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MILITARY STANDARD

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

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

MIL-STD-1547B (USAF)

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

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

FOREWORD

The requirements of this standard were developed for long life and/or high reliability space and launch vehicles and equipment. 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 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 Systems 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 USAF Space Systems Division initiated a program with the objective of establishing a "space quality baseline" of parts, materials, and processes that have a proven track record of high reliability. In addition, this standard was developed to document the technical requirements for parts, materials, and processes for space and launch vehicles.

The objective of this parts, materials, and processes control program standard is to ensure technical baseline in the selection, application, procurement, control and standardization of parts (electrical and mechanical), materials, and processes for space and launch vehicles. The requirements presented herein should reduce program costs and should improve the reliability of space and launch vehicles.

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

FIGURE PAGE

TABLES

CONTENTS

CONTENTS

CONTENTS

SECTION 1

SCOPE

1.1 PURPOSE

This standard establishes the minimum technical requirements for parts, materials, and processes used in the design, development, and fabrication of space and launch vehicles. Application information, design and construction information, and quality assurance provisions are provided in the standard.

1.2 APPLICATION OF THE STANDARD

This standard is intended for use in acquisition of space and launch vehicles. The standard should be cited in the contract statement of work. This standard may be tailored by the acquisition activity for the specific application or program.

1.3 PMP MANAGEMENT AUTHORITY

Implementation and changes or modifications of the requirements of this document shall be accomplished in accordance with the provisions and authority of the PMP management requirements. In space and launch vehicle programs typically MIL-STD-1546 will define these provisions.

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-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-R-874	Resistor Networks, Fixed Film, Established Reliability, 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-W-5088	Wiring, Aerospace Vehicle
MIL-S-5594	Switches, Toggle, Electrically Held, Sealed
MIL-R-6106	Relays, Electromagnetic (Including Established Reliability (ER) Types), General Specification for
MIL-S-6807	Switch, Rotary, Selector, General Specification for
MIL-W-6858	Welding, Resistance, Spot and Seam

MIL-I-6870	Inspection Program Requirements, Non-destructive testing for Aircraft and Missile Materials and Parts
MIL-W-6873	Welding, Flash, Carbon and Alloy Steel
MIL-H-6875	Heat Treatment of Steels (Aircraft Practice), Process for
MIL-F-7190	Forging, Steel, For Aircraft and Special Ordnance Applications
MIL-C-7438	Core Material, Aluminum, For Sandwich Construction
MIL-B-7883	Brazing of Steels, Copper, Copper Alloys, Nickel Alloys, Aluminum and Aluminum Alloys
MIL-S-8802	Sealing Compound, Temperature-Resistant, Integral Fuel Tanks and Fuel Cell Cavities, High-Adhesion
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
MIL-W-8939	Welding, Resistance, Electronic Circuit Modules
MIL-I-8950	Inspection, Ultrasonic, Wrought Metals, Process for
DOD-E-8983	Electronic Equipment, Aerospace, Extended Space Environment, General Specification for
MIL-T-9046	Titanium and Titanium Alloy, Sheet, Strip and Plate
MIL-T-9047	Titanium and Titanium Alloy Bars, Forging Stock
MIL-A-9117	Adhesive: Sealing, for Aromatic Fuel Cells and General Repair
MIL-S-9395	Switches, Pressure, (Absolute, Gage and Differential), General Specification for
MIL-S-13165	Shot Peening of Metal Parts

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-T-21038	Transformer, Pulse, Low Power, General Specification for
MIL-A-21180	Aluminum Castings, High Strength
MIL-S-22710	Switch Code, Indicating Wheel (Printed Circuit) (Thumb Wheel and Push-Button), General Specification for
MIL-W-22759	Wire, Electric, Fluoropolymer-Insulated, Copper or Copper Alloy
MIL-A-22771	Aluminum Alloy Forgings, Heat Treated
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, Miniature, 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	Microcircuits, General Specification for
MIL-H-38534	Hybrid Microcircuits, General Specification for
MIL-I-38535	Integrated Circuits (Microcircuits) Manufacturing, General Specification for
MIL-M-38780	Manual, Technical Non-destructive Inspection
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-39008	Resistors, Fixed, Composition (Insulated), 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-R-39015	Resistor, Variable, Wirewound (Lead Screw Actuated), Established Reliability, General Specification for
MIL-R-39016	Relays, 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-A-46146	Adhesive Sealants, Silicone, RTV, Non-corrosive (For Use With Sensitive Metals and Equipment)
MIL-C-49467	Capacitors, Fixed, Ceramic, Multilayer, High Voltage, (General Purpose), Established Reliability, General Specification for
MIL-C-49468	Crystal Units, Quartz, Precision, General Specification for
MIL-P-50884	Printed Wiring, Flexible, and Rigid-Flex
MIL-P-55110	Printed Wiring Boards, 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-H-81200	Heat Treatment of Titanium and Titanium Alloys
MIL-W-81381	Wire, Electric, Polyimide - Insulated, Copper or Copper Alloy
MIL-T-81556	Titanium and Titanium Alloys, Bars, Rods and Special Shaped Sections, Extruded
MIL-F-83142	Forging, Titanium Alloys, For Aircraft and Aerospace Applications
MIL-A-83376	Adhesive Bonded Aluminum Sandwich Structures
MIL-A-83377	Adhesive Bonding (Structural) for Aerospace and Other Systems, Requirements For
MIL-C-83421	Capacitors, Fixed, Supermetallized, Plastic Film Dielectric, (DC, AC, or DC and AC). Hermetically Sealed in Metal Cases, ER
MIL-C-83513	Connectors, Electrical, Rectangular, Microminiature, Polarized Shell, General Specification for
MIL-R-83536	Relays, Electromagnetic, Established Reliability, General Specification for
MIL-W-83575	Wiring Harness, Space Vehicle, Design and Testing, General Specification for
MIL-A-83577	Assemblies, Moving Mechanical, for Space and Launch Vehicles, General Specification for
MIL-C-83723	Connector, Electrical, (Circular, Environment Resisting), Receptacle and Plugs, General Specification for
MIL-R-83726	Relays, Hybrid and Solid-state Time Delay, 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
MIL-R-87254	Resistors, Fixed Film, High Reliability, General Specification for

FEDERAL STANDARDS

FED-STD-209	Clean Room and Work Station Requirements, Controlled Environment
QQ-A-367	Aluminum Alloy Forgings

MILITARY STANDARDS

MIL-STD-129	Marking for Shipping and Storage
MIL-STD-130	Identification Marking of U.S. Military Property
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-401	Sandwich Constructions and Core Materials; General Test Methods
MIL-STD-403	Preparation for and Installation of Rivets and Screws, Rocket and Missile Structures
MIL-STD-750	Test Methods for Semiconductor Devices
MIL-STD-866	Grinding of Chrome Plated Steel and Steel Parts Heat Treated to 180,000 psi or Over
MIL-STD-883	Test Methods and Procedures for Microelectronics
MIL-STD-889	Dissimilar Metals

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-1523	Age Controls of Age Sensitive Elastomeric Materials for Aerospace Applications
MIL-STD-1580	Destructive Physical Analysis for Space Quality Parts
MIL-STD-1595	Qualification of Aircraft, Missile and Aerospace Fusion Welders
MIL-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) (Metric)
MIL-STD-1835	Microcircuit Case Outlines
MIL-STD-2000	Standard Requirements for Soldered Electrical and Electronic Assemblies
MIL-STD-2118	Flexible and Rigid-Flex Wiring for Electronic Equipment, Design Requirements for
MIL-STD-2175	Castings, Classification and Inspection of
MIL-STD-2219	Fusion Welding for Aerospace Applications

MILITARY HANDBOOKS

MIL-HDBK-5	Metallic Materials and Elements for Aerospace Vehicle Structures

MIL-HDBK-17	Plastics for Aerospace Vehicles
MIL-HDBK-23	Structural Sandwich Composites
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-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.)

AIR FORCE WRIGHT AERONAUTICAL LABORATORIES (AFWAL)

ADD436124L	DOD/NASA Structural Composites Fabrication Guide Vol I
ADD436125L	DOD/NASA Structural Composites Fabrication Guide Vol II
	DOD/NASA Advanced Composite Design Guide, Vol I - IV

NASA MANNED SPACECRAFT CENTER

Standard 125	Cadmium Restriction on Use

NASA PUBLICATIONS

TM X-64755	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

MSFC-SPEC-250	Protective Finishes for Space Flight Vehicle Structures and Equipment, General Specification for
MSFC-STD-355	Radiographic Inspection of Electronic Parts

MSFC-SPEC-469	Titanium and Titanium Alloys, Heat Treatment of
MSFC-SPEC-522	Design Criteria for Controlling Stress Corrosion Cracking
NASA-SP-8063	Lubrication, Friction and Wear
NHB 5300.4(3A-2)	Requirements for Soldered Electrical Connections
NHB 8060.1	Office of Space Transportation Systems Flammability, Odor, and Offgassing Requirements and Test Procedures for Materials in Environments that Support Combustion
SP-R-0022A	General Specifications, Vacuum Stability Requirements of Polymine Materials for Space Craft Applications

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 NATIONAL STANDARD INSTITUTE

CF-152	Composite Metallic Materials Specification for Printed Wiring Boards

Application for copies should be addressed to: American National Standard Institute, 11 West 42nd Street, New York, NY 10036

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-469	DPA of Ceramic Capacitors
RS-477	Cultured Quartz
IND-STD-557	Statistical Process Control Systems

Application for copies should be addressed to: Electronic Industries Association, 2001 Pennsylvania Ave, 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: American National Standards Industries, 1430 Broadway, New York, NY 10018

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.

SECTION 3

DEFINITIONS

Terms are in accordance with the following definitions:

3.1 ACQUISITION ACTIVITY

The acquisition activity is the Government office or contractor acquiring the equipment, system, or subsystem for which this standard is being contractually applied.

3.2 CASE TEMPERATURE

The case temperature is the hottest temperature on the external surface of the device's package. The case temperature shall be determined in accordance with the applicable military specification standard.

3.3 CONTRACTING OFFICER

A contracting officer is 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.

3.4 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.

3.5 DESTRUCTIVE PHYSICAL ANALYSIS (DPA)

A Destructive Physical Analysis (DPA) is a systematic, logical, detailed examination of parts during various stages of disassembly, conducted on a sample of completed parts from a given lot, wherein parts are examined for a wide variety of design, workmanship, and processing problems that may not show up during normal screening tests. The purpose of these analyses is to maintain configuration control and determine those lots of parts, delivered by a vendor, which have anomalies or defects such that they could, at some later date, cause a degradation or catastrophic failure of a system.

3.6 ELECTRONIC PARTS

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

3.7 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.

3.8 HOT-WELDED CAN

A Hot-Welded Can is a cap sealed component utilizing thermocompression attachment of the cap to the base of the device. The bond is a brazed attachment of the nickel plated cap to the nickel plated base, with nickel acting as a brazing agent.

3.9 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.

3.10 MATERIAL

Material is a metallic or nonmetallic element, alloy, mixture, or compound used in a manufacturing operation and which becomes either a permanent portion of a manufactured item or which can leave a remnant, residue, coating, or other material that becomes or affects a permanent portion of a manufactured item.

3.11 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.

3.12 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.

3.13 PARTS, MATERIALS, AND PROCESSES CONTROL BOARD (PMPCB)

The PMPCB is a formal contractor organization established by contract to manage and control the selection, application, procurement, and documentation of parts, materials, and processes used in equipment, systems, or subsystems.

3.14 PERCENT DEFECTIVE ALLOWABLE (PDA)

The percent defective allowable (PDA) of a production lot of parts or material is the maximum allowable percentage of parts or material specimens that fail to pass one or more tests before the entire production lot is considered to be unacceptable.

3.15 PROCESS

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

3.16 PRODUCTION LOT

Unless otherwise specified in the detail specification, a production lot of 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, same raw material, the same manufacturing and quality controls, and to the same baseline document revisions; and tested within the same period of time. All parts in the same lot have the same lot date code, batch number, or equivalent identification.

3.17 REGISTERED PART, MATERIAL AND PROCESSES (PMP)

A registered PMP is a part, material, or process which is registered with the PMPCB to call attention to special reliability, quality, or other concerns, relating to its procurement or application. Registered PMP includes, but is not limited to, reliability suspect PMP, limited application PMP, and PMP involving restricted or special controlled usage, storage, or handling due to safety or environmental concerns.

SECTION 4

GENERAL REQUIREMENTS

4.1 APPLICATION REQUIREMENTS

4.1.1 Electrical 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}).

4.1.2 Mechanical derating. Mechanical design properties shall have adequate strength margins for the intended application to sustain long-life performance in associated equipment over the specified design life. This derating shall include design properties associated with environments such as shock, vibration, acceleration, and temperature that produce force-function effects on flight hardware. Strength margins shall be based on mechanical property data from MIL-HDBK-5 where applicable and shall delimit susceptibility to mechanical failure modes such as bending, deformation, fracture, rupture, excessive deflection, and fatigue. Functional margins shall be calculated based on the recommendation of MIL-A-83577 wherever possible.

4.1.3 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. The detail sections of this standard specify the 10 year end-of-life limits.

4.1.4 Aging Sensitivity. Electronic, optical, and mechanical parts and materials are aging sensitive when they are subject to gradual shortening of their useful life or progressive degradation of their performance parameters. Aging mechanisms include the following:

Loss of hermeticity
Stress relaxation
Oxidation and corrosion
Outgassing
Cold flow and creep
Molecular cross-linking
Loss of adhesion
Embrittlement and hardening
Loss of torque

Loss of spring tension
Moisture absorption

Aging sensitivity shall be considered in the design, selection, and application of parts and materials. In addition, aging sensitivity shall be incorporated into mandatory plans for shelf-life and aging control. These plans shall include requirements for minimum shelf-life assurance when parts and materials are procured and for required inspection and/or testing of parts and materials after procurement. Where technical requirements are not provided in the appropriate technical requirement sections of this document or in an application PMP management document, the minimum shelf-life shall be three years and the maximum period of time after procurement and before inspection/testing is required shall be three years, except for mechanical parts or assemblies and metallic and ceramic materials where both periods of time shall be five years.

4.1.5 Sealed Packages. Hermetically sealed parts are preferred for use in space and launch vehicles. If 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.

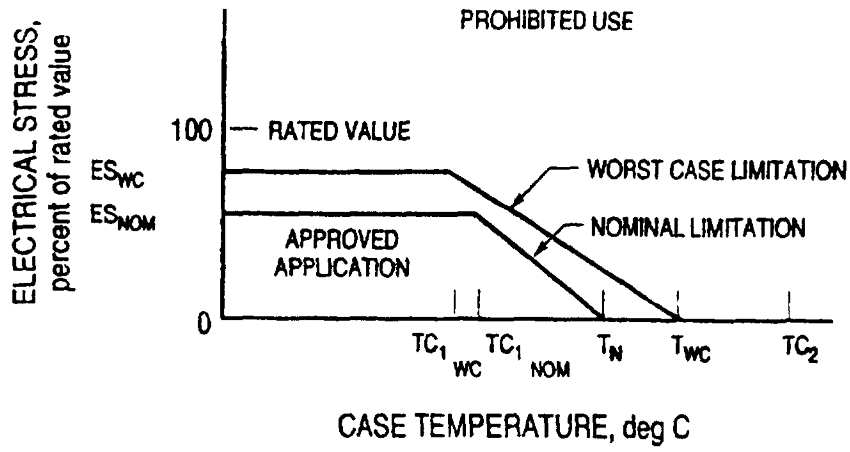
4.1.6 Registered PMP. The detailed sections of this standard identify known registered PMP including applications and procurement restrictions.

4.1.7 Handling. Protection against electrostatic damage to electrostatic sensitive devices shall be provided in accordance with 4.7.

4.1.8 Marking. Marking will be in accordance with the applicable military specification.

4.1.9 Outgassing. Materials and finishes shall exhibit total mass loss (TML) of not more than 1.0 percent and shall have a collected volatile condensable material (CVCM) of not more than 0.1 percent when tested in accordance with ASTM E 595. However, if the TML is greater than 1.0 percent, but it can be shown that contributions to the TML in excess of 1.0 percent are due only to absorbed water vapor, the materials shall be acceptable.

4.1.10 Alternate QCI Test/Sampling Plan. Alternate QCI test/sampling plan shall be in accordance with appendix C of this standard.



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

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 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 PART REQUIREMENTS

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.

4.3 PART DESIGN AND CONSTRUCTION

4.3.1 Design. Parts shall be designed and constructed to meet the program's technical requirements and the requirements stated herein. Parts shall be designed and constructed of corrosion resistant materials or treated to resist corrosion.

4.3.2 Material Hazards. Mechanical and electronic parts shall be constructed of materials that prevent exposure of either personnel or adjacent components to hazardous conditions. Hazardous conditions include, but are not limited to the following: arc generation, flammability, severe outgassing, toxicity, sublimation, and high vapor pressure.

4.3.3 Tin-Coated Surfaces.

4.3.3.1 Pure Tin Coatings. Mechanical parts, mounting hardware, optical and electronic parts and their packages shall have neither internal nor external surfaces coated with a pure tin or tin alloy layer.

4.3.3.2 Electronic Part Terminals and Leads. Electronic part terminals and leads may be coated with a tin alloy containing a minimum of 3 percent of lead (Pb) only when necessary for solderability.

4.3.3.2.1 Electronic Part Terminals and Leads and Solder Lugs Subject to Compressive Forces. Where electronic part terminals and leads and solder lugs are used in conjunction with bolts, nuts, or washers that apply a continuous load to the tin alloy surface and where solderability is a critical factor, these parts may be coated with a tin alloy layer. Such tin alloys shall contain a minimum of 37 percent of lead (Pb).

4.3.3.3 Exception. This prohibition does not apply to drawn wire products, such as cables, shielding and ground straps.

4.3.4 Processes and Controls. The manufacture of parts and materials shall be accomplished in accordance with processes and processing 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 which ensures that subsequent production items can be manufactured which 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 each material 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. Processing controls shall have a statistical basis if a sampling plan is used.

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

4.4 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

e. Other test (DPA, Hardness, etc.)

4.4.1 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.

4.4.2 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. 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, or sample size specified in the referenced military specification.

4.4.3 Lot Conformance Tests (/Quality Conformance Inspection). 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. When radiation hardness assurance requirements are specified, wafer lot conformance test shall be conducted per Appendix A of this standard. Radiation testing may be conducted anytime following the completion of wafer fabrication. 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.

4.4.4 Destructive Physical Analysis (DPA). Destructive Physical Analysis shall be performed in accordance with MIL-STD-1580 and the detailed section.

4.4.5 Qualification Tests. All part and material types shall be qualified in accordance with the requirements stated herein. Parts that have undergone destructive tests during qualification testing shall not be returned to the production lot for flight use.

4.5 MATERIAL QUALITY ASSURANCE PROVISIONS

The quality assurance provisions for specialized materials are specified in the detailed requirements for that material. The quality assurance provisions are classified as:

a. In-process controls
b. Screening (100 percent)
c. Lot conformance tests (sampling or periodic)
d. Qualification tests

4.5.1 In-Process Controls. Each production lot or batch or blend of material shall be subjected to the in-process controls specified in the detailed requirements section of this standard for that material.

4.5.2 Screening (100 Percent). Each item, piece, or container of material shall be subjected to the 100 percent screening requirements specified in the detailed requirements section of this standard for that material. Note that many of the tables in this standard list the additions, changes, and exceptions to the screening or testing requirements of the referenced specification. When a blank is shown opposite a specified screen or test, that means there are no changes to that test method, to that criteria, or sample size specified in the reference specification and that the test method or criteria are mandatory as referenced.

4.5.3 Lot Conformance Tests (/Quality Conformance Inspection) (Sampling or Periodic). Lot conformance testing shall be performed as a basis for final lot acceptance on each production lot or batch or blend of material. After a production lot or batch or blend of material has passed all in-process controls and screening requirements, the lot conformance tests shall be performed on randomly selected samples taken as specified from the production lot or batch or blend. The detailed requirements for these lot conformance tests are specified in the various requirement sections of this standard. A physical or chemical analysis shall be performed as a portion of lot conformance testing when specified in the detailed requirements section of this standard for that material. Test samples that have undergone destructive tests during lot conformance testing shall not be returned to the production lot or batch or blend.

4.5.4 Qualification Tests. All materials and blends or composites thereof shall be qualified in accordance with the requirements stated herein. Material samples that have undergone destructive tests during qualification testing shall not be returned to the production lot or batch or blend.

4.6 PACKAGING

Packaging of parts and materials during shipment shall be per the requirements imposed by the associated military specification for the particular item. Electrostatic-sensitive items shall be packaged in accordance with 4.7.

4.7 ELECTROSTATIC-SENSITIVE ITEMS

Electrostatic discharge (ESD) control for the protection of electrical and electronic parts, components, assemblies, and equipment (i.e. MOS transistors) shall be in accordance with MIL-STD-1686 (DOD-HDBK-263 may be used for guidance in establishing an ESD control plan).

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.

SECTION 100

BOARDS, PRINTED WIRING

1. SCOPE

This section sets forth detailed requirements for printed wiring boards, including:

Type 1 - Single Sided
Type 2 - Double Sided
Type 3 - Multilayer Board without Blind or Buried Vias
Type 4 - Multilayer Board with Blind and/or Buried Vias
Type 5 - Multilayer Metal Core Board without Blind or Buried Vias
Type 6 - Multilayer Metal Core Board with Blind and/or Buried Vias
Type 7 - Double sided printed boards with plated through holes
Type 8 - Multilayered printed boards with plated through holes (blind and buried vias permitted)

2. APPLICATION

2.1 General Requirements. Printed wiring boards shall be designed and fabricated in accordance with MIL-STD-275, MIL-P-55110, and this standard. In case of conflict, the provisions of this standard shall apply.

2.1.1 Qualifications. The manufacturer shall be certified to MIL-P-55110.

2.1.2 Raw Material Storage

2.1.2.1 Laminate. Laminates shall be stored flat in a cool dry environment. Laminates shall be supported over their entire surface area to prevent bow and twist. Also, the corners shall be protected to prevent crimping.

2.1.2.2 Prepreg. Prepreg material shall be stored in a protective area, containers, or packaging which minimizes its exposure to humidity and dust. During handling and storage adequate packing support shall be provided for both rolled and sheet material in order to prevent creasing, crazing, or wrinkling. Prepreg shall be protected in moisture resistant bags containing desiccant at all times prior to use. For storage longer than 30 days, prepreg shall be stored at 5° C ± 4° C at less than 50% relative humidity. Prepreg shall be stored in the absence of ultra violet light.

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 multilayer boards whenever clearance requirements permit.

b. Surface Mount Lands: When a minimum of three surface mount lands are tested in accordance with IPC-TM-650 method 2.4.21, after subjection to five cycles of soldering and four cycles of desoldering, the land shall withstand 500 psi of vertical pull 90 degrees to the board surface (tension).

c. Etchback: Etchback or equivalent processes shall be used to ensure complete resin smear removal from the holes of multilayer boards prior to plating. When etchback is used, the limits shall be between 0.0005 inch minimum and 0.002 inch maximum.

d. Flammability: Flame-retardant material shall be used for the construction of printed wiring boards.

e. Drill Bit Limit: The board manufacturer shall design and maintain a matrix which identifies the optimum number of drill hits allowed for specific types of materials, number of layers, and hole diameter.

f. Drill Changes: All drill bit changes shall be documented. Documentation may be in the form of a drill tape or any digital storage medium. Resharpening of drill bits is not permitted.

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

h. Stacking: Stacking of more than two panels is not permitted when drilling holes that are to be plated-through for double sided boards. Stacking is not permitted for multilayered boards.

i. Solder Mask: Solder mask shall comply with IPC-SM-840 class III. In addition, solder mask shall meet the outgassing requirements specified in section 4, para 4.1.9, of this standard.

j. 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, heatsink, or stiffener.

k. 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 with no pitting or pinholes and show no non-wet areas. Side walls of the conductors need not be solder coated. Touch-up is permitted.

l. 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 that has been shown on a consistent basis to yield equivalent results. Sampling frequency shall be at least once per week.

m. Process-control Coupons: As many process-control coupons as are necessary to control the manufacturing processes shall be utilized 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 on the purchase order. The process control coupons shall be identified and retained by the manufacturer or contractor for the length of the contract.

n. 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.

o. Deliverable Coupons: Double-sided and multilayer printed wiring boards shall be produced with two deliverable A or B coupons per board, or for small board sizes, two deliverable coupons per 150 square centimeters (24 square inches) of panel area, whichever is less. Coupons suitable to monitor the processes involved shall be located on the panel in positions 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 (See Figure 100-1 for preferred panel layups). These deliverable coupons are in addition to the process-control coupons required for each panel. All coupons shall be completely processed with the deliverable boards. For each panel, at least one of these deliverable coupons shall be break away (partially routed) and shall be delivered attached to a production board on that panel.

p. Marking: Each individual board and each set of quality conformance test circuit strips (as opposed to each individual coupon) shall be marked in accordance with the master drawing and MIL-STD-130 with the date code (as specified below), the traceability serial number, the part number, and the manufacturers CAGE code. Coupon marking shall be the same as board marking and all deliverable coupons shall be individually serialized. The date code shall be formatted as follows:

Year	Day of year (from 1 January)
90	001

This date shall reflect the date of final copper plating.

q. Traceability. The board manufacturer shall establish and maintain traceability for all boards. This traceability shall reflect the exact disposition of each board. Boards which are rejected shall also be included in the traceability documentation and the reason for rejection shall be identified. For traceability, each quality conformance test circuitry shall be identifiable with those corresponding production boards produced on the same panel. All separated individual coupons shall have their traceability maintained back to the quality conformance test circuitry. Traceability shall include board and coupon position on the panel.

r. Storage and Retrievability: All deliverable coupons shall be stored and shall be readily retrievable the life of the contract.

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 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 Metal Core Boards. Metal core boards shall be fabricated in accordance with ANSI/IPC-CF-152 and this standard. When metal core boards are used, the lateral dielectric spacing between the metal core and adjacent conducting surfaces shall pass the dielectric withstanding voltage test in accordance with IPC-TM-650, method 2.5.7, except the voltage shall be 750 volts D.C. minimum. There shall be no flashover, arcing, breakdown or leakage exceeding one microampere.

3.4 Flexible Wiring. Flexible printed wiring shall conform to MIL-P-50884 and shall be designed in accordance with MIL-STD-2118. The etchback requirements of 3.1c shall be applicable to flexible wiring.

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:

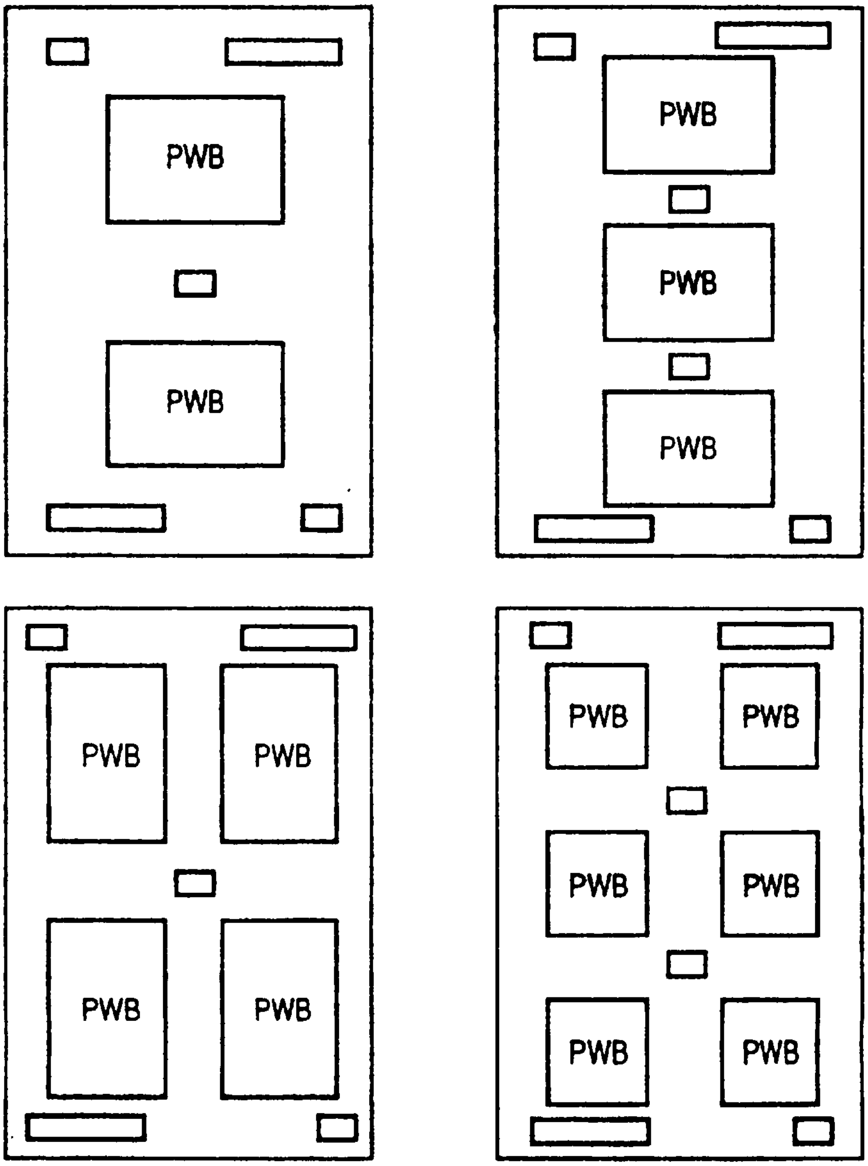


Figure 100-1 Deliverable Coupon Placement

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 tensileductility of 12 percent minimum. An alternate method is to monitor the copper plating bath to maintain the level of bath organic compound composition within specified limits that shall be directly correlatable to a 12 percent minimum tensile ductility.

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

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the general requirements of Section 4 and the requirements of MIL-P-55110. One hundred percent (100%) electrical continuity testing of all connections is required on internal layers both prior to lay up and at the completed bare board level. Electrical isolation shall be established by hi-pot testing, minimum 1500 volts.

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.

5 REGISTERED PMP

5.1 Reliability Suspect Designs.

a. Rigid-flex wiring board

6 PROHIBITED MATERIALS LIST

a. Tin plating in printed wiring boards (see section 4, paragraph 4.3.3)

SECTION 200

CAPACITORS, GENERAL

1. SCOPE

This section sets forth common requirements for capacitors. Table 200-1 lists, by dielectric type, the capacitor styles 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
215	Ceramic, High Voltage	MIL-C-49467	HVR
230	Metallized Film	MIL-C-83421/3 &/4	CRS
232	Metallized Film (Low-Energy Applications)	MIL-C-87217	CHS
240	Glass	MIL-C-23269	CYR
250	Mica	MIL-C-87164	CMS
260	Tantalum Foil	MIL-C-39006	CLR
270	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-39006/28 & MIL-C-39006/29	& CLS79 CLS81

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 4.1.1 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.

4. QUALITY ASSURANCE

See the detailed requirements section for each capacitor type.

4.1 Production Lot. 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 with other raw materials coming from one lot number, and processed as a single lot through all manufacturing steps, to the same baseline, and identified with the same date and code designation. The lot may contain all capacitance tolerances for the nominal capacitance value.

4.2 Solder Dip/Retinning. When solder dip/retinning is performed, the subsequent 100% testing, as specified in the applicable military specification, shall be performed.

5 REGISTERED PMP

5.1 Reliability Suspect Parts. See the detailed requirements section for each capacitor type not specified below.

a. Tantalum clad
b. Paper
c. Paper/plastic
d. Metallized paper in molded cases
e. Variable capacitors

6 PROHIBITED PARTS LIST

The following parts, part styles, and part types shall not be used.

a. CLR 65 (MIL-C-39006/9) and CLR 69 (MIL-C-39006/21) silver-cased wet tantalum slug capacitors

b. Mica capacitors per specifications other than MIL-C-87164

c. Glass capacitor styles, CYR 41, 42, 43, 51, 52, 53

d. Aluminum electrolytic capacitors

e. CKR06, 1 microFarad ceramic dielectric capacitors

f. Single-sealed CLR79 (MIL-C-39006/22) identified by it's compression seal construction

g. Capacitors with tin coated leads or packages (see section 4, paragraph 4.3.3)

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.

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.

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 Group A Requirements. Group A requirements shall be in accordance with the requirements of MIL-C-123.

4.3 Group B Tests. Group B tests shall be in accordance with the requirements of MIL-C-123. All Group B tests shall be done on a production lot by production lot basis.

4.3.1 Supplier DPA. Supplier DPA shall be in accordance with MIL-C-123.

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

4.5 Incoming Inspection DPA. Incoming Inspection DPA shall be in accordance with MIL-STD-1580.

5 REGISTERED PMP

5.1 Reliability Suspect Parts.

a. CKR06, 50 Volt rating, C > 0.47 microFarad
b. Dielectric thicknesses < 0.0009" (23 Micron)
c. Large length/width ratio (>2:1)
d. Variable devices

6 PROHIBITED PARTS LIST

a. Units with tin coated leads (see section 4, paragraph 4.3.3)

SECTION 215

CERAMIC CAPACITORS, HIGH VOLTAGE (HVR)
(MIL-C-49467)

1. SCOPE

This section sets forth the detailed requirements for high voltage encapsulated multilayer ceramic chip capacitors (HVR styles) up to 10,000 volts.

2. APPLICATION

2.1 Derating. Same as paragraph 2.1 of Section 210.

2.2 End-of-Life Design Limits.

	General Purpose BR or BZ	Temperature Compensated BP
Capacitance:	± 21 percent	± 1.25 percent or ± 0.75 Pf, whichever is greater
Insulation Resistance:	85 percent of initial limit	85 percent of initial limit

2.3 Mounting. Additional encapsulation is necessary in applications where the possibility of a voltage breakdown between the leads of the capacitor, or the capacitor to another potential, could occur. Heat sinks on each lead or adequate preheating is required when these capacitors are installed or removed from circuits by soldering.

2.3.1 Piezoelectric Concerns. Same as paragraph 2.3.1 of Section 210.

2.3.2 Capacitor Cracking. Same as paragraph 2.3.3 of Section 210.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-C-49467 and the requirements of this standard.

3.1.1 Baseline Documentation. A manufacturing baseline shall be developed and maintained by the capacitor manufacturer in accordance with the requirements of MIL-C-123.

3.1.2 Production Lot. A production lot shall be as defined in MIL-C-123.

3.1.3 Lead Attachment. Leads shall be attached to the ceramic chip body using high temperature solder with a minimum plastic point of 260° C.

3.1.4 Encapsulation. Encapsulation type shall be carefully considered by the user regarding specific environmental requirements and the ceramic chip physical size. Conformally coated parts using the dip or fluidized bed process provide a true glue bond to the ceramic body. However, severe thermal shock or temperature cycling may cause cracking due to thermal coefficient difference. True molded cases are prone to voids between the ceramic and the coating because there is no glue bond between the encapsulant and the ceramic. This condition may lead to corona failure on the surface of the ceramic. An epoxy cup with the capacitor back filled with a resilient material may be subject to internal solder joint damage during vibration.

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 inspection shall be in accordance with the requirements of MIL-C-123.

4.2 Group A Requirements. Group A Requirements shall be in accordance with the tests in MIL-C-49467 and Table 215-1. The total percent defective allowable for all the electrical tests of subgroup 1 shall not exceed 5%.

4.3 Group B Tests. Group B tests shall be in accordance with the tests in MIL-C-49467 and Table 215-2. All Group B tests shall be done on a production lot by production lot basis.

4.4 Qualification Tests. Qualification testing shall be in accordance with MIL-C-49467.

4.5 Sample and Data Retention. Sample and data retention for all manufacturing lots shall be in accordance with the requirements of MIL-C-123.

4.6 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

Table 215-1 Additions to Group A Requirements of MIL-C-49467

MIL-C-49467	Additions to the Methods and Criteria of MIL-C-49467
Subgroup 1 2/	
Thermal Shock	a. 25 cycles
Voltage Conditioning	a. 168 hours minimum
Subgroup 4 1/	
Solderability	

1/ Sample size shall be in accordance with MIL-C-49467.
2/ Total PDA for electrical tests in Subgroup 1 shall not exceed 5%.

5. REGISTERED PMP

5.1 Reliability Suspect Parts.

5.1.1 Large Aspect Ratio Product. The length-to-width aspect ratio for these thicker ceramic capacitors should not exceed 1.8 to 1.

5.1.2 Thin Dielectric Product. The maximum stress allowed between plates shall not exceed 100 volts/mil for BX dielectric or 200 volts/mil for BP dielectric.

Table 215-2 Additions to Group B Tests of MIL-C-49467

MIL-C-49467	Additions and Exceptions to the Methods and Criteria of MIL-C-49467
Subgroup 1	
Thermal Shock	a. 100 cycles b. Sample size and accept/reject criteria shall be per MIL-C-123
Life Test	a. 1,000 hours b. Sample size and accept/reject criteria shall be per MIL-C-123
Partial Discharge	
Subgroup 2 (10 pieces, same samples, reject on 1) 1/	
Voltage-temperature Limits	
Terminal Strength	
Moisture Resistance	
Resistance to Soldering Heat	
Resistance to Solvents	

1/ Similar tests in MIL-C-49467 Group B inspection shall not be repeated.

SECTION 230

METALLIZED FILM CAPACITORS (CRS)
(MIL-C-83421/3 &/4)

1. SCOPE

This section sets forth the detailed requirements for fixed, metallized film capacitors (CRS style) for high-energy circuit applications.

2. APPLICATION

2.1 Circuit Requirements. Metallized 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 and Polypropylene Dielectric. The voltage-derating factor for these capacitors shall be as follows:

	Polycarbonate	Polypropylene
ES_{NOM}:	0.50 to +85 deg C.	0.50 to +70 deg C
ES_{WC}:	0.65 to +85 deg C.	0.65 to +70 deg C

2.3 Temperature Derating. Metallized polycarbonate capacitors shall be used to a maximum operating temperature of 85°C, and polypropylene capacitors shall be used to a maximum operating temperature of 70°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 Recommendations (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-type 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. Internal heating due to dielectric and termination losses

b. AC corona inception

For high frequency ac applications (≥400 Hz), 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. Those parts exhibiting increases in ESR greater than 5% or 5 milliohms, whichever is larger, shall be removed from the lot.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-C-83421/3 & /4 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 Failure Level. Only failure rate level "S" parts shall be used.

4.2 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-C-83421/3 & /4.

4.3 Group A Requirements. Group A requirements shall be in accordance with the requirements of MIL-C-83421/3 & /4.

4.4 Group B Tests. Each lot offered for inspection under MIL-C-83421/3 & /4 shall be sampled for the Group B inspection of MIL-C-83421.

4.5 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-C-83421/3 & /4.

4.6 Incoming Inspection DPA. Incoming Inspection DPA shall be in accordance with MIL-STD-1580.

5 REGISTERED PMP

5.1 Reliability Suspect Parts.

a. Devices manufactured with 2.0 or less microns polycarbonate film or 4.0 or less microns polypropylene film
b. Parts not vacuum baked for 48 hours to remove contaminant residues
c. Capacitor windings installed in 0.312 inch diameter or larger, cases not wrapped or encapsulated to prevent radial motion during shock or vibration
d. Parts not metallized with 99.9% aluminum

SECTION 232

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

1. SCOPE

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

2. APPLICATION

2.1 Low-Energy Circuits. These capacitors can exhibit momentary breakdowns in low-energy applications. To insure clearing of breakdowns, the circuit in which capacitors of 0.1 microfarads and greater capacitance value are intended for use, shall be capable of providing at least 100 microjoules of energy. Applications for these capacitors shall be limited to circuits that can provide the minimum energy and that are insensitive to momentary breakdowns/clearing actions.

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 except that the minimum clearing energy requirement is 100 microjoules.

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.

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 Group A Requirements. Group A requirements shall be in accordance with the Group A test requirements of MIL-C-87217 in the order shown.

4.3 Group B Tests. Each lot offered for inspection under MIL-C-87217 shall be sampled for the Group B inspection of MIL-C-83421.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-C-83421, failure rate level "S".

4.5 Incoming Inspection DPA. Incoming Inspection DPA shall be in accordance with MIL-STD-1580.

5 REGISTERED PMP

5.1 Reliability Suspect Parts.

Same as paragraph 5 of Section 230.

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

2.3 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 50,000 megohms at +125 deg C
Dissipation Factor:	0.2 percent maximum

2.4 Electrical Considerations

2.4.1 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".

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-23269.

4.2 Group A Requirements. Group A requirements shall be in accordance with the requirements of MIL-C-23269.

4.3 Group C Tests. Group C tests shall be in accordance with the requirements of MIL-C-23269. All Group C tests shall be done on a production lot by production lot basis.

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

4.5 Incoming Inspection DPA. Incoming Inspection shall be in accordance with MIL-STD-1580.

5 REGISTERED PMP

None

6 PROHIBITED PARTS

a. Radial leaded devices: CYR41, CYR42, CYR43, CYR51, CYR52, and CYR53 styles

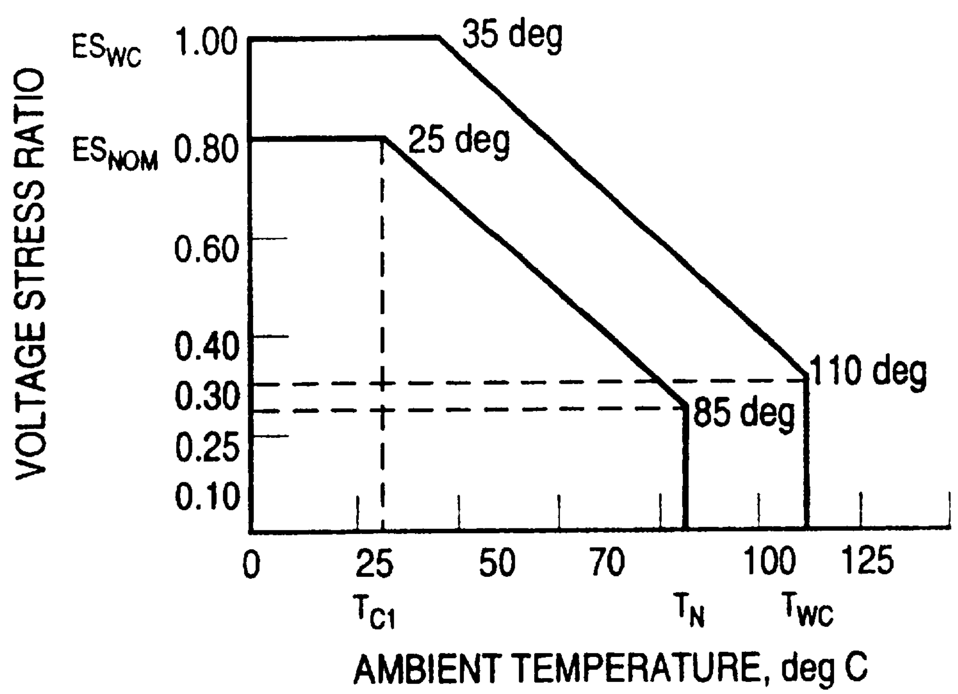


FIGURE 240-1. Voltage Derating for Glass Capacitors

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 glass capacitors, 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.

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 Group A Requirements. Group A requirements shall be in accordance with the requirements of MIL-C-87164.

4.3 Group B Tests. Group B tests shall be in accordance with the requirements of MIL-C-87164. All Group B tests shall be done on a production lot by production lot basis.

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

4.5 Incoming Inspection DPA. Incoming Inspection DPA shall be in accordance with MIL-STD-1580.

5 REGISTERED PMP

None

6 PROHIBITED PARTS

a. All mica capacitors except MIL-C-87164 types

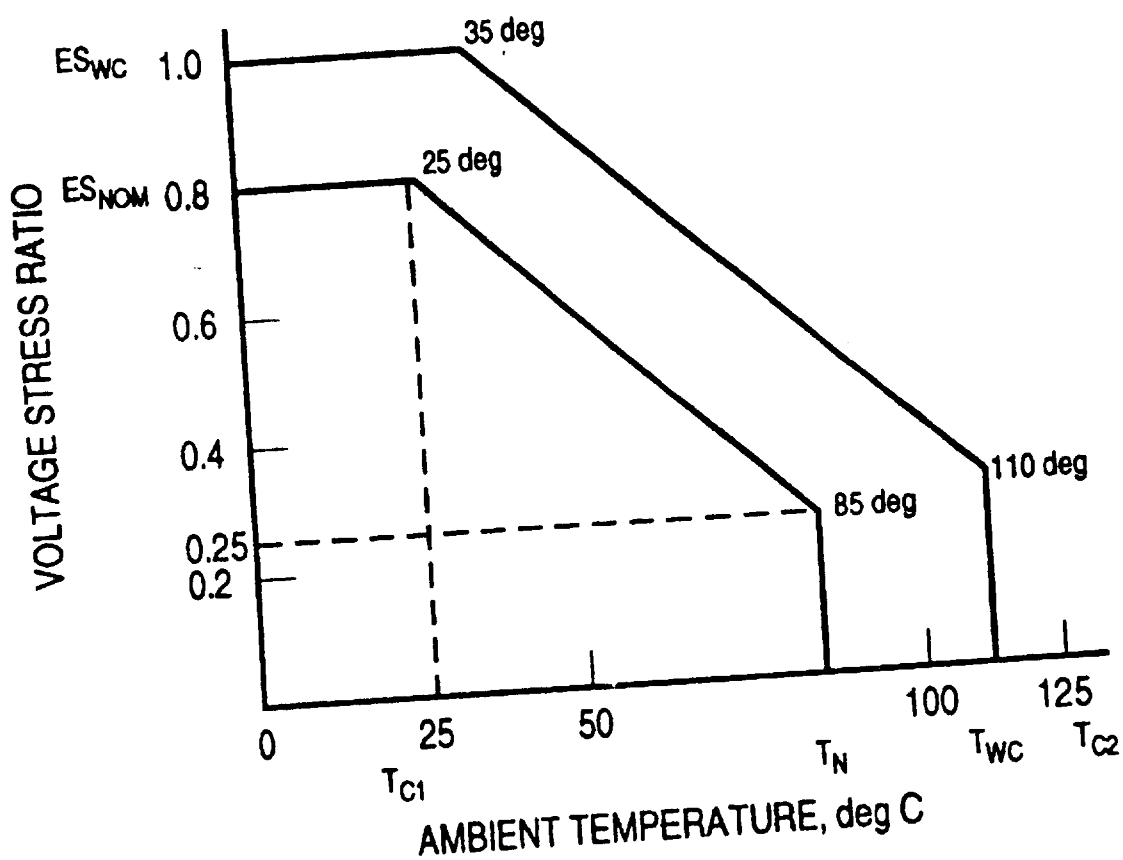


FIGURE 250-1. Voltage Derating for Mica Capacitors

SECTION 260

FIXED TANTALUM FOIL CAPACITORS (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

MIL-C-39006 tantalum foil capacitors are not recommended for incorporation in new designs. Being a single-source item, there is a likelihood that the supplier will not support users needs indefinitely.

There have been a number of failures involving misapplication of tantalum foil capacitors in excessive shock or vibration environments. Only "H" designated units shall be used for these application conditions, and only within the design capability and qualification of the parts.

Additionally, tantalum foil capacitors are not recommended for use at temperatures above 85°C, due to lack of evidence that these parts will perform reliably at the higher temperatures even with the voltage derated.

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

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. Parts shall not be used at temperatures above 85°C.

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)

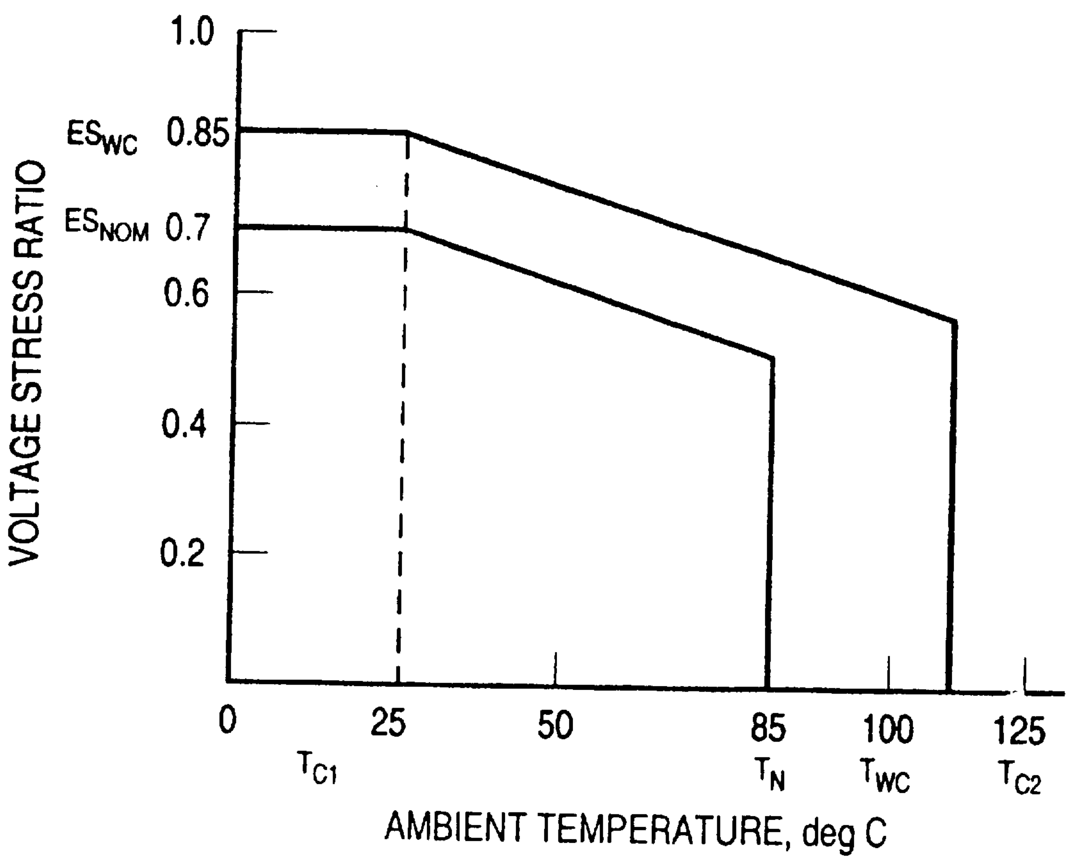


FIGURE 260-1. Voltage Derating for Tantalum-Foil Capacitors

2.4 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.

2.5 Vibration Environment. Only "H" designated tantalum foil capacitors shall be used in high shock or vibration environments, and only to within the design capability and qualification of the parts.

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.

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.

4.2 Group A Requirements. Group A requirements shall be in accordance with the 100 percent screening requirements of MIL-C-39006 and Table 260-1.

4.3 Group B Tests. Group B tests shall be in accordance with the test requirements in MIL-C-39006 and Table 260-2. All Group B tests shall be done on a production lot by production lot basis.

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

4.5 Incoming Inspection DPA. Incoming Inspection DPA shall be in accordance with MIL-STD-1580.

5. REGISTERED PMP

None.

TABLE 260-1. Additions to Group A Requirements for Tantalum Foil Capacitors

MIL-C-39006	Additions to Group A Inspection of MIL-C-39006
Constant Voltage Conditioning	a. Maximum series resistance: 33 ohms b. Burn-in time of 168 hours at +85 deg C
Seal	a. Test conditions A and C
Radiographic Inspection	a. Per MSFC-STD-355; 2 views 90 deg. apart by X-ray, or 360 deg. view by using real-time X-ray systems capable of viewing through 360 deg rotation. b. Case Size / Max Width Incl. Telescoping G1 — 0.350" G2 — 0.4375" G3 — 0.7175" G4 — 1.4219" G5 — 2.00"

TABLE 260-2. Additions to Group B Tests of MIL-C-39006

MIL-C-39006	Additions to the Methods and Criteria of MIL-C-39006
<u>Subgroup 1</u>	
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
ESR	a. At 40 Khz or greater b. Test may be waived if for DC applications only
Seal	a. Test conditions A and C
<u>Subgroup II</u>	
Vibration (Random)	a. MIL-STD-202, Method 214, Test Condition II, K for 15 minutes each axis.
Seal	a. Test conditions A and C

SECTION 270

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

1. SCOPE

This section sets forth detailed requirements for fixed solid tantalum capacitors, styles CSS 13 and CSS 33.

2. APPLICATION

Solid tantalum capacitors, styles CSS 13 and CSS 33 are specially screened parts to be used in those special applications where circuit impedances of 1 ohm per volt cannot be achieved.

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

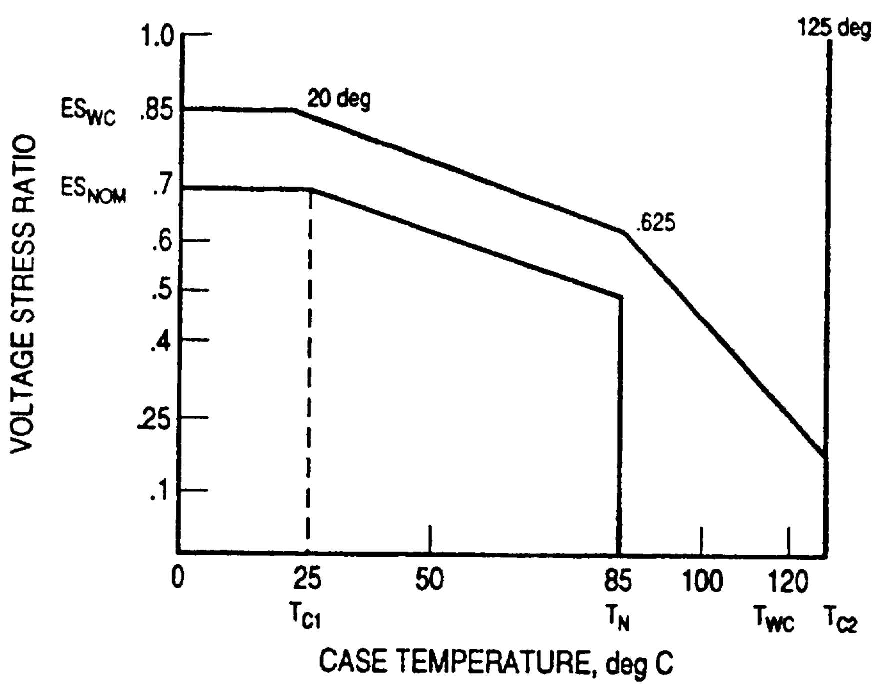


FIGURE 270-1 Voltage Derating for Solid Tantalum Capacitors

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.

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. Use failure rate level "C" when available. If not available, use failure rate level "B".

3.1.2 Voltage Ratings. These solid tantalum capacitors shall be designed with a dc working voltage of 75 volts or less, because parts with higher voltage ratings require thicker dielectrics which contain more impurities, hence, more breakdown sites.

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 Group A Requirements. Group A Requirements shall be in accordance with the requirements of MIL-C-39003/10.

4.3 Group B Tests. Group B tests not required.

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

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

SECTION 275

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

1. SCOPE

This section sets forth detailed requirements for fixed, solid tantalum chip capacitors.

2. APPLICATION

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.

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.

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

2.4 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.

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 "C", or better.

3.2 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 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, colloidal 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 Group A Requirements. Group A requirements shall be in accordance with the requirements listed in MIL-C-55365 and Table 275-2.

4.3 Group B Tests. Group B tests shall be in accordance with the requirements of MIL-C-55365. All Group B tests shall be done on a production lot by production lot basis.

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

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

TABLE 275-2. Additions to Group A Requirements of MIL-C-55365

MIL-C-55365	Additions to Group A Inspection, (Weibull distribution) 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. Weibull aging conditions of MIL-C-55365 to achieve a minimum of "C" failure rate
DC Leakage	a. +25 deg C and +85 deg C
ESR	a. Test may be waived if for DC applications only b. At 40 Khz or greater. If the application involves frequencies above 1 MHz, measurement at a minimum frequency of 1 MHz shall be required.

SECTION 280

FIXED TANTALUM-TANTALUM CAPACITOR (SINTERED WET SLUG, CLS79, & CLS81)
(MIL-C-39006/28 &/29)

1. SCOPE

This section sets forth detailed requirements for Class S wet sintered tantalum slug capacitors in tantalum cases.

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.

2.2 End-of-life Design Limits.

Capacitance: ±10 percent of initial limits

Leakage Current: 130 percent of initial maximum limit

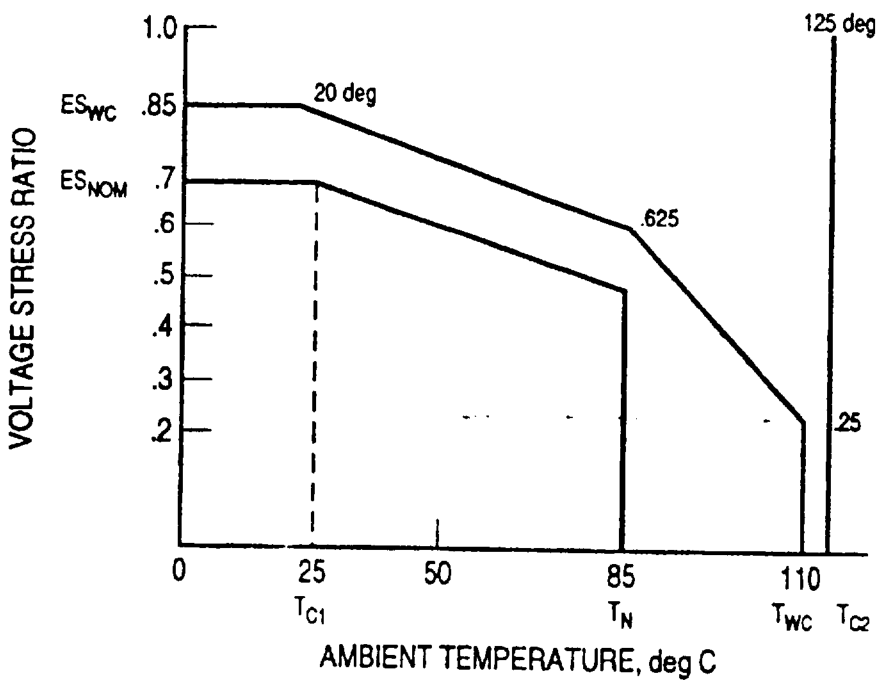


FIGURE 280-1. Voltage Derating for Tantalum-Tantalum (Sintered Wet Slug) Capacitor

2.3 <u>Electrical Considerations</u>.

2.3.1 <u>ESR versus Frequency</u>. 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 shall be read and recorded during Group A testing on a 100% basis for data collection.

2.3.2 <u>Vibration and Shock</u>. Parts have been tested to 80 g sine vibration (0.06 double amplitude) from 10 to 2000 Hz for 1½ 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 79 capacitors 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.

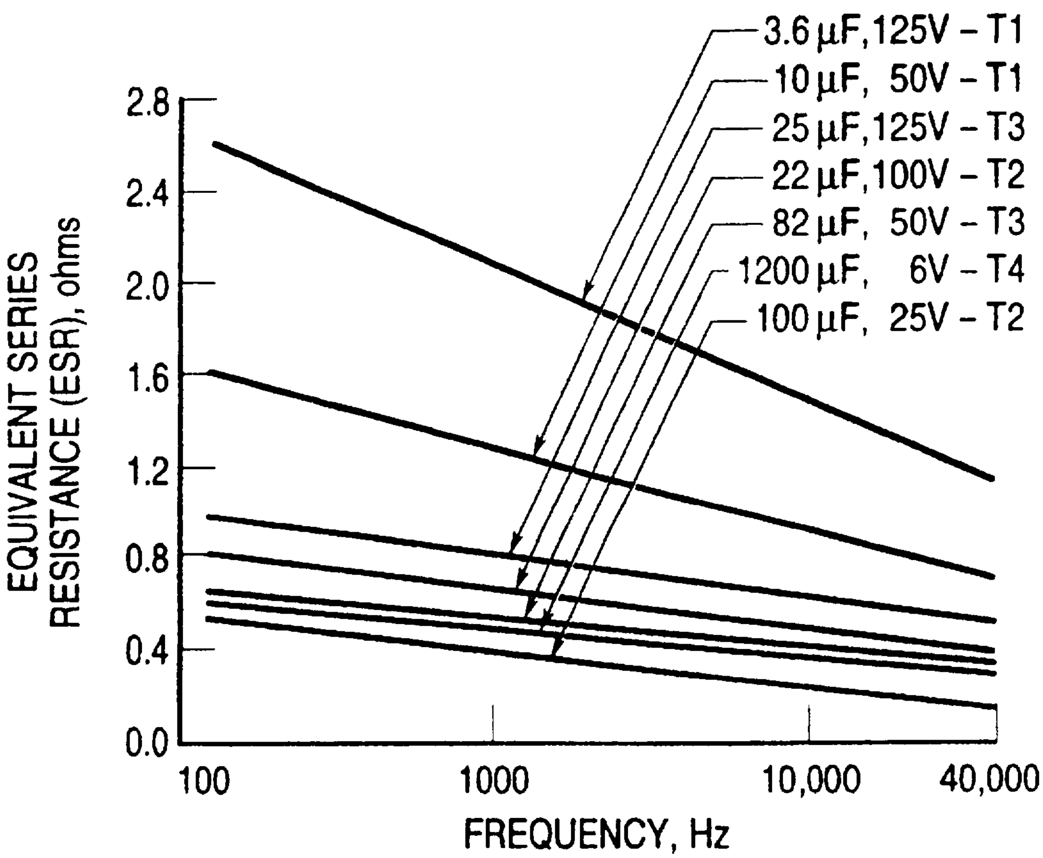


FIGURE 280-2. ESR versus AC Frequency

2.3.3 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.

2.3.4 Other. Detailed mechanical and electrical characteristics shall be as stated in MIL-C-39006/28 and /29.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with MIL-C-39006/28 & /29.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of Section 4 and MIL-C-39006/28 & /29.

4.1 In-process Control. In-process control shall be in accordance with MIL-C-39006/28 & /29.

4.2 Group A Requirements. Group A requirements shall be in accordance with MIL-C-39006/28 & /29.

4.3 Group B Tests. Group B tests shall be in accordance with MIL-C-39006/28 & /29.

4.4 Qualification. Qualification shall be in accordance with MIL-C-39006/28 & /29.

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5. REGISTERED PMP

None.

6 PROHIBITED PARTS LIST

a. Single-sealed CLR79 design (identified with its compression seal construction) incorporating liquid electrolytes

b. Silver cased, CLR wet slug types

SECTION 300

CONNECTORS

1. SCOPE

This section sets forth detailed requirements for space-qualified connectors. 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 demating 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. Non-flight connector savers shall be brightly colored so as to be easily identified. Protective covers on the connectors shall be ESD design compatible.

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

2.1 Derating. Connectors shall be derated as follows: The current shall be derated such that the temperature of any connector will be less than the maximum rated temperature minus 50°C.

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.

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. All organic materials used in the manufacture of connectors, connector accessories, and protective caps shall have a total maximum loss (TML) in accordance with section 4, paragraph 4.1.9 of this standard.

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

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, miniature, quick disconnect, environment resisting)

j. NASA Marshall Space Flight Connectors MSFC 40M38277

k. NASA Marshall Space Flight Connectors MSFC 40M38298

l. NASA Marshall Space Flight Center Connectors and hardware MSFC 40M39569

m. MIL-C-85049 Backshells and hardware

n. MIL-C-83513 (rectangular microminiature)

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 Group A Requirements. Group A requirements shall be in accordance with the applicable requirements in the applicable military specifications.

4.3 Group B Tests. Group B tests shall be in accordance with the applicable Group B requirements in the applicable military specifications.

4.4 Qualification Tests. Qualification testing shall be in accordance with the applicable requirements in the applicable military specifications. As a minimum, separation connectors shall be tested mating/demating a minimum of 10 times, with the mate/demate force measured each time. No increase in insertion or removal force will be allowed.

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5 REGISTERED PMP

5.1 Reliability Suspect Parts.

a. Silver contact overplate or underplate
b. Inserts of nonapproved organic materials
c. Noncaptivated contact coaxials
d. Nickel, Ferromagnetic, or Ferrimagnetic materials on RF connectors
e. Filter pins
f. Dissimilar metal mates
g. External flat cable connectors

6 PROHIBITED PARTS.

a. Cadmium plating
b. Zinc plating
c. Wire wrap contacts

d. Tin coated shells or contacts (see section 4, paragraph 4.3.3)

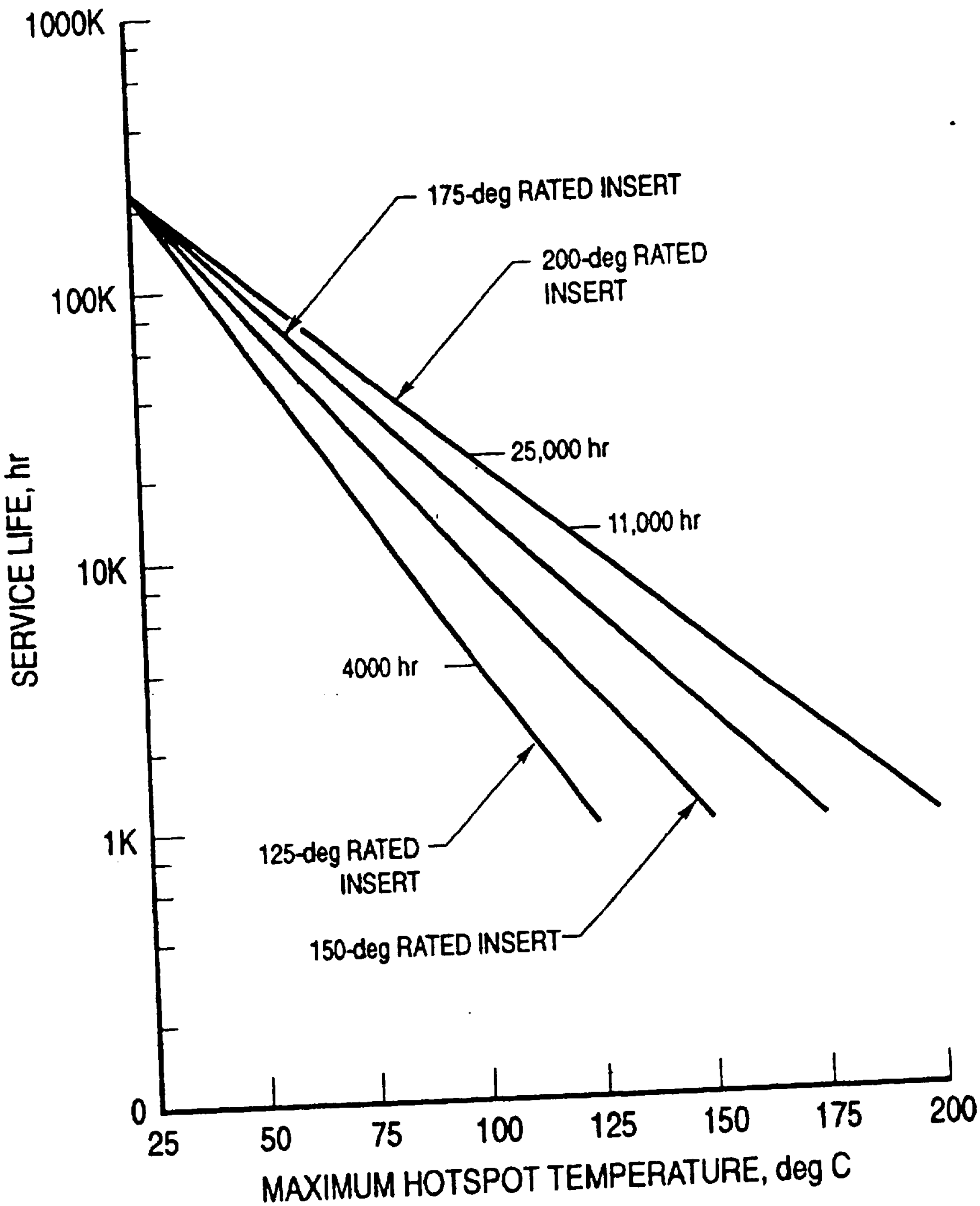


FIGURE 300-1. Maximum Hot Spot Temperature Versus Service Life

SECTION 400

QUARTZ CRYSTALS
(MIL-C-49468)

1. SCOPE

This section sets forth detailed requirements for precision quartz crystal units.

2. APPLICATION

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

2.2 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.

2.3 Installation and Handling. Precautions shall be taken to prevent seal damage and 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.

2.4 Aging. Aging is the drift of resonant frequency with time. It may alternatively be specified as drift rate vs time. Aging 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-49468 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 drive current of 1.0 ± 0.2 Ma through the crystal.

3.1.1 Hermetic sealing. Only hermetically sealed crystals shall be used. If a crystal filter or oscillator manufacturer also manufacturers the quartz crystal units, nonhermetically-sealed crystal units may be used provided the manufacturer arranges for transportation of the crystal to his manufacturing area in a manner that precludes them from being contaminated. Individual crystal units shall be sealed in a package by cold-welding, resistance-welding, or an alternate form of sealing that shall ensure a leak rate or less than 10^{-8} atm-cc/sec).

3.1.2 Metallization. Crystal metallization materials and application techniques shall be selected to provide adhesion of the electrode contacts. If gold electrodes are used, an undercoat, such as chromium or tungsten, shall be used.

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. MIL-H-10056/21/23/27/29/30/31/32/33/34/39 are not conducive to a minimum 3 point mount with the supports 120° 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 prepared by the electrodiffusion process (swept quartz). Quartz prepared by the electrodiffusion process is recommended for all applications because of the resulting low levels of Al and Na ions.

3.1.5 Gold. Gold plating on package surfaces shall be in accordance with MIL-G-45204.. Type, grade, and class shall be specified for each finish system. Examples are: Type 1, Grade C, Class 2 (0.000100 inch minimum) over copper underplate (0.000010 inch minimum). As an alternative gold (0.000050 inch minimum) over nickel (0.000100 inch) with gold thickness maximum equal to 0.000200 inch.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of MIL-C-49468 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the Class S requirements of MIL-C-49468 and the following:

4.1.1 Pre-cap Visual and Mechanical Examination. Visual and mechanical examination shall be performed in accordance with MIL-C-49468, except that the magnification shall be a minimum 30X magnification. 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

f. Less than 0.005-inch clearance between quartz crystal and the package wall

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/ corrosion (adhering particulate, film, flux residue, finger print, or other type of material)

j. Non-uniform quantities of bonding cement at mounting points; bonding cement in areas other than mounting points is acceptable if deliberately applied to the resonator surface to suppress harmonic responses

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

n. Dimensions out of tolerance

4.1.2 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 per MIL-C-49468 (applicable to devices requiring stability greater than 1 part per million).

b. Electrical tests for mounted crystal:

F_0 (series and parallel resonant frequency)

R_1

C_1, motional capacitance. C_1 testing may be waived for crystals used in oscillator circuits.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements listed in Table 400-1.

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 Sampling Plans. Sampling plans shall be in accordance with the requirements of MIL-C-49468.

4.3.2 Lot Conformance Subgroup 1 Tests. Subgroup 1 tests shall be in accordance with the requirements of MIL-C-49468 and the following:

4.3.2.1 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.

4.3.2.2 Terminal Strength. Terminal strength shall be determined in accordance with MIL-C-49468.

4.3.3 DPA. A Destructive Physical Analysis (DPA) shall be conducted on a random sample of each manufacturing lot in accordance with MIL-STD-1580.

4.4 Qualification Tests. Qualification tests per MIL-C-49468 are not required for manufacturers listed on the QPL. Otherwise, qualification tests shall be in accordance with MIL-C-49468.

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5 REGISTERED PMP

5.1 Reliability Suspect Parts.

a. Solder sealed packages
b. Gold metallization without barrier metal
c. Two point mount internal construction
d. Quartz other than EIA STD RS-477 premium Q type
e. Non swept quartz in radiation (space) environments
f. Plug-in packages

6 PROHIBITED PARTS LIST

a. Tin coated packages and leads (see section 4, paragraph 4.3.3)

TABLE 400-1. 100 Percent Screening Requirements for Quartz Crystals

MIL-C-49468	Additions to the Methods and Criteria of MIL-C-49468
Pre-Seal Visual Examination	a. Para 4.1.1 of this Section
<u>Subgroup 1</u> Visual (External) and Mechanical Examination	
Mechanical Shock	
Frequency Resistance vs Temp Frequency vs Temp (static) Coupled Modes Unwanted Modes	
Capacitance	
Shunt	a. When specified
Motional	a. When specified
Quality Factor	a. When specified
Seal	
<u>Subgroup 2</u> Accelerated Aging	
Drive Sensitivity (frequency, resistance)	
<u>Subgroup 3</u> Vibration	a. Random vibration per MIL-STD-202, Method 214, Condition F b. Delta f/f $\leq 1 \times 10^{-6}$
Temperature Cycling	a. -65°C to +125°C to +65°C b. 50 cycles c. Delta f/f $\leq 1 \times 10^{-6}$
Temperature Run	
Insulation Resistance	
Electrical Measurements	
Resonant Frequency	
Seal	

TABLE 400-2. Lot Conformance Tests

MIL-C-49468	Additions to the Methods and Criteria of MIL-C-49468
<u>Subgroup 1</u>	
Particle Impact Noise (PIND)	
Moisture Resistance	
Salt Spray	
Terminal Strength	
Bond Strength	a. When specified
<u>Subgroup 2</u>	
Solderability or Lead Attachment	
Resistance to Solvents	
Vibration, Acceleration and Acoustic Noise	a. Vibration shall be random, per MIL-STD-202, Method 214, Condition K b. Delta $f/f \leq 1 \times 10^{-6}$
Thermal Shock	
Mechanical Shock	
Thermal Time Constant	a. When specified
Thermal Frequency Repeatability	a. When specified
Seal	

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 Table 500-1.

TABLE 500-1. Derating Guidelines for Diodes

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

Leakage Current: 100 percent of initial maximum limit

2.3 Power 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 where practicable. All plastic encapsulation shall not be used. Monometallic bonding is preferred. Unglassified semiconductors in which leads cross scribe lines with clearance of less than 0.002 inch shall not be used.

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 Mesa Construction:

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

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the JAN S requirements of MIL-S-19500. The recommended electrical test are listed in Table 500-2. Unless otherwise specified the reject criteria shall be per the detail specification limit.

4.3 Quality Conformance Inspection (QCI). QCI shall be in accordance with the quality conformance tests for JAN S per MIL-S-19500.

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

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

TABLE 500-2. Recommended 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
5. Delta limits, Delta V_F and Delta I_R, after burn-in and after high temperature reverse bias (when applicable)

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

HOT CARRIER

1. Forward voltage, V_F at rated I_F
2. Reverse current, I_R at +25 deg C and maximum rated operating temperature
3. Reverse recovery time at specified V_R, I_R load resistance, load capacitance
4. Capacitance C at specified voltage and frequency
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_z 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)

5. REGISTERED PMP

5.1 Reliability Suspect Parts. The following designs are reliability suspect:

a. Hot welded cans
b. Nonpassivated dice
c. Bimetallic bonds at die
d. Point contact (whisker) devices
e. Silver bump, ramrod construction
f. Nonmetallurgically bonded construction (except schottky devices), unless supported by operational thermal cycle data.
g. Germanium devices
h. Gallium Arsenide devices
i. Flip chip units
j. Glass die attach
k. Parts containing organic materials

6. PROHIBITED PARTS LIST

The following parts, part styles, and part types shall not be used unless in accordance with contractor's approved PMP Control Plan.

a. All plastic encapsulated types
b. Coated tin packages and leads (see section 4, paragraph 4.3.3)

SECTION 600

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

1. SCOPE

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

2. APPLICATION

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 BR 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 Section 3500.

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. Insulation resistance or dielectric with standing voltage should be performed after torquing.

2.4.3 Connecting Wires. When connecting wires to the device, always heat sink the filter stud lead. Caution, rework involving solder removal by wicking may damage high temperature solder seals in stud leads.

2.5 Aging Sensitivity. Filters with ceramic discoidal capacitors using BR 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 or ferrite bead 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.

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 Group A Requirements. Group A requirements shall be in accordance with the Group A screening requirements of MIL-F-28861, Class S.

4.3 Group B Tests. Group B tests shall be in accordance with the Group B tests of MIL-F-28861, Class S requirements.

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

4.5 Incoming Inspection DPA. Incoming inspection shall be in accordance with MIL-STD-1580.

4.6 Solder Dip/Retinning. When solder dip/retinning is performed, the subsequent 100% testing, as specified in the applicable military specification, shall be performed.

5. REGISTERED PMP

5.1 Reliability Suspect Parts.

a. Devices with suspect constituents (see specific capacitor, etc. sections)

b. Nonhermetic devices (polymeric seals)

c. External tooth locking hardware

5.1.1 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.

6. PROHIBITED PARTS LIST

The following parts, part styles, and part types shall not be used unless in accordance with contractor's approved PMP Control Plan.

a. EMI or RF filters with tubular ceramic elements

b. EMI or RF filters with coated tin packages or terminals (see section 4, paragraph 4.3.3)

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
e. Maximum current delivered by the power source. The fuse selected shall be matched to the maximum current of the power source, such that the current shall not be so low as to fail to blow the fuse nor so high as to destroy the fuse completely.

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

a. Atmospheric. For atmospheric or non-vacuum operating conditions, at 25°C use a derating factor of 0.70 rated current to compensate for individual tolerances and provide a safety factor.

b. Vacuum. For use under vacuum conditions at 25°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°C, additional derating is necessary for operation under either atmospheric or vacuum conditions. The derating factor should decrease by either 0.2% or the manufacturer's suggested derating factor, whichever is higher, for each degree C above the rated temperature, up to the maximum allowed temperature.

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

2.1.1 Solid, Molded Fuses. For solid, molded fuses with no internal air cavity:

a. Atmospheric and vacuum. At 25°C use a derating factor of 0.70 rated current.

b. Temperature. Above 25°C additional derating is necessary. The derating factor should decrease by either 0.2% or the manufacturer's suggested derating factor, whichever is higher, for each degree C above the rated temperature, up to the maximum allowed temperature.

2.2 Electrical Considerations

2.2.1 Fuse Characteristics. Factors to be considered in the selection of fuses and in their derating 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.

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 most 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 without derating per Table 700-1 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.)

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, except that for fuses with opaque bodies, radiographic inspection viewed at 7X minimum shall be acceptable at a minimum of 2 orthogonal views or 360° turn.

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 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.

5. REGISTERED PMP

5.1 Reliability Suspect Parts The following fuse types are reliability suspect:

a. Fuses requiring spring clip-type fuse holders

b. Fuses comprised of low-melting-point alloys

6. PROHIBITED PARTS LIST

The following parts, part styles, and part types shall not be used unless in accordance with contractor's approved PMP Control Plan.

a. All fuses requiring fuse holders
b. Fuses with coated tin package or leads (see section 4, paragraph 4.3.3)

TABLE 700-2. 100 Percent Screening Requirements for Fuses

MIL-F-23419 Screens	Additions 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 d. Test may be waived, except for ceramic and molded-body fuses, if the manufacturer can present written, detailed records to indicate that there have been no anomalies or failures detected in previous tests of similar fuses for the last 3 years
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 50% 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

* Burn-in not required for pico fuses

SECTION 800

MAGNETIC DEVICES (TRANSFORMERS, INDUCTORS, AND COILS)

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 not exceed T_I - 30°C, where T_I is 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

e. MIL-C-83446/5 for Fixed Chip Radio Frequency Coils

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.

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. MIL-STD-981 shall be used in the preparation of contractor specification control drawings.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the Class S requirements of MIL-STD-981. MIL-STD-981 shall be used in the preparation of contractor specification control drawings.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the Class S requirements of MIL-STD-981.

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.

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5. REGISTERED PMP

5.1 Reliability Suspect Parts.

a. Wire sizes not compliant with paragraph 3.1.2 above

b. Variable devices

6. PROHIBITED PARTS

a. Tin coated devices or leads (see section 4, paragraph 4.3.3)

SECTION 900

MICROCIRCUITS
MIL-M-38510

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 for Digital Microcircuits

Parameter	Derating Factor	
	Nominal	Worst Case
Output load current (total) (1)	0.80	0.90
Vcc specified nominal supply voltage	1.1 Vcc	1.1 Vcc
Transients (2)	1.2 Vcc	1.2 Vcc
Propagation delay	110 percent	
Fanout	(3)	(3)
Power dissipation, PD	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 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)	1.20Vcc	1.40Vcc
Gain (application)	0.75	0.85
Power dissipation, PD	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 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, PD	0.75	0.85
Junction or "hot-spot" temperature, maximum	+105 deg C	+125 deg C

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

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 for SCD product.

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.

4.3 Quality Conformance Inspection (QCI). QCI shall be in accordance with Appendix C and the quality conformance test requirements for Class S in MIL-M-38510.

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

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5. REGISTERED PMP

5.1 Reliability Suspect Parts.

a. Hot welded cans
b. Nonpassivated devices
c. Plastic encapsulated units
d. Packages other than those defined in MIL-STD-1835
e. Programmable units which do not program with a single pulse
f. Internal organic/polymeric materials (lacquers, varnishes, coatings, adhesives, or greases)
g. Internal desiccants
h. Flip chips
i. Beam leaded devices
j. Bimetallic lead bond at die
k. Ultrasonic cleaned parts

6. PROHIBITED PARTS LIST

The following parts, part styles, and part types shall not be used unless in accordance with contractor's approved PMP Control Plan.

a. All plastic encapsulated types
b. All tin coated packages or leads (see section 4, paragraph 4.3.3)

SECTION 910

INTEGRATED CIRCUITS
(Qualified Manufacturing Line (QML) Methodology)

1. SCOPE

This section sets forth detailed requirements for integrated circuits devices which are produced under a quality management system and technical program as described in MIL-I-38535.

The acquiring activity shall assess the design, verification, documentation, construction, and testing of devices in addition to the manufacturer's processes, process monitors, and procedures as described in MIL-I-35835, and as specified herein. MIL-HDBK-339 is to be used as guidance in the assessment.

2. APPLICATION

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, device specification, and test conditions shall make allowances for 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-I-38535 and as specified below.

3.1.1 Design Verification. Design verification shall include model, layout, performance, testability, and fault coverage verification and shall be in accordance with MIL-38535.

3.1.2 TCV/SEC/PM Program. Technology characterization vehicle, standard evaluation circuit, and parametric monitor programs, including appropriate documentation shall be implemented in accordance with MIL-I-38535.

3.1.3 Wafer Fabrication. Wafer fabrication shall be in accordance with MIL-I-38535.

3.1.4 Assembly and Packaging. Assembly and Packaging process and product characterizations (e.g. package design, thermal, and electrical) shall be in accordance with MIL-I-38535.

3.1.5 Radiation Hardness Assurance. RHA characterization shall be in accordance with MIL-I-38535 and Appendix A of this standard.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with MIL-I-38535 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with MIL-I-38535 and the following:

4.1.1 Statistical Process Control Program. An SPC program, including wafer fabrication, assembly, and packaging shall be implemented in accordance with MIL-I-38535.

4.1.2 Process Monitors. Process Monitors shall be implemented in accordance with MIL-I-38535.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with Appendix B of MIL-I-38535.

4.3 Technology Conformance Inspection. TCI shall be in accordance with Appendix B of MIL-I-38535.

4.4 Qualification. Qualification shall be in accordance with MIL-I-38535 and the following:

4.4.1 Qualification Requirements. Qualification requirements shall consist of Process capability demonstration, Design Verification, and Radiation Hardness Assurance, if applicable, and shall be in accordance with MIL-I-38535.

4.4.2 Product Qualification. Product qualification shall consist of the TCI tests and inspections in Appendix B of MIL-I-38535.

4.5 Quality Assurance Program.

4.5.1 Quality Management Plan/Program. A QM plan and program shall be implemented in accordance with MIL-I-38535.

4.5.2 Change Control Plan/Program. A change control program shall be implemented in accordance with MIL-I-38535.

4.5.3 Technology Review Board (TRB). TRB shall be as defined by the acquiring activity and in accordance with MIL-I-38535.

4.6 Incoming Inspection DPA. The acquiring activity shall perform an incoming inspection DPA in accordance with MIL-STD-1580.

4.7 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°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.

4.3 EPROMs and EEPROMs. EPROMs and EEPROMs shall be burned in after initial programming.

5. REGISTERED PMP

Same as Section 900.

6. PROHIBITED PARTS LIST

a. All plastic encapsulated types
b. All tin coated packages or leads (see section 4, paragraph 4.3.3)

SECTION 960

HYBRIDS
(MIL-H-38534)

1. SCOPE

This section sets forth detailed requirements for hybrid microcircuits.

2. APPLICATION

2.1 Derating. Derating shall be in accordance with the derating criteria in Section 900 of this document.

a. Verification of junction-case thermal resistance by testing and thermal mapping is recommended for new designs, especially with new technology.

2.2 Electrical Considerations. The circuit design for each die shall make allowances for the worst case variation of the actual output logic "L" state sink current, actual logic "H" state sink current, 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-H-38534, class K, and as specified below.

3.2 Packaging. Packaging shall be in accordance with MIL-H-38534, class K.

3.3 Traceability. Traceability shall be in accordance with MIL-H-38534, class K.

3.4 Configuration Control. Configuration Control shall be in accordance with MIL-H-38534.

3.5 Serialization. Serialization shall be in accordance with MIL-H-38534, class K.

3.6 Rework. Rework shall be in accordance with MIL-H-38534.

4. QUALITY ASSURANCE

Quality assurance shall be in accordance with MIL-H-38534, class K, and as follows:

4.1 Element Evaluation. Element evaluation shall be in accordance with MIL-H-38534, class K.

4.2 Process Control. Process control shall be in accordance MIL-H-38534, class K.

4.3 Screening (100 percent). Screening (100 percent) shall be in accordance with MIL-H-38534, class K.

4.4 Quality Conformance Inspection. QCI shall be in accordance with MIL-H-38534, class K.

4.5 Quality Assurance Plan. A quality assurance plan shall be established in accordance with Appendix A of MIL-H-38534, class K.

4.6 Incoming Inspection DPA. The acquiring activity shall perform an incoming inspection DPA in accordance with MIL-STD-1580.

5. REGISTERED PMP

None

6. PROHIBITED PARTS LIST

a. Any internal parts, packages, or leads with tin coating (see section 4, paragraph 4.3.3)

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. External 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 and will decrease the operating life cycles for a given relay.

Therefore, the coil operating voltage shall not be subject to a lesser value by derating; that is, should not be less than the rated coil voltage nor more than the maximum rated coil voltage over the operating temperature range of the relay. For pulsed applications when the duty cycle is 10% or less, the coil energizing voltage shall be no greater than 150% of the rated coil voltage, and the maximum allowable "on" time shall be 50 milliseconds.

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-6106, MIL-R-28776, MIL-R-39016, and MIL-R-83726.

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.

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 be used to maintain cleanliness. The relays may be remagnetized and stabilized, if applicable.

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 (30-50X), 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 into 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, 10X minimum for relays larger than 1 ampere).

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:

a. Proper alignment for both positions of the armature.

b. Fibers and other contaminants (20X)

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

d. Contact terminals for weld splatter (20X)

4.1.3.3 Coil Inspection. Inspect coil for the following:

a. Coil lead welds of inadequate quality; 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 (20X). The weld area probing procedure shall be defined in a manner to minimize the possibility of mechanical damage.

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. Tool marks that affect reliability

b. Glass seal defects

c. Weld splatter

d. Cracked or peeling plating

e. Misalignment 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 125 ± 5 grams applied using an approved force gage calibrated for a range of 110 to 135 grams pressure force. User may apply a maximum force of 125 ± 5 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 length from the pin or outer edge is 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 clean parts in a 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 assembly using the following procedure, or a procedure approved by the contracting officer. First obtain reagent grade solvent both compatible with the relay components and meeting other necessary requirements from pre-filtered supply. Assemble pre-cleaned 1000 milliliter flask, vacuum pump, filter holder, pre-cleaned 0.80 micrometer filter, and pre-cleaned funnel. Fill funnel with pre-filtered reagent grade solvent and turn vacuum pump on. Repeat until flask is filled. Fill a pressurized container with cleaned reagent grade solvent. Clean filter by blowing both surfaces with ionized air. Using the pressurized container, wash both sides of the filter with clean filtered reagent grade solvent. Observe filter under 30X magnification; if any particles are observed, repeat the cleaning process until no particles are observed. 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 reagent grade solvent, pour the reagent grade solvent into the funnel, covering the parts to be cleaned. Cover funnel. Turn on vacuum pump. When all the reagent grade solvent 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 inch) or larger are present, or three or more visible particles under 2.5 micrometers (0.001 inch) are present on the filter, repeat the process until no additional particles are observed. 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 characterized by mechanical chatter, the Particle Impact Noise Detection (PIND) test may not detect particles. In this case, 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 ± 0.1 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. Internal moisture shall be determined per MIL-R-6106.

4.4 Qualification Tests. Qualification tests shall be in accordance with MIL-R-39016 and MIL-R-6106.

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5. REGISTERED PMP

5.1 Reliability Suspect Parts.

a. Nonapproved organic materials
b. Soldered-sealed cases
c. Units not subjected to a vibration miss test
d. External dielectric coatings
e. Plug-in devices
f. Internal suppression diode

6. PROHIBITED PARTS LIST

a. Wire sizes < 44 AWG
b. Tin coated packages or terminals (see section 4, paragraph 4.3.3)

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

MIL-R-39016 Screens	Additions 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
Intermittency & Particle Impact Noise Detection (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. The lot may be tested a maximum of 5 times. If less than 1% of the lot fails during any of the 5 runs, the lot may be accepted. All defective devices shall be removed after each run. Lots which do not meet the 1% PDA on the fifth run, or exceed 25% defectives cumulative, shall be rejected.

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

MIL-R-39016 Screens	Additions to the Methods and Criteria of MIL-R-39016
Electrical Characteristics	a. See requirements in paragraph 4.2.2 of this standard
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 or MIL-R-39016 (as applicable)
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
1110	Fixed Carbon Composition	MIL-R-39008	RCR
1120	Fixed Film	MIL-R-39017	RLR
1125	Fixed Film Resistor Chips	MIL-R-55342	RM
1130	Fixed Film	MIL-R-87254	RSC
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	Resistor Network	MIL-R-874	RZR
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.

3. DESIGN AND CONSTRUCTION

See the detailed requirements section for each resistor type.

4. QUALITY ASSURANCE

See the detailed requirements section for each resistor type.

4.1 Production Lot. See Section 4 of this standard.

4.2 Solder Dip/Retinning. When solder dip/retinning is performed, the subsequent 100% testing, as specified in the applicable military specification, shall be performed.

5. REGISTERED PMP

5.1 Reliability Suspect Parts. The following resistor types have failure modes that cannot be completely removed by existing controls and screens. These types are not recommended for mission-significant or critical space applications.

a. All carbon film

b. All variable types

c. Films over solid cores without initial undercoating

d. Chip devices with silver or silver/palladium terminations that have no barrier metallization

e. Film chips with films <350 Angstroms thick

f. Non-hermetic film resistors with aluminum terminations without protective undercoating

g. Wirewound resistors with crimped or soldered terminations

h. Wirewound resistors with wire size < 0.001 inch

i. Nichrome film networks

j. Network resistors using tantalum nitride films < 350 Angstroms thick

k. Nonhermetic resistor networks

l. Non-welded networks

6 PROHIBITED PARTS.

a. Non-hermetic hollow core (ceramic) film types
b. All hermetic hollow ceramic core film resistors with internal metallization
c. Parts with tin coated leads or terminations (see section 4, paragraph 4.3.3)

SECTION 1110

FIXED COMPOSITION, INSULATED, CARBON COMPOSITION (RCR) (MIL-R-39008)

1. SCOPE

This section sets forth detailed requirements for fixed composition resistors (commonly identified as carbon composition resistors).

2. APPLICATION

2.1 Derating.

2.1.1 Power Derating. In accordance with Figure 1110-1.

2.1.2 Voltage Derating. Steady-state voltage applied to RCR resistors shall be limited to 0.8 times values shown in Figure 301-2 of MIL-STD-199.

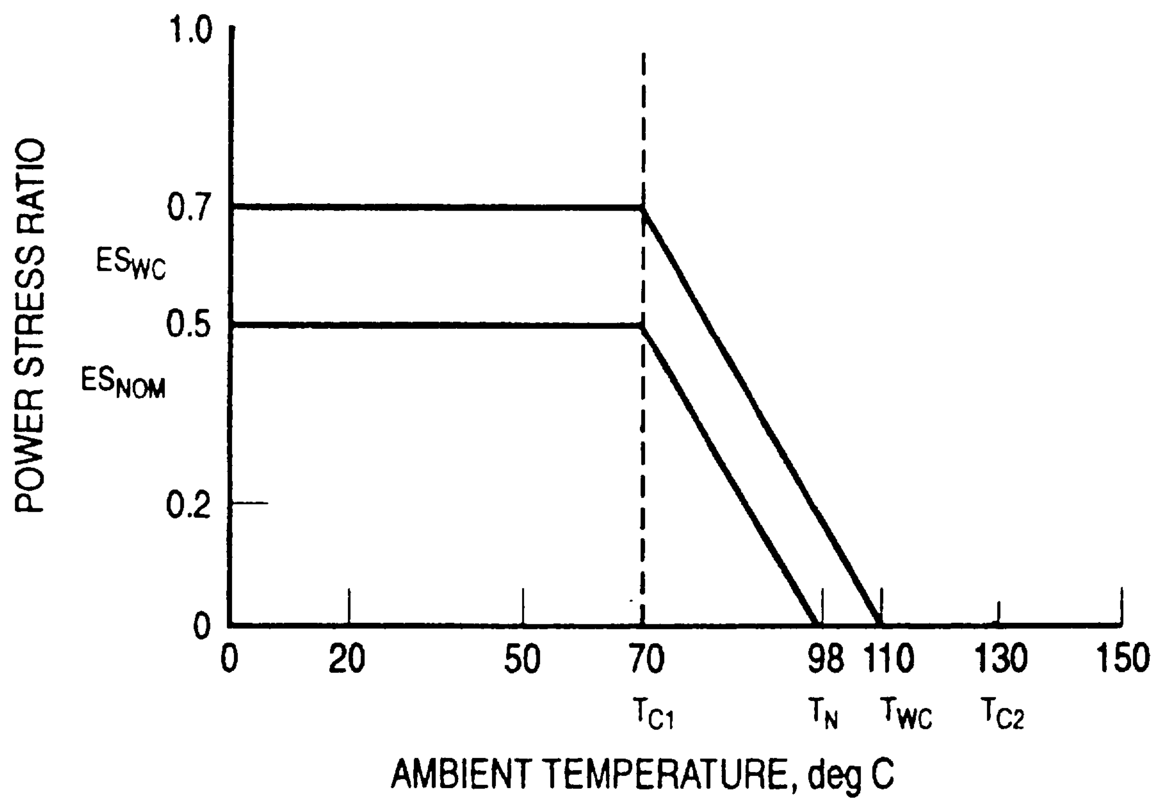


Figure 1110-1. Power Derating for Carbon Composition Resistors

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

a. ± 15 percent for approved application

b. ± 20 percent for worst case application

2.3 Aging Sensitivity. Carbon composition resistors typically exhibit resistance and noise changes of ± 15 percent due to moisture and temperature effects. When a closer tolerance or higher accuracy is needed, metal film or precision wire-wound devices shall be used.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-R-39008.

4. QUALITY ASSURANCE REQUIREMENTS

Quality Assurance provisions shall be in accordance with the requirements of MIL-R-39008 unless specified otherwise.

5. REGISTERED PMP

5.1 Reliability Suspect Parts.

a. Carbon film types (pyrolitic carbon film deposited on glass or ceramic core).

b. Carbon composition (RCR type) resistors shall be limited to applications where a resistance accuracy (excluding initial resistor tolerance) in excess of ±20 percent is acceptable.

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.

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.

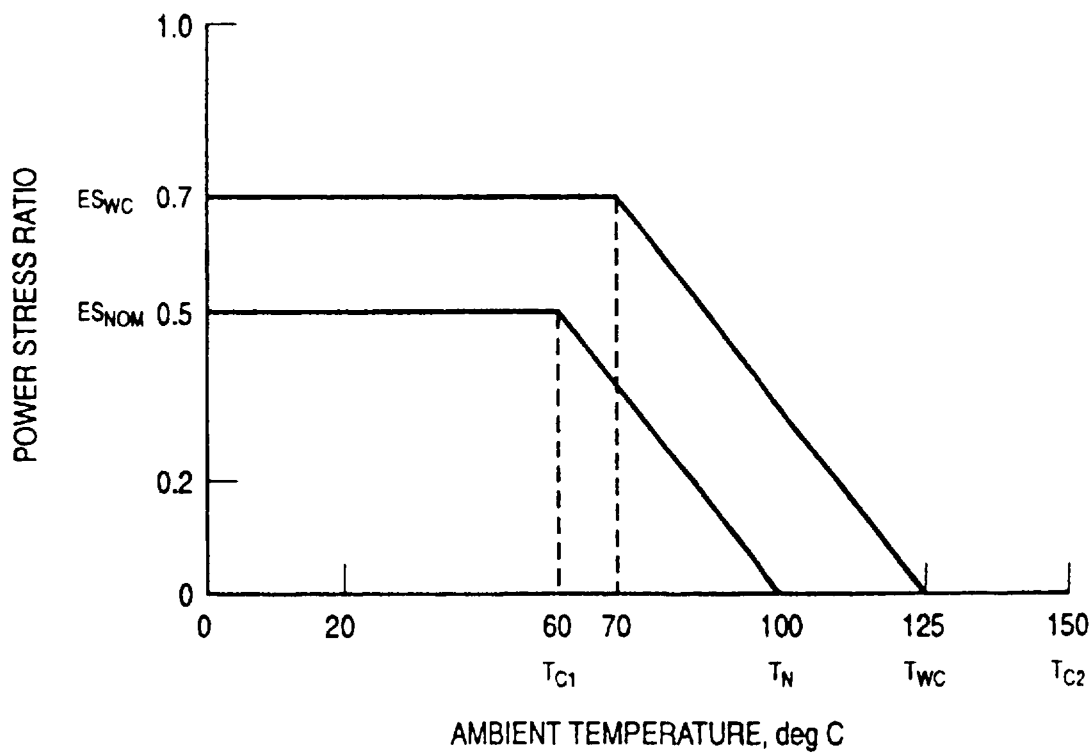


FIGURE 1120-1. Power Derating for Film Resistors

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

Design and construction shall be in accordance with MIL-R-39017, failure level "S".

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 Group A Requirements Group A requirements shall be in accordance with the requirements in MIL-R-39017 and Table 1120-2.

4.3 Group B Tests. Group B tests shall be in accordance with the Group B tests in MIL-R-39017.

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

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5. REGISTERED PMP

5.1 Reliability Suspect Parts.

a. Devices constructed with a deposited thin metal film over a solid core that do not have a protective undercoating between the metal film and the outer jacket shall not be used.

b. Resistors not protected from electrostatic discharge during shipping and handling may experience permanent damage.

c. Resistors using aluminum terminations are susceptible to corrosion due to moisture penetration. These parts shall not be used, or procured, unless with protective undercoating.

TABLE 1120-2. Additions to Group A Requirements for Fixed Film (Thick) Resistors

MIL-R-39017	Additions to the Methods and Criteria of MIL-R-39017
<u>Subgroup 1 (100%)</u> Thermal Shock	
DC Resistance	a. Read and record
Overload	a. 24 hours minimum at 25 ± 5°C with 1.5X rated power
Power Conditioning	a. 96 hours minimum at maximum rated temperature with full rated power; do not exceed maximum voltage specified in the spec
DC Resistance (after Power Conditioning)	a. Change in DC resistance shall not exceed 0.5 percent +0.05 ohm or ±3 standard deviation, whichever is less, for the combined overload and power conditioning tests b. DC resistance shall be within initially specified tolerance limits; lots having more than 10% out-of-tolerance rejects shall not be used
<u>Subgroup 2 (100%)</u> Resistance Noise	a. Procedure and accept/reject criteria shall be per MIL-R-87254 (Optional for applications that are not noise-sensitive)
<u>Subgroup 3</u> Solderability	
<u>Subgroup 4</u> Visual and Mechanical Examination	

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. Power applied to these resistors shall be derated with temperatures in accordance with the following:

	≤ 70°C	70 to 125°C
Nominal	50% of rated power	linearly derate to zero power
Worst Case	75% of rated power	linearly derate to zero power

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 MIL-R-55342.

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 suitable 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.

2.4.1 Humidity/Power Conditions. Chip resistors using nichrome films are susceptible to large increases in resistance values, or open failures, when operated under humid conditions. For such environments, use tantalum nitride thin films with low ohms/square sheet resistance or ruthenium oxide thick films. Additionally, performing the laser trimming prior to passivation minimizes exposure of the metal film to moisture.

2.5 Mounting. The terminations of these chips (usually platinum or gold) are subject to leaching when exposed to molten solder at high temperatures.

2.6 Electrostatic Discharge Sensitivity. Under low humidity conditions fixed film chip resistors, particularly those of smaller case sizes manufactured with high sheet resistance films, are subject to electrostatic discharge (ESD) damage and sudden shifts in resistance and the temperature coefficient of resistance. Precautions against ESD shall be used in packaging, handling, storage and kitting.

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.

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 Group A Requirements Group A requirements shall be in accordance with the requirements in MIL-R-55342 and Table 1125-1.

4.3 Group B Tests. Group B tests shall be in accordance with the Group B tests in MIL-R-55342.

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

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5. REGISTERED PMP

5.1 Reliability Suspect Parts.

5.1.1 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.

5.1.2 **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.

6. PROHIBITED PARTS LIST

a. Fixed film resistor chips with copper or nickel conductor films

TABLE 1125-1. Additions to Group A Requirements for Fixed Film Resistor Chips

MIL-R-55342	Additions to the Methods and Criteria of MIL-R-55342
Subgroup 1 1/ Pre-glassivation visual inspection	a. Paragraph 3.19 of MIL-R-55342
DC Resistance	a. Read and record
Thermal Shock	
Power Conditioning	a. 96 +4, -0 hours, full rated power at 70°C applied 90 minutes ON, 30 minutes OFF b. Delta DC resistance shall not exceed the limits specified for thermal shock test
DC Resistance	a. DC resistance shall be within initially specified tolerance limits; lots having more than 10% out-of-tolerance rejects shall not be used
Subgroup 2 Solderability (when applicable)	
Subgroup 3 Visual and Mechanical Examination	a. Paragraphs 3.19 and 4.7.1 of MIL-R-55342

1/ Lots having more than 3% PDA for Subgroup 1 screening due to exceeding the resistance change limits shall not be used.

SECTION 1130

FIXED METAL FILM RESISTORS (RSC)
(MIL-R-87254)

1. SCOPE

This section sets forth detailed requirements for fixed metal film resistors (style RSC).

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.

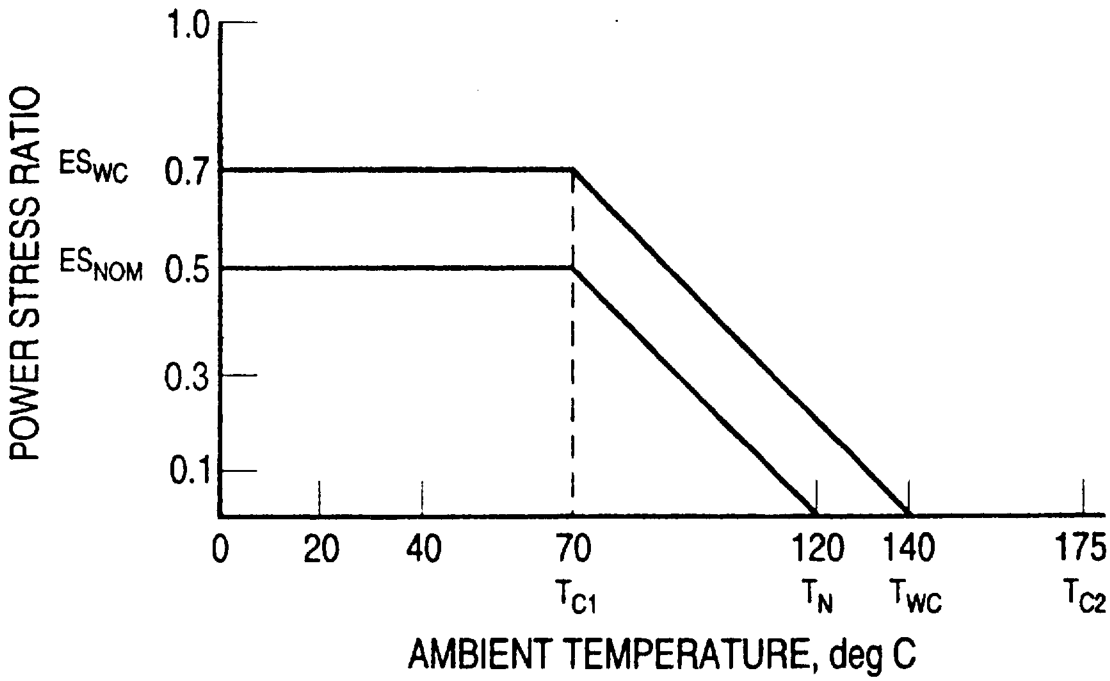


FIGURE 1130-1. Power Derating for Metal Film Resistors

2.1.2 Voltage Derating. Steady-state voltage applied to RSC resistors shall be limited to 0.80 of the maximum allowable voltage ratings in MIL-R-87254 for applications at 71 deg C to 125 deg C. Steady-state voltage applied shall be limited to 0.80 of the voltage ratings in MIL-R-87254 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-87254 specifies resistance changes of ±5 or ±25 ppm/°C (relative to 25°C resistance reading) over the operating temperature range. It should be noted that the TC is established relative to resistor temperature and not the environment. The temperature coefficient is nonlinear but can be approximated by a straight line for small temperature changes.

2.3.2 Electrostatic Discharge. These devices are susceptible to ESD damage.

3. DESIGN AND CONSTRUCTION

3.1 Requirements. Design and construction shall be in accordance with the requirements of MIL-R-87254 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-R-87254.

4.2 Group A Requirements Group A requirements shall be in accordance with the requirements of MIL-R-87254.

4.3 Group B Tests. Group B tests shall be in accordance with the requirements of MIL-R-87254.

4.4 Qualification Tests. Qualification tests shall be in accordance with the requirements of MIL-R-87254.

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5 REGISTERED PMP

5.1 Reliability Suspect Design.

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

b. Resistors using aluminum terminations are susceptible to corrosion due to moisture penetration. These parts shall not be used, or procured, unless with protective undercoating.

c. Non-hermetic resistors using thin film metallization without a corrosion-resistant precoat over the metal film.

6 PROHIBITED PARTS LIST

a. Non-hermetic hollow-core types.

b. Hermetic hollow-core types with internal (inside surface of the core) metallization (susceptible to film corrosion due to contamination from the manufacturing process).

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 ingress 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.

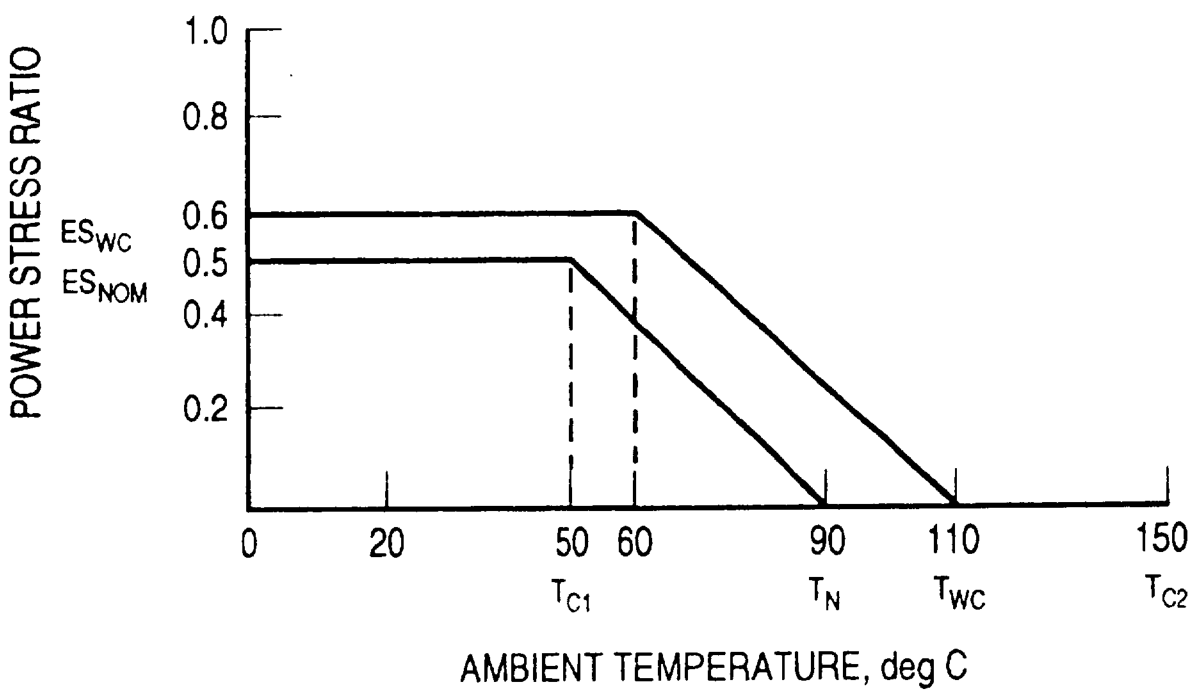


FIGURE 1140-1. Power Derating for Variable, Nonwire-wound Resistors.

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.

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. The entire lot shall be rejected if the fall-out exceeds 7.0% of the lot.

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 Group A Requirements Group A requirements shall be in accordance with the requirements in MIL-R-39035 and Table 1140-1.

4.3 Group B Tests. Group B tests shall be in accordance with the Group B tests in MIL-R-39035.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-R-39035.

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5. REGISTERED PMP

5.1 Reliability Suspect Parts. All variable resistors are reliability suspect.

TABLE 1140-1. Additions to Group A Requirements for Variable, Nonwire-wound Resistors

MIL-R-39035	Additions to the Methods and Criteria of MIL-R-39035
Subgroup 1 (100%)	1/
Thermal Shock	
Conditioning	a. 168 hours minimum at 85 ±5°C
Contact Resistance Variation	
Immersion	
Subgroup 2	
Vibration, random	a. 12 samples (6 highest, 6 lowest in resistance value), 0 failure b. MIL-STD-202, Method 214, Test Condition IIK (or to the requirements of the application c. Two cycles of 10 minutes each in two orthogonal planes d. Post vibration measurements shall meet specification limits
Subgroup 3	
Visual and Mechanical Examination	

1/ PDA is 5%

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 ingress 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

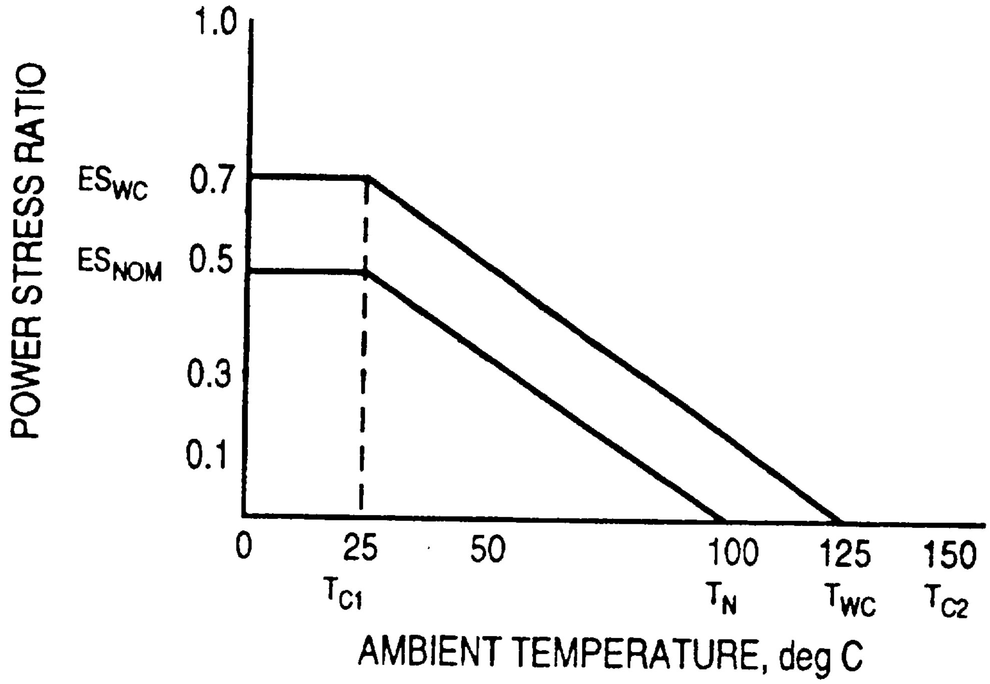


FIGURE 1150-1. Power Derating Requirements for Variable, Wire-wound Resistors

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 Section 3500. 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

3.2.1 Wire Diameter. A minimum wire diameter of 25.4 micrometers (0.001 inch) zero negative tolerance shall be used.

3.2.2 Internal Connections. All internal connections shall be welded.

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 a coaxial illumination 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. Nonwelded internal connections

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, flux residue, or metallic particles.

4.2 Group A Requirements Group A requirements shall be in accordance with the requirements in MIL-R-39015 and Table 1150-2.

4.3 Group B Tests. Group B tests shall be in accordance with the Group B tests in MIL-R-39015.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-R-39015.

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5. REGISTERED PMP

5.1 Reliability Suspect Parts. All variable resistors are reliability suspect.

TABLE 1150-2. Additions to Group A Requirements for Variable, Wire-wound Resistors

MIL-R-39015	Additions to the Methods and Criteria of MIL-R-39015
Subgroup 1 (100%) 1/	
Thermal Shock	
Conditioning	a. 168 hours minimum at 85°C
Peak Noise	
Total Resistance	
Immersion	
Subgroup 2	
Vibration, random	a. 12 samples (6 highest, 6 lowest in resistance value), 0 failure b. MIL-STD-202, Method 214, Test Condition IIK or the vibration level requirements of the application c. Two cycles of 10 minutes each in two orthogonal planes d. Measurements before, during and after test shall be in accordance with MIL-R-39015 e. Change in total resistance and setting stability shall meet specification limits
Subgroup 3	
Continuity	
Absolute Minimum Resistance	
End Resistance	
Actual Effective Electric Travel	
DWV	
IR	
Torque	
Subgroup 4	
Visual and Mechanical Examination	

1/ PDA is 5%

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.

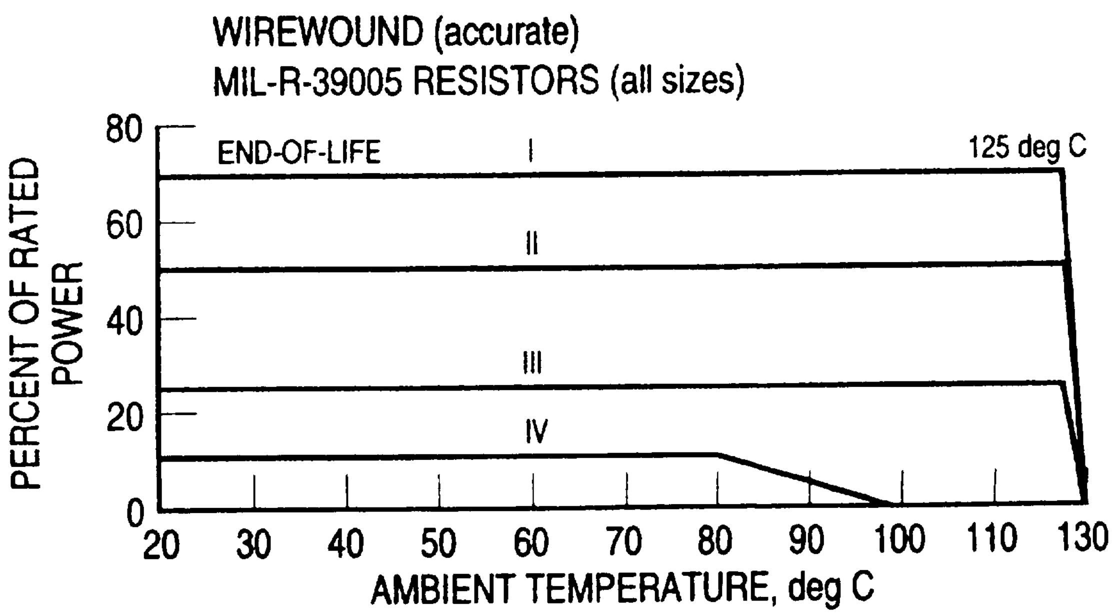


FIGURE 1160-1. High Temperature Derating Curves for Accurate Wire-wound Resistors

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 Diameter. A minimum wire diameter of 25.4 micrometers (0.001 inch) zero negative tolerance shall be used.

3.2.2 Internal Connections. All internal connections shall be welded.

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 Group A Requirements Group A requirements shall be in accordance with the requirements in MIL-R-39005 and Table 1160-2.

4.3 Group B Tests. Group B tests shall be in accordance with the Group B tests in MIL-R-39005.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-R-39005.

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5. REGISTERED PMP

5.1 Reliability Suspect Parts. Designs using soldered or crimped internal connections are reliability suspect. Designs using a wire diameter of less than 25.4 micrometers (0.001 inch) zero negative tolerance is reliability suspect.

TABLE 1160-2 Additions to Group A Requirements for Fixed, Wire-wound, Accurate Resistors

MIL-R-39005	Additions to the Methods and Criteria of MIL-R-39005
Thermal Shock	
DC Resistance	
Conditioning	a. 168 hours minimum
Short Time Overload	
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 using real-time X-ray systems capable of viewing through 360 deg rotation. 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.

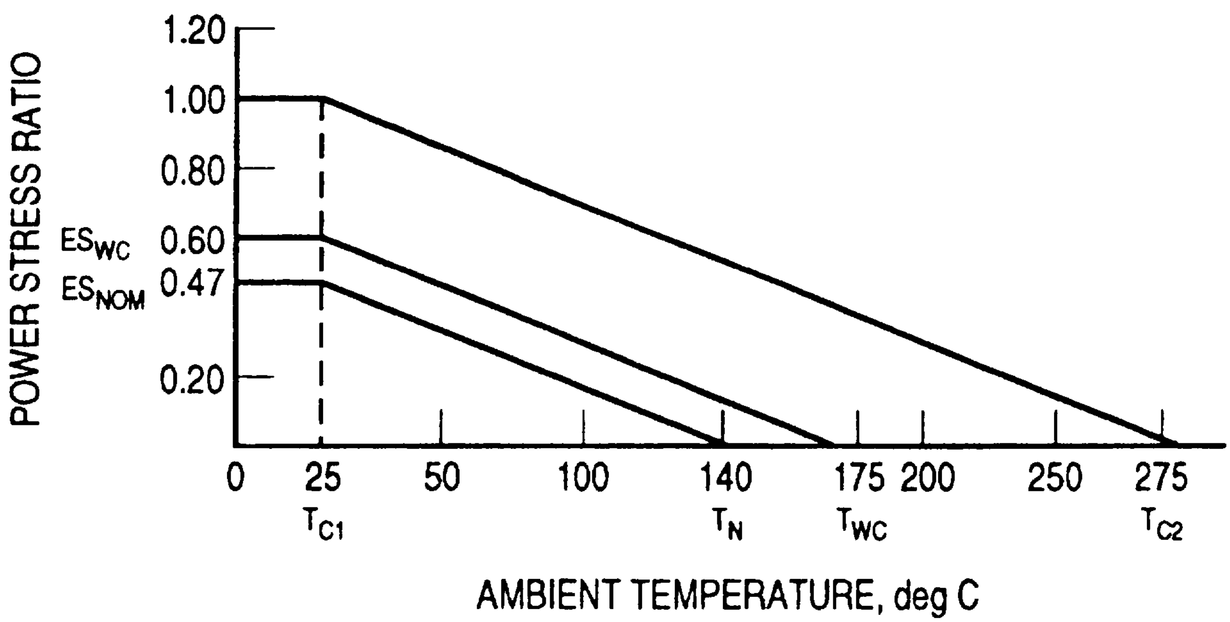


FIGURE 1170-1. Power Derating Requirements for Wire-wound (Power-type) Resistors

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 = (E2/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.

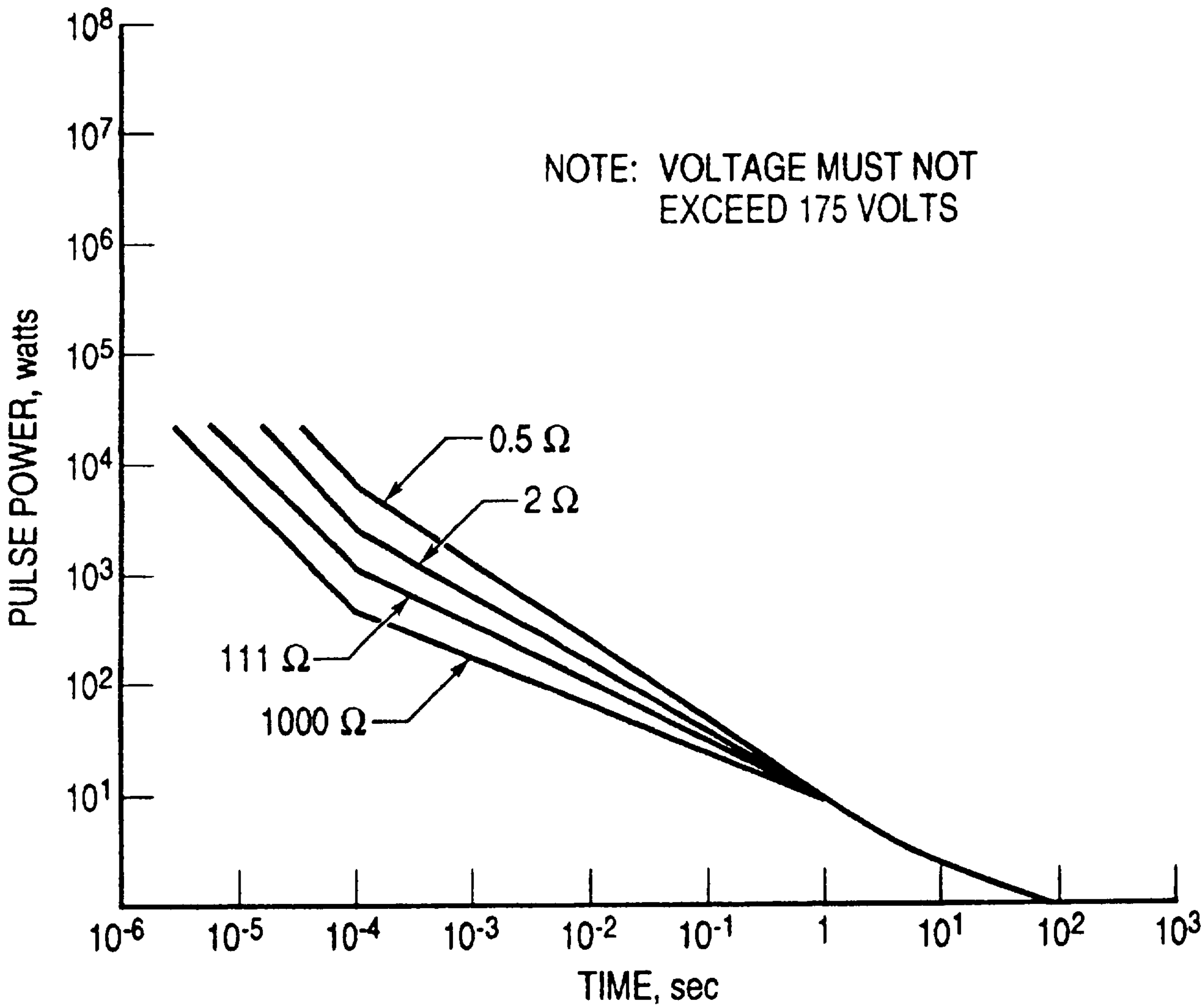


FIGURE 1170-2. Typical Maximum Pulse Power versus Time for RWR 81 (1-watt) Resistors

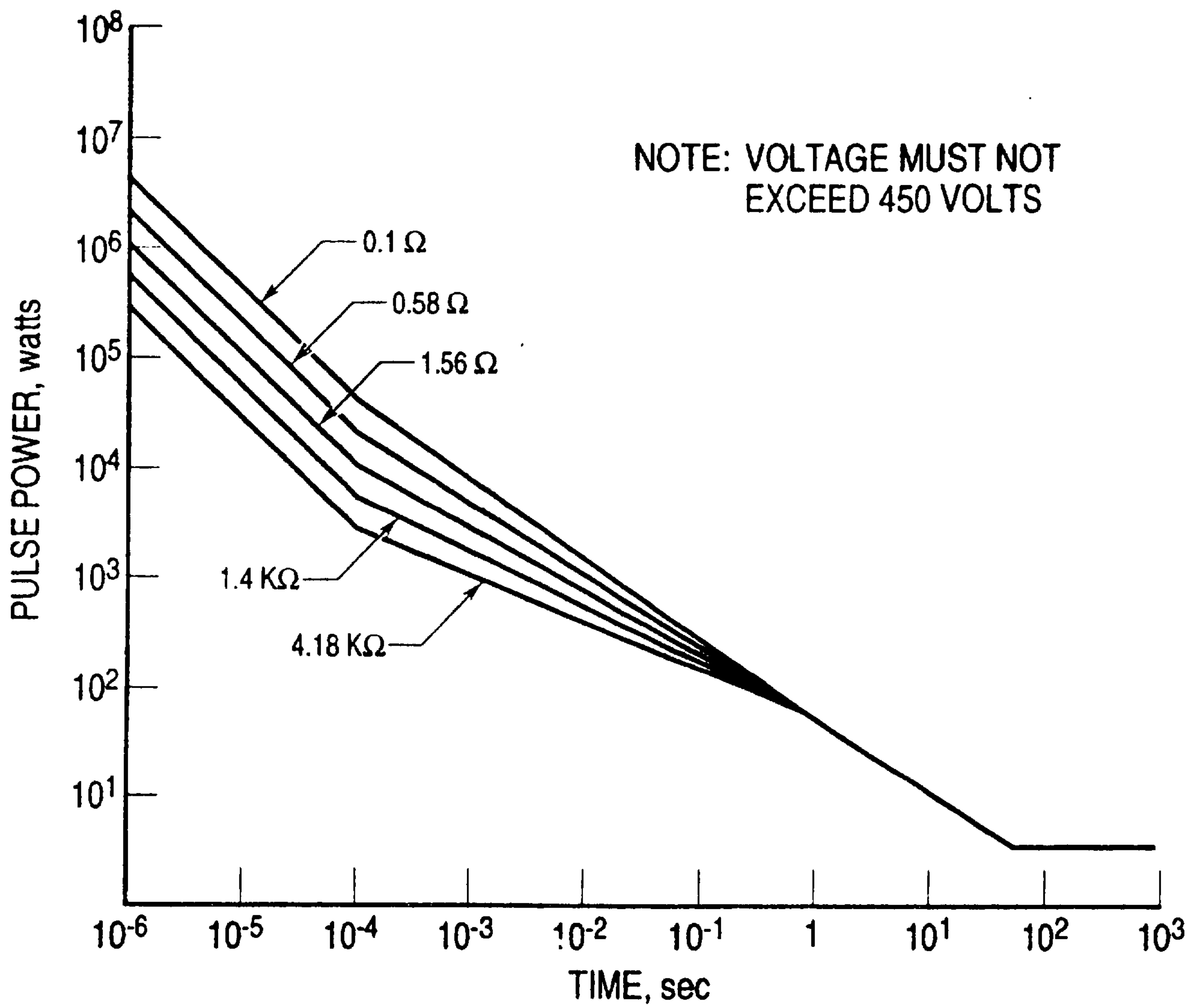


FIGURE 1170-3. Typical Maximum Pulse Power versus Time for RWR 89 (3-watt) Resistors

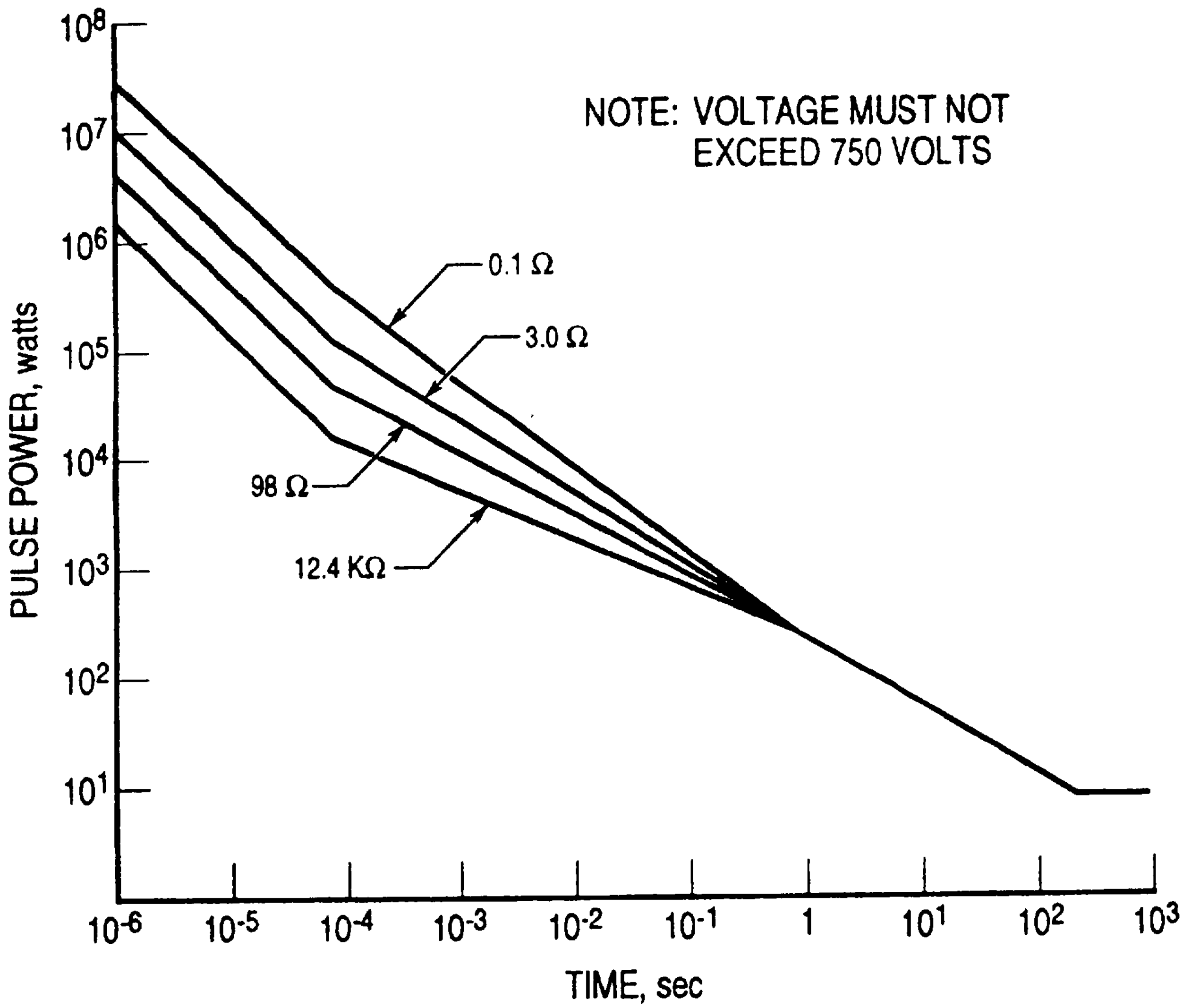


FIGURE 1170-4. Typical Maximum Pulse Power versus Time for RWR 84 (7-watt) Resistors

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 maximum pulse voltage shall not exceed 50% of the reduced dielectric strength of the air under the reduced pressure condition.

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 Diameter. A minimum wire diameter of 25.4 micrometers (0.001 inch) zero negative tolerance shall be used.

3.1.2 Internal Connections. All internal connections shall be welded.

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 5 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 Group A Requirements Group A requirements shall be in accordance with the requirements in MIL-R-39007 and Table 1170-1.

4.3 Group B Tests. Group B 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.

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

TABLE 1170-1. Additions to Group A Requirements for Wire-wound (Power Type) Resistors

MIL-R-39007	Additions the Methods and Criteria of MIL-R-39007
Subgroup 1 (100%) Thermal Shock	1/
Conditioning	
Short Time Overload	
Dielectric Withstanding-Voltage	
DC Resistance	a. DC resistance shall be within initially specified tolerance limits; lots having more than 10% out-of-tolerance rejects shall not be used
Subgroup 2 (100%) Radiographic Inspection	
Subgroup 3 Visual and Mechanical Examination	

1/ PDA for Subgroup 1 tests is 5%, or one resistor, for rejects due to exceeding resistance change limits and DWV failures.

5. REGISTERED PMP

5.1 Reliability Suspect Parts. Designs using soldered or crimped internal connections are reliability suspect. Designs using a wire diameter of less than 25.4 micrometers (0.001 inch) zero negative tolerance is reliability suspect.

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 Diameter. A minimum wire diameter of 25.4 micrometers (0.001 inch) zero negative tolerance shall be used.

3.2.2 Internal Connections. All internal connections shall be welded.

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 Group A Requirements Group A requirements shall be in accordance with the requirements in MIL-R-39009 and Table 1180-1.

4.3 Group B Tests. Group B 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.

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5. REGISTERED PMP

5.1 Reliability Suspect Parts. Designs using soldered or crimped internal connections are reliability suspect. Designs using a wire diameter of less than 25.4 micrometers (0.001 inch) zero negative tolerance is reliability suspect.

TABLE 1180-1. Additions to Group A Requirements for Wire-wound, Power-type, Chassis-mounted Resistors.

MIL-R-39009	Additions to the Methods and Criteria of MIL-R-39009
<u>Subgroup 1 (100%)</u>	<u>1</u>/
Thermal Shock	a. Test conditions and measurements after test shall be per MIL-R-39007
Conditioning	
Short Time Overload	
Dielectric Withstanding-Voltage	
DC Resistance	a. DC resistance shall be within initially specified tolerance limits; lots having more than 10% out-of-tolerance rejects shall not be used
<u>Subgroup 2 (100%)</u> Radiographic Inspection	
<u>Subgroup 3</u> Visual and Mechanical Examination	

<u>1</u>/ PDA for Subgroup 1 tests is 5%, or one resistor, for rejects due to exceeding resistance change limits and DWV failures.

SECTION 1190

FIXED FILM RESISTANCE NETWORK (RZR)
(MIL-R-874)

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 to temperatures below +70°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 to temperatures below +70°C to 0.75 of the power rating values given in Table 1190-1 for worst case applications. Both the steady-state and the worst case power applied to these resistors shall be linearly reduced to zero power from +70°C to +125°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)
RZR 010	A	0.2	1.4	100
RZR 010	B	0.1	1.3	100
RZR 020	A	0.2	1.6	100
RZR 020	B	0.1	1.5	100
RZR 030	A	0.05	0.35	50
RZR 030**	B	0.025	0.325	50
RZR 030**	A	0.2	1.0	50
RZR 030	B	0.1	1.0	50
RZR 040	C	0.2	1.8	50
RZR 040	G	0.2	1.0	50
RZR 050	C	0.2	1.8	50
RZR 050	G	0.2	1.0	50
RZR 060	C	0.2	1.8	50
RZR 060	G	0.2	1.0	50
RZR 070	C	0.12	0.6	50
RZR 070	G	0.12	0.36	50
RZR 080	C	0.12	0.84	50
RZR 080	G	0.12	0.48	50
RZR 090	C	0.12	1.08	50
RZR 090	G	0.12	0.6	50

* Schematics are shown in detail specification of MIL-R-874.

** RZR 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-874 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

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 at least 100X magnification and a coaxial illuminated 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 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 residue from the spiral cutting operation at 100X 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. 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 mottled 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. A partial bridging defect is that which 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 partially 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 0.001 inch 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.

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 Group A Requirements Group A requirements shall be in accordance with the requirements in MIL-R-874 and Table 1190-2 and the following:

4.2.1 Fail Criteria. Resistor networks that are out of resistance tolerance, or which exhibit 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 in accordance with MIL-R-83401. The supply voltage shall be regulated and controlled to maintain a tolerance ± 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, with a tolerance of +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 Group B Tests. Group B tests shall be in accordance with the Group B tests in MIL-R-874.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-R-874.

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5. REGISTERED PMP

5.1 Reliability Suspect Parts.

5.1.1 Thick Film Designs. Resistor networks manufactured by thick film technology are reliability suspect due to the internal solder connections required.

5.1.2 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.

5.1.3 Excessively Thin Tantalum Nitride. Designs requiring tantalum nitride thicknesses below 35 nanometers 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.

5.1.4 Nonhermetically Sealed Packages. Parts in nonhermetically sealed packages are reliability suspect.

TABLE 1190-2 Additions to Group A Requirements for Fixed-film Resistor Networks

MIL-R-83401	Additions to the Methods and Criteria of MIL-R-874
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. The lot may be tested a maximum of 5 times. If less than 1% of the lot fails during any of the 5 runs, the lot may be accepted. All defective devices shall be removed after each run. Lots which do not meet the 1% PDA on the fifth run, or cumulatively exceed 25% defectives, shall be rejected. c. Applicable to cavity devices only.
Visual and Mechanical Examination (External)	a. Marking and identification b. Defects and damage; i.e., body finish, lead finish, misalignment, cracks

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.

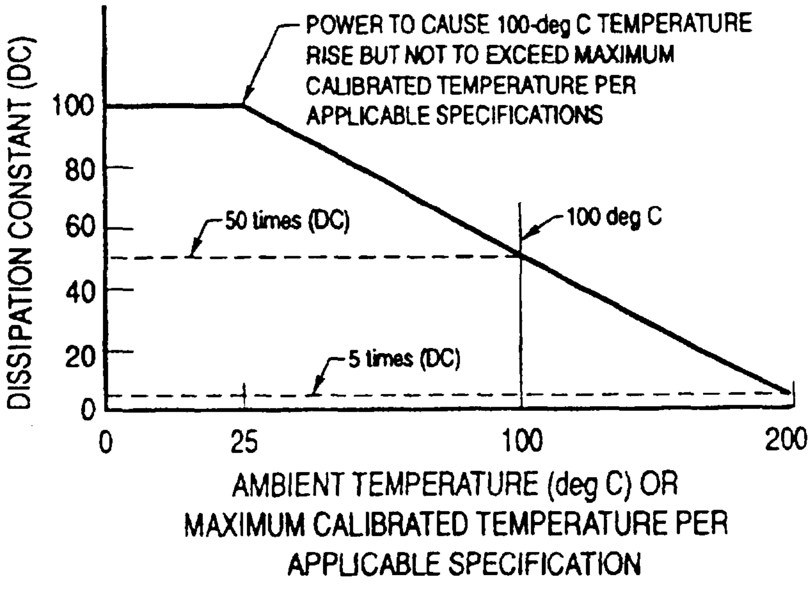


FIGURE 1195-1 Derating Curve for Negative Coefficient Thermistors

2.2 End-of-life (EOL) Design Limits, (for Five Years), Resistance

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:

$$\text{Total design tolerance} = \left[(\text{Aging} + \text{initial tolerance})^2 + (\text{environments})^2 \right]^{1/2}$$

2.3 Electrical Considerations. 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 Mounting. 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.

b. Hermetically sealed thermistor where appropriate. (The only hermetically sealed thermistor available in MIL-T-23648 is the -/19, a PTC device type.)

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 Group A Requirements Group A requirements shall be in accordance with the requirements in MIL-T-23648 and Table 1195-1.

4.3 Group B Tests. Group B tests shall be in accordance with the requirement in MIL-T-23648 and Table 1195-2.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-T-23648.

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

TABLE 1195-1 Additions to Group A Requirements for Thermistors

MIL-T-23648	Additions 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. 100 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 500 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. Additions to Group B Tests for Thermistors

MIL-T-23648 Screens	Additions 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

5. REGISTERED PMP

5.1 Reliability Suspect Parts. 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.

6. PROHIBITED PARTS LIST

a. Thermistors with tin coated case or leads (see section 4, paragraph 4.3.3)

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.

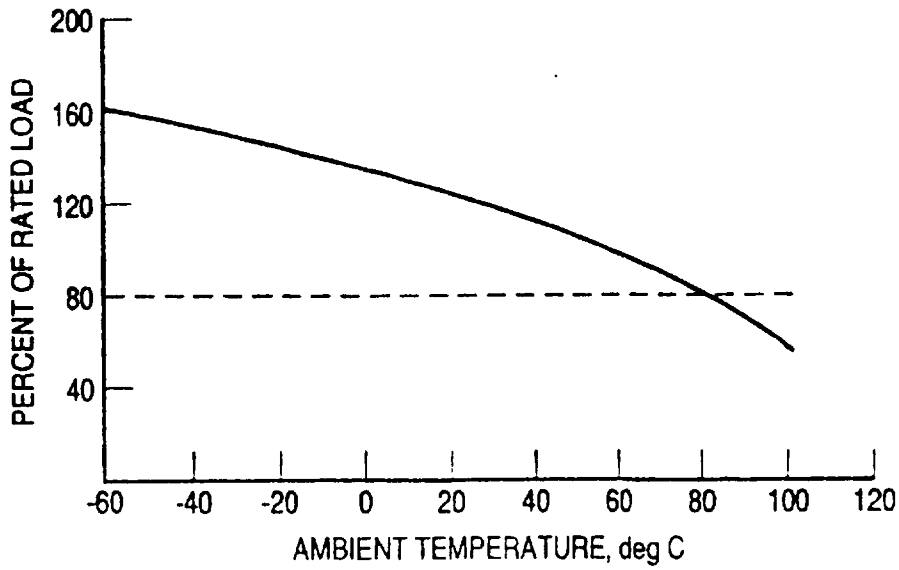


FIGURE 1200-1. Switch Current Rating versus Temperature for a Typical Switch

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 their load handling capabilities 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

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 particles greater than 25.4 micrometers (0.001 inch) in maximum dimension

b. Solder and weld joints

c. Proper alignment

d. Feedthroughs with contamination, debris damage or misalignment

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, straight, and free of tin

c. Each switch shall have its contact closure force setting checked by the manufacturer with full documentation provided.

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.

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5 REGISTERED PMP

5.1 Reliability Suspect Parts.

a. Nonhermetic units

b. Noncorrosion resistant materials or tin in units

c. Slide devices

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 swaging or staking of assembly components (not 360 degrees)

c. Scratches or nicks in contact 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.

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5 REGISTERED PMP

5.1 Reliability Suspect Parts.

a. Switches using thermoplastic dielectric or packaging

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 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. The lot may be tested a maximum of 5 times. If less than 1% of the lot fails during any of the 5 runs, the lot may be accepted. All defective devices shall be removed after each run. Lots which do not meet the 1% PDA on the fifth run, or exceed 25% defectives cumulative, shall be rejected.
Insulation Resistance	
Mechanical Run-in	a. 500 cycles at 10 cycles per minute at +25°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

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 are 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.

2.3 Electrical Requirements. To alleviate the possibility of dither, require a 2.2° C minimum for the thermal deadband (temperature separation between the thermal switch "on" position and the switch "off" position) and require a temperature rate-of-change greater than 0.11 deg C per minute.

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 +2.2 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 +2.2 deg C minimum

c. Temperature rate-of-change accommodated, 0.11 deg C per minute minimum.

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 maintained in a Class 100 environment per FED-STD-209.

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 25.4 micrometers (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. First obtain reagent grade solvent both compatible with the switch components and meeting other necessary requirements from pre-filtered supply. Assemble pre-cleaned 1000 milliliter flask, vacuum pump, filter holder, pre-cleaned 0.80 micrometer filter, and pre-cleaned funnel. Fill funnel with pre-filtered reagent grade solvent and turn vacuum pump on. Repeat until flask is filled. Fill a pressurized container with cleaned reagent grade solvent. Clean filter by blowing both surfaces with ionized air. Using the pressurized container, wash both sides of the filter with clean filtered reagent grade solvent. Observe filter under 30X magnification; if any particles 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 reagent grade solvent, pour the reagent grade solvent into the funnel, covering the parts to be cleaned. Cover funnel. Turn on vacuum pump. When all the reagent grade solvent 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 visible 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 sealing and store in a Class 100 environment.

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

b. 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.

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5 REGISTERED PMP

5.1 Reliability Suspect Designs. See Paragraph 2.2 in this section.

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) - Choice of Vibration Method shall be based on application	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) - Choice of Vibration Method shall be based on application	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. The lot may be tested a maximum of 5 times. If less than 1% of the lot fails during any of the 5 runs, the lot may be accepted. All defective devices shall be removed after each run. Lots which do not meet the 1% PDA on the fifth run or exceed 25% defectives cumulative, shall be rejected. c. This test is optional for small switches with organic case construction.
Creepage	a. Temperature rate of change shall be 0.11 deg C per minute minimum 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. SCOPE

This section sets forth detailed requirements for hermetically sealed pressure 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-9395 and the requirements of this standard. (See the requirements of Section 1200 and Section 300, as applicable.)

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-9395 and Paragraph 4.1 in Section 1200.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the requirements listed in Table 1230-1.

4.3 Lot Conformance Tests. Lot conformance tests shall be in accordance with the requirements in Table 1230-2.

4.4 Qualification Tests. Qualification testing shall be in accordance with the requirements of MIL-S-9395.

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

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.
Vibration (Sine)	a. MIL-STD-202, Method 204
High Temperature	
Low Temperature	
Particle Impact Noise (PIND)	a. MIL-STD-202, Method 217 Detection b. The lot may be tested a maximum of 5 times. If less than 1% of the lot fails during any of the 5 runs, the lot may be accepted. All defective devices shall be removed after each run. Lots which do not meet the 1% PDA on the fifth run, or exceed 25% defectives cumulative, shall be rejected.
Mechanical Run-in	a. 500 cycles at 10 cycles per minute at +25°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

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
Contact Resistance	
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
<u>Group I</u>	a. 3 Samples. NOTE: Because this sampling plan is different than MIL-S-9395, the group samples must be unique and can not be used in more than 1 group test.
Solderability	a. If applicable
Shock	
Moisture Resistance	
Overload Cycling	
Seal	
<u>Group II</u>	a. 3 Samples
Mechanical Endurance	
Electrical Endurance	
Contact Resistance	
Seal	
Dielectric Withstanding-Voltage	
<u>Group III</u>	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. Power
d. Switching
e. Unijunction

2. APPLICATION

2.1 Derating. The derating factors for transistors shall be as follows:

a. In accordance with Table 1400-1.

b. For all transistors, transient peaks shall not exceed the supply voltage by more than the derating factor.

c. For all transistors, voltage deratings apply to VCBO, VEBO, and VCEX ratings. Precautions against secondary breakdown shall be taken.

2.2 End-of-Life Design Limits.

Leakage Current: 80 percent of initial maximum limit

H_{FE}: ±10 percent of initial minimum value

2.3 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.

Table 1400-1. Derating Factors for Transistors

Factor	Bipolar Silicon Transistors		Field-Effect Transistors	
	Nominal	Worst Case	Nominal	Worst Case
Maximum Junction Temperature(°C)	105	125	105	125
Power Dissipation (% of Rated Value)	60	70	60	70
Breakdown Voltage (% of Rated Value)	Low-Power Device 75	Low-Power Device 75	75	75
High-Power Device Safe Operating Area 1/ (% of Rated Value)	VCE 75 IC 75	VCE 75 IC 75	---	---
On-State Current (% of Rated Value)	---	---	---	---
Off-State Voltage (% of Rated Value)	---	---	---	---

1/ The safe operating area is a curve parallel to the one specified in the JAN specification or vendor-prepared specification at the stated percent of rated value.

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. 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. For transistors in hot-welded cans, the header design shall include an effective weld-splash barrier ring.

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 Special Concerns. The special screens, tests, or precautions stated below shall be used when the identified construction or materials are used in semiconductors.

4.1.1.1 Organic Materials or Desiccants. Devices containing desiccants, internal organic materials, or organic materials shall meet MIL-S-19500, JAN S requirements.

4.1.1.2 Mesa Construction Mesa construction is susceptible to contamination and the following precautions should be considered:

a. Review process controls for assurances of clean surfaces.
b. Require at least 6000 angstroms of glass or oxide passivation over junctions.

4.2 Screening (100 percent). Screening (100 percent) shall be in accordance with the JAN S Screening requirements of MIL-S-19500. The recommended electrical tests are listed in Table 1400-2 or compliance with the applicable JAN S military specification. Unless otherwise specified the reject criteria shall be per the detail spec limit.

4.3 Quality Conformance Inspection (QCI). QCI shall be in accordance with the quality conformance tests of MIL-S-19500 for JAN S.

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

4.5 Incoming Inspection DPA. Incoming inspection DPA shall be in accordance with MIL-STD-1580.

5 REGISTERED PMP

5.1 Reliability Suspect Parts.

a. Hot welded cases
b. Nonpassivated dice on devices < 4 Watts
c. Bimetallic bonds at die
d. Plastic encapsulation
e. Silver/glass die attach
f. Internal organic/polymeric materials (lacquers, varnishes, coatings, adhesives, or grease)
g. Mesa design

h. Alloy junction
i. Gallium Arsenide
j. Flip chips
k. Beam leaded units
l. Ultrasonically cleaned parts
m. Unprotected MOSFETs (ESD)

6 PROHIBITED PARTS LIST

The following parts, part styles, and part types shall not be used unless in accordance with contractor's approved PMP Control Plan.

a. All plastic encapsulated types
b. Tin coated packages or leads (see section 4, paragraph 4.3.3)

TABLE 1400-2. Electrical Test and Reject Criteria (Page 1 of 3)

Transistor Types					Tests and Criteria
FET (1)	GENPUR (2)	UNI (3)	POWER (4)	SWITCH (5)	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 greater than ± 10 percent of spec. limit, whichever is greater
X					$V_{GS\ (th)}$ or V_P, whichever is appropriate, $V_{DS\ (on)}$, Delta $V_{GS\ (th)}$, or V_P, whichever is appropriate, or Delta $V_{DS\ (on)}$, or R_{DS}, whichever is appropriate, 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	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	I_{EBO}
	X			X	I_{CES} if specified
	X		X	X	V_{CE} (sat), Delta V_{CE} (sat) greater than ± 50 mVdc
	X		X	X	h_{FE} & Delta h_{FE} shall be in accordance with the applicable military specification

TABLE 1400-2. Electrical Test and Reject Criteria (Continued, Page 2 of 3)

Transistor Types					Tests and Criteria
FET (1)	GENPUR (2)	UNI (3)	POWER (4)	SWITCH (5)	NOTE: Unless otherwise specified reject criteria shall be per detail spec limit
		X			I_{EB20}, Delta I_{EB20} greater than ± 100 % of initial value or greater than ± 10 % of spec. limit, whichever is greater.
		X	X		Delta I_{EBO} greater than ± 100 percent of initial value or greater than ± 10 percent of spec. limit, whichever is greater.
		X			r_{BBO}, Delta r_{BBO} greater than ± 20 percent
	X		X	X	$V_{(BR)CBO}$, $V_{(BR)CEO}$, $V_{(BR)EBO}$
	X		X	X	$V_{BE(sat)}$
		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. Unijunction
   - Emitter to base two reverse current, I_{EB2O}
   - Interbase resistance, r_{BBO}
   - Intrinsic standoff ratio, n

4. Power
   Same as General Purposes (see Note 2)

5. Switching
   Same as General Purposes (see Note 2)

SECTION 1410

RF AND MICROWAVE TRANSISTORS

1. SCOPE

This section sets forth detailed requirements for RF and Microwave Transistors. The transistor types covered in this section are:

a. Microwave and RF Field Effect Transistors (FET)

b. Microwave and RF Bipolar Transistors

2. APPLICATION

2.1 Derating. The derating factors for transistors shall be as follows:

a. For bipolar silicon transistors derate breakdown voltage to 0.75 of the rated value.

b. For field effect transistors, derate breakdown voltage to 0.75 of the rated value.

c. Bipolar transistor derating factors shall provide adequate current and voltage derating to preclude second breakdown.

d. For all transistors, the maximum junction temperature shall be +105 degrees C nominal and 125 degrees C worst case.

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. Passivated semiconductors shall be used when available.

4. QUALITY ASSURANCE

Quality assurance provisions shall be in accordance with the general requirements of MIL-S-19500 and the following:

4.1 In-process Controls. In-process controls shall be in accordance with the requirements of MIL-S-19500, JAN S.

4.2 Epoxy Materials. Devices containing internal epoxy materials, or epoxy materials used for sealing shall have a residual gas analysis. A maximum of 5000 parts per million of water at +100 degrees C shall be allowed.

4.3 Screening (100 percent). Screening (100 percent) shall be in accordance with the JAN S Screening requirements of MIL-S-19500. The recommended electrical tests shall include the parameters listed in Table 1410-1 and all other Group A electrical parameters specified in the detail drawing. Unless otherwise specified the reject criteria shall be per the detail spec limit.

4.4 Quality Conformance Inspection (QCI). QCI shall be in accordance with the quality conformance 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.

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

5. REGISTERED PMP

5.1 Reliability Suspect Parts.

a. Hot-welded cases

b. Gold-aluminum bonds

c. RF and microwave devices

TABLE 1410-1. Electrical Test Criteria for Radio Frequency and Microwave Transistors

Bipolar	FET	Tests and Criteria NOTE: Unless otherwise specified reject criteria shall be per detail spec limit
	X	I_{GSS}, Delta I_{GSS} greater than ± 100% of initial value or greater than ± 10% of specification limit, whichever is greater
	X	$V_{GS(th)}$, $V_{DS(on)}$, Delta $V_{GS(th)}$ or Delta $V_{DS(on)}$ greater than ± 15% of initial value
	X	I_{DSS}, Delta I_{DSS} greater than ± 100% of initial value or greater than ± 10% of specification limit, whichever is greater
	X	Δ Gm Transductance ± 10 percent
X	X	Δ Pout ± 0.5 dB output power
	X	Δ Vp pinchoff voltage ± 15 percent
	X	Δ I_{DS}, specific drain current ± 15 percent
X	X	NF ± 10 percent where appropriate
X		I_{EBO}
X		I_{CES}
X		V_{CE} (sat), ΔV_{CE} (sat) greater than ± 50 mVdc
X		h_{FE}, Δh_{FE} greater than ±15% of initial value
X		$V_{(BR)CBO}$, $V_{(BR)CEO}$, $V_{(BR)EBO}$
X		V_{BE}(sat)
X		I_{CBO}, Δ I_{CBO} greater than ± 100% of initial value or greater than ± 10% of specification limit, whichever is greater
X		C_{obo}, Δ C_{obo} greater than ± 25%
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

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 the requirements below and MIL-W-83575.

2.2 Internal. Wiring internal to electronic enclosures shall be in accordance with MIL-STD-454, Requirement 61.

2.3 Coaxial Cable. Coaxial cable, both flexible and semi-rigid shall be in accordance with MIL-C-17.

2.4 Derating. Derating factors and wire current shall be based on wire size, on the wire insulation, and the number of wires used in a cable or harness. The current ratings and deratings used shall be in accordance with either the individual wire specification or MIL-W-5088.

2.5 Electrical and Handling Considerations - Insulations. The characteristics of the insulation used on wire shall be used as an aid in the selection of the proper wire type for each application.

2.5.1 Ethylene Tetrafluoroethylene (Tefzel - ETFE). Tefzel, a Du Pont trade name, is a high temperature resin consisting of 75 percent TFE by weight and its balance or properties is well suited for space vehicle applications. It can withstand an unusual amount of physical abuse during and after installation, has good electrical characteristics, good thermal and low temperature properties and chemical inertness. Its high flex life and exceptional impact strength are better than Kynar's. It has better service temperature, 150°C as compared with Kynar's 135°C and has no known solvent below 200°C. Its embrittlement temperature is below -100°C. This insulation meets the outgassing requirements of NASA SP-A-0022. This wire insulation material is in MIL-W-22759/16,/17,/18, and/19. The equivalent cable specifications are MIL-C-27500 types TE, TF, TG, and TH.

2.5.2 Crosslinked ETFE. This material is a modified version of ETFE. The properties are higher service temperature, 200°C and better resistant to radiation effects. The flexibility, tensile strength, chemical inertness remain unchanged. This insulation meets the outgassing requirements of NASA SP-A-0022. This wire insulation material is in MIL-W-22759/32,/33,/34,/35, /41,/42,/43,/44,/45, and /46. The equivalent cable specifications are MIL-C-27500 types SB, SC, SD, SE, SM, SN, SP, SR, SS, and ST.

2.5.3 Polyvinylidene fluoride (PVF_2) (Kynar). Kynar, a Pennwalt Corporation trade name, is a crystalline, high molecular weight polymer of vinylidene fluoride with excellent abrasion and cut through resistance. Its electrical, thermal, chemical and radiation resistance properties are inferior to Tefzel. Its nominal service temperature is -65°C to +135°C. Kynar is typically used as a jacket material over a soft insulation material such as polyalkene, rather than as a primary insulation. The high dielectric constant makes it undesirable as primary insulation. This insulation material is specified in MIL-C-27500 jacket symbol 08, 10, 58, and 60. This material is a reliability suspect PMP item.

2.5.4 Polyalkene. This is a dual extrusion of polyolefin and polyvinylidene fluoride (Kynar), with those materials crosslinked for increased heat resistance and greater mechanical strength. Combining these two insulating materials mutually offsets their individual disadvantages. This insulation material exhibits good properties for thinner-walled, lighter weight wire construction. This insulation meets the outgassing requirements of NASA SP-A-0022. This wire insulation material is in MIL-W-81044/6,/7,/9,/10,/12, and /13. The equivalent cable specifications are MIL-C-27500 types ME, MF, MH, MJ, ML, and MM. This material is a reliability suspect PMP item.

2.5.5 Aromatic polyimide (Kapton). Kapton, a Du Pont trade name, has excellent thermal and electric properties, and solvent resistance except when exposed to concentrated acids and alkalies. Its nominal service temperature is 200°C with some extended operations at 250°C. Kapton's main benefit is that it is the lightest weight wire insulation material. This insulation meets the outgassing requirements of NASA SP-A-0022 and the flammability and toxicity requirements of MSFC-HDBK-527. Some of its drawbacks are its inflexibility (stiffness), water absorption, and lack of abrasion and cut through resistance. This insulation material is prone to both wet-arc and dry-arc tracking, especially from abrasions and cuts in the insulation material exposing the conductors. This failure results in an explosive (rapid) carbonization of the insulation materials. Tests conducted under the auspices of Naval Air Development Center have shown this insulation material to cause fires, explosions, and other damage to the host vehicle when the insulation fails. This wire insulation material is in MIL-W-81381, all slash sheets. The equivalent cable specifications are MIL-C-27500 types MR, MS, MT, MV, MW, MY, NA, NB, NE, NF, NG, NH, MK, and NL. This material is a reliability suspect PMP item.

2.6 Electrical and Handling Considerations - Conductors. The characteristics of the conductors used on wire shall be used as an aid in the selection of the proper wire type for each application. Conductors strands shall be made of soft annealed copper, high strength copper alloy, or beryllium-copper alloy. The conductor strands shall be coated with either silver, nickel, or tin alloy.

2.6.1 Silver Coated Wire. Temperature range is above 150°C to about 200°C, and is good for high frequency applications due to its higher conductivity. Silver coating shall be used on beryllium copper wire. Silver coated wire is susceptible to "red plague", corrosion of the silver material, when exposed to high humidity. A minimum of 40 microinches of silver coating is required.

2.6.2 Nickel Coated Wire. 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°C. It is acceptable for crimp applications, provided the crimp values in MIL-C-39029 are used.

2.6.3 Tin Coated Wire. Tin or tin alloy is the least expensive, but is susceptible to oxide film formation and corrosion when exposed to traces of chlorine, oxides of nitrogen, or humidity. Tin whisker formation may be possible but not probable due to alloying of the thin tin coating with the copper of the wire.

2.7 Stripping. Thermal stripping of wire insulation is the preferred method for most wire insulation types. 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. If non-military specification wire is used (wire procured to a contractor prepared specification) the Quality Conformance Inspection tests in accordance with MIL-W-22759 Table VI shall be required.

3.2 General Purpose Cable. If non-military specification cable is used (cable procured to a contractor prepared specification) the Quality Conformance Inspection tests in accordance with MIL-C-27500 Table VII shall be required.

3.3 Radiation Hardness Assurance. If the wire or cable shall be used in an application where exposure to a total ionizing irradiation of greater than 10^5 rads (Si), the contractor shall develop a test method to insure that the selected insulation material shall withstand the radiation environment.

4. QUALITY ASSURANCE

Quality assurance requirements shall be in accordance with the general requirements of Section 4 and the requirements of the applicable military specification.

5. REGISTERED PMP

5.1 Reliability Suspect Parts.

a. MIL-W-22759 with only one layer of PTFE
b. Teflon insulated wire
c. MIL-W-76 wire
d. Aluminum wire
e. MIL-W-81381 wire
f. MIL-W-81044 wire

6. PROHIBITIVE PARTS LIST

a. MIL-W-16878 wire types
b. All Polyvinyl chloride (PVC) insulated wire and cable

SECTION 1600

CLASS 3 SCREW THREADED PRODUCTS

1. SCOPE

This section sets forth the procurement and testing requirements for all aerospace Class 3 screw threaded products.

2. APPLICATION

Class 3 screw threaded products shall be procured and tested to the requirements of MIL-STD-1515, MIL-STD-1312, MIL-S-007742, and MIL-S-008879, as well as the following requirements.

3. SPECIAL CONSIDERATIONS

3.1 Mission and Safety Critical Applications. For these applications the manufacturer or authorized distributor shall be required to conduct 100% screening of all nondestructive quality conformance inspection (QCI) requirements specified. All destructive QCI tests and screens shall be performed on a manufacturing lot sample basis as specified. The contractor is responsible for ensuring that the seller has performed all testing required and that his product meets these requirements. For "other" threaded products, as defined in MIL-S-007742 and MIL-S-008879, the seller shall perform inspections per the item specifications as approved per the buyer's PMP control plan.

3.2 Application Classification. All applications of class 3 screw threaded product shall be classified according to the potential impact of the fastener failure on the system. Classification shall result from the application of a Failure Modes, Effects, and Criticality Analysis (FMECA). Two application categories shall be identified and are defined as follows:

3.2.1 Mission or Safety Critical. A fastener failure may cause severe injury, death, mission degradation, or system loss.

3.2.2 Other. All other failure consequences.

3.3 Critical Items List. All class 3 screw threaded product used in Mission or Safety Critical Applications shall be included on the critical items list.

3.4 Engineering Drawings. Engineering drawings shall identify "Mission or Safety Critical" Class 3 fastener applications in accordance with DOD-STD-100, MIL-S-007742, and MIL-S-008879. Physical Configuration Audit (PCA) procedures or other government reviews of engineering drawings shall include verification of this requirement.

3.5 Certifications and Test Data. Procurement specifications shall require that copies of all certifications, chemical analyses, and test data be provided with the fasteners.

3.6 Manufacturing Lot Procurement. Procurement shall only be from the original manufacturer or authorized distributor and shall be on a manufacturing lot basis, forbidding the commingling of more than one manufacturing lot.

4. QUALITY ASSURANCE

Quality assurance requirements shall be in accordance with the general requirements of Section 4 and the requirements of the applicable military specification.

5. REGISTERED PMP

None

6. PROHIBITED PARTS LIST

a. Tin coated fasteners (see section 4, paragraph 4.3.3)
b. Cadmium or zinc plated fasteners

SECTION 2000

MATERIALS REQUIREMENTS

1. SCOPE

This section sets forth the common requirements for non-electronic materials. Materials fall into two main categories: Metals and Non-metals.

2. APPLICATION

The selection of all materials for space and launch vehicles shall be made such that the system can operate in the specified environments without maintenance over a specified lifetime with an acceptable level of deterioration and degradation. Therefore, the selection of suitable materials and appropriate processing methods and protective treatments shall be made such that design allowables are adequate for the systems anticipated worst case environment.

3. SPECIAL CONSIDERATIONS

All materials used shall meet the requirements of Section 4.3.2 of this standard.

4. PROHIBITED MATERIALS LIST

a. Items with exposed surfaces of cadmium or zinc shall not be used on space flight items
b. Mechanical and electronic parts within electronic boxes with tin coated internal or external surfaces not including drawn wire products (see section 4, paragraph 4.3.3)
c. Alloys or compounds containing mercury
d. Parylene (paraxylylene) coatings containing chlorine
e. Corrosive (acetic acid evolving) silicone sealants, adhesives, or coatings

SECTION 2100

METALS

1. SCOPE

This section sets forth the common requirements for the use of metals.

2. APPLICATION

MIL-HDBK-5 shall be used as the basic document for defining strength allowables and other mechanical and physical properties for metallic materials. When data is not contained in MIL-HDBK-5, contractor allowables developed in accordance with MIL-HDBK-5 may be used.

3. SPECIAL CONSIDERATIONS

3.1 Forgings

3.1.1 Forging Design. Forgings shall be produced in accordance with MIL-F-7190 for steel, MIL-A-22771 or QQ-A-367 for aluminum and MIL-F-83142 for titanium. Recognized industrial association or contractor specifications shall be used for alloys not covered by the above specifications. Because mechanical properties are maximum in the direction of material flow during forging, forging techniques shall be used that produce an internal grain flow pattern such that the direction of flow in all stressed areas is essentially parallel to the principle tensile stresses. The grain flow pattern shall be free from reentrant and sharply folded flow lines. After the forging technique, including degree of working is established, the first production forging shall be sectioned to show the grain flow patterns and to determine mechanical properties and fracture toughness values at control areas. The procedure shall be repeated after any significant change in the forging technique. The information gained from this effort shall be utilized to redesign the forging as necessary. These data, material samples, and results of the tests on redesign, shall be retained by the contractor for the life of the program.

3.1.2 Forging Surfaces. Surfaces of structural forgings in regions identified by analyses as fatigue critical or in regions of major attachment shall be shot peened or placed in compression by other suitable means. Those areas of forgings requiring lapped, honed, or polished surface finishes for functional purposes shall be shot peened prior to surface finishing operations.

3.2 Residual Stresses. Residual stresses are normally induced into manufactured parts as a result of forging, machining, heat treating, welding or special metal removal processes. Residual stresses are generally controlled or minimized during the fabrication sequence by special heat treatment such as annealing and stress relieving. Even with in-process controls to minimize the potential buildup of residual stresses, the final production parts will usually contain some residual stresses. These stresses may be harmful in structural applications when the part is subjected to fatigue and loading, additive operation stresses, or corrosive environments. Therefore, every effort shall be made to eliminate or minimize residual stresses from finished structural parts by appropriate heat treatments and process optimization.

3.3 Stress Corrosion Factors. Some high strength 2000 and 7000 series aluminum alloys and high strength alloy steels are subject to stress corrosion cracking. As a general criteria, MFSC-SPEC-522 and the references contained therein shall be used to provide design and material selection guidelines for controlling stress corrosion cracking in all alloys. Alloys and heat treatments which result in a high resistance to stress corrosion cracking shall be utilized in all structural, load-carrying applications. Particular emphasis shall be in the area of design, fabrication and installation of parts to prevent the sustained surface tensile stresses from exceeding the stress corrosion threshold limitations for the particular material and grain-flow orientation. Stress corrosion threshold values are generally determined by actual testing. Stress corrosion can be avoided by incorporating the guidelines for aluminum and steel alloys mentioned in the following sections.

3.4 Castings. Castings shall be classified and inspected in accordance with MIL-STD-2175. Structural castings shall be procured to guaranteed property, premium quality specifications including MIL-A-21180, AMS 5343, or other document in accordance with the contractor's approved PMP control plan.

3.5 Protective Finishes. The requirements for and application of protective finishes, including cleaning prior to application, shall be in accordance with MSFC-SPEC-250, with the exception of zinc, cadmium, and tin finishes which are prohibited.

3.6 Dissimilar Metals. Use of dissimilar metals, as defined by MIL-STD-889, in contact shall be limited to applications where similar metals cannot be used due to design requirements. When use is unavoidable, metals shall be protected against galvanic corrosion by a method listed in MIL-STD-889. Composite materials containing graphite fibers shall be treated as graphite in MIL-STD-889.

SECTION 2110

ALUMINUM and ALUMINUM ALLOYS

1. SCOPE

This section sets forth the common requirements for the use of aluminum and its alloys.

2. APPLICATION

In structural applications requiring the selection of aluminum alloys, maximum use shall be made of those alloys, heat treatments and coatings which minimize susceptibility to general corrosion, pitting, intergranular and stress corrosion and maximize fracture toughness. Aluminum alloys 2020-T6, 7079-T6 and 7178-T6 shall not be used for structural applications. The use of 7075-T6, 2024-T3, -T4 and 2014-T6 sheet (<0.25" thick) material shall only be used provided that short transverse loads (design, fitup, thermal and residual) are below acceptable stress corrosion limits and that proven corrosion protection systems are provided. Other forms of 7075 shall be heat-treated to the -T73 temper.

3. SPECIAL CONSIDERATIONS

3.1 Aluminum Heat Treatment. Heat treatment of aluminum alloy parts shall meet the requirements of MIL-H-6088. Heat treatments not included in MIL-H-6088 may be used if sufficient test data is available to prove that the specific heat treatment improves the mechanical and/or physical properties of the specific aluminum alloys without altering susceptibility to degradation. This data shall be retained by the contractor and is subject to review.

3.2 Aluminum Forming and Straightening. Forming and straightening operations shall be limited to processes which do not result in stress corrosion sensitivity of the part or to detrimental residual stresses or losses in mechanical properties or fracture toughness on structurally critical parts. The contractor shall maintain adequate controls and data which support the use of the forming and straightening processes.

3.3 Stress Corrosion Cracking. Aluminum alloys shall not be used where assembly or assembly-induced stresses are greater than 75% of the stress corrosion threshold for that alloy (including consideration of the grain direction and launch and mission environments).

4. PROHIBITED MATERIALS LIST

a. Alloys with a stress corrosion threshold in any grain direction less than 25 ksi
b. Aluminum alloy 5083-H32, where temperature > 150° F
c. Aluminum alloy 5083-H38, where temperature > 150° F
d. Aluminum alloy 5086-H34, where temperature > 150° F
e. Aluminum alloy 5086-H38, where temperature > 150° F
f. Aluminum alloy 5456-H32, where temperature > 150° F
g. Aluminum alloy 5456-H38, where temperature > 150° F

SECTION 2120

BERYLLIUM

1. SCOPE

This section sets forth the common requirements for the use of beryllium and its alloys.

2. APPLICATION

Beryllium and beryllium alloys shall be restricted to applications in which their properties offer definite performance and cost advantages over other materials. Additionally, the life of beryllium parts shall be tested under simulated service conditions, including any expected corrosive environments, prior to Critical Design Review.

3. SPECIAL CONSIDERATIONS

3.1 Toxicity. The toxicity of beryllium dust and fumes is a critical problem and minimization of exposure shall be a goal during fabrication, assembly, installation, and usage of beryllium parts.

3.2 Storage. Beryllium products that may generate dust or particles shall be stored in closed containers, which shall only be opened in a controlled environment.

3.3 Design. Design of beryllium parts shall include consideration of it's low impact resistance, and notch sensitivity, particularly at low temperatures, and it's directional material properties and sensitivity to surface finish requirements.

SECTION 2130

MAGNESIUM

1. SCOPE

This section sets forth the requirements for the use of magnesium and its alloys.

2. APPLICATION

Magnesium alloys shall not be used for structural applications, in any area subject to wear, abrasion, erosion or where fluid entrapment is possible. Magnesium alloys shall not be used except in areas where minimal exposure to corrosive environments can be expected and protection systems can be maintained with ease and high reliability.

3. SPECIAL CONSIDERATIONS

3.1 Stress Corrosion Cracking. Magnesium and magnesium alloy products shall be treated after forming to avoid stress corrosion cracking.

3.2 Corrosion. Magnesium and magnesium alloy products shall not be used without a corrosion protection system that can be maintained with ease and a high reliability.

SECTION 2140

MERCURY

1. SCOPE

This section sets forth the requirements for the use of Mercury and Mercuric compounds.

2. APPLICATION

Since mercury and mercuric compounds can cause accelerated stress cracking of aluminum and titanium alloys, their use is prohibited in conjunction with the manufacturing, storage, or use of aluminum or titanium alloys.

3. SPECIAL CONSIDERATIONS

The use of devices containing mercury or mercuric compounds, including temperature sensing devices, shall be prohibited from use during fabrication or utilization of space flight structures and subsystems.

SECTION 2150

STEELS

1. SCOPE

This section sets forth the requirements for the use of steels.

2. APPLICATION

Special consideration shall be given when using high strength steels heat-treated at or above 200 ksi Ultimate Tensile Strength (UTS). These steels are subject to delayed failure mechanisms, such as those caused by contamination elements introduced during fabrication processing. Also, the effect of low temperature on reducing high strength steel toughness and ductility shall be considered. Steels heat-treated to strength levels at or above 200 ksi UTS shall be used in accordance with the contractor's approved PMP Control Plan.

3. SPECIAL CONSIDERATIONS

3.1 Heat Treatment of Steels. Steel parts shall be heat-treated as specified to meet the requirements of MIL-H-6875. All high strength steel parts heat-treated at or above 180 ksi UTS shall include appropriate test coupons or specimens, which will accompany the part through the entire fabrication cycle to assure that desired properties are obtained. Heat treatments not included in MIL-H-6875 may be used if sufficient test data are available that assure the heat treatment improves the mechanical and/or physical properties of the specific steel without altering susceptibility to degradation. This data will be retained by the contractor.

3.2 Drilling and Machining of High Strength Steels. The drilling of holes, including beveling and spot facing, in martensitic steel hardened to 180 ksi UTS or above shall be avoided. When such drilling or machining is unavoidable, carbide tipped tooling and other techniques necessary to avoid formation of untempered martensite shall be used. Microhardness and metallurgical examination of test specimens typical of the part shall be used to determine if martensite areas are formed as a result of drilling or machining operations. The surface roughness of finished holes shall not be greater than 63 RHR, and the ends of the holes shall be deburred by a method which has been demonstrated not to cause untempered martensite. (An etching procedure may be used as an alternate to metallurgical testing to determine the presence of untempered martensite.)

3.3 Grinding of High Strength Steels. Grinding of martensitic steels hardened to 180 ksi UTS and above shall be performed in accordance with MIL-STD-866. Grinding of chromium plated martensitic steels hardened to 180 ksi UTS and above shall also be performed in accordance with MIL-STD-866.

3.4 Corrosion Resistant Steels

3.4.1 Austenitic Stainless Steels. Free machining stainless steels intended for fatigue critical applications shall be avoided. Sulfur or selenium additions improve machinability but lower fatigue life.

3.4.2 Precipitation Hardened Stainless Steels. These steels shall be aged at temperatures not less that 1000° F. Exception is made for castings which may be aged at 935° F ±15° F, fasteners which may be used in the H950 condition and springs which have optimum properties at the CH 900 condition.

3.5 Forming or Straightening of Steel Parts. Precautions shall be taken to minimize warping during heat treatment of steel parts. Steel parts shall be formed or straightened as follows:

a. Parts hardened up to 165 ksi UTS may be straightened at room temperature.

b. Parts hardened from 165 to 200 ksi UTS may be straightened at room temperature provided they are given a stress relieving heat treatment subsequent to straightening.

c. Parts hardened over 200 ksi UTS shall be hot formed or straightened within a temperature range from the tempering temperature to 50° F below the tempering temperature.

3.6 Shot Peening. After final machining, shot peen in accordance with MIL-S-13165, all surfaces of critical or highly stressed parts which have been heat treated to or above 200 ksi UTS except for rolled threads; inaccessible areas of holes; pneumatic or hydraulic seat contact areas; and thin sections or parts which, after shot peening, violate engineering and functional configuration. Areas requiring lapped, honed, or polished surfaces shall be shot peened prior to finishing.

3.7 Stress Corrosion Cracking. The assembly stresses of low alloy steel heat treated above 200 ksi UTS shall not exceed the stress corrosion threshold limitation for the particular material and grain-flow orientation.

3.8 Low Alloy, High Strength Steel Corrosion Prevention. All low alloy, high strength steel parts 180 ksi UTS and above, including fasteners, require corrosion preventative metallic coatings by a process that is nonembrittling to the alloy/heat treatment combination.

SECTION 2160

TITANIUM

1. SCOPE

This section sets forth the requirements for the use of titanium and its alloys.

2. APPLICATION

Titanium sheet and plate stock shall be procured to meet the requirements of MIL-T-9046, as supplemented by contractor specifications, drawing notes or other approved documents which reflect the quality properties and processing to provide material suitable for its intended use. All titanium extruded bars, rods or special shaped sections shall be procured to meet the requirements of MIL-T-81556 and supplemented by such contractor documents as necessary to assure that the metallurgical and structural properties required to meet the reliability and durability requirements of the system are met. Heat treatment of titanium and titanium alloy products shall be in accordance with MSFC-SPEC-469. For titanium alloy products not covered in MSFC-SPEC-469, heat treatment shall be in accordance with MIL-H-81200, as specified by contractor specifications.

3. SPECIAL CONSIDERATIONS

3.1 Hardenability. Most titanium alloys have limited hardenability with section size and shall not be used in sections which exceed their specified limits. The surfaces of titanium parts shall be machined or chemically milled to eliminate all contaminated zones formed during processing.

3.2 Titanium Forgings. All titanium bar and forging stock shall be procured in accordance with the requirements of MIL-T-9047, supplemented by contractor documents as necessary to assure the metallurgical and structural properties required to meet the reliability and durability requirements of the system.

3.3 Titanium Contamination. Care shall be exercised to ensure that cleaning fluids and other chemicals used on titanium are not detrimental to performance. Materials that can induce stress corrosion, hydrogen embrittlement, or reduce fracture toughness include:

a. Hydrochloric Acid

b. Silver

c. Halogenated solvents

d. Methyl Alcohol

e. Mercury

f. Mercuric Compounds

g. Trichloroethylene/Trichloroethane

h. Carbon Tetrachloride

i. Halogenated Cutting Oils

j. Halogenated Hydrocarbons

k. Cadmium or silver plated clamps, tools, fixtures or jigs

Use of any of these materials on or with titanium or in its manufacturing shall be prohibited.

3.4 Fretting of Titanium. Components manufactured of titanium and titanium alloys shall be designed to avoid fretting.

3.5 Titanium Corrosion Considerations.

3.5.1 Surface Considerations. The surfaces of titanium and titanium alloy mill products shall be 100 percent machined, chemically milled or pickled to a sufficient depth to remove all contaminated zones and layers formed while the material was at elevated temperature. This includes contamination as a result of mill processing, heat treating and elevated temperature forming operations.

3.5.2 Special Considerations. Titanium parts shall not be cadmium or silver plated. Cadmium plated clamps, tools, fixtures and jigs shall not be used for fabrication or assembly of titanium and titanium alloy components or structures.

SECTION 2170

OTHER METALS

1. SCOPE

This section sets forth the requirements for the use of metals not otherwise specified in this standard.

2. APPLICATION

Other metals such as nickel and copper and their alloys, that are commonly utilized in aerospace applications, may be used. Metals and alloys that are rarely utilized in aerospace applications shall not be used unless the contractor performs and maintains a design trade study that (1) demonstrates the desirability over commonly used materials and (2) indicates that no additional reliability risks or hazards, such as specified in paragraph 4.3, will be incurred by using these uncommon materials.

3. SPECIAL CONSIDERATIONS

3.1 Stress Corrosion Cracking. For those metals and alloys which have no available stress corrosion data, documented use history, or are not covered in MIL-HDBK-5, the contractor shall develop and use threshold values similar to those listed for other alloys based on the ability to withstand exposure to alternate immersion tests in 3.5 percent sodium chloride solutions in water for 180 days without cracking, where cracking is defined as detectable by Class AA ultrasonic inspection per MIL-I-8950, or for 30 days without cracking, where cracking is defined as detectable defects identified by cross-sectioning and metallographic examination at 200 times magnification, minimum.

SECTION 2200

NONMETALS

1. SCOPE

This section sets forth the common requirements for the use of nonmetallic materials.

2. APPLICATION

Nonmetallic materials shall be selected and qualified with each application by consideration of the following, as a minimum:

a. Design engineering properties
b. Application operational requirements
c. Compatibility with other materials used
d. Material hazards and restrictions specified in Section 4
e. Environmental and health restrictions mandated by applicable federal, stat and local regulations

2.1 Composition and Processing. Specifications for composition and processing shall be used to ensure a product that is reproducible and meets all physical, chemical, and mechanical requirements.

2.2 Compatibility. Nonmetallic materials shall be evaluated and tested or documented on the basis of detailed history for compatibility with temperature, pressure, radiation and fluid or gas environments. Tests for compatibility with hazardous fluids and gases such as oxygen or hydrogen must consider energy sources available in the proposed application that could initiate adverse reactions.

3. SPECIAL CONSIDERATIONS

3.1 Chlorinated Fluorocarbons (CFCs). All PMP shall be free of CFCs as mandated by federal or state regulations.

3.2 Shelf-Life Limitations. Many nonmetallic flight materials have a shelf life specified by the manufacturer. All flight materials so specified shall be controlled by a shelf-life control program and shall not be used beyond expiration dates unless based on test information supplied by the manufacturer or obtained by the user for the production lot(s) of concern.

SECTION 2210

ELASTOMERS

1. SCOPE

This section sets forth the general and specific requirements for the use of Cured Elastomers, Non-cured Elastomers, and Silicone Elastomers.

2. APPLICATION

Elastomeric components shall be hydrolytically stable not subject to reversion and possess adequate resistance to aging, low temperature, ozone, heat aging, working fluids, lubricants and propellants for the system. Elastomeric materials in contact with hydrazine shall be limited.

3. SPECIAL CONSIDERATIONS

3.1 Cured Elastomers. Cured elastomers that are age sensitive shall be controlled by MIL-STD-1523. All cured elastomeric materials shall be cure dated either on the item itself or on the packaging. A policy of first in, first out shall be maintained. Cured elastomeric materials should be protected from sunlight, fuel, oil, water, dust and ozone. A maximum storage temperature 37.8° C (100° F) is recommended; the maximum storage temperature shall not exceed 51.7° C (125° F).

3.2 Non-cured Elastomers. Materials that are procured in non-cured state such as sealants and potting compounds shall be held in controlled temperature storage not to exceed 26.7° C (80° F). Some specific materials require storage at reduced temperatures and should be stored as recommended by the manufacturer. Adequate storage times shall be set up and those times maintained. A first in, first out policy shall be maintained. Overage materials may be used if testing can insure that the material is adequate for use.

3.3 Silicone Elastomers. Some one-part silicone products including commercial adhesives/sealants, as well as those meeting the requirements of MIL-S-46106, give off acetic acid during cure. These materials can cause corrosion to copper, aluminum and steel. Alcohol liberating sealants should be used instead of acetic acid liberating sealants.

SECTION 2220

FOAMED PLASTICS

1. SCOPE

This section sets forth the requirements for the use of foamed plastics.

2. APPLICATION

2.1 Hydrolytic Stability. Foamed plastics used shall be hydrolytically stable and shall not be subject to reversion.

2.2 Application. Foamed plastics shall be applied in a manner as to preclude damaging fragile components or exerting undue stress on adjacent surfaces.

2.3 Outgassing and Flammability. Only a few foamed plastics meet outgassing and flammability requirements. Often such materials require baking at elevated temperatures to reduce outgassing to acceptable levels.

3. SPECIAL CONSIDERATIONS

Foam plastics shall not be used for metal skin reinforcement in structural components, nor as a core material in sandwich structural components other than all plastic sandwich parts, low density filler putties or syntactic foam.

SECTION 2230

LUBRICANTS

1. SCOPE

This section sets forth the general requirements for the use of lubricants.

2. APPLICATION

NASA SP-8063 shall be used as a guide in the design and application of lubricants for space flight systems and components.

3. SPECIAL CONSIDERATIONS

3.1 Application Documents. Application documents for dry film lubricants shall define surface finish requirements for surfaces to be coated. The use of film lubricants are recommended for applicants requiring minimum levels of friction, maximum life, and maximum load-bearing capability.

3.2 Lubricant. Selection of a lubricant shall consider life cycles, including installation, test, and utilization, as well as a design margin.

SECTION 2240

ADHESIVES, SEALANTS, COATINGS, & ENCAPSULANTS

1. SCOPE

This section sets forth the requirements for the use of adhesives, sealants, coatings, and encapsulants.

2. APPLICATION

2.1 Adhesives. Adhesives for general use shall be qualified to MIL-A-46146. Adhesives for structural applications shall be qualified to MIL-A-83377 for the specific materials to be bonded.

2.2 Couplants. Silicone grease shall not be used as a thermal couplant except in hermetically-sealed assemblies.

2.3 Coatings. Conformal coatings shall be qualified to MIL-I-46058 and shall meet the requirements of section 4.1.10 of this standard.

2.4 Encapsulants. Materials and processes used to encase components and assemblies in plastic or elastomeric resins for electrical insulation, protection from environmental conditions, and protection from mechanical damage shall be qualified by component or assembly-level testing or past space experience under equivalent or more limited thermomechanical and radiation stresses.

2.5 Cleaning Prior to Application. All processes involving these materials require careful surface preparation to ensure adequate adhesion. Each qualified material shall be associated with one or more documents describing its application and usage. Each application document shall detail the specific cleaning procedure for all surfaces to be coated or bonded and a maximum time period between surface preparation and bonding or coating, after which surfaces shall be reprocessed. Materials covered by this section shall be qualified with the specific surface preparation procedure described.

3. SPECIAL CONSIDERATIONS

3.1 Glass Transition Temperature. The secondary or glass transition temperature of silicone-based adhesives or sealants subjected to application to cryogenic temperatures during test or usage shall be a minimum of 30° F lower than the usage qualification temperature.

3.2 Parylene. When parylene (paraxylylene) is used as a conformal coating, the chlorine-free grade of parylene shall only be used.

3.3 Processing Requirements. Processing requirements for encapsulation shall consider as a minimum the following: surface preparation or cleaning, resin or elastomer preparation, processing temperatures (including exothermic heat of reaction), shrinkage during cure, and rework or repair requirements.

3.4 Asbestos. Asbestos-containing materials shall not be used.

SECTION 2250

COMPOSITES

1. SCOPE

This section sets forth the general requirements for the use of composites and the specific requirements for the use of advanced composites, metal matrix composites, and conventional composites.

2. APPLICATION

Composite materials are material systems made up of more than one constituent, usually a strong stiff fiber and a relatively weak soft binder. For the purposes of this standard, composite materials are divided into three broad categories, these being conventional composites, advanced composites and metal matrix composites. Conventional composites are fiberglass reinforced organic resins. Advanced composites are organic resins reinforced with high strength, high stiffness fibers such as aramid boron or carbon. Metal matrix composites are fiber, whisker or particulate reinforced metals. Selection of materials and processes for composites must consider all aspects of the intended application. These aspects include: service environment, system requirements, structural and functional requirements, electrical or dielectric requirements, serviceability and repairability.

3. SPECIAL CONSIDERATIONS

3.1 Advanced Composites. Advanced composites consist of an organic matrix reinforced by high modulus and/or high strength fibers. The fiber reinforcement takes the form of continual unidirectional filaments (tape), woven fabric (cloth), chopped fibers etc. The fiber materials are boron, carbon, aromatic polyamide etc. Guidance in the processing and production of advanced composite materials can be found in the DOD/NASA Structural Composites Fabrication Guide. Guidance in the effective utilization of advanced composite materials and design concepts in aerospace structures can be found in the DOD/NASA Advanced Composites Design Guide, Vol I - Vol IV.

3.2 Metal Matrix Composites. In a metal matrix composite, the metal serves the same purpose as the organic binder of an organic matrix composite. Aluminum, magnesium and titanium alloys are common metal matrices.

3.3 Conventional Composites. Glass fiber reinforced plastic parts shall be designed using the guidelines of MIL-HDBK-17.

SECTION 2260

GLASSES and CERAMICS

1. SCOPE

This section sets forth the general requirements for the uses of glasses and ceramics as structural elements.

2. APPLICATION

2.1 Limitations on Material Use. Glasses and ceramics are limited in their use as structural elements due to their brittleness at ambient temperatures and lack of suitable nondestructive inspection techniques to ensure adequate strength and fracture resistance for specific stress and environmental conditions. Mechanical properties and fracture toughness information, as well as a plan to ensure adequate quality, are thus mandatory to demonstrate ability to use these materials.

3. SPECIAL CONSIDERATIONS

3.1 Materials Design Information. There is no central source of materials design on glasses and ceramics similar to MIL-HDBK-5 for metals. The following sources of information are useful:

a. Larsen, D.C., J.W. Adams, and S.A. Bortz, "Survey of Potential Data for Design Allowable MIL-Handbook Utilization for Structural Silicon-Based Ceramics," prepared by IIT Research Institute, Materials and Manufacturing Technology Division, Chicago, IL 60616, December 1981, Final Report in Contract No. DAAG 46-79-C-0078.

b. Touloukian, Y.S., R.W. Powell, C.Y. Ho, and P.G. Klemens, "Thermophysical Properties of Matter - the TPRC Data Series," Volumes 2,5,8,9,11, and 13, IFI/Plenum, New York-Washington 1970.

c. Lynch, J.F., C.G. Ruderer, and W.H. Duckworth, "Engineering Properties of Selected Ceramic Materials," published and distributed by the American Ceramic Society, Inc., 4055 N. High Street, Columbus, Ohio 43214, 1966.

d. Bradt, R.C., D.P.H. Hasselman, and F.F. Lange, "Fracture Mechanics of Ceramics," Volumes 1-6, Plenum Press, New York-London 1974 (Volumes 1 and 2), 1978 (Volumes 3 and 4), 1983 (Volumes 5 and 6).

SECTION 2300

SANDWICH ASSEMBLIES

1. SCOPE

This section sets forth the requirements for the use of Sandwich Assemblies.

2. APPLICATION

All sandwich assemblies shall be vented and designed to prevent entrance and entrapment of water or other contaminants in the core structure. Sandwich assemblies shall satisfy the requirements of MIL-HDBK-23 and be tested in accordance with MIL-STD-401. Aluminum honeycomb core sandwich assemblies shall use MIL-C-7438 perforated core. Non-metallic cores may be used in structural applications where technically advantageous.

3. SPECIAL CONSIDERATIONS

3.1 Nonmetallic Sandwich Assemblies. Nonmetallic structural sandwich assemblies shall be qualified for specific applications by passing a test program subjecting them to anticipated worst case environments.

SECTION 3000

PROCESSES

1. SCOPE

This section sets forth the common requirements for use of processes.

2. APPLICATION

Processing specifications herein represent minimum standards of quality required for space and launch vehicles and associated hardware. In most instances, manufacturing, installation, and inspection processes are controlled by contractor specifications. The use of these specifications is encouraged provided that the minimum standards of quality and quality assurance required by the appropriate contractual specifications is ensured.

3. SPECIAL CONSIDERATIONS

3.1 Corrosion Considerations. Adequate precautions shall be taken during manufacturing, testing, and installation operations to maintain corrosion prevention requirements and to prevent the introduction of contamination, corrosion, or corrosive elements.

3.2 Statistical Process Control. Process quality controls shall be maintained through a formal, documented, statistical process control program meeting the requirements of EIA-STD-557.

3.3 Process Records. Written or computerized process records that demonstrate successful application and completion of all required processes and related quality assurance requirements shall be maintained for life of the program. Certifications of compliance are not acceptable proofs without associated results of analyses or documentation showing successful processing or testing.

3.4 Cleaning and Storage. All materials, parts, and assemblies that have been subjected to processing shall be appropriately cleaned and maintained in a cleaned state prior to the next process, test, use, or installation. Where appropriate, verification of appropriate levels of cleanliness and freedom from contamination shall be required.

SECTION 3100

ADHESIVE BONDING

1. SCOPE

This section sets forth the requirements for the use of adhesive bonding.

2. APPLICATION

Structural bonding shall meet the requirements of MIL-S-83377.

3. SPECIAL CONSIDERATIONS

Bonding of structural components, except for high temperature nozzle bonds, shall be tested under simulated service conditions using tag-end test specimens when ever possible to demonstrate that the materials and processes selected will provide the desired properties for the entire life of the component. When thermal cycle testing is required, the rate of temperature change shall not exceed the expected rate of temperature change in service. Hardware qualifications and acceptance tests plus lap shear witness coupons processed concurrently using the same material cleaning method and cure cycles can be used in lieu of tag-end test specimens.

SECTION 3200

WELDING

1. SCOPE

This section details the general requirements for the use of welding operations and the specific requirements for weld rework and weld filler material.

2. APPLICATION

Resistance welding of electronic circuit modules shall meet the requirements of MIL-W-8939. Training and certification of personnel and machine qualification are required. The design and selection of parent materials and weld methods shall be based on consideration of the weldments, including adjacent heat affected zones, as they effect operational capability of the parts concerned. Welding procedures and supplies shall be selected to provide the required weld quality, minimum weld energy input, and protection of heated metal from contaminants. The suitability of the equipment, processes, welding supplies and supplementary treatments selected shall be demonstrated through qualification testing of welded specimens representing the materials and joint configuration of production parts. As a minimum requirement, welding operators shall be qualified in accordance with MIL-STD-1595. In addition, the contractor shall provide the necessary training and qualification requirements to certify each operator and the applicable welding equipment for specific welding tasks required of critical spaceflight hardware such as pressure vessel weldments, tubing weldments, and other primary structural components.

3. SPECIAL CONSIDERATIONS

3.1 Weld Filler Material. Weld rod or wire used as filler metal on structural parts shall be fully certified and documented for composition, type, heat number, manufacturer, supplier etc., as required to provide positive traceability to the end use item. In addition, qualitative analysis and nondestructive testing shall be conducted on segments of each filler rod or wire as necessary to assure that the correct filler metal is used on each critical welding task. Quantitative analyses of weld filler metal on a lot by lot basis will be considered acceptable, provided that each structural weldment is subjected to simulated service testing or proof loading prior to acceptance.

3.2 Weld Rework. Weld rework shall be minimized by discriminating selection of acceptable methods, procedures and specifications developed by the contractor. Weld rework is limited to the rework of welding defects in a production weld as revealed by inspection. Weld rework does not include the correction of dimensional deficiencies by weld buildup or "buttering" of parts in areas where the design did not provide for a welded joint. All weld rework shall be fully documented. Documentation as a minimum shall include weld procedures and schedules, location of the rework, nature of the problem and appropriate inspection and qualification requirements for acceptance. The quality of rework welds shall be confirmed by 100 percent inspection of both surface and subsurface, using visual, dimensional and nondestructive techniques. Rework of welds in high performance or critical parts is not permitted.

SECTION 3300

BRAZING

1. SCOPE

This section sets forth the requirements for brazing operations.

2. APPLICATION

Brazing shall meet the requirements of MIL-B-7883. Metals not covered by MIL-B-7883 shall not be brazed. Fusion welding operations in the vicinity of brazed joints or other operations involving high temperatures which may affect the brazed joint are prohibited. Brazed joints shall be designed for shear loading and shall not be used to provide strength in tension for structural parts. Allowable shear strength and design limitations shall conform with those specified in MIL-HDBK-5.

3. SPECIAL CONSIDERATIONS

None.

4. PROHIBITED MATERIALS LIST

a. All metals not listed in MIL-B-7883

b. Cadmium and zinc alloys that are not plated as to preclude the material hazards in paragraph 4.3.2

SECTION 3400

FASTENER INSTALLATION

1. SCOPE

This section sets forth the requirements for the use and installation of fasteners.

2. APPLICATION

The installation of mechanical fasteners and associated parts, including cleaning prior to installation and application of protective finishes, shall meet the requirements of MSFC-SPEC-250 or MIL-STD-403 as appropriate.

3. SPECIAL CONSIDERATIONS

Zinc and/or Cadmium platings/coatings are prohibited materials in accordance with Section 2170 and shall not be used on space flight hardware. Tin coating on space flight hardware is prohibited (see section 4, paragraph 4.3.3).

SECTION 3500

PRINTED CIRCUIT ASSEMBLY

1. SCOPE

This section sets forth the requirements for printed circuit assemblies.

2. APPLICATION

2.1 Rigid Printed Circuit Assemblies. Rigid printed circuit assemblies shall be designed in accordance with MIL-STD-275. Surface mount designs shall be in accordance with the Class 3 requirements of ANSI/IPC-D-275.

2.2 Flexible Printed Circuit Assemblies. Flexible printed circuit assemblies shall be designed in accordance with MIL-STD-2118.

2.3 Installation and Mounting. Installation and mounting shall be in accordance with Appendix B of MIL-STD-2000. NASA NHB 5300.4 (3A-2) may be used for through-hole mounting only.

2.3.1 Sleeving. Fragile parts shall be fitted with sleeving or buffer coat to prevent damage.

2.3.2 Hermetic Seals. Hermetically sealed devices susceptible to damage during lead formation shall be identified, controlled, and tested on a sample basis after lead formation.

2.4 Soldering. Soldering shall be per MIL-STD-2000 and as tailored in the system specification. NASA NHB 5300.4 (3A-2) may be used for through-hole soldering only.

2.4.1 Terminal Soldering. Step-soldering with a high temperature solder conforming to QQ-S-571 shall be used when it is necessary to solder terminals to the printed circuit board per the mounting requirements of MIL-STD-2000.

2.4.2 Solder in the Bend Radius. The requirements for solder in the bend radius from MIL-STD-2000 shall only be acceptable for axial leaded components with a body diameter of 0.125 inch or less and with leads formed to a 90° bend.

2.5 Cleanliness Testing. All uncoated printed wiring assemblies (circuit card assemblies) shall be free from ionic and other contaminants when tested as specified in MIL-STD-2000 or approved equivalent test methods.

2.5.1 Packaging After Test. To ensure that cleanliness levels are maintained after cleanliness testing, all PWAs shall be protected from the environment by packaging or some other comparable means.

2.6 Conformal Coatings. All printed wiring board assemblies shall be conformally coated per MIL-STD-275, with the selection of materials from MIL-I-46058 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 when rigid coating materials are used. Flexible polymeric coatings shall be used to bridge the gap between the underside of components and the substrate otherwise.

b. The coated assemblies shall exhibit no blisters, cracking, crazing, peeling, wrinkles, measling, or evidence of reversion or corrosion at 3-5X magnification. 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. For any of the cited coated assembly anomalies, the maximum number of reworks is two (2).

The Table(s) 3500-1 and 3500-2 are to be used as guidelines for the appropriate selection of conformal coating materials based on their electrical, mechanical, and thermal properties and application methods.

3. SPECIAL CONSIDERATIONS

3.1 Reliability Suspect Design.

3.1.1 Leadless Ceramic Chip Carriers. The use of leadless ceramic chip carriers (LCCCs) shall be considered reliability suspect when:

a. The LCCC body size is greater than 0.400 square inches.

b. The difference between the coefficient of thermal expansion (CTE) of the LCCC body and the CTE of the printed circuit board is greater than a factor of 2.

c. The operating power of the device inside the LCCC is greater than 300 milliwatts.

Table 3500-1 General Physical Properties and Application Methods of Conformal Coatings

Conformal Coating	General Physical Properties	Application Methods
Paraxylylene (Parylene)	Excellent moisture and solvent resistance, provides pin-hole free conformal coating with uniformity of thickness, high purity.	Material applied by vapor condensation to the substrate at room temperature in vacuum (i.e., vapor deposition polymerization).
Epoxies	Excellent chemical resistance, good mechanical properties, low permeability to moisture, high dielectric strength and volume resistivity, brittleness at low temperatures.	Material applied typically by dipping or flow coating. Brush coating is used mainly to spot coat areas of poor coverage.
Silicones	Excellent electrical properties, elasticity, ionic purity and thermal stability, low permeability to moisture, poor mechanical stability.	Material can be applied by dipping brushing, spraying or flow coating dilution of material maybe necessary to achieve desired thickness.
Urethanes	Good mechanical, chemical and moisture resistance properties, excellent electrical insulating properties, relatively poor thermal stability.	Material can be applied by dipping, spraying, brushing or flow coating, manufacturers can supply material with viscosities appropriate to their application.
Fluoropolymers	Excellent electrical properties, good thermal stability, water repellent, resistant to high energy radiation.	Material can be used as received or diluted to a 0.1 to 5% solution with suitable solvents. Material usually applied by dipping or spraying. Best film properties achieved at film thickness of 5 mils.
Acrylics	Excellent moisture resistance and dielectric properties, poor chemical and solvent resistance, resistance to mechanical abrasion is poor.	Material can be applied by spray, roller or curtain coating methods. For high production applications automated spraying systems are recommended.

Table 3500-2 Typical Properties of Selected Conformal Coatings

Property	Paraxylylene (Parylene)	Epoxies	Silicones	Urethanes	Fluoropolymers	Acrylics
Dielectric Strength Volts/MII(ASTM D149-64)	5400-7000	4000-5000	5400	4500-5000	2500-3000	3500
Dielectric Constant 1MHz	2.65-2.95	3.3-4.0	2.6-2.7	4.2-5.2	2.7	2.2-3.2
Dissipation Factor 23°C at 1 MHz	0.006-0.013	0.03-0.05	0.001-0.002	0.05-0.07	0.016	0.02-0.04
Volume Resistivity 23°C and 50% RH, Ohms-CM	10^{16}	10^{14}	10^{15}	10^{14}	10^{15}	10^{15}
Young's Modulus PSI (ASTM D882-565)	350,000-400,000	350,000	900	1000-10,000	-------	-------
Tensile Strength PSI (ASTM D882-56T)	10,000-13,000	10,800	800-1,000	175-10,000	-------	2500
Rockwell Hardness	R80-R85	M80-M110	40-45	10A-250	-------	D90
Glass Transition Temperature °C	60-100	110	-130	-10	-------	-------
Thermal Conductivity 10^{-4} Cal/Sec/CM °C/CM	2.0-3.0	4.5	3.5-7.5	5	-------	-------
Pot Life	-------	GOOD-POOR	FAIR	GOOD-POOR	EXCELLENT	EXCELLENT
Repairability (Solder-Through)	FAIR	POOR	POOR	GOOD	EXCELLENT	GOOD
Repairability (Removal by Solvent)	NO	NO	POOR	NO	EXCELLENT	EXCELLENT
Repairability (Physical Removal)	FAIR	POOR	GOOD	GOOD	-------	GOOD

APPENDIX A

RADIATION HARDNESS ASSURANCE REQUIREMENTS

This Appendix is a mandatory part of the standard.

10. SCOPE

This Appendix establishes the general requirements pertaining to radiation hardness assurance during the design, development and production of space vehicles or other systems with radiation hardness requirements. It 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

MIL-HDBK-280 Neutron Hardness Assurance Guidelines For Semiconductor Devices and Microcircuits

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 A-II and Table A-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.

b. Total ionizing dose specified in rad(Si) and the dose rate specified in rad(Si) per second.

c. Transient ionization that may cause upset, latch-up, or burnout. The peak dose rate should be specified in rad(Si) per second and the transient pulse duration in seconds.

d. Particles that could cause a single event upset, latch-up or burn-out. The particle type, flux (particles per square centimeter per second), and energy spectra or LET spectra should be specified.

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 lot acceptance tests and/or electrical screens.

b. Hardness Critical Category 1H (HCC-1H). These part types do not require radiation 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 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).

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 radiation characterization tests shall consist of exposing the test sample to increasing radiation levels until the parameter or the functional failure value for the device has been reached. The characterization data shall be accompanied by the mean and standard deviation of the critical parameters. These failure values shall be based on a worst case circuit analysis.

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 iterative process for the parts because the location, and therefore transported environment for the application, may change during development. In addition, the characterization for the actual parts used may vary from that for the parts 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

$$R_{MF} = \exp\left[\overline{\ln(R_{FAIL})}\right] \quad (2)$$

$$\overline{\ln(R_{FAIL})} = \frac{1}{n} \sum_{i=1}^{n} \ln(R_{FAIL_i}) \quad (3)$$

where R_{FAIL_i} is the radiation failure level for i^{th} 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 (PCC) method. 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 predetermined 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 specifically for each part. This number depends upon the standard deviation, sample size, required confidence level, and required survival probability.

40.5.1 Breakpoint Part Categorization Method. 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. For total dose, the recommended acceptable minimum design margin is 3. Parts with an RDM of 2 or less, shall not be used. 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 Part Categorization Criterion Method. 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. For total dose, the recommended acceptable minimum design margin is 3. Parts with an RDM of 2 or less, shall not be used.

Unless otherwise specified, the survival probability shall be 99 percent and the confidence level shall be taken as 95 percent.

50. LOT CONFORMANCE PROCEDURES

50.1 Test Requirements. The requirements for 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. Lot conformance testing, conducted in accordance with table A-I, is required for parts in Hardness Critical Category 1M for a particular radiation environment. Hardness Critical Category 2 parts, may also require periodic radiation testing because of possible changes in design or processing steps affecting hardness.

50.2 Lot Conformance Testing Methodology. The radiation hardness of the sample is determined by testing parameter degradation to failure (the radiation to failure test of 50.2.1), or by testing at a single radiation level (50.2.2). 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. 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 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.

50.2.1 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 (see Figure A-1), the data shall be recorded.

From the data, the values of R_{FAIL} at PAR_{FAIL} are obtained. (Annealing effects 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 50.2.2).

50.2.2 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, 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 A-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 i^{th} device.

The parameter mean value degradation is calculated as:

$$P_{MD} = \exp\left[\overline{\ln(PAR_{RAD})}\right] \qquad (7)$$

The lot is acceptable if the design margin, PDM, is greater than the exponential of the product K_{TL} and the sample standard deviation, S_R, for the lot.

(a) For parameter value increasing with radiation:

$$PDM = \frac{PAR_{FAIL}}{P_{MD}} \geq \exp(K_{TL} S_P) \quad (8)$$

where PAR_{FAIL} is the parameter or function failure value for the lot.

(b) For parameter value decreasing with radiation:

$$PDM = \frac{P_{MD}}{PAR_{FAIL}} \geq \exp(K_{TL} S_P) \quad (9)$$

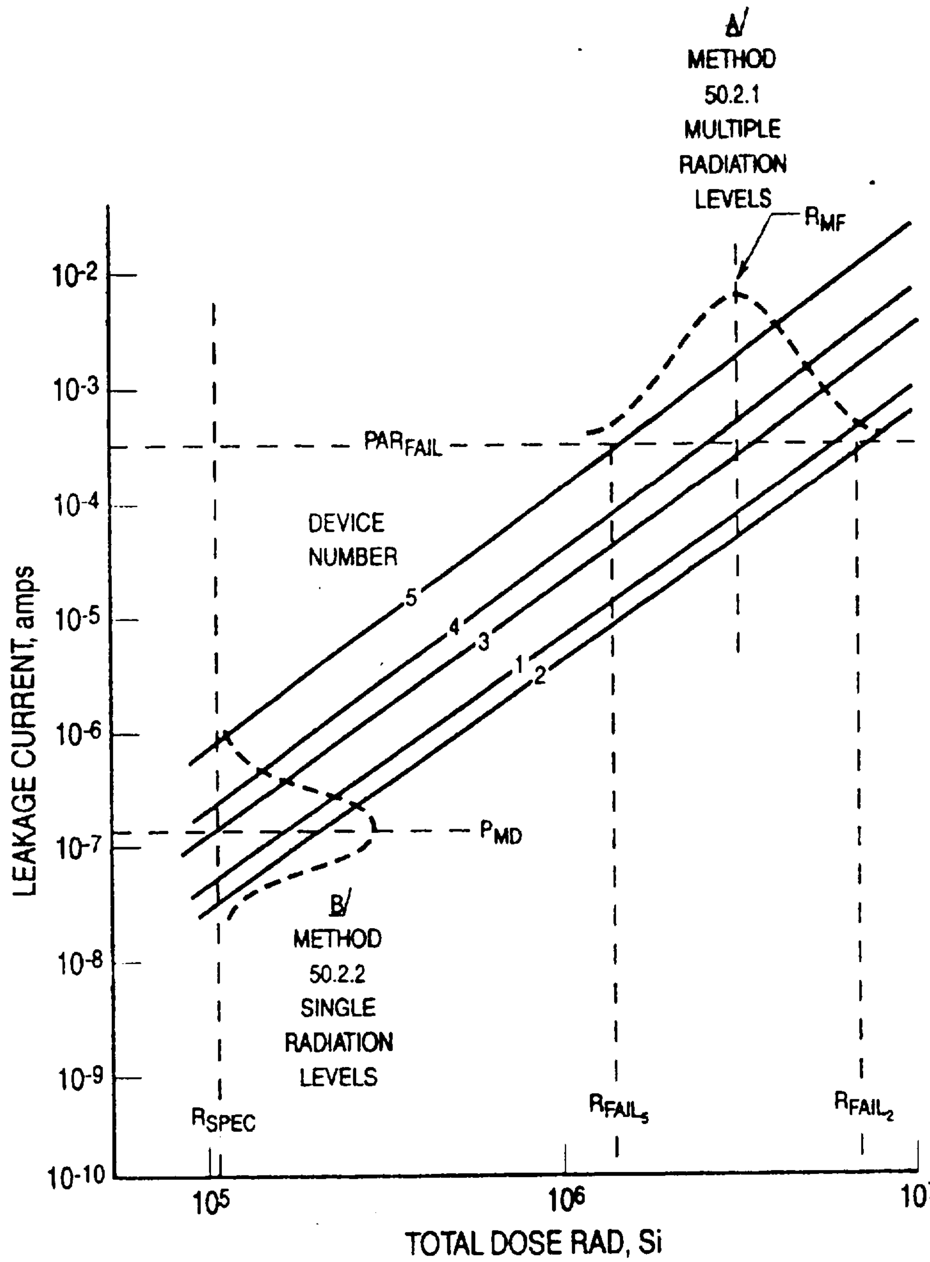
where

$$S_P = \left(\frac{1}{n-1} \sum_{i=1}^{n} \left[\ln(PAR_{RAD_i}) - \overline{\ln(PAR_{RAD})} \right]^2 \right)^{1/2} \quad (10)$$

50.3 Radiation Testing

50.3.1 Radiation Testing. 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 A-I. The test conditions shall be based on characterization data including post-irradiation effects, and latchup windows in latchup testing.

When 100 percent latchup screen is specified, testing shall be done in accordance with Test Method 5004 and Test Method 1020 in MIL-STD-883. Test conditions, temperature, and electrical parameters to be measured pre, during and post irradiation shall be specified in the detailed specification.



Notes: A/ Method 50.2.1: Multiple radiation levels
B/ Method 50.2.2: Single radiation level

FIGURE A-1. Lot Conformance Tests

Microcircuits and semiconductor devices subjected to radiation testing shall pass the specified Group A electrical tests pre and post irradiation. When specified in the detailed specification, the same devices may be used for testing in more than one environment.

50.3.2 Sampling Plans. Test samples shall be randomly selected from a single wafer lot, or if unavailable, from a single production lot, except for total ionizing dose testing, where a test sample shall be selected from each wafer.

50.3.3 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.

50.3.4 Hybrid Microcircuits. The qualification of hybrid circuits to specified radiation environments consists of three steps:

a. Radiation characterization of the microcircuit and semiconductor dice,

b. Worst Case Circuit Analysis of the hybrid circuit and,

c. Radiation testing of the complete circuit.

Samples of microcircuits and semiconductor dice shall be tested in accordance with the applicable subgroup in Table A-1. Dice or hybrid circuits subjected to radiation testing shall pass the specified group A electrical tests. The contractor may elect to replace the element testing by testing the complete hybrid. The lot definition per MIL-H-38534 sampling plan and Test Methods per Table A-1 can be applied as an alternate test plan.

50.3.5 Quartz Crystals. Radiation testing shall be conducted in accordance with the applicable test methods in Table A-1. The minimum sample size shall be 5 parts from a single lot. The same parts may be used for more than one environment. The frequency shift and resistance change shall be measured per MIL-C-49468 at the turnover temperature (the temperature at which the slope of frequency versus temperature is equal to zero). For total dose irradiation, the shift in frequency and resistance shall be measured pre and post irradiation with the time limit between irradiation and testing specified in Test Method 1019. For neutron irradiation, the test shall be conducted in situ with the parts maintained at turnover temperature. Transient irradiation testing shall be conducted with the parts kept at turnover temperature. The frequency and resistance changes shall meet the specified 95 percent confidence level and 99 percent survival probability.

50.3.6 <u>Test Plans and Test Procedures.</u> Radiation testing shall be based on documented radiation test plans and procedures. The test plan shall define the details of the testing to be performed in 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, during and post-electrical tests, bias and test conditions during irradiation and worst case temperature environment.

f. Irradiation test levels and accelerated annealing test conditions for MOS devices post total ionizing dose testing (see test method 1019 in MIL-STD-883), identification of latchup windows, if any, during latchup testing.

g. Documentation of test results.

h. Data processing and analysis.

60 COMBINED ENVIRONMENTS, MATERIAL SELECTION AND SHIELDING

60.1 <u>Combined Environments Damage.</u> The parameters degradation limit X_{LLC} or Parameter PAR due to the combined total ionizing dose and neutron fluence environments shall be calculated as follows:

For a normal distribution:

$$X_{LLC} = PAR_{MFN} + PAR_{MFD} + \left[(K_{TLN} S_N)^2 + (K_{TLD} S_D)^2 \right]^{1/2} \qquad (11)$$

X_{LLC} is the combined limit for parameter PAR.

PAR_{MFN} and PAR_{MFD} are the respective arithmetic means for the neutrons and total ionizing dose environments.

K_{TLN} and K_{TLD} is the one sided tolerance limit factor for neutrons and total ionizing dose environments.

For lognormal distributions, the combined end point is equal to $\exp[X_{LLC}]$, where X_{LLC} is the combined end point limit for the normally distributed logarithms as calculated from equation 11.

60.2 Material Selection. Materials shall be selected based on radiation design margin equal to or greater than 10. When specific data is lacking, radiation testing shall be performed to characterize the material. Unacceptable degradation may include outgassing, elongation, embrittlement or darkening of optical materials. The evaluation should include materials such as elastomers, adhesives, lubricants, coatings and films, propellants, optical and dielectrics.

60.3 Radiation Shielding. Unacceptable parts may under certain conditions be upgraded to Category 1 by the addition of localized shielding for total dose and transient environments. The method of calculating the reduced total dose level, and the reduced transient level at the device location shall be specified. The method of applying the metal shield shall be documented.

TABLE A-I. Radiation Test Methods

TEST	TEST METHOD	SAMPLE SIZE 1/
Neutrons Irradiation 2/	MIL-STD-883/750 METHOD 1017	10
Total Ionizing Dose Irradiation	MIL-STD-883/750 METHOD 1019	10 3/
Transient Ionization	For microcircuits only MIL-STD-883 METHOD	
Upset	1021/1023	10
Latchup	1020	as specified
Burnout	detailed specification	10
Single Event Phenomena	ASTM F-1192	4

1/ For device types with greater than 4000 equivalent transistors per chip, the minimum sample size shall be five for each environment.

2/ Not required for MOS devices unless bipolar elements are included by design.

3/ Sampling plan shall be 4 parts per wafer for MSI and 2 parts per wafer for device types with greater than 4000 equivalent transistors per die. For device types with greater than 100,000 equivalent transistors per die, sampling plan shall be one device per wafer and four test structures per wafer, or alternatively, 5 devices per wafer lot and four test structures per wafer. An X-Ray source may be used on test structures at the wafer level provided correlation has been established between the X-Ray and Cobalt-60 source.

TABLE A-II. K_{TL} Factors for One-sided Tolerance Limits for Normal Distributions

	C = 0.75					C = 0.90				
	p	p	p	p	p	p	p	p	p	p
n	0.75	0.90	0.95	0.99	0.999	0.75	0.90	0.95	0.99	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 A-III. K_{TL} Factors for One-sided Tolerance Limits for Normal Distributions

	C = 0.95					C = 0.99				
	p	p	p	p	p	p	p	p	p	p
n	0.75	0.90	0.95	0.99	0.999	0.75	0.90	0.95	0.99	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

APPENDIX B

RESCREENING/QUALITY CONFORMANCE INSPECTION REQUIREMENTS

10. SCOPE

This appendix specifies rescreening requirements for Class B microcircuits, JANTXV transistors and diodes, and Class H hybrids.

20. APPLICATION

When allowed per contract the following rescreening and quality conformance inspection requirements shall be applied. These requirements are applicable only to QPL product and only to the product assurance levels specified. All other product assurance levels are unacceptable unless otherwise specified in the contract.

30. CLASS B MICROCIRUIT UPSCREENING/LOT ACCEPTANCE TESTING

MIL-M-38510 microcircuits, Class B shall be rescreened and lot acceptance (1/) tested in accordance with Table B-1.

40. CLASS H HYBRID UPSCREENING/LOT ACCEPTANCE TESTING

MIL-H-38534 hybrids, Class H shall be rescreened and lot acceptance (1/) tested in accordance with Table B-2.

50. JANTXV TRANSISTOR AND DIODE UPSCREENING/LOT ACCEPTANCE TESTING

MIL-S-19500 transistors and diodes, JANTXV, shall be rescreened and lot acceptance (1/) tested in accordance with Table B-3.

1/ Validated manufacturer lot acceptance test data in accordance with Tables B-1b, B-2b, and B-3b may be used in lieu of testing.

TABLE B-1a. MIL-M-38510 Class B Microcircuit Upscreening (Test 100%), Test Methods of MIL-STD-883 (Page 1 of 3)

SCREEN	METHOD	REQUIREMENTS 1/
1. Prescreen electricals 3/ & 7/	5005	YLN of 2% 9/ Optional but encouraged.
2. Particle Impact Noise Detection (PIND)	2020	2/
3. Serialization	–	100%
4. Radiographic	2012	Optional
5. Pre-HTRB electrical parameters 3/ & 7/	–	Read and record at 25°C
6. High Temperature Reverse Bias (HTRB) burn-in 6/ & 8/	1015	Test condition A or C, 48 hours minimum at +150°C or the device maximum operating limit, whichever is lower
7. Post HTRB electricals and deltas 3/ & 7/	–	Read and record at 25°C within 16 hours of removal from bias. Percent Defective Allowable: First Pass: 5% or 1, whichever is greater 5/ Second Pass: 3% or 1, whichever is greater 6/
8. Power Burn-in test 8/	1015 4/	240 hours minimum at +125°C
9. Post burn-in electrical parameters and deltas 3/ & 7/	–	Read and record at 25°C within 96 hours of removal from bias. Percent Defective Allowable: First Pass: 5% or 1, whichever is greater 5/

TABLE B-1a. MIL-M-38510 Class B Microcircuit Upscreening (Test 100%), Test Methods of MIL-STD-883 (Page 2 of 3)

SCREEN	METHOD	REQUIREMENTS 1/
10. Final Electricals 3/ & 7/		All failures must be data logged
a. Static Tests Subgroups 1, 2, and 3 of Table I, Method 5005	5005	Electrical testing performed at step 9 does not need to be repeated
b. Dynamic Tests Subgroups 4, 5, and 6 - or - Subgroups 7 and 8 of Table I, Method 5005	5005	
c. Switching Tests Subgroup 9 of Table I, Method 5005	5005	
11. Seal test (a) Fine (b) Gross	1014	Reject criteria per test method
12. External Visual	2009	100%

Notes:

1/ Except as stated below, the requirements shall be per Class S of applicable MIL-M-38510 detail specifications
2/ Test condition A, multiple pass criteria of MIL-STD-883, Method 2020
3/ Parameters as called out in MIL-STD-883, Method 5004 for Class S and:
  a. The Class S slash sheet if released.
  b. The Class B slash sheet if released.
  c. The most similar Class S family device slash sheet if there is no detail Class S slash sheet.
  d. The most similar Class B family device slash sheet if there is no detail Class B slash sheet.
4/ Test condition as specified in the applicable detailed slash sheet as determined in note 3/ above. Test conditions A,B,C, and F of Method 1015 shall not apply.
5/ The lot may be automatically resubmitted to a second Power Burn-in or HTRB one-time only without the necessity for MRB approval if the PDA does not exceed 20%. A PDA of greater than 20% shall require lot rejection.

TABLE B-1a. MIL-M-38510 Class B Microcircuit Upscreening (Test 100%), Test Methods of MIL-STD-883 (Page 3 of 3)

Notes (Cont.):

6/ HTRB shall be performed when specified in the applicable MIL-M-38510 detail slash sheet, as determined in note 3/ above, and for certain MOS, linear, and other microcircuits where surface sensitivity is of concern.

7/ Two correlation samples shall be used to verify functionality of all Automatic Test Equipment (ATE) and bench testing equipment. Correlation units shall be tested prior to any electrical testing. All parameters specified in the applicable detail slash sheet, as determined in note 3/ above, shall be read and recorded. If correlation units are not available, they may be removed from the lot being processed. Correlation units shall be controlled by the contractor for future upgrade screening.

8/ The order in which Power Burn-in and HTRB are performed may be switched at the contractor's option.

9/ Perform group A, subgroups 1 and 7. This test is designed to evaluate lots for continued upscreening or return to the vendor. A yield loss notification (YLN) of 2% should be imposed as a flag for review and disposition.

TABLE B-1b. MIL-M-38510 Class B Microcircuit Lot Acceptance Testing (Sample as Specified), Test Methods of MIL-STD-883 (Page 1 of 2)

SUBGROUP	METHOD	REQUIREMENTS 11/
Subgroup 1		3 devices sampled with 0 failures or 5 devices sampled with 1 failure
(b) Internal water-vapor content 5/	1018	5,000 ppm max water content at 100°C
Subgroup 5		LTPD = 10 over subgroup 5 9/
(a) Electrical measurements 1/ & 2/ a. Subgroups 1, 2, and 3 of Table I, Method 5005	5005	Read and record
(b) Steady state life 4/ & 10/	1005	1000 hours minimum at +125°C
(c) Electrical measurements and deltas 1/ & 2/ a. Subgroups 1, 2, and 3 of Table I, Method 5005	5005	Read and record 8/
Subgroup 6		LTPD = 15 over subgroup 6 9/
(b) Temp cycling 3/	1010	Condition C, 100 cycles minimum
(c) Constant acceleration 6/	2001	Test condition E, Y_1 orientation only
(d) Seal - fine and gross 7/	1014	Reject criteria per test method
(e) Electrical measurements 1/, 2/ & 7/ a. Subgroup 1 of Table I, Method 5005	5005	Read and record 9/

Notes:

1/ Parameters as called out in MIL-STD-883, Method 5005 and:
   a. The Class S slash sheet if released.
   b. The Class B slash sheet if released.
   c. The most similar Class S family device slash sheet if there is no detail Class S slash sheet.
   d. The most similar Class B family device slash sheet if there is no detail Class B slash sheet.

2/ Two correlation samples shall be used to verify functionality of all Automatic Test Equipment (ATE) and bench testing equipment. Correlation units shall be tested prior to any electrical testing. All parameters specified in the applicable detail slash sheet, as determined in note 1/ above, shall be read and recorded. If correlation units are not available, they may be removed from the lot being processed. Correlation units shall be controlled by the contractor for future upgrade screening.

3/ Temperature cycling may be performed as part of 100% testing with 10 thermal cycles performed to test Condition C of MIL-STD-883, Method 1010.

TABLE B-1b. MIL-M-38510 Class B Microcircuit Lot Acceptance Testing (Sample as Specified), Test Methods of MIL-STD-883 (Page 2 of 2)

Notes (Con't):

4/ A 340 hour intermittent operating life test per MIL-STD-883, Method 1006, and the applicable slash sheet may be performed in lieu of steady state life.

5/ Internal water-vapor testing may be performed as part of the DPA.

6/ Constant acceleration may be performed as part of 100% testing. If performed as part of 100% testing, constant acceleration shall be performed prior to seal leak testing.

7/ Seal leak and electrical testing need not be performed if thermal cycling and constant acceleration are performed as part of 100% screening.

8/ Life test samples tested at temperatures below the maximum specified junction temperature, meeting all specified acceptance criteria, and not subjected to the destructive testing of Subgroup 1, test (b), Internal Water Vapor and/or Subgroup 6, test (a), Temp cycling may be used in flight hardware with contractor's approved PMP Control Plan.

9/ Reference MIL-M-38510, Table B-1 for the number of samples required for each specified LTPD. Resubmission of a failed lot shall be permitted one time only. The resubmission sample size shall be the sample size called out in the next lower LTPD for the number of failures experienced during the first submission with zero additional failures or larger sample sizes at the same lower LTPD with total failures between the first and second submission as specified. Parts passing the first test shall not be included in the resubmission sample without contractor's approved PMP Control Plan.

10/ Test condition as specified in the applicable detailed slash sheet as determined in note 1/ above. Test conditions A, B, C, and F of Method 1005 shall not apply.

11/ Post burn-in electrical rejects from the same inspection lot may be used for all subgroups when end-point measurements are not required.

TABLE B-1c. MIL-M-38510 Class B Microcircuit Destructive Physical Analysis (DPA)

DPA per MIL-STD-1580A or approved procedure	Double the sample size All anomalies shall be dispositioned as acceptable or rejectable.
Internal water-vapor content 1/	Per MIL-STD-883, Method 1018. 3 devices sampled with 0 failures or 5 devices sampled with 1 failure. 5,000 ppm max water content at 100°C

Notes:

1/ Internal water-vapor may be performed as part of Lot Acceptance Testing.

TABLE B-2a. MIL-H-38534 Class H Hybrid Upscreening (Test 100%), Test Methods of MIL-STD-883 (Page 1 of 2)

SCREEN	METHOD	REQUIREMENTS 1/
1. Prescreen electricals 3/ & 6/	5005	YLN of 2% 7/ Optional but encouraged.
2. Particle Impact Noise Detection (PIND)	2020	2/
3. Serialization	–	100%
4. Radiographic	2012	2 views
5. Pre burn-in electrical parameters 3/ & 6/	–	Read and record at 25°C
6. Power Burn-in test	1015	320 hours at +125°C
7. Post burn-in electricals and deltas 3/ & 6/	–	Read and record at 25°C within 96 hours of removal from bias. Percent Defective Allowable: First Pass: 2% or 1, whichever is greater 5/
8. Final Electricals 3/ & 6/		All failures must be data logged
a. Static Tests Subgroups 1, 2, and 3 of Table X, Method 5008	5008	Electrical testing performed at step 7 does not need to be repeated
b. Dynamic Tests Subgroups 4, 5, and 6 of Table X - or - Functional Tests Subgroups 7 and 8 of Table X	5008	
c. Switching Tests Subgroups 9, 10, and 11 of Table X, Method 5008	5008	
9. Seal test (a) Fine (b) Gross	1014	Reject criteria per test method
10. External Visual	2009	100%

TABLE B-2a. MIL-H-38534 Class H Hybrid Upscreening (Test 100%), Test Methods of MIL-STD-883 (Page 2 of 2)

Notes:

1/ Except as stated below, the requirements shall be per Class K of applicable MIL-H-38534 detail specifications.
2/ Test condition A, multiple pass criteria of MIL-STD-883, Method 2020.
3/ Parameters as called out in MIL-STD-883, Method 5008 for Class K and:
   a. The Class K slash sheet if released.
   b. The Class H slash sheet if released.
   c. The most similar Class K family device slash sheet if there is no detail Class K slash sheet.
   d. The most similar Class H family device slash sheet if there is no detail Class H slash sheet.
4/ Test condition as specified in the applicable detailed slash sheet as determined in note 3/ above. Test conditions A, B, C, and F of Method 1015 shall not apply.
5/ The lot may be automatically resubmitted to a second Power Burn-in one-time only without the necessity for MRB approval if the PDA does not exceed 10%. A PDA of greater than 10% shall require lot rejection.
6/ Two correlation samples shall be used to verify functionality of all Automatic Test Equipment (ATE) and bench testing equipment. Correlation units shall be tested prior to any electrical testing. All parameters specified in the applicable detail slash sheet, as determined in note 3/ above, shall be read and recorded. If correlation units are not available, they may be removed from the lot being processed. Correlation units shall be controlled by the contractor for future upgrade screening.
7/ Perform group A, subgroups 1 and 4. This test is designed to evaluate lots for continued upscreening or return to the vendor. A yield loss notification (YLN) of 2% should be imposed as a flag for review and disposition.

TABLE B-2b. MIL-H-38534 Class H Hybrid Lot Acceptance Testing (Sample as Specified), Test Methods of MIL-STD-883 (Page 1 of 2)

SUBGROUP	METHOD	REQUIREMENTS 11/
Subgroup 1		3 devices sampled with 0 failures or 5 devices sampled with 1 failure
(b) Internal water-vapor content 4/	1018	Max water content per MIL-H-38534
Subgroup 2		15 devices sampled with zero failures 5/ & 6/
(a) Electrical measurements 1/, 2/ a. Subgroups 1, 2, and 3 of Table X, Method 5008	5008	Read and record
(b) Steady state life 3/ & 10/	1005	1000 hours minimum at +125°C
(c) Electrical measurements and deltas 1/ & 2/ a. Subgroups 1, 2, and 3 of Table X, Method 5008	5008	Read and record 5/
Subgroup 3		15 devices sampled with zero failures 6/
(b) Temp cycling 7/	1010	Condition C, 20 cycles minimum
(c) Constant acceleration 8/	2001	Y_1 orientation only 12/
(d) Seal - fine and gross 9/	1014	Reject criteria per test method
(e) Electrical measurements 1/ and 2/ a. Subgroups 1, 2, and 3 of Table X, Method 5008	5008	Read and record

Notes:

1/ Parameters as called out in MIL-STD-883, Method 5008 for Class K and:
- a. The Class K slash sheet if released.
- b. The Class H slash sheet if released.
- c. The most similar Class K family device slash sheet if there is no detail Class K slash sheet.
- d. The most similar Class H family device slash sheet if there is no detail Class H slash sheet.

TABLE B-2b. MIL-H-38534 Class H Hybrid Lot Acceptance Testing (Sample as Specified), Test Methods of MIL-STD-883 (Page 2 of 2)

Notes (Cont):

2/ Two correlation samples shall be used to verify functionality of all Automatic Test Equipment (ATE) and bench testing equipment. Correlation units shall be tested prior to any electrical testing. All parameters specified in the applicable detail slash sheet, as determined in note 1/ above, shall be read and recorded. If correlation units are not available, they may be removed from the lot being processed. Correlation units shall be controlled by the contractor for future upgrade screening.

3/ A 340 hour intermittent operating life test per MIL-STD-883, Method 1006 and the applicable slash sheet may be performed in lieu of steady state life.

4/ Internal water-vapor testing may be performed as part of the DPA.

5/ Life test samples tested at temperatures below the maximum specified junction temperature, meeting all acceptance criteria, and not subjected to the destructive testing of Subgroup 1, test (b), Internal Water Vapor, and/or Subgroup 3, test (b), Temperature Cycling may be used in flight hardware with contractor's approved PMP Control Plan.

6/ Resubmission of a failed lot shall be permitted one time only using double the sample size with zero failures allowed. Parts passing the first test shall not be included in the resubmission sample without contractor's approved PMP Control Plan.

7/ Temperature cycling may be performed as part of 100% testing with 10 thermal cycles performed to test Condition C of MIL-STD-883, Method 1010.

8/ Constant acceleration may be performed as part of 100% testing with 10 thermal cycles performed to test Condition C of MIL-STD-883, Method 1010.

9/ Seal leak and electrical testing need not be performed if thermal cycling and constant acceleration are performed as part of 100% screening.

10/ Test Condition as specified in the applicable detailed slash sheet as determined in note 1/ above. Test conditions A, B, C, and F of Method 1005 shall not apply.

11/ Post burn-in electrical rejects from the same inspection lot may be used for all subgroups when end-point measurements are not required.

12/ Test condition A of MIL-STD-883, Method 2001

TABLE B-2c. MIL-H-38534 Class H Hybrid Destructive Physical Analysis (DPA)

DPA per MIL-STD-1580A or approved procedure	Double the sample size All anomalies shall be dispositioned as acceptable or rejectable.
Internal water-vapor content 1/	Per MIL-STD-883, Method 1018. 3 devices sampled with 0 failures or 5 devices sampled with 1 failure. 5,000 ppm max water content at 100°C.

Notes:

1/ Internal water-vapor may be performed as part of Lot Acceptance Testing.

TABLE B-3a. MIL-S-19500 JANTXV Transistor and Diode Upscreening (Test 100%), Test Methods of MIL-STD-750 (Page 1 of 3)

SCREEN	METHOD	REQUIREMENTS 1/
1. Prescreen electricals 3/ & 9/	-	YLN of 2% 11/ Optional but encouraged.
2. Particle Impact Noise Detection (PIND) 6/	2020	Per MIL-STD-883 2/
3. Serialization	-	100%
4. Pre HTRB electrical parameters 3/ & 9/	-	Read and record at 25°C
5. High temperature reverse bias burn-in (HTRB) 10/ & 12/		48 hours minimum at +150°C or the device maximum operating temperature, whichever is lower and at minimum applied voltage as follows:
Reverse bias burn-in (for transistors)	1039	Transistor - 80% of rated V_{CB} (bipolar) or V_{GS} (FET and MFET)
Reverse bias burn-in (for diodes and rectifiers)	1038	Diodes (except zeners of 10 volts or less) and rectifiers - rated < 10 amps at T_C > 100°C - 80% at rated V_B
6. Interim electricals and deltas 3/ & 9/	-	Read and record at 25°C within 16 hours of removal of bias. Percent Defective Allowable: First Pass: 5% or 1, whichever is greater 4/ Second Pass: 3% or 1, whichever is greater 5/
7. Power burn-in 10/& 13/		240 hours minimum per the applicable slash sheet
Burn-in (for transistors)	1039	
Burn-in (for diodes and rectifiers)	1038	

TABLE B-3a. MIL-S-19500 JANTXV Transistor and Diode Upscreening (Test 100%), Test Methods of MIL-STD-750 (Page 2 of 3)

SCREEN	METHOD	REQUIREMENTS 1/
8. Post burn-in electrical parameters and deltas 3/ & 9/	-	Read and record at 25°C within 96 hours of removal of bias. Percent Defective Allowable: First Pass: 5% or 1, whichever is greater 4/
9. Final electricals 3/ & 9/ a. Static Tests Subgroups 2 and 3 of Table III, MIL-S-19500 b. Dynamic Tests Subgroups 4 and 7 Table III of MIL-S-19500	-	All failures must be data logged Electrical testing performed at step 8 does not need to be repeated.
10. Radiography	2076	Optional
11. Seal test (a) Fine 7/ & 8/ (b) Gross	1071	(a) Test conditions G or H, max leak rate = 5 X 10^{-6} atm cc/s except 5 X 10^{-7} atm cc/s for devices with internal cavity > 0.3 cc (b) Test conditions A, C, D, E, or F
12. External Visual	2071	100%

TABLE B-3a. MIL-S-19500 JANTXV Transistor and Diode Upscreening (Test 100%), Test Methods of MIL-STD-750 (Page 3 of 3)

Notes:

1/ Except as stated below, the requirements shall be per JANS requirements of the applicable MIL-S-19500 detail specifications.
2/ Test condition A, multiple pass criteria of MIL-S-19500.
3/ Parameters as called out in MIL-S-19500, Table II, JANS Requirements and:
   a. The JANS slash sheet if released.
   b. The JANTXV slash sheet if released.
   c. The most similar JANS family device slash sheet if there is no detail JANS slash sheet.
   d. The most similar JANTXV family device slash sheet if there is no detail JANTXV slash sheet.
4/ The lot may be automatically resubmitted to a second Power Burn-in or HTRB one-time only without the necessity for MRB approval if the PDA does not exceed 20%. A PDA of greater than 20% shall require lot rejection.
5/ A PDA of greater than 3% on the Power Burn-in or HTRB resubmittal shall require lot rejection.
6/ For all devices with an internal cavity.
7/ Omit this test for painted glass diodes.
8/ Omit this test for metallurgically bonded, double plug diodes.
9/ Two correlation samples shall be used to verify functionality of all Automatic Test Equipment (ATE) and bench testing equipment. Correlation units shall be tested prior to any electrical testing. All parameters specified in the applicable detail slash sheet, as determined in note 1/ above, shall be read and recorded. If correlation units are not available, they may be removed from the lot being processed. Correlation units shall be controlled by the contractor for future upgrade screening.
10/ The order in which Power Burn-in and HTRB are performed may be switched at the contractor's option.
11/ Perform group A, subgroups 2 and 4. This test is designed to evaluate lots for continued upscreening or return to the vendor. A yield loss notification (YLN) of 2% should be imposed as a flag for review and disposition.
12/ Test Condition A of the appropriate test method shall apply.
13/ Test Condition B of the appropriate test method shall apply.

TABLE B-3b. MIL-S-19500 JANTXV Transistor and Diode Lot Acceptance Testing (Sample as Specified), Test Methods of MIL-STD-750 (Page 1 of 2)

SUBGROUP	METHOD	REQUIREMENTS
Subgroup 1		3 devices sampled with 0 failures or 5 devices sampled with 1 failure
(a) MIL-M-38510, Method 5005 Internal water-vapor content 4/	1018 of MIL-STD -883	On cavity devices only. 5000 ppm max water content at 100°C
Subgroup 4		LTPD = 5 over subgroup 4 8/
(a) Electrical measurements 1/ & 2/ a. Subgroups 2 and 3 of Table III of MIL-S-19500	-	Read and record
(b) Intermittent Operating Life	1037	340 hours per the applicable slash sheet
(c) Electrical measurements and Deltas 1/ & 2/ a. Subgroups 2 and 3 Table III of MIL-S-19500	-	Read and record
Subgroup 3		LTPD = 15 over subgroup 3 8/
(a) Temp cycling 3/	1051	Condition C3, 100 cycles minimum
(b) Constant acceleration 5/ & 9/	2006	Y_1 orientation only
(c) Seal - fine and gross 6/	1014	Reject criteria per test method
(d) Electrical measurements 1/, 2/ & 6/ a. Subgroup 2 of Table III of MIL-S-19500	-	Read and record

Notes:

1/ Parameters as called out in MIL-S-19500, Table IVa and:
 a. The JANS slash sheet if released.
 b. The JANTXV slash sheet if released.
 c. The most similar JANS family device slash sheet if there is no detail JANS slash sheet.
 d. The most similar JANTXV family device slash sheet if there is no detail JANTXV slash sheet.

2/ Two correlation samples shall be used to verify functionality of all Automatic Test Equipment (ATE) and bench testing equipment. Correlation units shall be tested prior to any electrical testing. All parameters specified in the applicable detail slash sheet, as determined in note 1/ above, shall be read and recorded. If correlation units are not available, they may be removed from the lot being processed. Correlation units shall be controlled by the contractor for future upscreening.

TABLE B-3b. MIL-S-19500 JANTXV Transistor and Diode Lot Acceptance Testing (Sample as Specified), Test Methods of MIL-STD-750 (Page 2 of 2)

Notes (Con't):

3/ Temperature cycling may be performed as part of 100% testing with 20 thermal cycles performed to test Condition C of MIL-STD-750, Method 1051.
4/ Internal water-vapor may be performed as part of the DPA.
5/ Constant acceleration may be performed as part of 100% screening. If constant acceleration is performed as part of 100% screening, it shall be performed prior to seal leak testing.
6/ Seal leak and electrical testing need not be performed if temperature cycling and constant acceleration are performed as part of 100% screening.
7/ Life test samples tested at temperatures below the maximum specified junction temperature, meeting all acceptance criteria, and not submitted to destructive testing of Subgroup 1, test (a), Internal Water Vapor, of Subgroup 3, test (a), Temperature Cycling may be used in flight hardware with contractor's approved PMP Control Plan.
8/ Reference MIL-S-19500, Table IX for the number of samples required for each specified LTPD. Resubmission of a failed lot shall be permitted one time only. The resubmission sample size shall be the sample size called out in the next lower LTPD for the number of failures experienced during the first submission with zero additional failures or larger sample sizes at the same lower LTPD with total failures between the first and second submission as specified. Parts passing the first test shall not be included in the resubmission sample without contractor's approved PMP Control Plan.
9/ Omit this test for non-cavity devices.

TABLE B-3c. MIL-S-19500 JANTXV Transistor and Diode Destructive Physical Analysis (DPA)

DPA per MIL-STD-1580A or approved procedure	Double the sample size All anomalies shall be dispositioned as acceptable or rejectable.
Internal water-vapor content 1/	Per MIL-STD-883, Method 1018. 3 devices sampled with 0 failures or 5 devices sampled with 1 failure. 5,000 ppm max water content at 100°C

Notes:

1/ Internal water-vapor may be performed as part of Lot Acceptance Testing.

APPENDIX C

ALTERNATE QCI TEST/SAMPLING PLAN

10. SCOPE

This appendix sets forth the requirements for implementing an alternate Quality Conformance Inspection (QCI) test plan and reduced sample size plan which may be applied in lieu of the QCI requirements in the detailed device specification.

20. APPLICATION

This section may be applied to part acquisitions which satisfy the criteria defined below. These requirements supersede the detailed requirements specified in paragraph 4.3 of the individual part sections.

20.1 Supplier. Use of the alternate QCI test/sampling plans specified in paragraph 30 of this section may be used under the following conditions:

a. The product being purchased is manufactured within the United States at a supplier with a current QML/QPL certification for similar product and product technology.

b. The product being purchased is similar in design, materials, and processes to the product listed in the QPL (e.g. die size, die attach, bonding interconnects, etc.).

20.2 Product. Use of the alternate QCI test/sampling plans specified in paragraph 30 of this section may be used under the following conditions:

a. The manufacturer has qualified the product in accordance with the qualification requirements of the part general specification (reduced sample size quantities are acceptable).

b. The contractor has a demonstrated manufacturing history of space quality product of this type.

c. The contractor has qualification and/or lot acceptance data which demonstrates the reliability of this technology from this manufacturer.

d. All product alerts (GIDEP, etc.) applicable to the product in question have been reviewed and dispositioned.

30. ALTERNATE QCI TEST PLAN/REDUCED SAMPLE SIZE PLAN

30.1 Microcircuits per MIL-M-38510.

30.1.1 Reduced Group B Sample Size. For space quality microcircuits the requirements of MIL-STD-883, Method 5005 apply. For reduced sample size group B testing, Table C-1 may be used as an alternate to Table IIA of Method 5005.

30.1.1.1 If valid Group B data per MIL-M-38510 for similar devices fabricated within 6 months to this lot date code is available, only subgroups 1 and 5 per Table C-1 need be performed.

30.1.2 Reduced Group D Sample Size. For space quality microcircuits the requirements of MIL-STD-883, Method 5005 apply. For reduced sample size group D testing, Table C-2 may be used as an alternate to Table IV of Method 5005.

30.1.2.1 If valid Group D data per MIL-M-38510 for similar devices fabricated within 6 months to this lot date code is available, the data may be used as evidence of conformance otherwise use Table C-2.

30.2 Diodes and Transistors per MIL-S-19500.

30.2.1 Reduced Group B Sample Size. For diodes and transistors the requirements of MIL-S-19500 apply. For reduced sample size group B testing, use table IVa of MIL-S-19500.

30.2.1.1 If valid Group B data per MIL-S-19500 is available for similar devices fabricated within 6 months to this lot date code, only Group C subgroup 6 per table V of MIL-S-19500 need be performed.

30.2.2 Reduced Group C Sample Size. For diodes and transistors the requirements of MIL-S-19500, table V apply for reduced group C sample size.

30.2.2.1 If valid Group C data per MIL-S-19500 for QPL devices fabricated within 6 month to this lot date code is available, the data may be used as evidence of conformance. The life tes per 30.2.1.1 shall still be performed.

TABLE C-1. REDUCED GROUP B SAMPLE SIZE (Page 1 of 2)

SUBGROUP AND TEST 1/	MIL-STD-883 METHOD	QUANTITY 3/ USE PARTS FROM PREVIOUS TESTS	FRESH NO. OF PARTS ELEC REJ 1/	FRESH NO. OF PARTS ELEC GOOD	REJECTS ALLOWED
Subgroup 1					
a) Physical Dimensions	2016	---	3		0
b) Internal Water-Vapor Content 12/	1018	3			0
Subgroup 2		--			
a) Resistance to Solvents	2015	---	3		0
b) Internal Visual	2013	2			0
	2014	2			0
c) Bond Strength 4/	2011 Cond D	3			0
d) Die Shear	2019	3			0
Subgroup 3 2/					
Solderability	2003	3			0
Subgroup 4					
a) Lead Integrity	2004 Cond B2	---	2		0
b) Seal 6/	1014	2			0
1) Fine	Cond A or B				
2) Gross	Cond C				
c) Lid Torque 5/	2024	2			0
Subgroup 5 7/ 8/ 13/					
a) Electrical Parameters	per detail spec	5		5	0
b) Steady State Life (1000 hrs. min) 11/	1005 Cond D				0
c) Electrical Parameters	per detail spec	5			0
Subgroup 6 8/ 9/					
a) Electrical Parameters	per detail spec	---		4	0
b) Temperature Cycling	1010-C 100 cycles	4			0
c) Constant Acceleration	2001 Cond E	4			0
d) Seal 6/	1014	4			0
1) Fine	Cond A or B				
2) Gross	Cond C				
e) Electrical Parameters	per detail spec	4			0
TOTAL - 18 10/			8	9	

TABLE C-1. REDUCED GROUP B SAMPLE SIZE (Page 2 of 2)

NOTES:

1/ At vendor's risk, electrical rejects or delta failures may be used for Subgroups 1,2,3, & 4 but must have been processed through all the S level screening requirements of MIL-STD-883, method 5004. Sequence of tests may be altered at vendor's option. To minimize the total sample size requirements, the suggested sequence of subgroup testing is 1a), 4a), 4b), 3, 2a), 1b), 4c), 2b), 2c), 2d). The same four samples may then be used throughout subgroups 1-4 (saving five samples from the total required). Care should be taken in samples selected for tests following test 1b) (internal water-vapor content) in this sequence since the lid puncture may effect the integrity of the seal or the internal cavity. Additional samples may be required to substitute damaged parts.

2/ Subgroup 3 (solderability) shall be performed prior to Subgroup 2 (Resistance to Solvents, etc.) when the same samples are used for both subgroups. LTPD and footnote for Subgroup 3 of Method 5005 Table IIa shall apply.

3/ Quantities stated represent minimum quantities. If larger sample sizes are used, the reject criteria shall not change.

4/ Number of bonds to be pulled shall be equally distributed among the test parts using the quantity/accept no. (based on the number of bonds to be pulled) of MIL-STD-883, method 5005, Table IIa.

5/ Lid Torque test shall apply only to glass-frit-sealed packages.

6/ Test Conditions D and E prohibited.

7/ Unless otherwise specified, all test conditions and end points shall be per the Table I, Group B requirements of the detail specification.

8/ A minimum of 5 samples shall be randomly selected from each wafer lot after successful completion of Group A.

9/ At the vendors option, with written approval from the acquiring activity, Subgroup 5 samples may be used for Subgroup 6.

10/ If the sample options of notes 1/ and 9/ are used the total sample size requirement is nine (9) parts.

11/ The time/temperature regression table (for Class S) of Method 1005 may be utilized, however, the life test temperature shall be the same as the burn-in screen temperature.

12/ Internal water-vapor content test is required only on glass-frit-sealed packages. On other package types the periodic group D test is therefore required, using the same quantity/accept no. samples as identified for this group B test. The internal water-vapor content quantity/accept no. footnote of Method 5005 Table IIa shall apply here.

13/ Read and record.

TABLE C-2. REDUCED GROUP D SAMPLE SIZE. 1/ (Page 1 of 2)

SUBGROUP AND TEST 2/	MIL-STD-883 METHOD-CONDITION	QUANTITY 3/			
		USE PARTS FROM PREVIOUS TESTS	FRESH NO. OF PARTS ELEC REJ 6/	FRESH NO. OF PARTS ELEC GOOD	REJECTS ALLOWED
Subgroup 1 4/ 6/					
a) Physical Dimensions	2016	---	3		0
Subgroup 2 4/ 6/					
Lead Integrity	2004-B2	3 and	2		0
Seal 5/	1014	5			0
a) Fine	Con A or B				
b) Gross	Cond C				
Subgroup 3					
Thermal Shock	1011-B, 15 cycles	---		5	0
Temperature Cycling	1010-C,100 cycles	5			0
Moisture Resistance	1004	5			0
Seal 5/	1014	5			0
a) Fine	Cond A or B				
b) Gross	Cond C				
Visual Examination	1004/1010	5			0
End-Point Elect. Paramtrs	per detail spec	5			0
Subgroup 4					
Mechanical Shock	2002-B	5			0
Vibration, Var. Freq.	2007-A	5			0
Constant Acceleration	2001-E	5			0
Seal 5/	1014	5			0
a) Fine	Cond A or B				
b) Gross	Cond C				
Visual Examination	1010/1011	5			0
End-Point Elect. Paramtrs	per detail spec	5			0
Subgroup 6 4/ 6/					
Internal Water-Vapor Content	1018	---	N/A 10/		
Subgroup 7 6/					
Adhesion of Lead Finish	2025	---	5 8/		0
Subgroup 8 4/ 6/					
Lid Torque 7/	2024	5			0
TOTAL - 15 9/			10	5	

TABLE C-2. REDUCED GROUP D SAMPLE SIZE. (Page 2 of 2)

NOTES:

1/ Footnotes to MIL-STD-883, Method 5005 apply.

2/ Unless otherwise specified, all test conditions and end-points shall be per the Table I, Group D requirement of the detail specification.

3/ Quantities stated represent minimum quantities. If larger sample sizes are used, the reject criteria shall not change.

4/ Data results from Group B samples may be used in lieu of performing Group D, Subgroups 1, 2, 6, and 8 where Group B inspection is being performed on samples from the same inspection lot.

5/ Test Conditions D and E prohibited.

6/ Electrical rejects or delta failures from the same inspection lot may be used provided they have been processed through all the S level screening requirements of MIL-STD-883, method 5004.

7/ To be performed only on packages which used glass-frit seal to lead frame.

8/ At the vendor's option Subgroup 2 samples may be used for Subgroups 7 & 8.

9/ If the sample option of note 8/ is used the total sample size requirement is ten (10) parts.

10/ See Table C-1, Note 12/.

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 and Milssile Systems Center on 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 supersede 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 usually 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 acceptable 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
derating
electrical
electronic
electromagnetic
electromechanical
electro-optical.
in-process controls
JAN Class S
lot
lot conformance tests
parts
qualification
space

CONCLUDING MATERIAL

Custodians
Army - AR
Navy - AS
Air Force - 19
NS - TCM

Preparing activity:
Air Force - 19

Project: 1820-F019

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-STD-1547B	2. DOCUMENT DATE *(YYMMDD)* 921201

3. DOCUMENT TITLE
Electronic Parts, Materials, and Processes for Space and Launch Vehicles

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)* (1) Commercial (2) AUTOVON *(If applicable)*	7. DATE SUBMITTED *(YYMMDD)*

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE *(Include Area Code)*	
SMC/SDFP (Attn: A. WANG)	(1) Commercial (310) 363-3234	(2) AUTOVON 833-3234

c. ADDRESS *(Include Zip Code)*	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT:
PO Box 92960 Los Angeles AFB Los Angeles, CA 90009-2960	Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340