workmanship precautions are taken to avoid quality problems such as nicks due to the use of improper tools.

3. DESIGN AND CONSTRUCTION

3.1 General Purpose Wire General purpose internal wiring shall be in accordance with MIL-W-22759. Detail specifications -/16, -/17, -/18, and -/19 are the recommended types. When better insulation characteristics are required, detail specifications -/32, -/35, -/41, -/42, and -/43 are acceptable. Teflon insulated conductors and jacketing materials shall not be utilized. Polyvinyl chloride (PVC) insulated conductors and jacketing materials shall not be utilized.

3.1.1 Conductors. Conductors shall be copper or copper alloy in accordance with the controlling specifications. The choice depends on the user application. Conductor finish shall be selected based on the following:

a. Nickel finish. Solder does not wick under the insulation beyond the joint, leaving a good flexible area. Also, the finish is good for temperatures up to +260 deg C. It is acceptable for crimp applications, provided the crimp values in MIL-C-39029 are used.

b. Silver finish. Temperature range is above +150 deg C to about +200 deg C, and is good for applications where high frequencies are used due to its higher conductivity.

   Silver-coated copper wire shall not be exposed to a moist or high humidity environment, as it is susceptible to oxidation, corrosion, whisker growth, and to silver migration through the insulator material.

c. Tin or Tin Alloy. This finish is the least expensive, but is susceptible to oxide filming and corrosion if exposed to traces of chlorine, oxides of nitrogen, or humidity. Tin is also prone to formation of whiskers. Tin or tin alloy finish may be used with solder terminations, but they are not recommended with crimp terminations. They shall not be used with wrapped wired terminations.

3.2 Cables. Cables containing shielded and unshielded wires shall be in accordance with MIL-C-27500. Inner and outer jacketing materials of polyvinyl chloride (PVC) is prohibited.

3.3 RF Coaxial Cables

3.3.1 Flexible Coaxial Cables. Flexible coaxial cables shall be in accordance with MIL-C-17. Preferred cables are -/95 for 95 ohm cable, -/94 and -/110 for 75 ohm cable, and -/60, -/93, -/111, -/112, -/127, and -/128 for 50 ohm cable applications.

3.3.2 Semi-rigid Coaxial Cables. Semi-rigid cables shall be in accordance with MIL-C-17. Where RG-402/U or RG-405/U cables (0.141 or 0.086 diameters) are used with SMA connectors, the crimp termination shall be used in lieu of solder terminations where frequency range does not exceed 18 GHz.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and the requirements in the applicable military specifications.

Custodians
Air Force - 19

Preparing Activity
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(Project No. 1820-F008)

Documents 1337b Arch 1207b
1338b Arch 1208b
1339b Arch 1209b

APPENDIX A. PART MOUNTING AND INSTALLATION

This Appendix is a mandatory part of the standard.

10. SCOPE

This appendix sets forth the general requirements for mounting and installation of parts.

20. GENERAL

Mounting and installation of parts shall be in accordance with the requirements of DOD-STD-2000-2, "Part and Component Mounting for High Quality/High Reliability Soldered Electrical and Electronic Assemblies" as applicable, and the requirements contained herein.

20.1 Sleeving. Fragile parts shall be fitted with sleeving or buffer coat to prevent damage.

20.2 Hermetic Seals. All hermetically sealed devices with glass-to-metal seals shall be subjected to a hermetic seal test following machine formation of the leads.

30. TERMINALS

When terminals are used as an electrical interface to printed circuitry, a "redundant" wire shall be used for circuit attachment to an adjacent plated through hole (see Fig. A-1). An alternate to redundant wiring is step soldering of the terminal to the printed wiring to preclude solder reflow during subsequent soldering operations.

40. POWER DEVICE MOUNTING

All metal power packages requiring electrical connection to the case shall be mounted with stressed hardware appropriately torqued that will assure electrical contact during expansion and contraction of the printed wiring board during thermal excursion. An alternate is a metallurgical correction to the cases.

50. POTTED MODULES

Potted modules are not recommended for new designs. All use of potted modules shall require contracting officer approval.

60. PROTECTION AGAINST DAMAGE FROM ELECTROSTATIC DISCHARGE

Extreme care shall be taken to conform to the preservation, packing, handling, and storage requirements that protect against damage from electrostatic discharge (see Appendix B).

70. SOLDERING

Soldering shall be per DOD-STD-2000-1, "Soldering Technology, High Quality/High Reliability," and inspection per DOD-STD-2000-3, "Criteria for High Quality/High Reliability Soldering Technology."

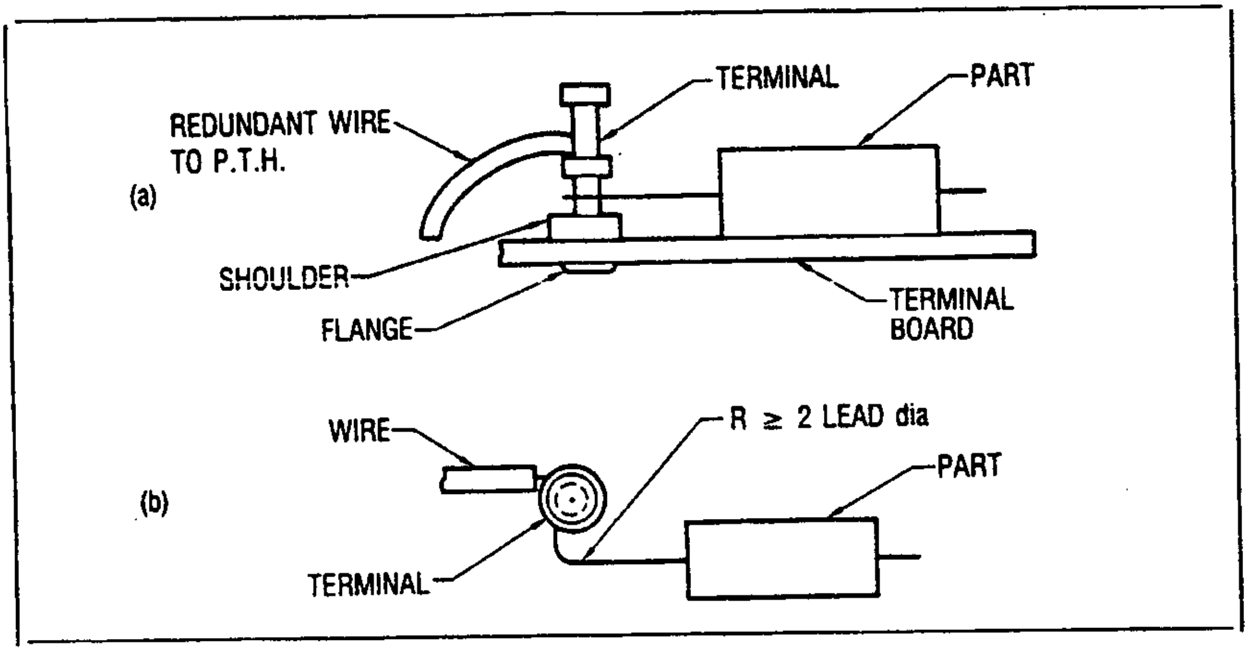


FIGURE A-1. Part Atachment to Terminal

APPENDIX B. PROTECTION AGAINST ELECTROSTATIC DISCHARGE

This Appendix is a mandatory part of the standard.

10. SCOPE

10.1 History. Electrostatic charge (static electricity) can be generated and stored on a multitude of commonly used nonconductive surfaces. Unless grounding provisions are incorporated, an electrostatic discharge could result that may damage adjoining equipment. The impact of possible electrostatic discharge shall be addressed at all levels of design from the electronic parts to the spacecraft and launch vehicle itself. Electrostatics are known to have caused arc breakdowns and voltage offsets in spacecraft circuits in digital logic, guidance computers, solar arrays, optical sensors, communication subsystems, and electro-explosive devices. The launch vehicle itself is not immune and, in fact, provisions shall be incorporated to neutralize the impact of precipitation-produced electricity during liftoff and to neutralize charging of spacecraft orbit.

10.2 Purpose. This appendix establishes the criteria and minimum requirements for protecting electronic parts, assemblies, and equipment that are susceptible to destruction or degradation from static discharge.

10.3 Application. This appendix provides guidelines for everyone involved in handling electrostatic discharge-sensitive devices and assemblies intended for use in space systems. The requirements for an electrostatic discharge program shall be as specified herein and in accordance with DOD-STD-1686 and DOD-HDBK-263. In the event of any conflicts, this appendix takes precedence.

20. GENERAL REQUIREMENTS

20.1 Electrostatic-sensitive Devices. As the use of electronic devices that are sensitive to electrostatic discharge increases, it is essential that these parts be identified and controlled to protect them during manufacturing, incoming inspection, test, storage, handling, assembly, and delivery.

20.2.2 Devices. Electronic parts and assemblies have all degrees of electrostatic discharge sensitivity. No attempt need be made to classify these degrees of sensitivity as those listed as Class I, II, and III in DOD-HDBK-263.

30. DETAIL REQUIREMENTS

Requirements in DOD-HDBK-263 and DOD-STD-1686 shall be the controlling requirements regarding static-generating devices, identification requirements, work stations, facilities, equipment, handling, operator procedures, and training.

30.1 Supplemental Data. The following general data also form a necessary part of the work procedures:

a. All multi-sheet manufacturing instructions, visual aids, work orders, or other paperwork used in a protected area shall be contained in an approved carrier. Drawings may be present in a protected area providing the operator is properly grounded and the drawing does not electrically isolate the part or assembly from the approved, protected worksurface.

b. Only natural bristle brushes shall be used.

c. Nonconductive areas (such as vapor degreasing, vacuum packing, and wave soldering) shall have the equipment grounded, provisions made for operator grounding, and shall be provided with conductive carriers or baskets to provide part and assembly protection from electrostatic discharge damage.

d. Any tool or material that is not antistatic approved shall not be allowed in work areas.

e. Electrostatic discharge-sensitive items shall never be inserted into unapproved conductive antistatic plastics during part or assembly storage periods.

f. A rework area shall be equipped with the same static protection equipment as that provided in the assembly cycle.

g. Periodic inspection of the protected work areas for assembly, rework, and test stations shall be made to ensure that the work areas are electrically connected to ground.

h. The operator's wrist straps shall be periodically checked between strap, skin, and ground wire to verify continuity. The reading shall be 250k ohms minimum to a maximum of 2.5 megohms.

i. Operators in antistatic areas shall avoid friction-producing activity such as rubbing hands, wiping feet, putting on a smock, or taking off a smock.

j. The operators shall avoid touching device leads and shall only handle parts by the device bodies, whenever possible.

k. Nonconductive plastics (e.g., the common "bubble" type) found in some electrostatic discharge-sensitive item packing shall be replaced with an approved antistatic cushioning material.

l. Cold chambers using CO_2 gas or nitrogen for cooling ESDS parts or assemblies shall have the baffles and shelves grounded, and the shelves shall be conductive. The parts or assemblies shall be contained in or on conductive material.

m. The same precautions that are used for good electrostatic discharge-sensitive parts and assemblies shall be used for parts and assemblies thought to be defective.

n. Cleaning with Q-tips (or the equivalent) soaked in an approved solvent is permissible.

o. Shunt (shorting) clips attached to electrostatic discharge-sensitive parts or assemblies shall remain in place during all in-plant transport, handling, and storage. They are to be removed only when the device has been, or is about to be, installed in a wired circuit or receptacle, or be subjected to piece part electrical testing.

p. Bare multilayer boards shall have power and ground circuits grounded prior to assembly. Internal layers can retain static charges during handling that can degrade or destroy electrostatic discharge-sensitive devices at assembly.

30.2 Susceptibility.

a. Sunlight and ultraviolet light gradually fade the pink color of polyethylene and the orange color of nylon but has no detrimental effect on the antistatic material.

b. Solvents such as alcohol, ketones, and hydrocarbons shall not be used to clean or come in contact with any antistatic material.

c. Water has a detrimental effect on antistatic materials as they are usually water soluble in order to function properly. Therefore, the antistatic-impregnated plastic should not be washed or immersed in water for long periods.

30.3 Cleaning and Cooling Agents

30.3.1 Cleaning Agents. Serious static electricity problems (up to 5000 V) can develop from cleaning solutions such as trichlorethylene. Low resistivity cleaners shall be used. One solution that has been used, but which is not commercially available, is the following:

A Butyl Acetate	33 percent
Trichlorethylene	33 percent
Methyl Chloroform	17 percent
Isopropyl Alcohol	17 percent
	100 percent

Volume resistivity: 90 kohms per meter

30.3.2 Cooling Agents. Cryogenic cooling agents such as freon, used to cool parts during testing, often cause static potentials up to 3500 V. Great care should be taken in selecting a cooling agent. One possible propellant is EPMS-240X-A Quick Freeze, recently developed by the Miller Stevenson Chemical Co., Los Angeles, California.

APPENDIX C. RADIATION HARDNESS ASSURANCE REQUIREMENTS

This Appendix is a mandatory part of the standard.

10. SCOPE

This Appendix establishes the general requirements pertaining to piece part radiation hardness assurance during the design, and construction and production of the space vehicle or other systems with radiation hardness requirements.

The Appendix provides methodology for part selection based on characterization and categorization procedures. It also establishes the lot acceptance criteria in order to meet specific hardness assurance requirements based on system application and environments.

20. REFERENCED DOCUMENTS

MIL-HDBK-279	Total Dose Hardness Assurance Guidelines For Semiconductor Devices and Microcircuits, February 1985.
MIL-HDBK-280	Neutron Hardness Assurance Guidelines For Semiconductor Devices and Microcircuits, February 1985.
MIL-HDBK-339	Custom Large Scale Integrated Circuit Development and Acquisition for Space Vehicles.

30. SYMBOLS

R_{SPEC} is the specified radiation environment level

R_{FAIL} is the radiation environment failure level of a test device.

$\overline{\ln(R_{FAIL})}$ is the mean of the logarithms of the sample failure levels.

K_{TL} is the one-sided tolerance limit for a normal distribution. It is a function of the confidence level, sample size, and survival probability (see Table C-II and Table C-III).

S_R is the standard deviation of the logarithms of the sample failure levels; $S_R = S_{\ln(R_{FAIL})}$.

PAR_{FAIL} is the parameter or functional failure value for the device.

PAR_{RAD} is the radiation-induced parameter value for a given device.

$\overline{\ln(PAR_{RAD})}$ is the mean of the logarithms of the values PAR_{RAD} for the tested devices.

S_P is the standard deviation in the sample values of $\ln(PAR_{RAD})$; $S_P = S_{\ln(PAR_{RAD})}$.

n is the sample size.

C is the confidence level.

P is the survival probability.

RDM is the radiation design margin.

R_{MF} is the geometric mean radiation failure value.

PDM is the parameter design margin.

P_{MD} is the parameter mean value degradation.

40. ENVIRONMENTS AND PART CATEGORIES

40.1 Radiation Environments. The various types of radiation environments and the design levels are specified in the detailed specification. These radiation environments are derived from the free field environments as transported through the materials surrounding the part for the worst case location and application. The types of radiation environments may include:

a. Neutron fluence (1 Mev equivalent) specified in neutrons per square centimeter, and the number of bursts

b. Total radiation dose specified in Gray(Si) and the dose rate specified in Gray(Si) per second

c. Transient ionization that may cause upset, latch-up, or burnout. The peak dose rate should be specified in Gray(Si) per second and the transient pulse duration in seconds.

d. Particles that could cause a single event upset or latch-up. The particle type, flux (particles per square centimeter per second), and energy spectra should be specified. (Note that there may be an acceptable number of upsets per gate, or per device, per day.)

e. Current and voltage transient waveforms at each external pin during exposure to EMP and system generated EMP (SGEMP). Each transient waveform can be specified by an equivalent open circuit voltage pulse of specified magnitude, width, rise and fall time, and source impedance.

40.2 Radiation Hardness Categorization. For each type of radiation environment, there are several radiation hardness categories of interest:

a. Hardness Critical Category 1M (HCC-1M). These part types are of marginal hardness and require radiation testing during lot acceptance tests and electrical screens.

b. Hardness Critical Category 1H (HCC-1H). These part types do not require radiation testing during lot acceptance tests, but are included in the HCC-1 classification because they are hardness dedicated parts.

c. Hardness Critical Category 1S (HCC-1S). These part types do not require radiation testing during lot acceptance tests, but are included in the HCC-1 classification because each is a sole-source part type that can only be obtained from a specific manufacturer due to its process-related radiation characteristics. HCC-1S parts may require occasional sample testing similar to that done for HCC-2 part types.

d. Hardness Critical Category 2 (HCC-2) These part types do not require lot acceptance tests, but they may require occasional sample testing because of possible changes in design process or material effecting hardness.

e. Hardness Noncritical Category (HNC) These part types have such large design margins that they require no testing even on an occasional basis (RDM greater than 100).

Devices that are in Hardness Critical Category 1M for a particular radiation environment have a lower radiation design margin in that environment than devices that are in Hardness Critical Category 1H, 1S, or 2. Devices that are in the Hardness Noncritical Category for a particular radiation environment have the highest radiation design margin in that environment. Because of the low radiation design margin, radiation hardness lot conformance testing is required on every production lot for each environment where the devices are in Hardness Critical Category 1M. To assure that the Hardness Critical Category 2 devices are in the correct category, radiation hardness testing may be required for device characterization for each applicable environment. Because of the even higher radiation design margins for the Hardness Noncritical Category, typically 100 or higher, no radiation hardness lot conformance testing is required for those environments, except as might be required for device characterization.

In each application, one would like to select devices in the Hardness Noncritical Category and, if they are not available, then in the Hardness Critical Category 2. This is not only because of their higher radiation design margins and therefore lower failure risk in the operational environment, but because the radiation hardness lot conformance testing costs are usually less than for Hardness Critical Category 1 devices. Of course, devices may not be available in either of these categories for the specified levels of all of the various types of radiation environments. For those radiation environments where the Hardness Critical Category 2 criteria cannot be met, devices would be specified in Hardness Critical Category 1M or 1S. Of course, Hardness Critical Category 1M or 1S devices may be used whenever Hardness Noncritical Category devices or Hardness Critical Category 2 devices would not be practicable or cost-effective or would not be available when needed.

The radiation hardness categorization criteria are based on the radiation design margin. The radiation design margin depends upon the specified radiation environments as well as the radiation hardness characterization results for the part. The categorization criteria in this document are based on a log normal failure distribution. In general, the categorization criteria should be based on a failure distribution that best fits the radiation test data. The standard deviation used in the categorization, S_R, must represent the variation between lots based on data or estimation of worst case value.

The radiation hardness categorization is typically an interative process for the parts because the location, and therefore the transported environment for the application, may change during the development. In addition, the characterization for the actual parts used may vary from that for the production units used in the initial characterization.

40.3 Radiation Design Margin (RDM). The radiation design margin, RDM, is defined as the ratio of the mean radiation failure value, R_{MF}, for a test sample to the device radiation specification level.

$$RDM = \frac{R_{MF}}{R_{SPEC}} \quad (1)$$

where $$R_{MF} = \exp\left[\overline{\ln(R_{FAIL})}\right] \quad (2)$$

and $$\overline{\ln(R_{FAIL})} = \frac{1}{n} \sum_{i=1}^{n} \ln(R_{FAIL_i}) \quad (3)$$

where R_{FAIL_i} is the radiation failure level for the ith sample in the test group.

40.4 Standard Deviation. The standard deviation, S_R, is defined for n greater than 1 as:

$$S_R = \left(\frac{1}{n-1} \sum_{i=1}^{n} \left[\ln(R_{FAIL_i}) - \overline{\ln(R_{FAIL})} \right]^2 \right)^{1/2} \quad (4)$$

40.5 Part Categorization Methods. HCC-1M and HCC-2 piece parts shall be categorized in each radiation environment. The categorization method options are:

a. The breakpoint method, (BM). The breakpoint method is usually applied to parts in systems with moderate radiation requirements

b. The part categorization criterion method, (PCC). The PCC method is usually specified for systems with stringent radiation requirements.

c. A combination of the methods may be applied (e.g., the breakpoint method may be applied to most of the parts and the PCC method to a selected number of parts).

Both categorization methods shall be based on radiation characterization data. The categorization is based on comparing the RDM of the part to a numerical value. In the breakpoint method, the same numerical value is applied to all parts in the system. In the part categorization method, the RDM is compared to a number determined separately for each part. This number depends upon the standard deviation, sample size, required confidence level, and survival probability.

40.5.1 <u>Breakpoint Part Categorization Method</u>. The breakpoint method may be applied to systems with moderate radiation requirements. In this method, a single specified radiation design margin is applied to all piece parts in the system. Unless otherwise specified, the breakpoint between Category 1M and Category 2 shall be at an RDM of 10. Therefore, parts with an RDM greater than 10 are Category 2. Parts with an RDM of 10 or less, but greater than 2, are Category 1M. This method is limited to those cases where the test data for the specific piece parts and radiation environment show a standard deviation less than 0.5 with 90 percent confidence level. In some special cases, the categorization of the part may be based on the parameter design margin at the specified radiation level. For example, in the case of bipolar transistors, considerable amounts of data may exist on the damage constants in neutrons and total dose environment which may be sufficient to establish the categorization of the part.

40.5.2 <u>Part Categorization Criterion Method</u>. In this method, the categorization criterion of the part is determined by comparing the radiation design margin, RDM, to a number which depends on the standard deviation, S_R, and the one-sided tolerance limit factor, K_{TL} (n, C, P). The value of K_{TL} is a function of the sample size n, required confidence level, C, and survival probability P. Parts with an RDM greater than $\exp(K_{TL}S_R)$ are Category 2. Parts with an RDM of $\exp(K_{TL}S_R)$ or less, but greater than 2, are Category 1M.

Unless otherwise specified, the survival probability shall be 99.9 percent and the confidence level shall be taken as 95 percent.

50. LOT CONFORMANCE TESTS

50.1 Test Requirements. Radiation lot conformance tests are specified in the detailed specification based upon the radiation hardness category classification of the parts for each type of radiation environment.

a. No radiation hardness lot conformance testing is required for parts that do not have a radiation environment specified.

b. Parts in Hardness Critical Category 1M for a particular type of radiation environment require radiation hardness lot conformance testing of every production lot for that radiation type. For those solid state parts where the radiation response to the specified radiation environment is largely variable from one wafer to the next within a diffusion lot, the radiation hardness lot conformance testing is required for the devices fabricated from each wafer.

c. Parts in Hardness Critical Category 2 for a particular type of radiation environment may require radiation hardness lot conformance testing for that radiation type on the first production lot if existing characterization data is inadequate to justify the Hardness Critical Category 2. Radiation hardness lot conformance testing may also be required periodically to track any variations in the characterization data, if so specified in the detailed specification.

d. Parts that are in a Hardness Noncritical Category for particular types of radiation environments do not require radiation hardness lot conformance testing for those radiation types.

Note that the parts may have different radiation hardness category classifications for each type of radiation. For example, a part could be in Hardness Critical Category 1M for one type of radiation, in Hardness Critical Category 2 for another type of radiation, in a Hardness Noncritical Category for another type of radiation, and it is possible that for another type of radiation no category could be identified because the actual radiation design margin might be less than the minimum specified for Hardness Critical Category 1M.

50.2 Lot Conformance Testing Methods. For each radiation environment where radiation hardness lot conformance testing is required, a sample of the parts is tested as a basis for acceptance of the production lot or as a basis for acceptance of devices from a single wafer. The radiation hardness of the sample is determined by testing parameter degradation to failure (the radiation to failure test of 50.3), or by testing at a single radiation level (50.4). Prior to testing at a single radiation level, it should be demonstrated that the specified parameter(s) degradation is a well-behaved function (monotonic) of the radiation environment over the specified range.

The lot acceptance criterion assumes a log normal failure distribution. In those cases where the distribution is shown to be other than log normal, the lot acceptance criterion should be determined by the appropriate type of distribution.

50.3 Radiation to Failure Test. This lot conformance test consists of exposing the sample of parts to increasing radiation levels until the radiation-induced parameter value, PAR_{RAD}, for each part exceeds the specified end point electrical failure limit, PAR_{FAIL}. Following each radiation test level, the data are recorded (see Figure C-1).

From the data, the values of R_{FAIL} at PAR_{FAIL} are obtained. (The annealing effect should be considered when applicable.)

The lot is accepted when

$$RDM(Lot) \geq \exp(K_{TL}S_R(lot)) \qquad (5)$$

The values for RDM and S_R are obtained from Equations (1), (2), (3), and (4).

Note that Equation (5) is similar in form to the equation used for categorization of Category 2 parts, except in that case, S_R is the standard deviation for several lots and is therefore larger than the S_R (lot) value used here.

If, in the course of categorization, the critical parameter does not reach the failure criterion at 10 times the specified radiation level, the categorization should be based on the parameter design margin at the specified radiation level (see Section 50.4).

50.4 Single Radiation Level Testing. When previous data have shown that radiation degradation of the electrical parameters over the specified range of radiation levels is well behaved (monotonic), then the lot conformance test can be conducted at a single radiation level, the specified level R_{SPEC}.

The lot acceptance is based on the parameter design margin, PDM, which is the ratio of the end point electrical parameter failure limit PAR_{FAIL} and the parametric mean value degradation P_{MD} following the radiation exposure (see Figure C-1).

The parameter mean value degradation P_{MD} is calculated from the radiation-induced parameter value PAR_{RAD} as follows:

$$\overline{\ln(PAR_{RAD})} = \frac{1}{n}\sum_{i=1}^{n} \ln(PAR_{RAD_i}) \qquad (6)$$

where PAR_{RAD_i} is the radiation-induced parameter value for the ith device

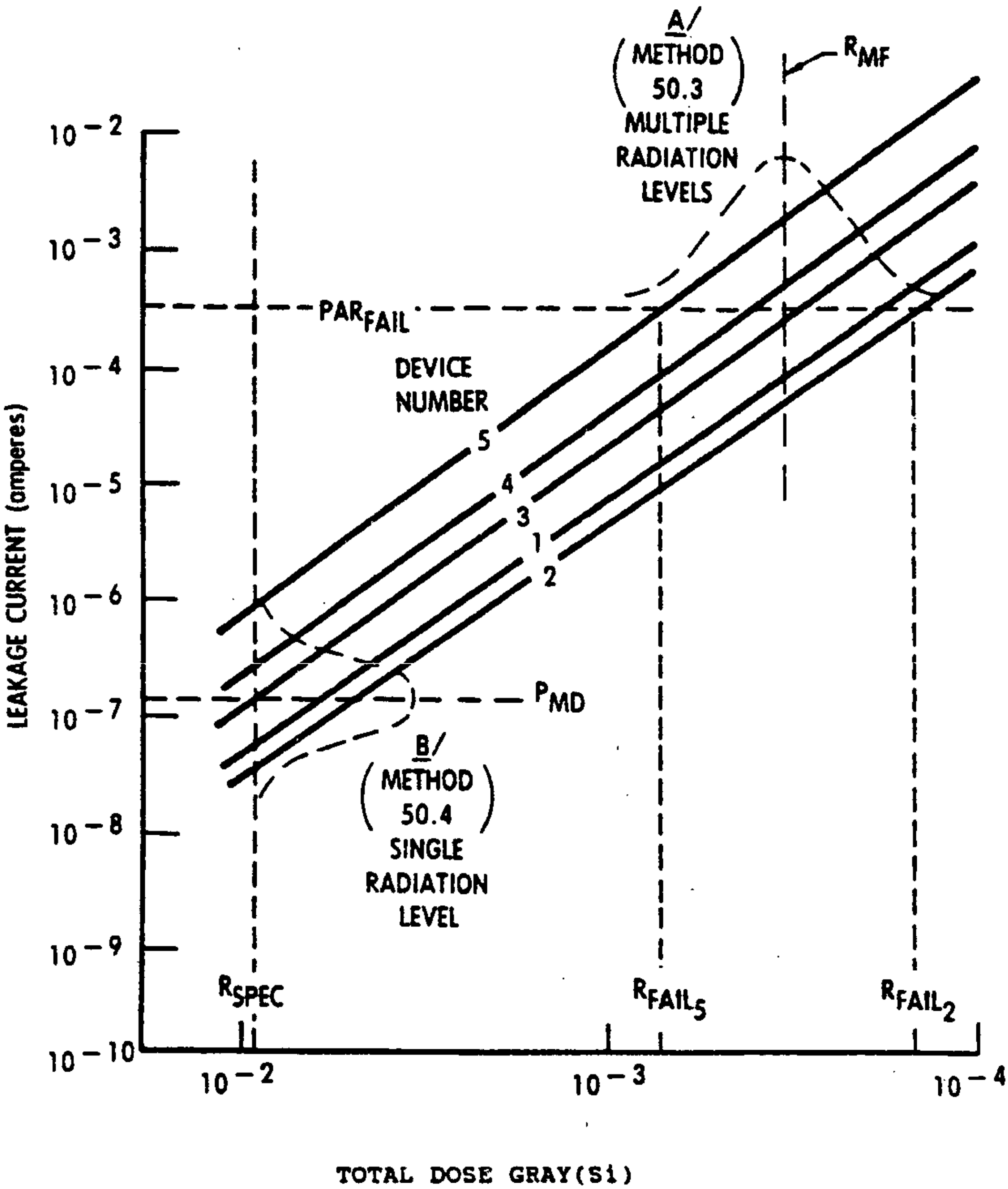
$$P_{MD} = \exp\left[\overline{\ln PAR_{RAD}}\right] \qquad (7)$$

The lot is acceptable if the design margin, DM, is greater than the exponential of the product K_{TL} and the sample standard deviation, S_P, for the lot.

(a) For parameter value increasing with radiation:

$$PDM = \frac{PAR_{FAIL}}{P_{MD}} \geq \exp(K_{TL}\ S_P) \qquad (8)$$

where PAR_{FAIL} is the parameter or function failure value for the lot.



Notes: A/ Method 50.3; Multiple radiation levels
B/ Method 50.4; Single radiation level

FIGURE C-1. Lot Conformance Tests

(b) For parameter value decreasing with radiation:

$$PDM = \frac{P_{MD}}{PAR_{FAIL}} \geq \exp(K_{TL}\ S_P) \qquad (9)$$

where

$$S_P = \left(\frac{1}{n-1} \sum_{i=1}^{n} \left[\ln(PAR_{RAD_i}) - \overline{\ln(PAR_{RAD})} \right]^2 \right)^{1/2} \qquad (10)$$

60. RADIATION TESTING

60.1 Sampling Plans. All test samples shall have passed the specified electrical screening tests prior to radiation testing. Except for total dose radiation testing, all test samples shall be randomly selected from a single wafer lot, or if unavailable, from a single production lot. For total dose testing, a test sample shall be selected from each wafer.

60.2 Lot Traceability. Lot traceability shall be maintained to the wafer lot for all radiation environments except for total dose where traceability is maintained to a single wafer.

60.3 Test Plans and Test Procedures. Radiation testing shall be based on documented radiation test plans and procedures. The test plan shall defines the details of the testing to be performed for each radiation environment for each part type. The test plans and procedures shall include as a minimum:

a. Method of test and sample selection.

b. Radiation test facility to be used.

c. Dosimetry procedure.

d. Equipment required and calibration procedures.

e. Step-by-step procedures including test circuit diagrams, pre and post-electrical tests, bias and test conditions during irradiation and worst case temperature environment, the time between total dose irradiation and electrical tests, and the bias during transport from irradiation source to the electrical test facilities.

f. Irradiation test levels, dose rate and post irradiation measurements for total dose testing; identification of latchup windows, if any, during latchup testing.

g. Documentation of test results.

h. Data processing and analysis.

60.4 Radiation Test Methods. The radiation test methods shall be conducted in accordance with the applicable test methods specified in MIL-STD-883 and MIL-STD-750, as listed in Table C-I. The test conditions shall be based on characterization data including post-irradiation effects, dose rate effects in total dose testing, and latchup windows in latchup testing. When specified in the detailed specification, the same devices may be used for testing in more than one environment. Unless otherwise specified in the detailed specification, the confidence level and survival probability shall be 95 percent and 99.9 percent, respectively.

60.5 Radiation Facilities and Dosimetry. The radiation test facilities used for radiation tests, the dosimetry methods, and the test procedures used shall be approved by the contracting officer. For Co-60 irradiation, the device under test should be placed in Lead-Aluminum containers (0.06-0.09 inch Pb-outside wall; 0.015-0.03 inch Al-inside wall). For Flash X-ray irradiation, the device under test should be placed in lead-tantalum containers (0.06 inch Pb-outside wall; 0.01 inch Ta-inside wall).

60.6 Radiation 100 Percent Screening Tests. 100 percent radiation screening tests may be required for some piece parts for certain radiation environments. Common examples are dose rate latchup screening or dose rate upset screening of microcircuits. In those cases where a 100 percent radiation screen is required by the detailed specification, the test method and procedures shall be as stated in the detailed specification.

70. RADIATION FAILURE ANALYSIS.

A radiation failure analysis is required on devices that fail the radiation hardness lot conformance tests. Details of the failure analysis requirements and procedures shall be as stated in the detailed specification.

TABLE C-I. Radiation Test Methods

TEST	TEST METHOD	SAMPLE SIZE 1/
Neutrons Irradiation	MIL-STD-883/750 METHOD 1017	10
Total Dose Irradiation	MIL-STD-883/750 METHOD 1019	10
Transient Ionization	For microcircuits only MIL-STD-883 METHOD	
Upset	1021/1023	10
Latchup	1020	100 percent
Burnout	detailed specification	10
Single Event Error	detailed specification	5
Latchup	detailed specification	5

1/ For device types with greater than 4000 equivalent transistors per chip, the minimum sample size shall be five for each environment.

TABLE C-II. K_{TL} Factors for One-sided Tolerance Limits for Normal Distributions

	C = 0.75					C = 0.90				
n	p 0.75	p 0.90	p 0.95	p 0.99	p 0.999	p 0.75	p 0.90	p 0.95	p 0.99	p 0.999
3	1.464	2.501	3.152	4.396	5.805	2.602	4.258	5.310	7.340	9.651
4	1.256	2.134	2.680	3.726	4.910	1.972	3.187	3.957	5.437	7.128
5	1.152	1.961	2.463	3.421	4.507	1.698	2.742	3.400	4.666	6.112
6	1.087	1.860	2.336	3.243	4.273	1.540	2.494	3.091	4.242	5.556
7	1.043	1.791	2.250	3.126	4.118	1.435	2.333	2.894	3.972	5.201
8	1.010	1.740	2.190	3.042	4.008	1.360	2.219	2.755	3.783	4.955
9	0.984	1.702	2.141	2.977	3.924	1.302	2.133	2.649	3.641	4.772
10	0.964	1.671	2.103	2.927	3.858	1.257	2.065	2.568	3.532	4.629
11	0.947	1.646	2.073	2.885	3.804	1.219	2.012	2.503	3.444	4.515
12	0.933	1.624	2.048	2.851	3.760	1.188	1.966	2.448	3.371	4.420
13	0.919	1.606	2.026	2.822	3.722	1.162	1.928	2.403	3.310	4.341
14	0.909	1.591	2.007	2.796	3.690	1.139	1.895	2.363	3.257	4.274
15	0.899	1.577	1.991	2.776	3.661	1.119	1.866	2.329	3.212	4.215
16	0.891	1.566	1.977	2.756	3.637	1.101	1.842	2.299	3.172	4.164
17	0.883	1.554	1.964	2.739	3.615	1.085	1.820	2.272	3.136	4.118
18	0.876	1.544	1.951	2.723	3.595	1.071	1.800	2.249	3.106	4.078
19	0.870	1.536	1.942	2.710	3.577	1.058	1.781	2.228	3.078	4.041
20	0.865	1.528	1.933	2.697	3.561	1.046	1.765	2.208	3.052	4.009
21	0.859	1.520	1.923	2.686	3.545	1.035	1.750	2.190	3.028	3.979
22	0.854	1.514	1.916	2.675	3.532	1.025	1.736	2.174	3.007	3.952
23	0.849	1.508	1.907	2.665	3.520	1.016	1.724	2.159	2.987	3.927
24	0.845	1.502	1.901	2.656	3.509	1.007	1.712	2.145	2.969	3.904
25	0.842	1.496	1.895	2.647	3.497	0.999	1.702	2.132	2.952	3.882
30	0.825	1.475	1.869	2.613	3.454	0.966	1.657	2.080	2.884	3.794
35	0.812	1.458	1.849	2.588	3.421	0.942	1.623	2.041	2.833	3.730
40	0.803	1.445	1.834	2.568	3.395	0.923	1.598	2.010	2.793	3.679
45	0.795	1.435	1.821	2.552	3.375	0.908	1.577	1.986	2.762	3.638
50	0.788	1.426	1.811	2.538	3.358	0.894	1.560	1.965	2.735	3.604

TABLE C-III. K_{TL} Factors for One-sided Tolerance Limits for Normal Distributions

	C = 0.95					C = 0.99				
n	P 0.75	P 0.90	P 0.95	P 0.99	P 0.999	P 0.75	P 0.90	P 0.95	P 0.99	P 0.999
3	3.804	6.158	7.655	10.552	13.857	--	--	--	--	--
4	2.619	4.163	5.145	7.042	9.215	--	--	--	--	--
5	2.149	3.407	4.202	5.741	7.501	--	--	--	--	--
6	1.895	3.006	3.707	5.062	6.612	2.849	4.408	5.409	7.334	9.550
7	1.732	2.755	3.399	4.641	6.061	2.490	3.856	4.730	6.411	8.348
8	1.617	2.582	3.188	4.353	5.686	2.252	3.496	4.287	5.811	7.566
9	1.532	2.454	3.031	4.143	5.414	2.085	3.242	3.971	5.389	7.014
10	1.465	2.355	2.911	3.981	5.203	1.954	3.048	3.739	5.075	6.603
11	1.411	2.275	2.815	3.852	5.036	1.854	2.897	3.557	4.828	6.284
12	1.366	2.210	2.736	3.747	4.900	1.771	2.773	3.410	4.633	6.032
13	1.329	2.155	2.670	3.659	4.787	1.702	2.677	3.290	4.472	5.826
14	1.296	2.108	2.614	3.585	4.690	1.645	2.592	3.189	4.336	5.651
15	1.268	2.068	2.566	3.520	4.607	1.596	2.521	3.102	4.224	5.507
16	1.242	2.032	2.523	3.463	4.534	1.553	2.458	3.028	4.124	5.374
17	1.220	2.001	2.486	3.415	4.471	1.514	2.405	2.962	4.038	5.268
18	1.200	1.974	2.453	3.370	4.415	1.481	2.357	2.906	3.961	5.167
19	1.183	1.949	2.423	3.331	4.364	1.450	2.315	2.855	3.893	5.078
20	1.167	1.926	2.396	3.295	4.319	1.424	2.275	2.807	3.832	5.003
21	1.152	1.905	2.371	3.262	4.276	1.397	2.241	2.768	3.776	4.932
22	1.138	1.887	2.350	3.233	4.238	1.376	2.208	2.729	3.727	4.866
23	1.126	1.869	2.329	3.206	4.204	1.355	2.179	2.693	3.680	4.806
24	1.114	1.853	2.309	3.181	4.171	1.336	2.154	2.663	3.638	4.755
25	1.103	1.838	2.292	3.158	4.143	1.319	2.129	2.632	3.601	4.706

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APPENDIX D. PROHIBITED PARTS

This Appendix is a mandatory part of the standard.

The following parts, part styles, and part types shall not be used in space and launch vehicles, even in heritage hardware.

Capacitors

- CLR 65 (MIL-C-39006/9) silver-cased wet tantalum slug capacitors
- Mica capacitors per specifications other than MIL-C-87164
- Glass capacitor styles, CYR 41, 42, 43, 51, 52, 53
- Aluminum electrolytic capacitors
- Ceramic capacitors without lot-sample DPA and lot-sample low-voltage moisture testing

Diodes

- All plastic encapsulated types

Filters

- EMI or RF filters with tubular ceramic elements

Fuses

- All fuses requiring fuse holders

Relays

- Plug-in types
- Solder-sealed relays

Resistors

- All hollow glass or hollow ceramic core devices

Thyristors

- All plastic encapsulated types

Transistors

- All plastic encapsulated types

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APPENDIX E.

NOTES

The contents of this Appendix are noncompliant and are intended for guidance and information only.

10. INTENDED USE

This standard should be cited in the program peculiar specifications for space or launch vehicles to specify the requirements for various space quality electronic part types when JAN Class S parts are not available. (A JAN Class S part is an electronic part that is built, tested, qualified, and procured in full accordance with the space quality level requirements as specified in its general and detailed military specification.) This standard is intended for use in all USAF Space Division acquisition contracts for new or modified designs of space vehicles, upper stage vehicles, payloads, launch vehicles, and for their subtier equipments.

The requirements in the text of this standard state the application requirements for all electronic parts for space and launch vehicles. These application requirements include derating requirements, end-of-life limitations, mounting requirements, and other requirements intended to ensure the high reliability of the parts when used in space equipment and critical launch equipment.

The requirements in the text of this standard are also intended to be the basis for preparing detailed part, material, and process specifications for the purchase of parts and materials for use in space and launch vehicles. These requirements include the design, construction, and quality assurance requirements that are necessary for space and launch vehicle parts. The requirements included supercede or supplement requirements in existing general military specifications to ensure the necessary performance in the space environment and the necessary quality and reliability for space and launch vehicle use.

For the convenience of everyone using this standard, and also using either MIL-STD-965 or MIL-STD-1546, the definition of key terms that are common are the same in this standard as in those documents.

Contracts for ground equipment (e.g., control segments and user segments of space systems) would usually apply other part specifications for equipment in those segments unless it is determined that a tailored application of this standard would be more appropriate for the reliability or standardization objectives of the program. Note that many space and launch vehicle acquisition contracts include both space and ground equipment, so care should be taken to ensure that the applicability of this standard is clearly stated in the program specifications.

There may be acquisition contracts for other types of equipment requiring high reliability where the special requirements stated in this standard should be applied. For those acquisition contracts, this standard may be cited to specify the applicable requirements. However, a statement should be included in the contract or the program specifications indicating that the words "space and launch vehicle" in this standard are to be interpreted as the applicable equipment. The requirements in this standard would then be interpreted as applying to the parts requirements for the acquisition of the applicable equipment. The use of such wording could avoid any possible misinterpretation or misapplication.

20. TAILORING

20.1 TAILORED APPLICATION

The parts requirements in each acquisition should be tailored to the needs of that particular program. Military specifications and standards need not be applied in their entirety. Only the minimum requirements needed to provide the basis for achieving the required performance should be imposed. The cost of imposing each requirement of this standard should be evaluated by the program office and by the contractors against the benefits that should be realized. Provisions not required for the specific application should be excluded. The surviving provisions should be tailored to impose only the minimum requirements necessary to support the system.

20.2 TAILORING TO CONTRACT PHASE

This standard contains comprehensive requirements for electronic parts that primarily apply during the design and production phases of a program. When this standard is made compliant in a contract for a concept development phase or for a validation and demonstration phases, it does not imply that space quality parts requirements apply to anything other than qualification and flight hardware (e.g. they do not apply to ground demonstration models). Contracts for the demonstration and validation phase are usually encouraged to require the development of a parts, materials, and processes control program plan and at least a first draft of a parts selection list. The contractor should, therefore, have a complete understanding of the parts requirements to successfully transition into subsequent phases of the contract. The standard is intended to be "self tailoring" in this respect so that specific tailoring to each phase of the contract should not be required.

20.3 TAILORING PART SPECIFICATIONS

The intent of the design and construction requirements, and quality assurance requirements, specified in this standard is to assure that accepable space quality parts are acquired. The part qualification is intended to verify the design. The in-process production controls specified in the detailed requirements section of this standard for each part type are intended to assist in maintaining the quality of each production lot. Additional in-process controls should be imposed as required to achieve the high quality and reliability goals of space and launch vehicle parts. The imposition of appropriate in-process controls is a more cost-effective way of screening out defects than the imposition of tests and inspections on completed units. In fact, the high reliability goals for space quality parts can only be achieved by the imposition of all of the appropriate in-process controls. Nonconforming material or items that do not meet the established tolerance limits set for the in-process production screens should be removed from the production lot.

The 100 percent screening requirements specified in the detailed requirements section of this standard for each part type are intended to be the last step in assuring the quality of each production lot. Nonconforming units that do not meet the established limits set for the 100 percent screens are removed from the production lot. When it has been thoroughly demonstrated that the purpose of a 100 percent screening requirement specified for a particular part type has been met by the in-process controls imposed by the manufacturer, consideration should be given to deleting that screening requirement. For most contracts, this tailoring of the requirements would require approval by the contracting officer.

The lot conformance testing requirements specified in the detailed requirements section of this standard for each part type are intended to be a sample check of the achieved quality of each production lot. If no failures occur during lot conformance tests, the remaining portion of the production lot is certified as acceptable. If any of the sample units subjected to the lot conformance tests fail during the testing, a detailed failure analysis should be conducted to establish the cause of failure and the corrective actions that would eliminate subsequent failures of a similar type. Failures not affecting the part reliability or performance, such as due to test equipment or procedural errors, should not be counted as a part failure, and another randomly selected sample taken from the production lot may be substituted. However, any part failure during lot conformance testing must be taken as a very serious matter. Each part failure should be identified as either screenable from the completed production items, screenable from new production items by implementing corrective actions that would eliminate subsequent failures of a similar type, or not screenable. Appropriate corrective actions may require approval by the contracting officer.

When it has been thoroughly demonstrated that the purpose of a lot conformance test requirement specified for a particular part type has been met by the in-process controls and the 100 percent screening requirements imposed by the manufacturer, consideration should be given to deleting that lot conformance test requirement. For most contracts, this tailoring of the requirements would require approval by the contracting officer.

30. DATA ITEMS

This document does not require the delivery of any data. Data requirements are not to be considered deliverable unless specifically identified as deliverable data in the contract or purchase order and the appropriate Data Item Description (DID) is referenced.

40. MILITARY PARTS CONTROL ADVISORY GROUP FUNCTIONS

The function of the Military Parts Control Advisory Group is to act as an advisor to the acquisition activities and contractors in its assigned commodity classes. The Military Parts Control Advisory Group recommends standard parts or inventory parts that meet the design requirements of the equipment or system in which the part is to be used. Moreover, the Military Parts Control Advisory Group accepts technical information about specification changes necessary to make a specification usable, and request action with the military activity responsible for that specification to expedite appropriate changes. NOTE: For a complete listing of the commodity classes for which the Military Parts Control Advisory Group is responsible as well as a listing of contact points with addresses and telephone numbers, see MIL-STD-965.

50. JAN CLASS S OPERATING STOCK PROGRAM

A JAN Class S Operating Stock has been initiated by the Defense Logistics Agency to allow contractors to procure JAN Class S parts that are readily available from stock. This reduces procurement lead times, and allows small quantity ordering. Standard contract clauses which authorize contractors to use the stock should be inserted in a separate section of the contract.

60. SUBJECT TERM (KEY WORD) LISTING

applications
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electrical
electronic
electromagnetic
electromechanical
electro-optical.
in-process controls
JAN Class S
lot
lot conformance tests
parts
qualification
space

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