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DEPARTMENT OF DEFENSE HANDBOOK

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

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AMSC N/A **FSC 1820**

FOREWORD

1. This military handbook is approved for use by all Departments and Agencies of the Department of Defense (DoD).
2. This handbook is for guidance only. This handbook cannot be cited as a requirement. If it is, the contractor does not have to comply.
3. This Handbook was developed to aid Designers and Parts, Materials, and Processes (PMP) specialists with the design, development, and fabrication of electronic systems required to have long life and/or high reliability while operating under extreme conditions/ environments of Space and Launch Vehicles. The term “electronic” is used in a broad sense in this handbook and includes electrical, electromechanical, electromagnetic, and electro-optical parts associated with electronic assemblies such as computers, communication equipment, electrical power, guidance, instrumentation, and space vehicles.
4. Analysis of space mission failures and on orbit anomalies by the USAF Space Systems Division revealed that the non-availability 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 had initiated a program, documented in MIL-STD-1546, 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, a standard was developed (MIL-STD-1547) to document the technical requirements for parts, materials, and processes for space and launch vehicles.
5. The objective of MIL-STD-1547 as a parts, materials, and processes control program standard was to ensure a technical baseline in the selection, application, procurement, control and standardization of parts (electrical and mechanical), materials, and processes for space and launch vehicles, to reduce overall program costs, and to improve the reliability of space and launch vehicles.
6. This Handbook was derived from the MIL-STD-1547 and individual piece part specifications in an effort to preserve the known reliability characteristics of space level qualified and flown PMP items which establish the “space quality baseline”. These characteristics are the basis for reliability predictions and part failure prediction models used in MIL-HDBK-217 which may be used as basis for evaluation of new technologies and product improvements. In addition, the individual component Military Specification criteria previously called out in MIL-STD-1547 for individual items will no longer be available since most of these Military Specifications are either changed to Performance Specifications, Test Standards, or canceled.
7. This handbook information is based on the lessons learned from over 30 years of space flight history and provides the basis for estimating of PMP element Application Information, Design and Construction Considerations, and Quality Assurance Provisions for the proposed Design Application.
8. Space and Launch Vehicles are mostly “single string” without redundant systems, except for the most critical components, due to weight and size considerations, and are required to perform to designed specifications every time and cannot be replaced in flight. Any component failures could cause

performance degradation and even mission failure. In today's environment of "faster, better, cheaper", high rate of technological turn-over and obsolescence, and push towards the use of "Best Industry Practices" the system designers and PMP specialists are faced with a real challenge.

9. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving the document should be addressed to SMC/AXMP, 160 Skynet Street Suite 2315, Los Angeles AFB, El Segundo, CA 90245-4683 by using a Standardization Document Improvement Proposal (DoD Form 1426).

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APPENDICES

1.SCOPE

This Handbook was developed to aid Designers and Parts, Materials, and Processes (PMP) specialists with the design, development, and fabrication of electronic systems required to have long life and/or high reliability while operating under extreme conditions/ environments of Space and Launch Vehicles.

1.1 Purpose

The purpose of this handbook is to establish and maintain consistent and uniform methods for development of technical requirements for electronic parts, materials, and processes used in the design, development, and fabrication of space and launch vehicles. It provides a common basis for the estimation of Application Information, Design and Construction Considerations, and Quality Assurance Provisions for the proposed Design Application. It also establishes a common basis for comparing and evaluating of industry practices for related or competitive designs. This handbook is intended to be used as a tool to increase the performance and reliability of the system under design.

1.2 Organization of the Handbook

This Handbook is organized in two (2) major parts: Part One is a general section from par. 1.0 through 5.0 detailing general information about how to use the handbook, applicable documents that are referenced and are an integral part of this handbook, definitions, and general good practices to be considered whenever dealing with PMP; Part Two is the EEE Parts Section which comprises all the specific parts sections. (i.e. Capacitors, Fuses, etc.); Each of the individual Parts Sectiona are further organized into two (2) areas: a General Section detailing all the technologies covered, recommended application and application information for each technology, Design and Construction information for each, and general Quality Assurance provisions for the individual Part Section; the second area contains individual detail sections for each major technology covered by the individual Part Section.

1.3 Application of the Handbook

This handbook is a guide and reference document intended to aid designers and parts engineers in the Parts Design Application Selection, Specification, and Verification for systems intended to be used in Space Flight and Launch Vehicles**.**

2.0 APPLICABLE DOCUMENTS

NONE

3.0 DEFINITIONS

Terms are in accordance with the following definitions:

<u>ACQUISITION ACTIVITY</u> The acquisition activity is the Government office or contractor organization acquiring the equipment, system, or subsystem.

<u>CASE TEMPERATURE</u> The Case Temperature (T_C) is the temperature measured (typically the hottest temperature point found on the mounting surface of the device) on the external surface of the device's package. The T_C is determined in accordance with the applicable specification standard.

<u>CHANGE CONTROL BOARD (CCB)</u> Change Control Board (CCB) is an organization established by the Contractor for managing and control of product changes.

<u>CONTRACTING OFFICER</u> 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.

<u>DERATING</u> Derating of a part is the intentional reduction of its applied stress, with respect to its rated designed stress capabilities, for the purpose of providing a margin between the applied stress and the demonstrated designed limit of the part's capabilities. Typical derating parameters are: applied Voltage, Current, Power, and Operating Temperature. Derating criteria is part type, technology, and design application dependent and is used by the Arhenius Reliability Prediction Model for in system operating life predictions. Therefore, the higher the derating margin the longer the part is expected to operate in the system.

<u>DESTRUCTIVE PHYSICAL ANALYSIS (DPA)</u> 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, to verify part Design and Construction, Workmanship, and Processing controls. 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. Anomalies found through DPA, and determined to have an impact to the part design application, are typically segregated into screenable (this means that the entire lot is subjected to a specified screen(s) prior to part stocking) and unscreenable (which will typically cause lot rejection) anomalies

<u>ELECTRONIC PARTS</u> The term "electronic" is used in a broad sense in this handbook 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.

<u>END-OF-LIFE DESIGN LIMIT</u> 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.

HOT-WELDED CAN A Hot-Welded Can is a cap-sealed component utilizing thermocompression attachment of the cap to the base of the device.

INTEGRATED PRODUCT TEAM (IPT) The Integrated Product Team (IPT) is a formal organization consisting of members from the Contracting Officer representatives, Contractor and Subcontractor representatives established to manage and control the program activities.

MANUFACTURING BASELINE The manufacturing baseline is a detailed description of the manufacturing and of the sequence of operations necessary to produce a specific item, part, or material. The manufacturing baseline includes all associated documentation and revisions, that are 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. Manufacturing Baseline includes a manufacturing process list (identifying each document by title, number, date of issue, applicable revision, and date of revision), the manufacturing sequence (normally in the form of a flow chart), and the manufacturing processes (normally in the form of travelers used for part and lot processing).

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

MATERIAL LOT A lot of 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.

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.

PARTS, MATERIALS, AND PROCESSES CONTROL BOARD (PMPCB) The PMPCB is a formal contractor organization, formally established by contract direction to manage and control the selection, application, procurement, and documentation of parts, materials, and processes used in equipment, systems, or subsystems.

PERCENT DEFECTIVE ALLOWABLE (PDA) The Percent Defective Allowable (PDA) of a production lot of parts or materials 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.

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

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, and 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.

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.

RELIABILITY SUSPECT PMP A reliability suspect PMP is a part, material, or process that has been determined from past performance data, analysis, and other industry sources to have special reliability and quality concerns that could affect its performance in the intended design application.

SPACE QUALITY PMP A space quality PMP is a part, material, or process, of the same quality and reliability, produced on the same production line, by the same vendor and of the same design and construction, previously qualified and flown under the same or more stringent space applications.

CONTRACTOR The term “contractor” signifies a producer of modules or higher level items of equipment. A contractor that provides items to another contractor can be identified as a “subcontractor”. Some system programs have one major contractor identified as a “prime contractor”, which is responsible directly to the acquisition activity. Other programs may have two or more major contractors, each responsible directly to the acquisition activity (neither one subordinate to the other), which are called “associate contractors”. In the case of programs with associate contractors, the acquisition activity may designate one associate contractor as responsible for managing the program Parts, Materials, and Processes Control Program.

COMMERCIAL - OFF - THE - SHELF (COTS) A commercial off-the-shelf (COTS) item is an item which has been produced to military or commercial standards and specifications, is readily available for delivery from a commercial source, is defined by an existing specification, and may be acquired without change to satisfy a military requirement.

ELECTROSTATIC DISCHARGE (ESD) A transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by electrostatic field.

SCREENING Screening is defined as a stress test or series of tests, (electrical, environmental, mechanical and or combinations thereof), imposed on 100% of the parts and or materials for the purpose of defect elimination.

QUALITY CONFORMANCE INSPECTION (QCI) Quality Conformance Inspection is defined as a stress test or series of tests, (electrical, environmental, mechanical and or combinations thereof), imposed on a sample of the parts and or materials from a lot, for the purpose of lot integrity and performance verification.

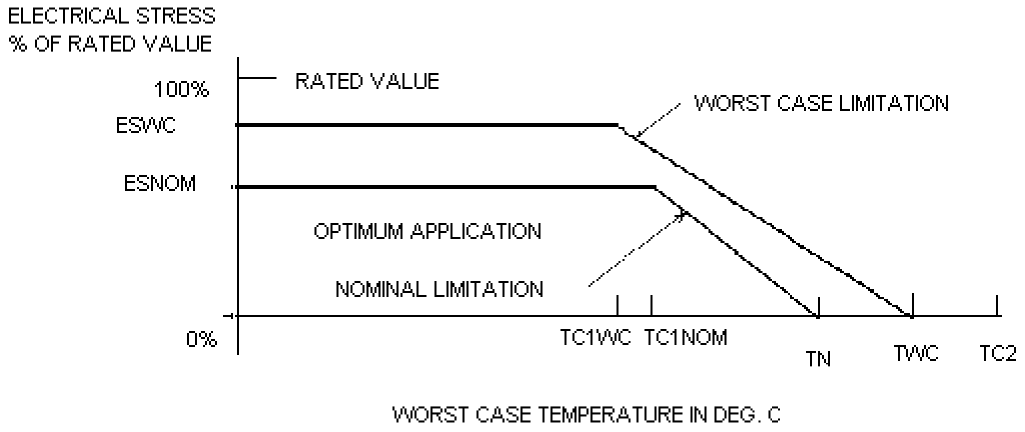
4.0 GENERAL CONSIDERATIONS

4.1 General The information covered by this section on space quality electronic parts, materials, and processes is categorized in four major areas covering the general application, design and construction, and quality conformance considerations that are applicable to all parts, materials, and processes as applicable. This information is based on proven track record of the past specified requirements over 30 years of space applications history and lessons learned. The application area includes derating, end-of-life limitations, mounting recommendations, and other design considerations intended to ensure the high reliability of the parts when used in space and launch vehicle applications. The design and construction, and the quality assurance considerations provide information that supersedes or supplement the referenced general military specifications to ensure their performance and necessary quality for space and launch vehicles applications. These design, construction, and quality assurance considerations have traditionally provided the basis for individual parts specifications and performance requirements developed by the contractors for space quality PMP types when Space Qualified PMP were not available. The Contractor, however, can provide alternative solutions based on specific designs and data which validate the proposed solutions.

4.2 Application Considerations

4.2.1 Electrical derating. Circuits are 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 operating temperature. The general interrelationship between electrical stress and temperature is shown in Figure 4-1. The optimum operating conditions lie within the area below the nominal limitation line (ES_{NOM}). 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.

4.2.2 Mechanical derating. Mechanical designs, much the same as electrical and electromechanical designs, require adequate mechanical stress margins for the intended application to sustain long-life performance in associated equipment over the specified design life. These margins are obtained through derating of parts' and materials' mechanical design characteristics and properties associated with environments such as shock, vibration, acceleration, and temperature that produce force-function effects on flight hardware. Strength margins (or derating criteria) are based on mechanical property data from MIL-HDBK-5 where applicable, and delimit susceptibility to mechanical failure modes such as bending, deformation, fracture, rupture, excessive deflection, and fatigue. Functional margins should be calculated based on the recommendation of MIL-A-83577 wherever possible.



Where:

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

TC_2 = Maximum allowable Case Temperature per detailed specification, based on the part design.

T_N = Nominal boundary limitation. Typically $T_N = T_{WC}$-10°C. Other temperature deltas may be given in the detail specification.

T_{WC} = Worst case thermal boundary. Typically $T_{WC} = T_{C2}$-30°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

4.2.3 End - of - life. Circuit design criteria needs to be robust such that the required functional performance is maintained, even if at the component level, the performance values of the parts used vary within the identified end-of-life design limits. The detail sections of this handbook provide the 10 year end-of-life parametric limits for each product type, based on proven device characteristics, and should be used as a guide whenever specific end - of - life limits are determined. The end - of - life design limits are based on sound engineering for component level performance to provide the required system level performance.

4.2.4 Aging sensitivity. Electrical, Electronic, Electromagnetic, Optical, and Mechanical parts and materials are considered aging sensitive when they are subject to gradual shortening of their useful life or degradation of their performance parameters over time. Aging mechanisms include the following: Loss of hermeticity, Stress relaxation, Oxidation, Electromigration, Hot carrier degradation, Corrosion, Outgassing, Cold flow and Creep, Loss of adhesion, Embrittlement and Hardening, Loss of Torque, Loss of Spring Tension, Increase in component Current Leakage, Breakdown Voltage and Forward conduction degradation, Annealing etc. Aging sensitivity effects should be taken into account in the design, selection, monitoring procedures, stocking, kitting, and application of parts and materials.

4.2.5 Aging sensitivity monitoring Typical procedures used for monitoring of Aging Sensitive PMP items include the following: Shelf Life Control program, Periodic stock recertification and testing, First In First Out, Lot Date Code limitation at Kitting, Storing environments controls, etc.

4.2.6 Sealed packages. Hermetically sealed parts are preferred for use in space and launch vehicles for their stability and robustness. If non-hermetically sealed parts are selected, careful consideration should be given to the following factors: in-process assembly and cleaning operations are not detrimental to the parts, the part outgassing, sublimation, moisture penetration, and or moisture absorption are adversely affecting the system and the part in its intended application.

4.2.7 Registered PMP. This is a leftover from MIL-STD-1547 and is provided for reference to aid designers and parts engineers with understanding of the traditional space level components requirements. The detailed sections of this handbook identify known registered PMP, their applications and their procurement restrictions. The contractors should identify how various restrictions are mitigated whenever components of this type are used in the design.

4.2.8 Reliability suspect PMP. The detailed sections of this handbook identify known reliability suspect PMP designs, their applications and their procurement restrictions. In addition, all parts containing desiccants and organic materials, dissimilar metals such as Au-Al, Al-Ag, Cadmium plating, Pure or unfused Sn, Teflon, and more than 5000ppm of moisture have been traditionally considered reliability suspect for use in space application.

4.2.9 Handling of electrostatic-sensitive items Protection against electrostatic damage to electrostatic sensitive devices is established through development of Electrostatic discharge (ESD) control program for the protection of electrical and electronic parts, components, assemblies, and equipment in accordance with MIL-STD-1686. DOD-HDBK-263 may be used for guidance in establishing an ESD control plan.

4.2.10 Marking The marking will be in accordance with the applicable military specification and contractor's established control procedures for the use and tracking of individual PMP items in the design.

4.2.11 Installation and mounting Parts and Materials could be damaged during the system manufacturing (assembly and test) by the thermo-mechanical stresses. It is therefore, recommended that these stresses be minimized through design, use of appropriate mounting techniques, and optimum processes. Mechanical stresses due to dissimilar materials joined together should also be compensated for by the design.

4.2.12 Outgassing. The outgassing requirements for materials and finishes of space and launch vehicles are documented in NASA specification SP-R-0022. Total mass loss (TML) (due to outgassing) of not more than 1.0 percent and a collected volatile condensable material (CVCM) of not more than 0.1 percent when tested in accordance with ASTM E 595 is recommended. 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 are acceptable.

4.2.13 Alternate qci test/sampling plan. An alternate QCI test/sampling plan is documented in appendix C of this Handbook

4.2.14 Space quality part characteristics The characteristics required for specific part types that allow them to be of space quality are stated in subsequent detailed part type sections of this handbook. The applicable Military Specification Requirements are identified in the detailed requirements section for each part type. NOTE: The referenced Military Specifications are of the revision in effect in through end of 1995 and their current revisions may not reflect the same requirements. PMP items manufactured may not meet the original qualified levels.

4.2.15 Conformal coatings. The Conformal Coatings and acceptance criteria used on the printed wiring boards that were qualified for space application are documented in MIL-STD-275 and below:

a To prevent stressing solder joints, the underside of components spaced off the printed wiring board should not bridge between the printed wiring board surface and the part(s) leads.

b Visual criteria for the conformal coating should reject any blisters, cracking, crazing, peeling, wrinkles, mealing, and evidence of corrosion. In addition, a pinhole, bubble or combination that bridge more than 50% of nonconnecting conductors can be reworked.

c Other than Type AR (MIL-I-46058) and solvent removable parylene (paraxylene) coatings, only mechanical removal means are recommended to be used during rework.

4.2.16 Reuse of parts and materials Installed Parts and Materials are not recommended to be reused if they have been completely removed from the assemblies due to high risk of part and/or material damage during the disassembly and the subsequent reassembly process. Contractor could, however, qualify the methodology it the high price associated with the qualification process is offset by other factors such as frequency of occurrence, etc.

4.2.17 Rework and repair considerations All rework and repair procedures that are used in the assembly manufacturing process should consider and incorporate the allowable practices specified in individual Military Specification for each part and material subjected to rework or repair. Whenever possible, the contractor should actively pursue the elimination of the frequent rework and repair activities through process improvements in order to minimize the end item performance variations.

4.3 PART DESIGN AND CONSTRUCTION

4.3.1 Design and construction. Traditionally, the Parts Design and Construction was required to be in accordance with the applicable Military Specification requirements for JAN Class S level which was the level of parts established to meet most space applications needs. Therefore, whenever these parts were not available as JAN Class S and the detail Military Specification did not have a JAN Class S criteria, the Military Specification JAN Class S criteria for the nearest part of the same family or technology was followed, and the design activity provided rationale and technical documentation illustrating their capability to meet the program's technical requirements. It is understood that under the current economic environments these types of components may not be available for use. However, under these conditions it is the contractor’s responsibility to ensure through sound engineering that the selected components are of a design and construction suitable and reliable for the intended application.

4.3.2 Material hazards. Reliability and Safety considerations require Mechanical and Electronic parts to 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. The contractor should take these elements into consideration as well as the long term storage, and storage environments associated with space systems, when selecting PMP items for the application.

4.3.3 Tin-coated surfaces. Mechanical and electronic parts with internal and or external surfaces coated with a pure unfused tin plating have been determined to be “Aging Sensitive” and Reliability Suspect due to high potential of Tin Whisker growth under certain environments which are capable of shorting out electronic circuitry. However, a tin alloy plating containing a minimum of 2 weight percent of a second element (i.e. 98% Sn, 2% Pb) has been determined to inhibit and prevent the formation and growth of tin whiskers. This phenomenon does not apply to drawn wire products, such as cables.

4.3.4 Processes and controls. Performance reliability of parts and materials depend first on their design robustness for the intended application, and second on the manufacturing processes and their controls used in the manufacture of parts and materials. A great emphasis has been put over the years on Statistical Process Controls (SPC), Statistical Experimental Design methodology, Taguchyi/ Deming methodologies, and other techniques for process development and control that could be effectively employed on high volume and continuous flows production lines. While the utilization of these methods are always encouraged, the part and or material design capabilities need to be reviewed carefully, since all of the above methods will only provide consistence in performance to the part and material design capabilities. Therefore, the process controls cannot be substituted for poor designs nor can the design be substituted for poor processes and controls.

Majority of the Military Specifications that govern each material and part technology type have been or are in the process of being transformed into Performance Specifications which pay close attention and emphasize the use of controls, such a those mentioned above, in an effort of maintaining a continuous product improvement, take advantage of industry practices developed for the High Volume and Continuous Flow Product Lines, and minimize the costs associated with specialty items. The part and material manufacturer should follow all the processes and processing controls that ensure the reliability and quality required, as delineated by the Military Specifications or accepted Industry Specifications which govern the part and material technology. These manufacturing processes and controls should be fully documented in a sufficient detail to provide a controlled manufacturing baseline for the manufacturer which ensures that subsequent production items can be manufactured and are equivalent in performance, quality, dimensions, and reliability to initial production items used for qualification or for flight hardware. This documentation should 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 should 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.

4.3.5 Rework during manufacture of materials and parts. All rework performed during the manufacture of materials and parts should follow the acceptable procedures and controls that are documented within the Military Specification and or Industry Specifications governing the individual part and material technology. Except as may be allowed by the detailed requirements section for each specific electronic part, rework during manufacturing is not recommended.

4.3.6 Design and construction limitations It is recommended that the design and construction, for the parts proposed for use in space applications, be validated for the intended application and any known limitations (from past history with the same or similarly constructed parts in similar applications) be mitigated either through design and or test methods.

4.4 QUALITY ASSURANCE PROVISIONS

The elements outlined below are characteristics that have to be considered of a space level PMP. Although their implementation is PMP technology and vendor specific, there are some common characteristics that if met the success of the part and or material in the system application is greatly enhanced. The elements outlined are included to establish a baseline for the past requirements imposed by the contract on the PMP items, and to explain their importance and effects on the space level PMP.

4.4.1 Produceability and baseline controls. Traditionally a great emphasis has been placed on PMP documentation control, especially for space level applications, since often the parts and materials were tested and exercised for the first time in the actual application and minimizing the risk of failure was key to successful space system. Also, since the parts and materials used for space applications were procured in small quantities, often processed in batches with tight controls, it became important to document the manufacturing methodology for future reference. Baseline documentation is a complete set of manufacturing and testing documentation maintained by the vendor, often also bought and delivered to the contractor, for a particular part or material. This documentation should cover all the revisions and the sequence of processing for the item. Major changes are validated prior to implementation, and the contractor is notified, while minor changes without impact to form, fit, function, or reliability are implemented.

4.4.2 Recommended process controls Traditionally, space level PMP were sought to have the tightest and highest process controls possible for each part and or material. These controls were documented in the applicable military specification for space level of each item. With the shrinking of space level parts and materials market share and perfection of high volume production controls for commercial product lines, it is recognized that the space level parts and materials of the past will not be available in the future and the contractors will be forced to use parts and materials from product lines such as commercial, third party assembly etc. The following is therefore a criteria that could be used to validate these controls:

4.4.3 Homogeneity Lot homogeneity is a key characteristic of good processing and controls, and it evaluates device to device, or batch to batch of materials variation. Therefore, the manufacturer's controls for maintaining product homogeneity need to be validated.

4.4.4 Production lot Production lot definition varies from manufacturer to manufacturer and from product type to product type but is typically defined as a group of parts or materials that are processed together and carry a unique identifier for future reference and lot traceability. Most manufacturers controls and verification methodology are based on and assume that production lot is homogeneous.

4.4.5 Traceability control for parts, materials, & processes The manufacturer should maintain good traceability records for all parts and materials to Incoming Receiving Inspection, and good change control traceability for processes, to allow for feedback on product performance as necessary.

4.4.6 Rework provisions The manufacturer's processes should be optimized and little or no rework should be allowed by the manufacturers processes that would affect the parts or materials homogeneity.

4.4.7 Process controls verification & validation The manufacturer should have a proven and documented system for process verification and validation that insures the part or material performance.

4.4.8 Screening tests (100%) The production lot, when subjected to 100% screening tests, should meet the accept reject criteria established for performance degradation allowed, Max. Percent Defective Allowed, etc. The established performance requirements should be consistent with the intended application for the product type which are outlined in specific sections of this handbook. NOTE: The screening is not designed to build the quality into the product, and should not be used as such, but instead the screening is designed to screen out the infant mortality defects. As the processes improve, the tendency by the manufacturers is to eliminate the screening tests completely without continuous verification that each subsequent production lot consistently meets the performance requirements. It is therefore, recommended that production lots are subjected to the recommended screens in this handbook.

4.4.9 Lot conformance tests (destructive & non-destructive tests) Lot conformance testing should be performed on each production lot as a basis for final lot acceptance after it has successfully passed the in-process controls and screening tests. The recommended tests are defined in each individual section of this handbook and were designed to verify a product's performance for the widest possible usage.

4.4.10 Qualification tests (destructive & non-destructive tests) The Part Qualification testing requirements provided in the Military Specifications and in individual sections of this handbook are based on lessons learned and maximum functional and environmental limits of the specific part type to ensure the widest possible usage of the part. The qualification testing required by these specifications is specific to each manufacturer by product line, facility, and part number. However, radiation or other environments associated with specific space applications may not be stated in the military specifications for the parts, or the expected environments may be more severe than the standard levels specified for qualification testing of that part type. In those cases, qualification testing should be based on the actual environments associated with the specific space application, and the qualification test levels should be raised to levels above the maximum predicted usage levels to provide an appropriate margin for derating. The following provide different methods for part qualifications:

> New Part Type Qualification: This covers new part types, new technologies, or new vendors for an existing part type, and major design changes (that affect form, fit, function, or reliability) to an existing part type without any previous space usage. The qualification is established by the satisfactory completion of the established qualification tests that follow the rules outlined above.
>
> Existing Part Types: This covers existing part types and existing technologies from existing vendors, product lines, and facilities with a previous record of identical or more severe high reliability performance in space vehicle applications for which previous qualification is still valid. For existing part types with a previous record of less severe space application, the part should be qualified for the intended application.

4.4.11 Parts and materials data retention The contractor should have a method for retention of data generated for the parts and materials procured for the system for future risk assessment and technical evaluation as needed. In addition the contractor may consider retaining any or all of the destructive and non-destructive qualification samples which could be used for future validation of parts and or materials performance under certain conditions not previously accounted for.

4.4.12 Parts and materials storage and stocking The parts and materials storage and stocking practices should take into consideration the following elements: shelf life control and recertification of parts and materials, special packaging and handling consideration that may be required, inventory control and kitting practices, and parts and materials traceability.

SECTION 100 BOARDS, PRINTED WIRING

1.0 Scope

1.1 This section contains information for Printed Wiring Boards (PWB), application and handling, design and construction, and quality assurance provisions.

2. Application

2.1 It is recommended that the design and fabrication criteria of MIL-STD-275, MIL-P-55110 be followed for the rigid Printed Wiring Boards, and MIL - STD - 2118 and MIL-P-50884 for the Flexible and Rigid-Flex Wiring, that are intended to be used in the space applications. Table 100-1 covers the Types of printed wiring boards covered in his section.

TABLE 100-1 Printed Wiring Boards (PWB)

TYPE	DESCRIPTION
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)

2.2 **Derating** Although there is no derating criteria per se, for PWBs, there some areas that need to be considered.

Current density(i) through any trace or via should not exceed the criteria of MIL-P-55110.

Component Density The board population should be such that any hot spots due to individual components power dissipation does not cause components to operate in excess of the recommended operating temperatures.

2.3 Raw Material Storage

Laminate. It is recommended that Laminates are stored flat in a cool dry environment and are supported over their entire surface area to prevent bow and twist. Also, the corners should be protected to prevent crimping.

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

2.4 End of Life Considerations The end of life considerations are associated with the system design and component types that populate the boards. Assuming that sound engineering principles were followed through out the design and manufacturing processes the individual components end of life considerations should suffice.

2.5 Aging Sensitivity Follow the items outlined in the MIL-P-55110 and Tables 100-2 and 100-3.

3. DESIGN AND CONSTRUCTION

3.1 Rigid Printed Wiring Boards. Past history has shown that the primary failure mechanisms associated with the Printed Wiring Boards are due to the plated through hole contacts and barrel plating anomalies. Therefore, the criteria included below outlines some practices learned from past history. It is assumed that all rigid printed wiring boards with plated-through holes are in accordance with MIL-P-55110 and MIL-STD-275. Additional elements above and beyond the MIL-P-55110 and MIL-STD-275 are identified in TABLE 100-2.

TABLE 100-2: Design and Construction Considerations

Consideration	Mitigation Strategy	Rationale
Nonfunctional Lands (Internal Layers)	Nonfunctional lands are recommended to be included on internal layers of multilayer boards whenever clearance requirements permit.	
Surface Mount Lands	Recommended that surface mount lands meet a 500 psi of vertical pull 90 degrees to the board surface (tension) after being subjected to the five cycles of soldering and four cycles of desoldering, per IPC-TM-650 Method 2.4.21.	Space applications often require that systems survive high vibration, shock, and pull requirements which are above and beyond the capabilities of normally designed PWBs containing surface mount components.
Etchback	Etchback, of typically between 0.0005" minimum and 0.002" maximum, or equivalent processes proven to ensure complete resin smear removal from the holes of multilayer boards prior to plating are recommended.	This practice has been successful in minimizing the subsequent problems such as open or intermittent open contacts etc. that could result from poor plating coverage.
Flammability	Only flame-retardant material is recommended to be used for the construction of printed wiring boards	Fire prevention
Drill Bit Limit	Recommend that the PWB design is within the board manufacturer developed and maintained matrix, which identifies the optimum number of drill hits allowed for the specific types of materials, number of layers, and hole diameters to be used.	Prevent cracking, crazing, and other premature board failure.
Drilling Roadmap	Drilling of the panel should be such that drilling begins and ends in a coupon associated with each printed wiring board.	The coupons are used to validate the integrity of the boards. This allows for verification of drill bit integrity for the entire PWB.
Drill Changes	Drill bit changes should be documented (either on drill tape or digital storage medium). Do not resharpen the drill bits	

TABLE 100-2: Design and Construction Considerations (cont.)

Consideration	Mitigation Strategy	Rationale
Stacking	Do not stack multilayerred boards or more than two panels for double sided plated through hole boards when drilling holes.	
Solder Mask	Solder mask should meet the IPC-SM-840 class III and the vacuum stability specified in General Section of this handbook.	To meet the outgassing criteria
Tin-lead Plating	Recommended Tin-lead plating thickness is 0.0003" (0.001" and 0.002" before fusing on the surface mount boards to be processed by solder reflow) minimum. No solder plate on any surface which is to be laminated to an insulator, metal frame, heatsink, or stiffener should be allowed. Plating thickness and quality may be verified through coupons.	To provide good connections and to prevent any shorts or intermittent shorts that could cause latent board failure.
Fusing	Limit to one fusing operation, whether or not the fusing process heats one or both sides of the board for all PWBs after solder plating and other processes. Record the fuse time and temperature in accordance with the proven manufacturer's processes. After fusing and touch up, the solder coating should 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	Prevents solder embrittlement, uneven solder flow, development of cold joints, etc.
Ductility	Verify that the as-plated copper meets a minimum of 12% elongation factor on consistent basis typically once per week or in accordance with the manufacturer's proven procedures.	Process control verification to prevent plating solutions contamination and deterioration.

TABLE 100-2: Design and Construction Considerations (cont.)

Consideration	Mitigation Strategy	Rationale
Copper Lamination	Copper traces for mulilayer boards are recommended to be treated or primed prior to lamination. Subjecting the layers to a copper oxidation process has proven to be successful.	To increase the laminate bonding and prevent layer blistering and delamination
Ground Planes	Position large conductive areas such as ground planes close to the board midpoint thickness. When more than one ground plane is required, position them in layers that are equidistant from the midpoint.	To equalize the distribution of conductive areas in a layer and the distribution of conductive areas among layers.
Electrical interface Terminals	Mount terminal into a non-current carrying plated through hole and make the electrical connection using a redundant wire connecting the terminal to an adjacent current carrying plated through hole. An alternate to redundant wiring is step soldering of the terminal to the printed wiring board to preclude solder reflow during subsequent soldering operations or incorporate small redundant via holes adjacent to the terminal holes with both holes connected at all interfacial layer.	

3.2 Metal Core Boards. For metal core boards, follow the ANSI/IPC-CF-152 criteria for fabrication and design. Table 100-3 outlines additional criteria..

3.3 Flexible Wiring. For flexible printed wiring follow the MIL-P-50884 for fabrication and MIL-STD-2118 for design criteria. The etchback considerations outlined in Table 100-2 is also applicable to flexible wiring.

TABLE 100-3: Design and Construction Considerations (Metal Core PWBs)

Consideration	Mitigation Strategy	Rationale
Fabrication and design Dielectric spacing	ANSI/IPC-CF-152 Dielectric spacing between the metal core and adjacent conducting surfaces should not have more than 1µA at 750V when tested in accordance with IPC-TM-650, Method 2.5.7.	Prevents flashover, arcing, breakdown or leakage exceeding one microampere between conductive areas which could cause board failure at elevated altitudes, elevated temperatures, and high moisture environments.

4. QUALITY ASSURANCE Quality assurance provisions of MIL-P-55110, General Requirements of Section 4 and the additional criteria should be followed:

   Qualifications. The manufacturer should be certified to MIL-P-55110. Board qualification tests are not appropriate since the manufacturer should be a qualified MIL-P-55110 supplier and the populated boards are typically qualified at the assembly level.

   In-process Controls. In-process controls should be adequate to provide the quality of the PWBs needed for the application. The criteria outlined in MIL-P-55110, MIL-STD-275, should be followed for the rigid Printed Wiring Boards, and MIL - 2118 and MIL-P-50884 for the Flexible and Rigid-Flex Wiring, with the additions outlined in Table 100-4 herein.

   Screening (100 percent). 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 recommended on internal layers both prior to lay up and at the completed bare board level. Electrical isolation should be established by hi-pot testing, minimum 1500 volts.

   Lot Conformance Tests. In accordance with the general requirements of Section 4 and the requirements of MIL-P-55110. All deliverable coupons, specified in TABLE 100-4 herein, are sectioned, mounted, and inspected to verify that all applicable requirements have been met.

5. REGISTERED PMP

   Reliability Suspect Designs. Rigid-flex wiring board have been determined to be reliability suspect.

6. PROHIBITED MATERIALS LIST Pure Tin or unfused Tin plating are should not be used due to their tendency of Tin whisker growth under certain environments.

TABLE 100-4: Quality Assurance and Processing Considerations

Consideration	Mitigation Strategy	Rationale
Nonfunctional Lands (Internal Layers)	Verify nonfunctional lands are included on internal layers of multilayer boards whenever clearance requirements permit.	
Surface Mount Lands	Test a minimum of three surface mount lands; verify they meet 500 psi of vertical pull 90° to the board surface (tension) after being subjected to the five cycles of soldering and four cycles of desoldering, per IPC-TM-650 Method 2.4.21.	Space applications often require that systems survive high vibration, shock, and pull requirements which are above and beyond the capabilities of normally designed PWBs containing surface mount components.
Etchback	Verify etchback, of 0.0005" min. and 0.002" max., or equivalent processes is used to ensure complete resin smear removal from the holes of multilayer boards prior to plating.	This practice has been successful in minimizing the subsequent problems such as open or intermittent open contacts etc. that could result from poor plating coverage.
Flammability	Only flame-retardant material is recommended to be used for the construction of printed wiring boards	Fire prevention
Drill Bit Limit	Verify the PWB design is within the board manufacturer developed and maintained matrix, which identifies the optimum number of drill hits allowed for the specific types of materials, number of layers, and hole diameters to be used.	Prevent cracking, crazing, and other premature board failure.
Drill Changes	Recommend that all drill bit changes are documented. Documentation may be in the form of a drill tape or any digital storage medium. Resharpening of drill bits should not be permitted.	Critical process control targeted to minimize board damage due to inner layer cracking, tearing, or metal trace disturbance.

TABLE 100-4: Quality Assurance and Processing Considerations (cont.)

Consideration	Mitigation Strategy	Rationale
Drilling Roadmap	Drilling of the panel should be such that drilling begins and ends in a coupon associated with each printed wiring board.	The coupons are used to validate the integrity of the boards. This allows for verification of drill bit integrity for the entire PWB.
Stacking	Stacking of more than two panels should not be permitted when drilling holes that are to be plated-through for double sided boards. Stacking of multilayered boards is not recommended.	Causes misalignment, uneven hole diameters, board cracking etc.
Solder Mask	Solder mask should meet the IPC-SM-840 class III and the vacuum stability specified in General Section of this handbook.	To meet the outgassing criteria
Tin-lead Plating	Recommended Tin-lead plating thickness is 0.0003" (0.001" and 0.002" before fusing on the surface mount boards to be processed by solder reflow) minimum. No solder plate on any surface which is to be laminated to an insulator, metal frame, heatsink, or stiffener should be allowed. Plating thickness and quality may be verified through coupons.	To provide good connections and to prevent any shorts or intermittent shorts that could cause latent board failure.
Fusing	Recommend only one fusing operation, whether or not the fusing process heats one or both sides of the board for all PWBs after solder plating and other processes. The fuse time and temperature should be recorded and in accordance with the proven manufacturer's processes. After fusing and touch up, the solder coating should 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	Prevents solder embrittlement, uneven solder flow, development of cold joints, etc.

TABLE 100-4: Quality Assurance and Processing Considerations (cont.)

Consideration	Mitigation Strategy	Rationale
Ductility	Verify the board manufacturer copper plating meets a minimum of 12% elongation factor on consistent basis. Once per week and the rotating cylinder method have been used traditionally.	Process control verification to prevent plating solutions contamination and deterioration.
Process-control Coupons	Recommend the board manufacturer uses the process control coupons as the means for verification and validation of their processes. The process control coupons number to be used per panel should be derived by the manufacturer based on proven methodology. The coupons may be deliverable to the contract or maintained on file by the board manufacturer.	Provide the means for board process verification and validation at future date. The coupons are often used in Failure Analysis for board processing verification, thus saving the much more expensive boards from being destroyed unnecessarily.
Solder Plate Coupons	Remove the solder plate coupons from each board prior to fusing to verify the plating thickness and quality prior to fusing operation.	Independent means for verification of solder plating prior to fusing, used by the contractor as point of reference for incoming receiving inspection, process validation, etc.
Deliverable Coupons	Provide two deliverable A or B coupons, suitable to monitor the processes involved, per board for double-sided and multilayer PWBs, or two deliverable coupons per 150 square centimeters (24 square inches) of panel area, whichever is less for small board sizes.. These deliverable coupons are in addition to the process-control coupons required for each panel. All coupons need to be completely processed with the deliverable boards. For each panel, at least one of these deliverable coupons needs to be break away (partially routed) and delivered attached to a production board on that panel.	The coupons are key to process verification and therefore, their location selection is very important; The following locations have proven to be acceptable; 1st on the panel in positions across the diagonal of each board. 2nd 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)

TABLE 100-4: Quality Assurance and Processing Considerations (cont.)

Consideration	Mitigation Strategy	Rationale
Marking	Mark individual boards and each set of quality conformance test circuit strips, and individual coupons 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. The date code is the date of final copper plating and is formatted as follows: <u>Year</u> <u>Day of year (from 1 January)</u> 90 001	
Traceability	For traceability, it is recommended that each quality conformance test circuitry and all separated individual coupons are identifiable with those corresponding production boards produced on the same panel. Traceability should include all boards and coupons position on the panel, the exact disposition of each board, and documentation with the reason for rejection for the rejected boards.	
Storage and Retrievability	All deliverable coupons should be stored and be readily retrievable for the life of the contract.	
Qualification	The qualification should be based on the higher assembly levels qualification tests only, if the manufacturer is certified and qualified to MIL-P-55110.	

SECTION 200 CAPACITORS, INTRODUCTION

1.0 Scope

This section sets, forth common information for capacitors. Table 200-1 lists, by dielectric type, the capacitor styles included in this section and the applicable section in this handbook where the specific detailed information is located.

Table 200-1 Capacitor Styles Included in Section 200

Section	Dielectric Material	Ref. Specification	Style
210	Ceramic	Mil-C-123, MIL-C-4967	CKS, HVR
230	Metallized/Nonmetallized Film	MIL-C-83421/1, /2, /3, /4, MIL-C-87217, & MIL-C-19978	CRH, CRS, CHS, & CQR
240	Glass & Mica	MIL-C-23269, MIL-C-87164	CYR,
260	Tantalum Foil	MIL-C-39006	CLR
270	Solid Tantalum	MIL-C-39003 /1, /6, /10, & MIL-C-55365	CSR, CSS, & CWR
	Wet Tantalum-Tantalum Case	MIL-C-39006/22	CLR 79
	Wet Tantalum-Tantalum Case	MIL-C-39006/28 & MIL-C-39006/29	CLS 79 & CLS 81

2.0 **Application** For use of capacitors refer to MIL-STD-198 and the information contained in the capacitor type section of this handbook. For additional tantalum capacitor information refer to NASA TM X-64755.

3.0 **Design and Construction** The design and construction paragraph within the detailed part section provides information specific to the capacitor for recommended designs, known design and construction problems, known reliability suspect designs, known material hazards, and recommended topics to be addressed in a company unique drawing to control produceability and controlling a baseline from a vendor.

4.0 **Quality Assurance** The quality assurance section contains the recommended verification and validation during the procurement process, screening tests, lot conformance tests, and qualification tests for each capacitor type.

4.1 **Production Lot** The recommended production lot for high reliability capacitors is, capacitors of a single capacitance and voltage rating of one design, from the same dielectric material batch, and processed as a single lot through all manufacturing steps on the same equipment, to the same baseline documentation, and identified with the same date and lot code designation. The lot may contain all available capacitance tolerances for the nominal capacitance value.

5.0 **Lessons Learned** This paragraph has been inserted into this handbook to document information which from past experience and history which is not addressed in any other paragraph. This information was gained during failure reviews, incoming inspection history and any other source available which will give insight into problems which can be rectified.

SECTION 210 CERAMIC (CKS) MIL-C-123, (HVR) MIL-C-49467

1.0 Scope

1.1 This section contains information for fixed ceramic capacitors both general-purpose type (CKS) and High Voltage type (HVR). This section contains multiple styles, where the information is the same the style will not be indicated.

2.0 Application

2.1 This paragraph contains guidelines in Table 210-1 for derating and Table 210-2 for end-of life design limits that are considered minimum for Space Applications. Table 210-3 is an overview of specific product information which should considered prior to selection to an application, and one possible mitigation guide line if the product is selected.

Table 210-1 Derating

Device Type	Parameter	Derating Factor	Comments
CERAMIC			Not recommended for operation above 125°C Ambient Temperature
CKS, HVR	VOLTAGE 1/ CURRENT 2/	.50 of rated .70	Above 85°C derate linearly to 0.30 at 125°C Above 85°C derate linearly to 0.50 at 125°C

NOTES: 1/ Applied Voltage only.
2/ Applies to both Surge Current and Ripple Current

Table 210-2 End-of Life Design Limits

CKS Parameter	General Purpose BX (X7R)	Temperature Compensated BP (NPO)
Capacitance	± 21%	± 1.25% or ± 0.75pF, whichever is greater
Insulation Resistance	50% of initial limit	50% of initial limit
HVR Parameter	**General Purpose BR or BZ**	**Temperature Compensated BP**
Capacitance	± 21%	± 1.25% or ± 0.75pF, whichever is greater
Insulation Resistance	85% of initial limit	85% of initial limit

TABLE 210-3 Design Applications (Ceramic)

Style	Typical Applications	Application Considerations	Possible Mitigation
CKS	General Purpose	**Piezoelectric Concerns** Piezoelectric output: This can be minimized by → **Temperature Concerns** Ceramic cracks easily when subjected to extreme temperature environments.	Mounting chips on their side or on their end on the substrate or by using chips with a reduced length to width ratio. Mounting : Matching of temperature coefficient of expansions when mounting is key. 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.
HVR	High Voltage	**High Voltage Potential** This type of capacitor has the potential of voltage breakdown between the leads of the capacitor, or the capacitor to another potential **Piezoelectric Concerns** Same as CKS **Capacitor Cracking** Same as CKS	Additional encapsulation needs to be applied at mounting.
CKS HVR		**Environmental Limits** shock, vibe, operating ambient temperature, radiation, conformal coatings	Refer to MIL-C-123 Refer to MIL-C-123 & MIL-C-49467
		Handling Extreme care should be taken to avoid excessive thermal stresses when tinning or soldering termination's and leads or when mounting the capacitor on a substrate to prevent cracking.	Observe thermal management techniques during manufacturing operations.

TABLE 210-3 Design Applications (Ceramic) Cont'd

		Aging and Storage Sensitivity These devices are sensitive to cracking and chipping from rough handling or being dropped. No aging sensitivity on this product.	Observe packaging and storage techniques.

3.0 Design and Construction

3.1 Recommended Design for Space and Launch Vehicles Capacitors designed and qualified to MIL-C-123 for CKS, for HVR types capacitors designed and qualified to MIL-C-49467, screening and lot conformance to MIL-C-49467 and Table 210-9 (screen), Table 210-10 (lot conformance).

Table 210-4 Design and Construction Considerations

Style	Design & Construction Considerations	Possible Mitigation
CKS, HVR	Where avoidance of a significant piezoelectric output is critical to the circuit performance.	BP type dielectric is used in place of BX.

3.2 Known Reliability Suspect Designs The information in Table 210-5 describes products which have caused reliability problems in the past. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 210-5 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Capacitor type	Variable devices
Maximum Capacitance	50 V dc rated product in the CKS 06 style with a capacitance greater than 0.47 microFarad.
Thin Dielectric Product	
CKS	Capacitors containing active dielectric thickness of less then 0.0009" (23 Microns).
HVR	The maximum stress allowed between plates should not exceed 100 volts/mil for BX dielectric or 200 volts/mil for BP dielectric.
Large Aspect Ratio Product	
CKS	Capacitors manufactured with design length-to width aspect ratio of greater than 2 to 1. (This product difficult to manufacturer without delaminations or distortion.)
HVR	The length-to-width aspect ratio for these thicker ceramic capacitors should not exceed 1.8 to 1.
CKS	Capacitors that are manufactured with a conformally coated epoxy case

Conformal Coated Capacitors	rather than a thicker molded case.
CKS Testing	Capacitors not subjected to non-destructive testing as specified in MIL-C-123.
CKS Testing	Capacitors not subjected to low voltage, 85% relative humidity, 85°C test.

3.3 Known Material Hazards The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 210-6 Known Material Hazards

Material	Precaution
Tin coating	Capacitors with tin-coated leads are subject to tin dendrites.
HVR Encapsulation	The type of material should be carefully considered by the user regarding specific environmental requirements and the ceramic chip physical size.
HVR Conformal 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 encapsultant 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 resilient material may be subject to internal solder joint damage during vibration.
HVR Solder	Leads should be attached to the ceramic chip body using high temperature solder with a minimum plastic point of 260°C.

3.4 Produceability and Baseline Controls A product baseline should be established for all capacitors not purchased as a QPL MIL-C-123 device. Areas, which need to be specified and controlled in the drawing and baseline, are:

Table 210-7 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to MIL-C-123
Production Lot	Refer to MIL-C-123
Serialization	Refer to MIL-C-123
Traceability Control (Parts, Materials, & Processes)	Refer to MIL-C-123
Rework Provisions	Refer to MIL-C-123
Process Controls verification & validation	Refer to MIL-C-123
Screening Tests (100%)	Refer to MIL-C-123 for CKS & HVR styles additionally Table 210-9 herein for HVR
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to MIL-C-123 for CKS, Table 210-10 herein for HVR
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-C-123 for CKS, MIL-C-49467

Note: A manufacturing baseline should be developed and maintained by the manufacturer in accordance with MIL-C-123, and controlled and verified by the procuring organization.

4.0 Quality Assurance Provisions

4.1 The following table outlines the minimum areas, which should be considered and verified when purchasing QPL MIL-C-123 or Company specific ceramic capacitor drawings for styles CKS and HVR.

Table 210-8 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of MIL-C-123.	Lot Homogeneity Production Lot formation Device Serialization Traceability Control Rework Provisions I.A.W. approved procedures Process Controls and their verification & validation elements Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)
Screening (100 percent): refer to the requirements of MIL-C-123 for CKS style. Refer to the requirements of the SCD and Table 210-9 for HVR style.	Review screening data (Attributes & Variables). Verify test equipment correlation, repeatability, test windows were met, test conditions, and PDA compliance.
Lot Conformance: refer to the requirements of MIL-C-123 for CKS style. Refer to the requirements of the SCD and Table 210-10 for HVR style..	Review lot conformance data (Attributes & Variables).
Supplier DPA: should be in accordance with MIL-C-123.	Review supplier DPA and compare to incoming DPA.
Qualification Testing: refer to the requirements of MIL-C-123 for CKS style or MIL-C-49467 for HVR style.	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: should be in accordance with MIL-STD-1580.	Review incoming DPA and compare to supplier DPA.
Sample and Data Retention: Data retention information is found in Section 4 of the this handbook.	Maintain samples and data for further use.

5.0 Lessons Learned

5.1 Screening Multilayer ceramic capacitors inherently have delaminations due to the processing. Adding SLAM as a 100% screen is very successful in finding this type of defect. SLAM should be used in conjunction and before corona testing.

Table 210-9 Screening Table (HVR)

MIL-C-49467 Tests	Additions and Exceptions to MIL-C-49467
Subgroup 1 2/	
Thermal Shock	25 cycles
Dielectric Withstanding Voltage	168 hours min.
Voltage Conditioning	
Partial Discharge	
Radiographic Inspection	
Subgroup 2 1/	
Visual and Mechanical Examination	
Subgroup 3	
Destructive Physical Analysis	Use sample size, procedures and accept/reject criteria documented in MIL-C-123
Subgroup 4 1/	
Solderability	

1/ Use sample size documented in MIL-C-49467

2/ Total Percent Defect Allowed (PDA) for electrical tests in Subgroup 1 should not exceed 5%

Table 210-10 Lot Conformance Table (HVR)

MIL-C-49467 Tests	Additions and Exceptions to MIL-C-49467
Subgroup 1	
Thermal Shock 1/	100 cycles
Life Test 1/	1,000 hours
Partial Discharge	
Subgroup 2	Total subgroup sample 10 pieces, reject on 1
Voltage Temperature Limits Terminal Strength Moisture Resistance Resistance to Solder Heat Resistance to Solvents	

1/ Use sample size and accept/reject criteria documented in MIL-C-123

SECTION 230 FIXED, FILM METALLIZED/NONMETALLIZED (CRH,CRS) MIL-C-83421 /1,/2,/3,/4 (CHS) MIL-C-87217, AND (CQR) MIL-C-19978

1.0 **Scope** This section contains multiple styles of metallized film fixed capacitors, where the information is the same the style will not be indicated.

2.0 **Application** These film capacitors are used in DC and AC applications. Due to their non-clearing failure-to short characteristic and the general availability of parts of equivalent electrical performance and size within MIL-C-83421, it is recommended that the use of Style CQR capacitors be limited to those applications where capacitors covered by MIL-C-83421 are not available.

Table 230-1 Derating

Device Type	Parameter	Derating Factor	Comments
CRH CRS, CHS CQR			
Polypropylene 3/	VOLTAGE 1/	.50	Above 70°C derate linearly to 0.25 at 100°C
	CURRENT 2/	.65	
Polycarbonate 4/	VOLTAGE 1/	.50	Above 85°C derate linearly to 0.25 at 100°C
	CURRENT 2/	.65	
Vib environment	3db from screening 6db from QCI		

1/ Applied Voltage only.
2/ Applies to both Surge Current and Ripple Current
3/ Maximum operating temperature +70°C
4/ Maximum operating temperature +85°C

Table 230-2 End-of Life Design Limits

Capacitance	Insulation Resistance
± 2% of initial tolerance limits	70% of minimum limit

TABLE 230-3 Design Applications

Style	Typical Applications	Application Considerations	Possible Mitigation
CRH, CRS, CQR	High Energy and AC (E>500 μJ)	Not for circuits with less than 500 μJ of energy, or circuits that would be degraded by short duration voltage transients. <u>Resistance Variance</u> Polycarbonate capacitors may vary from 1 to 10,000MΩ at +125°C for capacitors values below 1.0μF.	**<u>Caution:</u>** Pin holes occur within the metallized film causing voltage transients. Energy is needed for clearing. Observe temperature derating
CHS	Low Energy (100μJ <E ≤500μJ)	These capacitors can exhibit momentary breakdowns in low-energy applications caused by pin holes within the metallized film. 100μJ of energy is needed to insure clearing breakdowns.	The circuit which uses capacitors of 0.1μF and greater capacitance value should be capable of providing at least 100μJ of energy. If circuit does not provide minimum energy needed it should be insensitive to momentary breakdowns.
CRH, CRS, CQR		Environmental Limits	Refer to MIL-C-83421
CHS		Environmental Limits	Refer to MIL-C-87217
	AC/DC Applications	Ac rated devices can be used in DC applications. However DC rated devices should not be used in AC applications because: 1. Dielectric heating 2. Pre-corona discharge 3. Resistance heating (Rs)	Use only AC rated devices for AC applications.
	Higher frequency applications	Needing stability at higher frequency	The equivalent series resistance (ESR) of each capacitor should be measured either at 100Khz or at a frequency approximately that of its intended application, which ever is higher.

3.0 Design and Construction

3.1 Recommended Design for Space and Launch Vehicles Capacitors designed and qualified to MIL-C-87217 (CHS), MIL-C-83421 /1, /2, /3, /4 (CRH, CRS) failure level S or MIL-C-19978 (CQR) failure level R and the additional tests of Screening Table 230-9, Lot Conformance Table 230-10

Table 230-4 Design and Construction Considerations

Construction	Information
CRH Style	Design information can be found in slash sheets 1 & 2
CRS Style	Design information can be found in slash sheets 3 & 4
CHS Style	Design information can be found in MIL-C-87217
CQR Style	Design information can be found in MIL-C-19978
Double-Wrap	Capacitors made with an extra layer of non-metallized film have a low percentage of parts exhibiting shorting and clearing. This design may also have reduced ac current capabilities.
Film Cleaning	Film used should be vacuum baked for 48 hours prior to winding to remove contaminant residues.
Winding Installation	Windings installed in cases whose diameter is 0.312 inch or larger needs to be wrapped or encapsulated to prevent radial motion during shock and vibration.

3.2 Known Reliability Suspect Designs The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 230-5 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Develops shorts in the 10 - 10,000Ω range.	Metallized/non-metallized film capacitors are made with very thin polymeric film which causes pin holes, which cause shorts exhibiting itself as a momentary transient.
Intermittent operation	The believed cause is ionic contamination within the capacitor enclosure, it can cause spurious, random conduction when operated during temperature changes and where the total circuit energy is less than 500 microjoules.
High Frequency applications	When device ESR readings are greater than twice the standard deviation above the lot average, even though within specified limits, those devices are a reliability risk to use in space applications.
CQR - DC voltage	Parts whose voltage rating is less than 50 volts.

3.3 Known Material Hazards_ The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 230-6 Known Material Hazards

Material	Precaution
Aluminum Alloy	Should not be used due to the thinness of the films and the contamination level of a normal alloy, when aluminum is used it should be 99.9% pure
Polycarbonate film	Devices manufactured with 2.0 or less microns.
Polypropylene film	Devices manufactured with 4.0 or less microns

3.4 Produceability and Baseline Controls A product baseline should be established for all capacitors not purchased as a QPL MIL-C-83421 CRS style or QPL MIL-C-87217 CHS style device. Areas which need to be specified and controlled in the drawing and baseline are:

Table 230-7 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to Section 4
Production Lot	Refer to Section 200
Serialization	Refer to Section 4
Traceability Control (Parts, Materials, & Processes)	Refer to Section 4
Rework Provisions	Refer to MIL-C-83421 (CRH, CRS), MIL-C-87217 (CHS), OR MIL-C-19978
Process Controls Verification & Validation	Refer to MIL-C-83421(CRH, CRS), MIL-C-87217 (CHS), or MIL-C-19978
Screening Tests (100%)	Refer to MIL-C-83421 and Table 230-9 for CRH and CQR style. MIL-C-83421 /3, /4 for CRS style. MIL-C-87217 for the CHS style
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to MIL-C-83421 Table 230-10 for CRH and CQR style. MIL-C-83421 /3, /4 for CRS style. MIL-C-87217 for the CHS style
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-C-83421 for CRH style. MIL-C-83421 /3, /4 for CRS style. MIL-C-87217 for the CHS style and MIL-C-19978

Note: A manufacturing baseline should be developed and maintained by the manufacturer and controlled and verified by the procuring organization for (company unique drawings),.for QPL reliability level S capacitors the manufacturing baseline should be verified by the procuring organization.

4.0 Quality Assurance Provisions

4.1 The following table outlines the minimum areas which should be considered and verified when purchasing QPL MIL-C-87217 and company specific capacitor drawings for styles CRH or QPL MIL-C-83421 /3 & /4 for CRS style, QPL MIL-C-87217 for CHS style and QPL MIL-C-19978 and company specific drawings for style CQR.

Table 230-8 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of the applicable manufacturing baseline.	Homogeneity Production Lot Serialization Traceability Control for Parts, Materials, & Processes Rework Provisions Process Controls verification & validation Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)
CRH and CQR style	Specifically the following verifications are essential for this product: 1. Internal visual examination at 5X minimum of the lead attachment to capacitor end metallization 2. Axial push test to verify tight fit between element and case. (Not necessary for potted parts or capacitors whose case diameter is less than 0.312 inch.)
CRH style	3. Lot sample pull test to verify attachment of lead wires to end metallization.
Screening (100 percent): refer to the requirements of the company unique drawing and MIL-C-83421 and Table 230-9 for CRH and CQR styles. MIL-C-83421 /3, /4 for CRS style. MIL-C-87217 for the CHS style.	Review screening data (Attributes & Variables).
Lot Conformance: refer to the requirements of the company unique drawing and MIL-C-83421 and Table 230-10 for CRH and CQR styles. MIL-C-83421 /3, /4 for CRS style. MIL-C-87217 for the CHS style	Review lot conformance data (Attributes & Variables).
Qualification Testing: refer to the requirements of MIL-C-83421 for CRH style. MIL-C-83421 /3, /4 for CRS style. MIL-C-87217 for CHS style and MIL-C-19978 for	Review qualification data (Attributes & Variables).

CQR style	
Incoming Inspection DPA: should be in accordance with MIL-STD-1580.	Review incoming DPA and compare to supplier DPA.
Sample and Data Retention: Data retention information is found in Section 4 of the this handbook.	Maintain samples and data for further use.

Table 230-9 Screening Table

MIL-C-83421 Screens for CRH/CQR style	Additions and Exceptions to the Methods and Criteria of MIL-C-83421
Thermal Shock	MIL-STD-202, Method 107, Cond. B except: 55°C to 100°C for 10 cycles
DC Burn-In	168 hours min. @ +100°C
AC Burn-In 1/	48 hours min. @ 100°C Maximum AC current, 120% of IAC rated @ 40 kHz 2/
Seal	
Dielectric Withstanding Voltage	
Insulation Resistance	
Capacitance	
Dissipation Factor	
ESR	Only AC applications
Visual/Mechanical Examination (External)	
Radiographic Inspection	To MSFC-STD-355; 2 views 90°.apart by x-ray, or 360° view by Vidicon. The use of “real-time” x-ray systems capable of viewing through 360° rotation is encouraged.
N-Ray (For potted parts only)	Verify that no detectable potting voids are present.

1/ Not necessary for DC applications only.
2/ VAC should not exceed 240 VRMS under any conditions

Table 230-10 Lot Conformance Table

MIL-C-83421 Screens for CRH/CQR style	Additions and Exceptions to Methods and Criteria of MIL-C-83421
Subgroup 1	
DC Life (Accelerated)	4 devices for 2,000 hours
AC Life (Accelerated) AC Application Only	4devices with the highest ESR readings for 250 hours Maximum AC current, 120 % of IAC (RMS); Minimum current 3 times the system application, adjusted for 40 kHz operation. VAC frequency of 40 kHz +2%. 1/
Capacitance Dissipation Factor Insulation Resistance Seal	Readings taken @ +25°C and +125°C
Subgroup 2	
Vibration (Random) (Sine)	Sample of 6, MIL-STD-202, Method 214, test Cond. II K Vib axis 2 orthogonal planes, 15 minutes vibration
Terminal Strength	
Dielectric Absorption	
Capacitance Dissipation Factor Insulation Resistance Seal	
Subgroup 3	
Shock	Sample of 6, MIL-STD-202, Method 213, Cond. D (500g)
Solderability	
Temperature Coefficient	
Capacitance Dissipation Factor Insulation Resistance Seal	

1/ VAC should not exceed 240 VRMS under any conditions

SECTION 240 FIXED GLASS CAPACITORS (CYR) MIL-C-23269, (CMS) MIL-C-87164

1.0 Scope This section contains information on two styles of fixed glass capacitors, where differences occur they will be noted by style.

2.0 Application, These parts are useful in ultrastable and high-frequency applications.

Table 240-1 Derating

Style	Parameter	Derating Factor	Comments
			Not recommended for operation above 85°C Ambient Temperature
CYR	VOLTAGE 1/ CURRENT 2/	.80 .70	Above 25°C derate linearly to .25 at 85°C

NOTES:

1/ Applied Voltage only.
2/ Applies to both Surge Current and Ripple Current

Table 240-2 End-of Life Design Limits

Style	Capacitance	Insulation Resistance
CYR	± 0.5% of initial limits or 0.5pf, whichever is greater	500,000 megohms @ +25°C 50,000 megohms @ +125°C
CMS	± 0.5% of initial limits	70% of initial minimum limit

TABLE 240-3 Design Applications

Style	Typical Applications	Application Considerations	Possible Mitigation
CYR, CMS	Ultrastable and High Frequency	Capacitance range limited to 10,000pf	Follow derating guidelines
		Glass capacitors are relatively expensive, have poor volumetric efficiency	
		Dielectric has near perfect properties (high IR, high Q, ultrastable capacitance, low dielectric absorption, and fixed TC	
CMS		Not hermetically sealed device	Use in a controlled environment application

3.0 Design and Construction Design and construction information can be found in MIL-C-23269(CYR) or MIL-C-87164 (CMS). The following table documents some key information about the design and construction of these type of capacitors.

Table 240-4 Design and Construction Considerations

Construction	Information
CYR Style	Hermetically sealed
CMS Style	Not hermetically sealed
CMS Style	Electrical characteristics almost identical to the CYR style
CYR Style	Design and construction information contained in MIL-C-23269
CMS Style	Design and construction information contained in MIL-C-87164

3.1 Recommended Design for Space and Launch Vehicles Capacitors designed and qualified to MIL-C-23269 failure level S, recommended styles CYR10, 15, 20, 30 only, or MIL-C-87164 CMS when application is a controlled environment.

3.2 Known Reliability Suspect Designs The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 240-4 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Radial lead devices	CYR41, 42, 43, 51, 52, and 53 styles
Non-hermetic device	CMS Style

3.3 Produceability and Baseline Controls A product baseline should be established for all capacitors not purchased as a QPL MIL-C-23269 CYR style or QPL MIL-C-87164 CMS style device. Areas which need to be specified and controlled in the drawing and baseline are:

Table 240-5 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to Section 4
Production Lot	Refer to Section 200
Serialization	Refer to Section 4
Traceability Control (Parts, Materials, & Processes)	Refer to Section 4
Rework Provisions	Refer to MIL-C-23269 (CYR),or MIL-C-87164 (CMS)
Process Controls Verification & Validation	Refer to MIL-C-23269 (CYR),or MIL-C-87164 (CMS)
Screening Tests (100%)	Refer to MIL-C-23269 (CYR),or MIL-C-87164 (CMS)
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to MIL-C-23269 (CYR),or MIL-C-87164 (CMS)
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-C-23269 (CYR),or MIL-C-87164 (CMS)

Note: A manufacturing baseline should be developed and maintained by the manufacturer and controlled and verified by the procuring organization for (company unique drawings),.for QPL reliability level S capacitors the manufacturing baseline should be verified by the procuring organization.

4.0 Quality Assurance Provisions The following table outlines the minimum areas which should be considered and verified when purchasing QPL MIL-C-23269 or company specific capacitor drawings for style CYR, or QPL MIL-C-87164 CMS style.

Table 240-6 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of the applicable manufacturing baseline.	Homogeneity Production Lot Serialization Traceability Control for Parts, Materials, & Processes Rework Provisions Process Controls verification & validation Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)
Screening (100 percent): refer to the requirements of MIL-C-23269 for CYR, MIL-C-87164 for CMS	Review screening data (Attributes & Variables).
Lot Conformance: refer to the requirements of MIL-C-23269 for CYR, MIL-C-87164 for CMS	Review lot conformance data (Attributes & Variables).
Qualification Testing: refer to the requirements of MIL-C-23269 for CYR, MIL-C-87164 for CMS	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: should be in accordance with MIL-STD-1580.	Review incoming DPA and compare to supplier DPA.
Sample and Data Retention: Data retention information is found in Section 4 of the this handbook.	Maintain samples and data for further use.

SECTION 260 FIXED, TANTALUM FOIL (CLR)MIL-C-39006

1.0 Scope

1.1 This section covers fixed tantalum-foil capacitors styles CLR 25, 27, 35, and 37.

2.0 Application

2.1. MIL-C-39006 tantalum foil capacitors are not recommended for new designs. This is a single-source item, there is a likelihood that the supplier will not support users needs indefinitely. These capacitors are recommended for either medium or high voltage applications where high capacitance is required.

Table 260-1 Derating

Device Type	Parameter	Derating Factor	Comments
CLR	VOLTAGE 1/ CURRENT 2/	.70 .70	Above 25°C derate linearly to .5 at 85°C Not recommended for operation above 85°C Ambient Temperature

NOTES:

1/ Applied Voltage only.
2/ Applies to both Surge Current and Ripple Current

Table 260-2 End-of Life Design Limits

Capacitance	Insulation Resistance
± 15% of initial tolerance limits	130% of maximum limit

TABLE 260-3 Design Applications

Style	Typical Applications	Application Considerations	Possible Mitigation
CLR 25, 27, 35, 37	Medium or High Voltage	Should not be used at temperatures above 85°C	Specially established derating is required, or reliability study needs to be performed as there is lack of evidence these parts will perform reliability at higher temperatures.
CLR 25,27	High capacitance	The etched-foil provides as much as 10 times the capacitance per unit area as the plain for a given size.	
CLR 35,37	High ripple currents, Temperature coefficient characteristics	This style can withstand approximately 30% higher ripple currents, has better temperature coefficient characteristics and a lower dissipation factor.	
	Shock or vibration environment	Excessive shock or vibration environment.	Only "H" designed devices should be used, with design capability and qualification of the parts.
		Polarized Style These styles can only withstand a maximum of three (3) volts dc reverse voltage at 85°C. Under these conditions Electrical characteristics changes which are possible are: Capacitance: ±10% of initial value. Leakage Current: 125% of initial max. limit.	Assure application is tolerant to these changes or limit reverse dc voltage. Use in applications below 85°C, use non-polarized style.
		CLR 25 & 35 are polarized CLR 27 & 37 are non-polarized	Mounting Care should be taken to ensure correct polarity.
	Potted Modules	Glass end seals are designed to withstand high internal pressure	Potted Modules End seals need to be protected to withstand high external pressures that can result from curing of the encapsulant.

3.0 Design and Construction Design and construction information can be found in MIL-C-39006. The following table documents some key information about the design and construction of these types of capacitors.

Table 260-4 Design and Construction Considerations

Construction	Information
Plain	Style CLR 35 and 37
Etched-foil	Style CLR 25 and 27
Tantalum Capacitor Packs	See NASA TM X-64755
Glass end seals	The glass end seals are designed to withstand internal pressure. When parts are potted, end seals should be protected to withstand high external pressures that can result from curing of the encapsulant.
Vibration spacer	Needed to prevent axial motion in a vibration environment.
Wrapped capacitive element	Needed to ensure element is securely positioned within the case in a vibration environment.
Internal lead wire welds	Should not be used in a shock or vibration environments.
Design and Construction	Design and construction is documented in MIL-C-39006.

3.1 Recommended Design for Space and Launch Vehicles Capacitors designed and qualified to MIL-C-39006 failure level R or higher and the additional test of this Handbook.

3.2 Produceability and Baseline Controls A product (manufacturing) baseline should be established for all capacitors purchased to MIL-C-39006. Areas which need specific attention in the drawing and manufacturing baseline are:

Table 260-5 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to Section 4
Production Lot	Refer to Section 200
Serialization	Refer to Section 4
Traceability Control (Parts, Materials, & Processes)	Refer to Section 4
Rework Provisions	Refer to MIL-C-39006
Process Controls Verification & Validation	Refer to MIL-C-39006
Screening Tests (100%)	Refer to MIL-C-39006 and Table 260-7 herein.
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to MIL-C-39006 and Table 260-8 herein.
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-C-39006, Table I.

4.0 Quality Assurance Provisions The following table outlines the minimum areas which should be considered and verified when purchasing QPL MIL-C-39006 and company specific capacitor drawings for style CLR.

Table 260-6 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of the applicable manufacturing baseline.	Homogeneity Production Lot Serialization Traceability Control for Parts, Materials, & Processes Rework Provisions Process Controls verification & validation 1. Verify that each capacitor element fits snugly within the case and that vibration spacers are installed. Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)
Screening (100 percent): refer to the requirements of MIL-C-39006 and Table 260-7 herein.	Review screening data (Attributes & Variables).
Lot Conformance: refer to the requirements of MIL-C-39006 and Table 260-8 herein	Review lot conformance data (Attributes & Variables).
Qualification Testing: refer to the requirements of MIL-C-39006 Table I	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: should be in accordance with MIL-STD-1580.	Review incoming DPA and compare to supplier DPA.
Sample and Data Retention: Data retention information is found in Section 4 of this handbook.	Maintain samples and data for further use.

Table 260-7 Screening Table

MIL-C-39006 Screens	Additions & Exceptions to MIL-C-39006
Thermal Shock	• -65°C to +125°C for 5 cycles • Transfer between chambers 5 minute max.
Constant Voltage Conditioning	• Maximum series resistance: 33 Ohms • Burn-in time 168 hours at +85°C
DC Leakage	
Capacitance	
Dissipation Factor	
Seal	Test conditions A and C
Radiographic Inspection	• To MSFC-STD-355; 2 views 90°.apart by X-Ray, or 360° view by using “real-time” X-Ray systems capable of viewing through 360° rotation. • Moderate “telescoping” of roll is acceptable • Case Size — Max Width Incl. Telescoping • G1 — 0.350" • G2 — 0.4375" • G3 — 0.7175" • G4 — 1.4219" • G5 — 2.00"
Visual/Mechanical Examination (External)	

Table 260-8 Lot Conformance Table

MIL-C-39006 Screens	Additions and Exceptions to Methods and Criteria of MIL-C-39006
Subgroup 1	
Thermal Shock	During last cycle, monitor capacitance to verify no opens.
Surge Voltage	Maximum series impedance: 33 Ohms
Life	At +85°C for 1,000 hours
DC Leakage	At +25°C and +85°C
Capacitance	
Dissipation Factor	
ESR	At 40 Khz or greater Does not apply to DC applications
Seal	Test condition A and C
Visual/Mechanical Examination (External)	
Subgroup 2	
Thermal Shock	20 cycles
Mechanical Shock	500g’s
Vibration (Random)	MIL-STD-202, Method 214, Test Condition II, K for 15 minutes each axis.
Moisture Resistance	
Reverse Voltage	
DC Leakage	At +25°C and +85°C
Capacitance	
Dissipation Factor	
Seal	Test conditions A and C
Visual and Mechanical Examination (External)	

SECTION 270 FIXED, ELECTROLITIC, TANTULUM SOLID (CSR 13, CSR 33) MIL-C-39003 /1 and /6 and (CWR) MIL-C-55365

1.0 **Scope** This section describes information for two styles of capacitors CSR (packaged) and CWR (chip). This section identifies the information which is different between the two styles by identifying the style the information applies to. Where the information is the same there is no notation of style.

2.0 Application

Table 270-1 CSR and CWR Derating

Device Type	Parameter	Derating Factor	Comments
CSR CWR	VOLTAGE 1/ CURRENT 2/	.70 .70	Above 25°C derate linearly to .5 at 85°C Not recommended for operation above 85°C Ambient Temperature

NOTES:

1/ Applied Voltage only.
2/ Applies to both Surge Current and Ripple Current

TABLE 270-2 CWR Surge Voltage Ratings

Voltage (volts, dc)			
Symbol	**Steady State Rated (+85°C)**	**Voltage Derated (+85°C)**	**Maximum Surge Voltage (-55°C to +85°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

TABLE 270-3 End-of Life Design Limits

Capacitance	Insulation Resistance
± 10% of initial limits	200% of initial maximum limit

TABLE 270-4 Design Applications Solid Tantalum

Style	Description	Typical Application	Application Considerations	Possible Mitigation
CSR13 & 33	Solid Tantalum	Low Energy Greater than 1ohm per volt applications	This style is polarized should not be used in mission significant circuits with an impedance of less than 1 ohm per volt. Capacitors of this type with voltage rating of more than 75 volts require thicker dielectrics, containing more impurities These devices exhibit high temperature coefficients of capacitance.	Mounting Care should be taken to ensure correct polarity CSS types may be directly substituted for CSR style parts of equal capacitance and voltage. Capacitors with a dc working voltage rating of 75 volts or less should be used. This part is recommended where a high capacitance to volume ratio is required and where relatively high temperature coefficients of capacitance can be tolerated.
CSR13 & 33	Solid Tantalum	Low Energy Less than 1ohm per volt applications	Source impedance of at least 1 ohm should be used in all circuits containing these parts to act as a transient suppressor This style is polarized These devices exhibit high temperature coefficients of capacitance.	Source impedance current limiting in circuits is needed to guarantee that the effective maximum current is not exceeded. Mounting Care should be taken to ensure correct polarity Recommended where a high capacitance to volume ratio is required and where relatively high temperature coefficients of capacitance can be tolerated
CWR	CHIP	Minimum Circuit Impedance Circuit impedance of 1W per volt or more.	Device is unencapsulated Provide improved protection from handling damage	Mount last in the assembly sequence. Perform detailed visual examination for surface damage before applying the circuit conformal coating or hybrid sealing. Apply a thin protective coating.

3.0 **Design and Construction** This table documents some key information about the design and construction of these type of capacitors.

TABLE 270-5 Design and Construction

Construction	Information
Style CSR13	Design and construction information documented in MIL-C-39003 /1
Style CSR33	Design and construction information documented in MIL-C-39003 /6
Style CWR	Design and construction information documented in MIL-C-55365
Style CSS	Design and construction information documented in MIL-C-39003/10
CWR Outer Case	This style has no outer case, nor does it have encapsulation to protect it.
CWR Terminations	Are either wrap around or T-bar.
CWR Protective Coating	The body of the CWR style needs to be covered by a thin protective coating to provide improved resistance to handling damage.
CSR 13, 33 and CSS 13, 33	Capacitors should be designed with a dc working voltage of 75 volts or less (Higher voltage ratings require thicker dielectrics, containing more impurities, while the lower voltage parts utilize a small tantalum slug).

3.1 **Recommended Design for Space and Launch Vehicles** Capacitors designed and qualified to MIL-C-39003 styles CSS13, CSS33, failure level "C" when available or use failure rate "B", CSR13 AND CSR33 failure level C or higher, and MIL-C-55365 style CWR failure level R or C or higher and the additional tests of this Handbook.

3.2 **Known Reliability Suspect Designs** The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. History from MIL-STD-1547 is included.

TABLE 270-6 Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
CWR - Highest Capacitance	The highest capacitance value in any given size is suspect
CWR - Terminations	The extended termination designs are more susceptible to handling damage than more compact termination designs.

3.3 **Known Design and Manufacturing Problems** The following table describes design and manufacturing problems which have been identified as the cause of reliability problems.

TABLE 270-7 Reliability Problems

Material	Precaution
CSR Thicker Dielectric	Contain more impurities. Device with a dc working voltage of 75 volts or less use small tantalum slug.

3.4 **Produceability and Baseline Controls** A product (manufacturing) baseline should be established for CSS style purchased to MIL-C-39003 /10, CSR style purchased to MIL-C-39003 /1 and /6, and for CWR style purchase to MIL-C-55365. Areas which need specific attention in the drawing and manufacturing baseline are:

Table 270-8 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to Section 4
Production Lot for CSS and CSR For CWR	Refer to Section 200 A Production lot is: all the capacitors of a single nominal capacitance (may include contain all available capacitance tolerances for that nominal value) and voltage rating of one design, processed as a single lot through all manufacturing steps on the same equipment and identified with the same date and lot code designation as outlined below: a. Raw materials (tantalum powder, manganese nitrate, colloidal carbon, and termination materials) should be from the same lot batch and the same manufacturer. b. Lot numbers should be assigned at anode formation and should be traceable to the anode pressing batch and tantalum powder batch used. c. The anode should be pressed in a continuous run on the same pressing machine and should be sintered and temperature-processed as a complete batch (not split during sintering or subsequent temperature conditioning). d. The entire production lot should 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. Terminations and lead materials (including and solder flux) should each be from a single receiving inspection lot and a single vendor.
Serialization	Refer to Section 4
Traceability Control (Parts, Materials, & Processes)	Refer to Section 4
Rework Provisions	Refer to MIL-C-39003 /1 and /6 for CSR styles, MIL-C-55365 for CWR style and MIL-C-39003/10 for CSS.
Process Controls Verification & Validation	Refer to MIL-C-39003 /1 and /6 for CSR styles, MIL-C-55365 for CWR style and MIL-C-39003/10 for CSS
Screening Tests (100%)	Refer to MIL-C-39003 /1 and /6 for CSR styles, MIL-C-55365 for CWR and Table 270-10 herein and MIL-C-39003/10 for CSS.
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to MIL-C-39003 /1 and /6 for CSR styles, and Table 270-11 herein, MIL-C-55365 for CWR and MIL-C-39003/10 for CSS..
Qualification Tests (Destructive & Non-	Refer to MIL-C- MIL-C-39003 /1 and /6 for CSR

destructive tests)	styles, MIL-C-55365 for CWR style and MIL-C-39003/10 for CSS.

4.0 **Quality Assurance Provisions** The following table outlines the minimum areas which should be considered and verified when purchasing QPL MIL-C-39006 and company specific capacitor drawings for style CLR.

Table 270-9 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of the applicable manufacturing baseline.	Homogeneity Production Lot Serialization Traceability Control for Parts, Materials, & Processes Rework Provisions Process Controls verification & validation Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)
Screening (100 percent): Refer to MIL-C-39003 /1 and /6 for CSR styles, MIL-C-55365 for CWR and Table 270-10 herein and MIL-C-39003/10 for CSS	Review screening data (Attributes & Variables).
Lot Conformance: Refer to MIL-C-39003 /1 and /6 for CSR style, and Table 270-11 herein, MIL-C-55365 for CWR and MIL-C-39003/10 for CSS.	Review lot conformance data (Attributes & Variables).
Qualification Testing: Refer to MIL-C- MIL-C-39003 /1 and /6 for CSR styles, MIL-C-55365 for CWR style and MIL-C-39003/10 for CSS	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: should be in accordance with MIL-STD-1580.	Review incoming DPA and compare to supplier DPA.
Sample and Data Retention: Data retention information is found in Section 4 of this handbook.	Maintain samples and data for further use.

TABLE 270-10 Screening

CSR Styles MIL-C-39003 /1 & /6 CWR Style MIL-C-55365 Screens	Additions to Group A Inspection (exponential distribution) MIL-C-39003 /1 and /6 for CSR Styles MIL-C-55365 for CWR Style
Thermal Shock	10 cycles
Surge Current	a) 5 cycles at -55°C and +85°C b) Maximum impedance in series with each capacitor: 1Ω including a fast blow fuse (10%), wiring, fixturing, and output impedance of power supply.

c)	Minimum peak current to each capacitor: 25A in 5µ seconds
Voltage Aging	Weibull aging conditions of MIL-C-39003 or MIL-C-55365 to achieve a minimum of “C” failure rate.
DC Leakage	+25°C and +85°C
Capacitance	
Dissipation Factor	
ESR	a) For AC applications only b) At 40 Khz c) If the application involves frequencies above 1 MHz, measurement should be a minimum frequency of 1 MHz.
Seal	
Radiographic Inspection	To MSFC-STD-355; 2 views 90^{o}.apart by X-Ray, or 360^{o} view by using “real-time” X-Ray systems capable of viewing through 360^{o} rotation.
Visual/Mechanical Examination (External)	

TABLE 270-11 Lot Conformance

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

SECTION 280 FIXED, TANTALUM-TANTALUM CAPACITOR (Sintered Wet Slug, CLS 79 & CLS 81, (MIL-C-39006/28 & /29) and CLR 79, (MIL-C-39006/22)

1.0 Scope

1.1 This section describes information for Class S wet sintered tantalum slug capacitors in tantalum cases. Also, CLR 70 style.

2.0 Application

Table 280-1 Derating

Device Type	Parameter	Derating Factor	Comments
CLR	VOLTAGE 1/	.70	Above 25°C derate linearly to .5 at 85°C
CLS	CURRENT 2/	.70	Not recommended for operation above 85°C Ambient Temperature

NOTES:

1/ Applied Voltage only.
2/ Applies to both Surge Current and Ripple Current

TABLE 280-2 End-of Life Design Limits

Capacitance	Insulation Resistance
± 10% of initial limits	130% of initial maximum limit

TABLE 280-3: Design Applications Solid Tantalum

Style	Description	Typical Application	Application Considerations	Possible Mitigation
CLS 79 & 81 and CLR 79	Wet tantalum slug	Low impedance	These are polarized devices	Mounting Care should be taken to ensure correct polarity
			Reverse voltage	Use at 3.0 Vdc @ +85°C or 20% of the rated dc voltage, which ever is less.
		High frequency applications		For applications between 10KHz and 100KHz measure and read and record 100% Equivalent Series Resistance (ESR) during Group A testing.
CLR 79			These parts can generate voltage spikes in active circuits during vibration or shock environments. Vibration and shock environments	Perform design analysis to assure circuit is robust for voltage spikes. Use "H" vibration screened parts tested to 80G sine vibration (0.06 double amplitude) from 10 to 2000 Hz for 1 1/2 hours in each orthogonal axis. Parts have been shocked to 100g for 6 milliseconds with saw tooth pulse.

3.0 **Design and Construction** This table documents some key information about the design and construction of these type of capacitors.

TABLE 280-4 Design and Construction

Construction	Information
Style CLS 79	Design and construction information documented in MIL-C-39006 /28
Style CLS 81	Design and construction information documented in MIL-C-39006 /29
Style CLR 79	Design and construction information documented in MIL-C-39006 /22

3.1 **Recommended Design for Space and Launch Vehicles** Capacitors designed and qualified to MIL-C-39006 styles CLS 79 & CLS 81, Class "S.

3.2 **Known Reliability Suspect Designs** The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. History from MIL-STD-1547 is included.

TABLE 280-5 Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Acid leaking	Single sealed CLR 79 design (identified with its compression seal construction) incorporating liquid electrolytes are reliability suspect and constitute a safety hazard.
Silver dendrites	Silver cased, CLR wet slug types

3.3 **Produceability and Baseline Controls** A product (manufacturing) baseline should be established for CLR styles purchased to MIL-C-39006 /22. Areas which need specific attention in the drawing and manufacturing baseline are:

Table 280-6 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to Section 4
Production Lot	Refer to Section 200
Serialization	Refer to Section 4
Traceability Control (Parts, Materials, & Processes)	Refer to Section 4
Rework Provisions	Refer to MIL-C-39006 /22
Process Controls Verification & Validation	Refer to MIL-C-39006 /22. In addition, each capacitor anode assembly should be inspected at a minimum of 10X magnification. All parts note meeting the following requirements should be rejected: a. The tantalum anode (slug) should be straight, not bent or distorted. All anodes in a given lot should be the same size. b. The anodes should be of the same uniform color. c. The anode should fit snugly and be firmly seated within the top and bottom PTFR vibration spacers.
Screening Tests (100%)	Refer to MIL-C-39006 /22 and Table 280-9 herein.
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to MIL-C-39006 /22, and Table 280-10 herein.
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-C-39006 /22

4.0 **Quality Assurance Provisions** The following table outlines the minimum areas which should be considered and verified when purchasing QPL MIL-C-39006 and company specific capacitor drawings for style CLR.

Table 280-7 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of the applicable manufacturing baseline.	Homogeneity Production Lot Serialization Traceability Control for Parts, Materials, & Processes Rework Provisions Process Controls verification & validation Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)
Screening (100 percent): Refer to MIL-C-39006 /22 and Table 280-9 herein.	Review screening data (Attributes & Variables).
Lot Conformance: Refer to MIL-C-39006 /22 and Table 280-10 herein.	Review lot conformance data (Attributes & Variables).
Qualification Testing: Refer to MIL-C-39006 /22	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: should be in accordance with MIL-STD-1580.	Review incoming DPA and compare to supplier DPA.
Sample and Data Retention: Data retention information is found in Section 4 of this handbook.	Maintain samples and data for further use.

4.1 **Table 280-8 Quality Assurance Provisions for CLS type Capacitors**

Quality Assurance Consideration	Recommended Verifications and Validations
Incoming Inspection DPA: should be in accordance with MIL-STD-1580.	Review incoming DPA and compare to supplier DPA.

TABLE 280-9 Screening

MIL-C-39006 /22 Screens	Additions and Exceptions to the Method and Criteria of MIL-C-39006 /22
Thermal Shock	10 cycles
Constant Voltage Conditioning	Maximum series resistance: 33°Ω Burn-in time: 168 hours @ +85°C
DC Leakage	
Capacitance	
Dissipation Factor	
ESR	a) For AC applications only b) At 10 KHz to 100 KHz c) Equivalent series resistance measurements should be read and recorded during Group A testing on 100% basis for data collection.
Vibration screening	When vibration screening is required the following test conditions apply a) Direction of Vibration - The direction of vibration should be perpendicular to the cylindrical axis of the capacitor. b) Test Potential - The rated voltage of each part should be applied. c) Sinusoidal Vibration - All parts should be tested per MIL-STD-202, Method 214, Test Condition H, (80 g) d) Random Vibration - All parts should be tested per MIL-STD-202, Method 214, Test Condition II, K (51.1 g rms) e) Continuous Monitoring - During all vibration tests the dc leakage current should be continuously monitored across a 10 kilohms resistor connected in series with each part under test. f) Post-Vibration Measurements - After completion of all testing, parts should be subjected to dc leakage measurements at +25°C and +125°C and capacitance and dissipation factor measurements at +25°C, all per MIL-C-39006 /22. g) Failure Criteria - All parts should be rejected whose post-vibration electrical measurements are not within the limits specified in MIL-C-39006 /22 or who exhibit intermittent voltage spikes of 0.3 milliseconds or greater duration, or arcing, open, or short circuiting during vibration testing. h) Visual and Mechanical Examinations - All parts should be visually examined per MIL-C-39006 /22 after testing. Any part showing evidence of mechanical damage or electrolyte leakage should be rejected.
Seal	
Visual/Mechanical Examination (External)	

TABLE 280-10 Lot Conformance

MIL-C-39006 /22 Screens	Additions and Exceptions to the Methods and Criteria of MIL-C-39006 /22)
Subgroup I	
Thermal Shock	During last cycle, monitor capacitor to verify no opens
Life	
DC Leakage	At +25°C and +85°C
Capacitance	
Dissipation Factor	
Seal	
Visual and Mechanical Examination	
Subgroup II	
Thermal Shock	100 cycles
Mechanical Shock	500g, 0.5 sine (1 millisecond duration)
Vibration (Random)	MIL-STD-202, Method 24, Test Condition 11K for 15 minutes each axis.
Moisture Resistance	
Reverse Voltage	
DC Leakage	At +25°C and +85°C
Capacitance	
Dissipation Factor	
Seal	
Visual and Mechanical Examination	

SECTION 300 CONNECTORS

1.0 Scope

This section contains detailed information for space qualified connectors. Additional information and guidance for the general use of connectors can be found in MIL-STD-1353.

2.0 Application

The following tables contain information about space qualified connectors to assist in the decision making process of selection and documentation for Design Engineers and Parts Engineers.

Table 300-1 Derating

Parameter	Derating Factor	Comments
Current	Based on max. rated temperature minus 50C	See TABLE 300-3 for temperature calculations
Altitude Voltage		Use the Voltage Derating at Altitude from AFSCP-800-27, Section I or 50% of the High Altitude Voltage listed in the detail specification.

End of life Design Considerations. 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. It is recommended that no contact carries 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 versus hot spot temperatures relationship Figure 7.04 is provide for guidance. It is recommended that the selected insert have a temperature rating which provides twice the service life of the system requirements (test and operational).

TABLE 300-2- Insert Temperature Rise ($\Delta T^{o}C$) Determination

Insert Type	Amperes Per Contact	Contact Gauge				
		26	**22**	**20**	**16**	**12**
A,B,C,D	1	2	1	1	1	0
A,B,C,D	2	8	4	2	2	0
A,B,C,D	3	16	8	5	4	1
A,B,C,D	4	27	13	8	5	1
A,B,C,D	5	41	19	13	8	2
A,B,C,D	6		27	18	10	3
A,B,C,D	7		36	23	13	4
A,B,C,D	8		46	30	16	5
A,B,C,D	9		57	37	19	6
A,B,C,D	10		70	45	41	7
Note 1	15			96	70	15
Note 2	20				106	26
A,B,C,D	25					39
A,B,C,D	30					54
A,B,C,D	35					72
A,B Only	40					92

$\Delta T=2.100(i)^{1.85}$	26 Gauge Contacts
$\Delta T=0.989(i)^{1.85}$	22 Gauge Contacts
$\Delta T=0.640(i)^{1.85}$	20 Gauge Contacts
$\Delta T=0.274(i)^{1.85}$	16 Gauge Contacts
$\Delta T=0.100(i)^{1.85}$	12 Gauge Contacts

ΔT= Insert Temperature Rise

i= Amperes per Contact

$\Delta T= 5^{o}C$	RF Coaxial Connectors
$\Delta T= 50^{o}C$	High Power Applications of RF Coaxial Connectors

Note 1: Use A,B Insert types only for 20 Gauge Contacts carrying 15A.

Note 2: Use A,B Insert types only for 16 Gauge Contacts carrying 20A.

TABLE 300-3 Design Applications

Typical Applications	Application Considerations	Possible Mitigation
Whenever possible		Use closed - entry - type socket contacts.
Blind Installation	Hard to reach areas	Use scoop - proof connectors
Critical signal and vibration applications	Prevent loss of connection	Use redundant contacts.
Axial Alignment and orientation		Use guide devices that do not carry current.
Frequent mating and demating	Connection and or joints wearout or breakage.	Provide strain relief for wires, harnesses, and cables. Use connector savers.
Severe shock and vibration environments	Possible connection loss.	Provide strain relief for wires, harnesses, and cables
Connector protection	Connector contamination and possible ESD system damage.	Use ESD connector covers (brightly colored for non-flight covers) until connectors are mated.
Hermetic Sealed applications	Loss of contact and hermetic seal integrity.	Use soldered contacts and encapsulate.
Coaxial Connectors SC series, TNC - type, and SMA - type.		Use only captivated contacts Use contact termination of the cable's center conductor for Right-angle connectors configurations
	Intermodulation of signals	Use Nickel, Ferromagnetic, or Ferrimagnetic materials.
	Contact corrosion	Use gold or passivated stainless steel plating or finish.

3.0 **Design and Construction** The connector styles and their associated specifications are documented below in Tables 300-4, 300-5, and 300-6.

Table 300-4 - Connectors (Except Printed Circuit Boards) Styles Included

Specification	Description	Comments
MIL-C-24308	Rack and Panel (Rectangular)	Recommended for space applications
MIL-C-28748	Rack and Panel	Note 1
MIL-C-28804	Rack and Panel	Note 1
MIL-C-83513	Rack and Panel	Note 1
MIL-C-83733	Rack and Panel (Rectangular)	Recommended for space applications
MIL-C-5015	Circular	Recommended for space applications
MIL-C-26482	Circular	Recommended for space applications
MIL-C-28840	Circular	Note 1
MIL-C-38999	Circular (High density)	Recommended for space applications
MIL-C-81511	Circular	Note 1
MIL-C-83723	Circular	Recommended for space applications
MIL-C-3607	Coaxial, RF	Note 1
MIL-C-3643	Coaxial, RF	Note 1
MIL-C-3650	Coaxial, RF	Note 1
MIL-C-3655	Coaxial, RF	Recommended for space applications
MIL-C-25516	Coaxial, RF	Note 1
MIL-C-39012	Coaxial, RF	Recommended for space applications
MIL-C-55235	Coaxial, RF	Note 1
MIL-C-55339	Coaxial, RF	Note 1
MIL-C-3767	Power	Note 1
MIL-C-22992	Power	Note 1
MIL-C-49142	Triaxial, RF	Note 1

Note 1: Follow the closest connector type “recommended for space application” for the application, Design and Construction, and Quality Assurance provisions guidelines outlined in this section.

Table 300-5 - Connectors (Printed Circuit Boards) Styles Included

Specification	Description	Comments
MIL-C-21097	One-Piece Connector	Note 1
MIL-C-55302	Two-Piece Connector	Recommended for space applications

Note 1: Follow the closest connector type "recommended for space application" for the application, Design and Construction, and Quality Assurance provisions guidelines outlined in this section.

Table 300-6 - Connectors (Integrated Circuit Sockets) Styles Included

	Specification	Description	Comments
7.3	MIL-S-83734	IC Sockets, Plug-in	Note 1

Note 1: Follow the closest connector type "recommended for space application" for the application, Design and Construction, and Quality Assurance provisions guidelines outlined in this section.

TABLE 300-7: Insert Material Determination

Configuration	Specification	Possible Insert Materials			
		A	B	C	D
Rack and Panel	MIL-C-28748		X		
	MIL-C-83733		X		
	MIL-C-24308	X	X		
	MIL-C-28804	X	X		
	MIL-C-83513	X	X		
Circular	MIL-C-5015		X		X
	MIL-C-26482	X	X		X
	MIL-C-28840	X	X		
	MIL-C-38999	X	X		
	MIL-C-81511		X		
	MIL-C-83723		X		
Power	MIL-C-3767		X		X
	MIL-C-22992		X		X
Coaxial	MIL-C-3607			X	
	MIL-C-3643			X	
	MIL-C-3650			X	
	MIL-C-3655			X	
	MIL-C-25516			X	
	MIL-C-39012			X	
	MIL-C-55235			X	
	MIL-C-55339		X	X	
Triaxial	MIL-C-49142		X	X	

TABLE 300-8: Insert Materials Characteristics

Insert Material Type	Common Insert Materials	Insert Temperature Range (^{o}C)
A	Vitreous Glass, Alumina Ceramic, Polyimide.	-55 to +250
B	Diallylphtalate, Melamine, Fluorosilicone, Silicone Rubber, Polysulfone, Epoxy Resin	-55 to +200
C	Polytetrafluorethylene (Teflon)	-55 to-+125
D	Polyimide (Nylon), Polychloroprene (Neoprene), Polyethylene	-55 to +125

3.1 Recommended Design for Space and Launch Vehicles All connectors listed in Tables 300-8.

Table 300-8 - Connectors Styles Recommended for use

Specification	Description	Comments
MIL-C-24308	Rack and Panel	Rev B (rack and panel, rectangular)
MIL-C-83733	Rack and Panel	Rack and panel, rectangular
MIL-C-5015	Circular	Class L, Series MS345X only.
MIL-C-26482	Circular	Miniature, quick disconnect
MIL-C-38999	Circular (High density)	Accepted configuration for space use
MIL-C-83723	Circular	Series III only.
MIL-C-39012	Coaxial, RF	
NASA MSFC	40M38277	
NASA MSFC	40M38298	
NASA MSFC	40M39569	
MIL-C-39029	CONTACTS	
MIL-C-55302	Printed Circuit Boards	
MIL-C-85049	Backshell and Hardware	

3.2 Known Reliability Suspect Designs The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 300-9 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Silver dendrites	Silver contact overplate or underplate
Outgassing and contamination	Inserts of nonapproved organic materials
Intermittent/ open contacts	Noncaptivated contact coaxials
Signal Interference	Nickel, Ferromagnetic, or ferrimagnetic materials on RF connectors
Signal Interference	Filter pins
Corrosion	Dissimilar metal mates
	External flat cable connectors
Outgassing and contamination	Cadmium or Zinc plating
Intermittent contact	Wire wrap contacts
Tin whiskers	Tin coated shells or contacts

3.3 Produceability and Baseline Controls A product baseline should be established for all custom resistors. Areas which need to be specified and controlled in the drawing and baseline are:

Table 300-10 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to Section 4
Production Lot	Refer to Section 4
Serialization	Refer to Section 4
Traceability Control (Parts, Materials, & Processes)	Refer to Section 4
Rework Provisions	Refer to appropriate Military Specification
Process Controls Verification & Validation	Refer to appropriate Military Specification
Screening Tests (100%)	Refer to appropriate Military Specification
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to appropriate Military Specification
Qualification Tests (Destructive & Non-destructive tests)	Refer to appropriate Military Specification

4.0 Quality Assurance Provisions

Quality Assurance provisions should be in accordance with the requirements of the appropriate Military Sp

Table 300-11 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
Incoming Inspection: Verification of resistor received on a sample basis.	Review incoming data for accuracy of test.
Incoming Inspection DPA: Materials and construction is verified upon receipt of each lot of devices, by performing DPA in accordance with MIL-STD-1580.	Review incoming DPA and compare to historical DPA data.
Sample and Data Retention: Data retention information is found in Section 4 of the this handbook.	Maintain samples and data for further use.

SECTION 400 QUARTZ CRYSTALS, MIL-C-49468

1.0 **Scope** This section sets forth detailed information for precision quarz crystals units.

2.0 **Application**.

Table 400-1 Derating 2/, 3/

Device Type	Parameter	Derating Factor	Comments
Crystals	Power	0.25	Rated max. input power (Rated drive level) 1/ Drive is 1.0 ±0.2 mA through the crystals.

Notes:

1/ Cut of crystal will affect frequency and start up

2/ This derating applies to parts procured to MIL-C-49468 or via a specification control drawing that duplicates the MIL-C-49468 power ratings.

3/ Crystals procured to SCDs that specify the optimum operating power for the devices require no power derating.

TABLE 400-2 Design Applications

Style	Typical Applications	Application Considerations	Possible Mitigation
	Timing circuits or circuits requiring frequency stability	Operation at high drive levels may cause degradation of normal aging characteristics, of spectral purity, and of short-term stability.	Use low drive levels in applications needing normal aging characteristics, spectral purity and/or frequency stability
		Aging is the drift of resonant frequency with time.	Aging as a drift rate vs. time should be considered for each application. Add shelf life criteria where stability over time is critical
		Crystal can easily be damaged during Installation and Handling	Handling and mounting precautions should be taken to prevent seal damage or excessive mechanical shock or vibration to the crystal. Precautions should be taken when trimming wire leads to minimize mechanical shock to the resonator.

3.0 **Design Construction** Design and construction information can be found in MIL-C-49468. This table documents some of the key information about design and construction for crystal usage.

3.1 **Recommended Design for Space and Launch Vehicles** Quartz crystals designed and qualified to MIL-C-49486 Class S and screening and lot conformance to Table 400-9 (screen), Table 400-10 (lot conformance).

Table 400-3 Design and Construction

Construction	Information
General	The design of the crystal should 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.
Controlled environment of non-hermetic crystal units.	Non hermetically-sealed crystals may be used inside hermetically sealed oscillators when the oscillator manufacturer also manufacturers the crystal and provides for controlled transport of the crystal to the oscillator manufacturing area.
Sealing	It is highly, recommended that individual crystal units be sealed using cold-weld or resistance-weld techniques. Or a form of sealing that ensures a leak rate of or less than 10^{-8} atm-cc/sec.
Metallization	Metallization should be selected to provide the necessary adhesion of the electrode contacts. If gold electrodes are used, an undercoat such as chromium or tungsten is needed.
Crystal support/mounting	Crystals should be supported by a minimum 3 point mount 120° apart. **Note:** MIL-H-10056/ 21/23/27/29/30/31/32/33/34/39 do not meet this criteria.
Type of Quartz	Cultured, premium Q quartz per EIA Standard RS-477 is recommended. For use in radiation environments, the quartz should be prepared by the electrodiffusion process. Quartz prepared by the electrodiffusion process is recommended for all applications because of its low levels of Al and Na ions.
Gold Plating	Gold plating on package surfaces should be in accordance with MIL-G-45204, Type, grade, and class should be specified for each finish system. Examples are: Type 1, Grade C, Class 2 (0.000100” min.) over copper underplate (0.000010”min.). As an alternative Gold (0.000050”min.) over Nickel (0.000100”) with Gold thickness maximum equal to 0.000200”.

3.2 Known Reliability Suspect Designs The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 400-4 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Two point mount internal construction	These devices were identified in MIL-STD-1547 as reliability suspect.
Plug-in packages	These devices were identified in MIL-STD-1547 as reliability suspect.

3.3 Known Material Hazards The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 400-5 Known Material Hazards

Material	Precaution
Solder sealed packages	These devices were identified in MIL-STD-1547 as reliability suspect.
Gold metallization without barrier metal	These devices were identified in MIL-STD-1547 as reliability suspect.
Quartz other than EIA STD RS-477 premium Q type.	These devices were identified in MIL-STD-1547 as reliability suspect.
Non swept quartz in radiation (space) environments	These devices were identified in MIL-STD-1547 as reliability suspect.
Tin plated packages and leads	100% tin causes tin whiskers which allows a current path causing a intermittent shorts or arcing.

3.4 Produceability and Baseline Controls A product baseline should be established for all capacitors purchased as a QPL MIL-C-49468 with a company unique drawing reflecting the information in this handbook. Areas which need to be specified and controlled in the drawing and baseline are:

Table 400-6 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to MIL-C-49468
Production Lot	Refer to MIL-C-49468
Serialization	Refer to MIL-C-49468
Traceability Control (Parts, Materials, & Processes)	Refer to MIL-C-49468
Rework Provisions	Refer to MIL-C-49468
Process Controls Verification & Validation	Refer to MIL-C-49468 and the following: Pre-Cap Visual and Mechanical Inspection IAW Table 400-8 of this section Motional capacitance IAW Table 400-8 this section. Quality Factor IAW Table 400-8 of this section. Controls documented in In-Process Appendix I of this section.
Screening Tests (100%)	Refer to Table 400-8 of this section.
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to Table 400-9 of this section.
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-C-49468 first article or qualification tests, Separate first article or qualification tests are not required for a manufacturer listed on the QPL for MIL-C-49468 for the slash sheet that best fits the component design required.

Note: A manufacturing baseline should be developed and maintained by the manufacturer and controlled and verified by the procuring organization for (company unique drawings),.for QPL reliability level S quartz crystals the manufacturing baseline should be verified by the procuring organization.

4.0 Quality Assurance Provisions

The following table outlines the minimum areas which should be considered and verified when purchasing QPL MIL-C-49468 and company specific quartz crystal drawings reflecting the information in this handbook.

Table 400-7 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of the applicable manufacturing baseline.	Homogeneity Production Lot Serialization Traceability Control for Parts, Materials, & Processes Rework Provisions Process Controls verification & validation Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests) Specifically the following verifications are essential for this product: Pre-Cap Visual and Mechanical Inspection IAW Table 400-8 of this section Motional capacitance IAW Table 400-8 this section. Quality Factor IAW Table 400-8 of this section. Controls documented in In-Process Appendix I of this section.
Screening (100 percent): refer to the requirements of the company unique drawing and Table 400-8 of this handbook.	Review screening data (Attributes & Variables).
Lot Conformance: refer to the requirements of the company unique drawing and Table 400-9 of this handbook.	Review lot conformance data (Attributes & Variables).
Qualification Testing: refer to the requirements of the company unique drawing.	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: should be in accordance with MIL-STD-1580.	Review incoming DPA and compare to supplier DPA.
Sample and Data Retention: Data retention information is found in Section 4 of the this handbook.	Maintain samples and data for further use.

Table 400-8 100% Screening Table

MIL-C-49468 Screens	Additions to the Methods and Criteria of MIL-C-49468
Pre-Seal Visual	Visual per MIL-C-49468, @ a min. of 30X. Units exhibiting one or more of the following anomalies are to be removed: Cracks or holes in the weld contact area where crystal support members are welded to the holder base terminal pins. Loose or broken terminal pins or crystal mounting supports. Cracks or separations in electrically conductive bonding cement between quartz crystal and support member. 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. Loose weld spatter, bonding cement, or other particulate matter. Less than 0.005” clearance between quartz crystal and the package wall. Quartz crystal resonator not parallel or perpendicular to crystal holder base within 10°. Joining of packages by interference, friction, crimping or similar methods unreinforced by welding. Any surface, including cover, exhibiting contamination/corrosion (adhering particulate, film, flux residue, finger print, or other type of material). 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. Adhering weld splatter exceeding 0.03” dimension through any plane. Weld splatter should be considered adherent when it cannot be removed with 20 psig gas blow of dry, oil-free nitrogen. Base terminal and crystal mounting support exhibiting nicks, misalignment, cuts, cracks, or distortion, Quartz crystal not centered within +0.030” in its mounting with respect to the quartz crystal holder base. Dimensions out of tolerance.
Subgroup 1 Visual/Mechanical External Examination Mechanical Shock Frequency Resistance vs Temp Frequency vs Temp (static) Coupled Modes Condensibles Unwanted Modes Capacitance Shunt Motional	When specified When specified, The motional capacitance, C1, is defined in accordance with EIA Standard 512. The resonant frequency (F_R) is measured using two load capacitances connected successively in series with the crystal unit. The results obtained with two load capacitors C_{L1} and C_{L2} can be combined so that:

Table 400-9 Lot Conformance Table

MIL-C-83421 Screens for CRH/CQR style	**Additions and Exceptions to Methods and Criteria of MIL-C-83421**
Subgroup 1	
DC Life (Accelerated)	Sample of 4, 2,000 hours
AC Life (Accelerated) AC Application Only	Sample of 4, samples should have the highest ESR readings 250 hours Maximum AC current, 120 % of IAC (RMS); Minimum current 3 times the system application, adjusted for 40 kHz operation. VAC frequency of 40 kHz +2%. 1/
Capacitance Dissipation Factor Insulation Resistance Seal	Readings taken @ +25^{o}C and +125^{o}C
Subgroup 2	
Vibration (Random) (Sine)	Sample of 6, MIL-STD-202, Method 214, test Cond. II K Vib axis 2 orthogonal planes, 15 minutes vibration
Terminal Strength	
Dielectric Absorption	
Capacitance Dissipation Factor Insulation Resistance Seal	
Subgroup 3	
Shock	Sample of 6, MIL-STD-202, Method 213, Cond. D (500g)
Solderability	
Temperature Coefficient	
Capacitance Dissipation Factor Insulation Resistance Seal	

1/ VAC should not exceed 240 VRMS under any conditions

SECTION 500 - DIODES

1. ORGANIZATION: This section covers the following device types Light Emitting, Rectifier, Schottky Barrier, Switching, Varactor, Voltage Reference, Voltage Regulator, Transient Suppresser, Silicon Control Rectifier, and Photodiode.

2. APPLICATION

TABLE 500-1 - SEMICONDUCTOR DEVICES DERATING

DEVICE TYPE	PARAMETER	DERATING FACTOR	COMMENTS
Axial Lead, Small Signal, Switching, Silicon & Schottky Rectifiers	PIV	.70	
	I Surge	.50	
	Io	.50	
	Tj	80% of Tj Max	Not to exceed 105°C
SCR	Off-State Voltage	.70	
	I Surge	.50	
	On-State Current	.50	
	Tj	80% of Tj Max	Not to exceed 105°C
VARACTOR	Forward Current	.75	
	Peak Inverse Voltage	.75	
	Power Disipation	.5	
	Tj	80% of Tj Max	Not to exceed 105°C
PHOTODIODES	Io	.50	
	Tj	80% of Tj Max	Not to exceed 105°C
TRANSIENT SUPPRESSORS	P_D	.75	
	Transient Current	.75	
	Zener Voltage (Vz)	.70	
	Tj	80% of Tj Max	Not to exceed 105°C
ZENERS	P_D	.50	Temperature Compensate zeners should be operated the specified point
	Zener Current	.80	
	Tj	80% of Tj Max	Not to exceed 105°C

Table 500-2 End-of Life Design Limits

Device Type	Parameter	Parameter Design Value
Axial Lead, Small Signal, Switching, Silicon & Schottky Rectifiers	Leakage Current (I_R) Forward Voltage (Vf)	100% of initial maximum limit ± 100mV from the original maximum limit
Varactors	Leakage Current (I_R) Forward Voltage (Vf)	100% of initial maximum limit ± 100mV from the original maximum limit
SCR	Gate Leakage Current Latching Voltage	100% of initial maximum limit ± 100mV from the original maximum limit
Photodiode	Input Current (If) Output photocurrent	50% of the max rated 25% of the initial value
Transient Supressors	Leakage Current (I_R)	100% of initial maximum limit
Zeners	Zener Voltage (Vz)	±10% of initial operating point

3. DESIGN AND CONSTRUCTION

BACKGROUND: Semiconductor devices design and construction has traditionally been maintained in accordance with the requirements of the applicable specifications (MIL-S-19500 and its Slash Sheets). The JANS design rules within the specifications were applied where available. The metallurgical bond for axial leaded devices and monometallic wire bond were two of the more disputed issues. However, with the push for the use of plastic encapsulated devices, and replacement of traditional JANS controls with the more cost effective high volume production line process controls the designer has to evaluate the acceptability of the proposed design and construction for the application. In addition, some of the old technology was never designed to meet the high reliability applications needs and application of the JANS rules was often limited to just screening the quality in.

The new approaches such as Surface Mount package, Multichip Module (MCM) technology, and Power Module technology that are currently beginning to be employed in the space application designs are often based on old technology, either old die designs, old package types etc., that are modified and supplied as Surface Mount, MCM, and Power Modules. As such the modifications are often performed after the discrete devices were screened and the final product is rarely verified and validated for the intended application. Therefore, the designer or the component engineer needs to ensure that the supplied components meet the application requirements. Table 500-3 provides some of the known Design and Construction Considerations.

Table 500-3 Design and Construction Considerations

Device Type	Design & Construction Considerations	Possible Mitigation
Axial Lead Devices	Pressure contact, Dumet or Soft Glass construction.	Monitored Temperature Cycling with hot monitored lead pull test.
	Point contact whisker cavity construction.	Forward and Backward Instability Shock Tests (FIST & BIST).
	Axial lead metal can with single crimp lead area.	X-Ray crimp area for inadequate contacts.
Cavity Devices	Lead solder based compounds used for die attach medium.	Maintain the moisture levels below 5000ppm to prevent solder decomposition.
	Silver filed epoxy or silver glass die attach mediums.	Maintain under 5000/ppm moisture, perform Transient Thermal Response and qualify process to 1000hrs. Power Burn-In.
	Organic passivating or conformal coating materials.	Qualify process to 1000/hr HTRB, perform extended vacuum bake prior to device sealing, maintain low moisture levels.
	Gold wire bonds on aluminum die metalization and aluminum wire on gold substrates.	Qualify wire bond process to survive 300°C without Au-Al intermetalic formation.
	Aluminum wire bonds on silver die metalization and on Ni plated Au flash posts.	Qualify process to survive an acceptable number (to the design application) of Intermittent Operating Life Cycles followed by wire pull test without any wire lifts.
	Au flash on Ni plated posts.	Maintain gold to 5 - 10µin over Ni plating on posts.
Hot Welded Cans	A high potential for loose conductive particles inside the cans.	Monitored cap welding and PIND test.
Glass to metal seals	High probability of developing glass cracks during testing and handling of devices.	Qualify packages to survive acceptable number of Temperature Cycles for the proposed application followed by die penetrant.

Produceability and Baseline Controls A product baseline should be established for all devices not purchased as a MIL-PERF-19500 QPL device. Areas which need to be specified and controlled in the drawing and baseline are:

Table 500-4 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to MIL-PERF-19500 for JANS
Wafer Lot	Refer to MIL-PERF-19500 for JANS
Wafer Lot Acceptance	Refer to MIL-PERF-19500 for JANS
Radiation Hardness	Refer to MIL-PERF-19500 for JANS
Assembly Lot accumulation period	
Manufacturing Location	
Assembly processes and their verification	
Inspection Lot formation	Refer to MIL-PERF-19500 for JANS
Test equipment validation	
Serialization	Refer to MIL-PERF-19500 for JANS
Traceability Control (Parts, Materials, & Processes)	Refer to MIL-PERF-19500 for JANS
Rework Provisions	Refer to MIL-PERF-19500 for JANS
Process Controls verification & validation	Refer to MIL-PERF-19500 for JANS
MRB and Change Control Authority	
Screening Tests (100%)	Refer to MIL-PERF-19500 Table II and Detail Specification as applicable
Quality Conformance Inspection (Destructive & Non-destructive tests)	Refer to MIL-PERF-19500 for Tables III, IVa, V, and Detail Specification as applicable
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-PERF-19500 for Table VI and Detail Specification as applicable

Note: A manufacturing baseline should be developed and maintained by the manufacturer in accordance with MIL-PERF-19500, and controlled and verified by the procuring organization.

4. QUALITY ASSURANCE There are four major areas to be covered under the Quality Assurance provisions. These are the Wafer Fabrication, Assembly, 100% Test or Screening, and Quality Conformance Inspection and Qualification. MIL-S-19500 has provided guidance for both the device manufacturers and designers in all of the four areas. The designer and component engineer has to understand the device application, the need for and application tolerance of device to device performance variation and how the device manufacturer controls in each of the four areas impact the performance. Table 500-5 provides a summary of the recommended controls for space level devices.

Table 500-5 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
Wafer Fabrication: In process controls should be per MIL-PERF-19500 Appendix D.	Wafer Lot formation Wafer Fabrication rework Wafer Lot Acceptance Wafer Fabrication Location
Assembly: In process controls should be per MIL-PERF-19500 Appendix D	Lot Homogeneity Production Lot formation Traceability Control Rework Provisions I.A.W. approved procedures Process Controls, their verification & validation elements Assembly Location
Screening Tests (100%): Screening should follow the MIL-PERF-19500 Table II and detailed specification. Quality Conformance Inspection (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)	Electrical parameters and performance specified meets application. Screening Temperature Range, QCI and Qualification specified meet application Test equipment accuracy and repeatability Accept and Reject criteria Failure Analysis and Corrective action.
Screening (100 percent): refer to the requirements of MIL-PERF-19500 for JANS and the detailed specification.	Review screening data (Attributes & Variables). Verify test equipment correlation, repeatability, test windows were met, test conditions, and PDA compliance.

Table 500-5 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
Quality Conformance Inspection: refer to the requirements of MIL-PERF-19500 for JANS and the detailed specification.	Review lot conformance data (Attributes & Variables), sampling techniques, and stress levels.
Qualification Testing: refer to the requirements of MIL-PERF-19500 and the detailed specification.	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: should be in accordance with MIL-STD-1580.	Review incoming DPA and compare to supplier documentation.
Sample and Data Retention: Data retention information is found in Section 4 of the this handbook.	Maintain samples and data for further use.

5.0 Lessons Learned

Wafer Fabrication: This is probably the most critical area that determines the device reliability and performance. Traditionally this area has been downplayed, with respect to end product screening and testing, in its importance to the reliability of the end product and consequently controlled by OEMs through a flow chart at best. However, with the change from “screening of devices to meet quality requirements” to “building of quality into devices” this part of the process has recently become the area of highest concentration. Table 500-6 outlines some of the activities that need specific attention.

NOTE: For most of the older semiconductor device technologies the wafer fabrication process is typically designed to a nominal level that would produce a range of device types and device families on the same line since it may not be cost effective to target the process for only one device type.

Assembly: This is area where the die or chips, processed through wafer fabrication, are put in packages or assembled so that they can used in systems. These packages and assembly materials used determine in most cases, where the die ratings outperform the package ratings, the final device ratings such as Power Dissipation, Operating and Storage Temperature Ranges, Output Steady State Current, and Thermal Resistance. It is very important that the assembly processes are closely monitored and controlled so that defects are not introduced. MIL-S-19500 Appendix D has traditionally provided the guidelines for process controls for semiconductor devices. Table 500-7 outlines some of the areas that need specific attention.

Screening: This area covers the 100% testing (electrical, mechanical, and environmental) that are applied to devices in order to eliminate the defects associated with infant mortality portion of the “Bathtub” reliability curve (see Figure 500-9). The Percent Defect Allowable (PDA), test windows post HTRB and Burn-In, and other controls determine the number of random defects expected when using the lot of devices. The implementation of effective process controls in the front areas, wafer fabrication and assembly, makes device to device performance variability more consistent, and therefore, could allow lots to be evaluated on a sample basis rather than screened on 100% basis. The intended design application requirements provide the basis for device performance valuation. Table 500-8 outlines some of the areas that need specific attention.

Quality Conformance Inspection (QCI): This area covers the sample verification of the lot integrity to be used in the application. The stress levels applied traditionally have been at the levels established, for the particular technology and product type, to simulate the end of life characteristics under accelerated conditions. Table 500-10 outlines some of the areas that need specific attention.

Table 500-6 - Wafer Fabrication

Area of Concern	Effect on Performance	Potential Remedy
Wafer Lot formation	Determines die lot performance homogeneity	Use wafers from single batches and manufacturers.
Wide resistivity and thickness, epi and epi thickness specifications	Allows wide range of electrical characteristics which lead to new device types and or product downgrading.	Use only the devices for which the target specifications of the raw wafers were designed and not the downgraded by products.
High defect count per cm^2.	Increase of device to device variation, risk of premature device failure, lower yields.	Lower the acceptable number of defects per cm on the incoming wafers.
Wafer Fab. Processing	Determines the device performance	
Particle size and count allowable in the clean room.	Depending on the device type, geometry, and technology may impact device reliability and electrical performance. Ionic contamination.	Use positive air flow interlocks and entries, air filters, process only devices for which the clean room characteristics were proven to be acceptable.
Water purity and Diffusion cleanness	Potential for ionic contamination.	Use water filters, test for bacteria, C-V plots.
Rework	Increase of device to device variation, risk of premature device failure, lower yields.	If allowed, verify that the rework did not have adverse effects on device performance in the intended application.
Wafer Fab Location	Use of foundries and other manufacturer’s die leads to loss of visibility into wafer fab processing and controls may impact device performance.	Verify the supplier of devices has visibility and control over the wafer fabrication processes, changes, and implementation.
Wafer Lot Acceptance	Data provided does not correlate or tie into the wafer fab process controls for oxide, die, metalization, and passivation layer thickness. Sampling may not be valid.	Ensure wafer lot acceptance provides meaningful data to ascertain the wafer fabrication process and controls.
Radiation Tolerance	Process, design, and layout can impact radiation performance.	Use design techniques & process methods that are minimally impacted (affected) by radiation influences.

Table 500-7 - Assembly

Area of Concern	Effect on Performance	Potential Remedy
Die attach is not consistent	Devices fail prematurely due to voids which cause overheating or current crowding effects	Implement die attach monitors such as Transient Thermal Response and die shear.
Attach materials are not optimized for the package and design application.	Devices fail prematurely due to die attach degradation when operated under simulated and accelerated application conditions.	Qualify and validate the attach process and materials for the intended design application.
Pressure contact, Ag bump, Dumet glass construction.	Devices may intermittently open during temperature transitions while under operation.	Validate and monitor the process through Monitored Temp Cycle and Hot Lead Pull.
Multiple Lots formation and loss of Lot Traceability	Increase potential for lot failure due to loss of traceability to individual lots.	Maintain traceability to individual lots.
Rework Provisions	Allowing rework on the production line may not enforce corrective action implementation and promote loose process controls.	If rework was allowed maintain traceability to the reworked portion of the lot for future valuation of adverse rework effects.
Purple Plague (Au wire on Al metalization)	Open circuit.	Validate process through extensive High temperature storage; subject lot to 300°C.
Purple Plague (Al wire on Au metalization	No impact if Gold is thin and the bonding is to the Ni under plate. Otherwise will lead to open circuit.	Validate process through Temperature and Operating Cycles; peel wire to verify bond.
Al wire bonds on Ag metalization.	Open circuit due to operating and Thermal cycles.	Validate process through Temperature and Operating Cycles;
Particles inside cavity	Potential short due to conductive particle such as Die attach slag, weld splash, etc.	Validate the processes to ensure loose particles are not introduced. Institute PIND.

Table 500-8 - 100% Screening

Screening Test (MIL-S-19500 Table II)	Effect on Performance	Rationale for Test Conditions
Pre-Cap Visual Inspection	Ensures the devices are free of defects prior to encapsulation	Depending on the manufacturer's process controls this may be done on a sample basis.
High Temperature Storage	Some device technologies require this to stabilize the junction characteristics.	Select the max. device rated temperature storage.
Temperature Cycling	Intended to screen out infant mortality defects due to die attach and other package mismatch defects.	20 cycles were initially established as sufficient to pass the infant mortality stage. Devices should reach temperature extremes.
Constant Acceleration	Test designed to stress the wire bonds and die attach areas.	The G-force level is determined by the package capability and should be above the application requirements.
Transient Thermal Response	Non-destructive die attach screen for voids outside the process capabilities.	Applicable only to devices with negative voltage temperature coefficient. Limits should track back to maximum $R_{\theta JC}$, P_D, and or Surge characteristics.
Surge Testing	Developed to screen out devices with die attach, junction, and or bulk silicon defects.	Surge should not exceed the max. designed capability of the die.
PIND	Developed to screen out devices with loose particles inside the cavity.	Set-up sensitivity, location and tester mounting, shock/ co-shock and vibration levels, and transducer couple medium are important to effective PIND screening.
Pre-HTRB electrical tests	Electrical parameters (at T_A=25°C) established for each technology and device type to be indicative of a good device.	Parameters most likely to change if ionic contamination is present such as Leakage currents, Forward Voltage, Breakdown Voltage

Table 500-8 - 100% Screening (cont.)

Screening Test (MIL-S-19500 Table II)	Effect on Performance	Rationale for Test Conditions
HTRB	Stress test designed to screen out ionic contaminated devices using DC Bias Voltage and Temperature to accelerate the effects. Ions are made mobile through Temperature exposure while the DC Bias Voltage acts as dipole magnet attracting the ions on each positive and negative side of the power supply.	The applied Temperature should be that of the Max. Operating Ambient without heat sink, and the applied voltage should be 80% of the rated breakdown voltage of the stressed junction. The magnitude of the exposing temperature and applied bias directly affect the result. Applying AC Voltage or removal of the bias before devices reach approx. 35°C will negate the test.
Post-HTRB electrical tests	Repeat of Pre-HTRB electrical tests to validate devices did not drift outside the established limits. Test should be performed within 16 hrs of bias removal.	Ionic contamination, if free to move around will cause a change in the device electrical characteristic. Depending on the contaminant type and level the ions will eventually return to original state.
Percent Defective Allowable (PDA)	Establishes the random failure rate expected during the useful life of the devices.	Typical PDA is 5% max. with a one time resubmission if Percent Defective (PD) < 20%. Lots failing this criteria are should be considered reliability suspect.
Power Burn-In	Test designed to screen out assembly defects.	Test conditions are typically established such that device junction temperature approaches that of the maximum Operating Junction Temperature Ratings.

Table 500-8 - 100% Screening (cont.)

Screening Test (MIL-S-19500 Table II)	Effect on Performance	Rationale for Test Conditions
Post Power Burn-In electrical tests	Verifies that devices still meet the established electrical characteristics.	Repeat the Post HTRB (Pre Burn-In) electrical tests plus the rest of the DC characteristics including those at high and low temperatures.
Percent Defective Allowable (PDA)	Establishes the random failure rate expected during the useful life of the devices.	Typical PDA is 5% max. with a one time resubmission if Percent Defective (PD) < 20%. Lots failing this criteria are should be considered reliability suspect.
X-Ray	Test was developed for workmanship verification (it does not replace Pre-Cap Visual Inspection).	Criteria and level of inspection is based on the package and defect type.

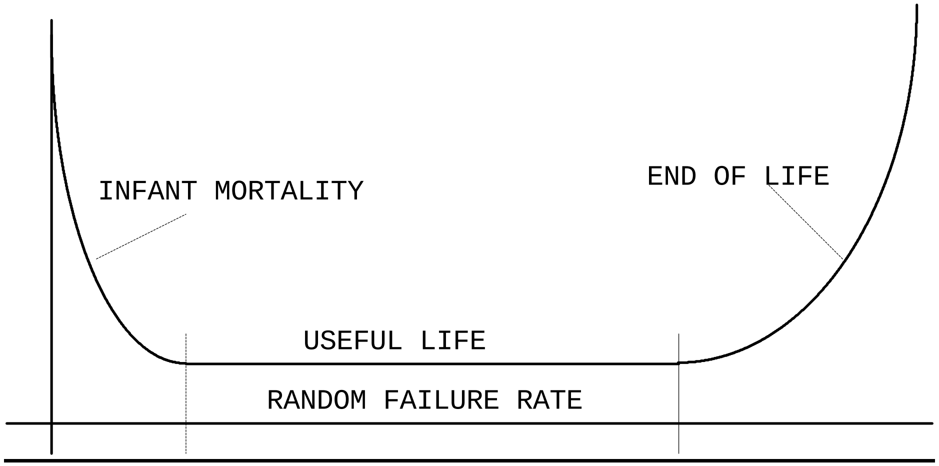


Figure 500-9: Reliability Bathtub Curve

Table 500-10 - Quality Conformance Inspection

Test Name	Effect on Performance	Test Rationale
Group A	Verifies device electrical performance under DC, AC or transient conditions, and over the Rated temperature range.	Validates device capability to meet its electrical characteristics. Usually performed on each lot on a sample basis after 100% screening was completed.
Group B	Verifies device operational performance within the useful life portion of the bath tub curve. This includes package design integrity verification (Temperature Cycling, Intermittent Operating Life, and Thermal Resistance Subgroups), device operational performance (Accelerated Life Test).	Validates lot homogeneity and process/design operational performance capability on a lot by lot basis. Validates screening was performed correctly and no defects were introduced.
Group C	Verifies device mechanical performance and operational performance up to 1000 hrs. Operational Life or 6000 Intermittent Operation Cycles.	Validates the processing and device design provide up to 1000 hrs. and or 6000 cycles of useful life under accelerated conditions. Most military and space design applications reliability predictions use this as basis for predictions.
Group D	Verifies the device design capability to withstand the radiation effects that some applications may require to operate under.	Validates wafer fabrication, device design, and processing are capable of meeting the total radiation exposure over the system operating life without degradation.
Group E	Verifies end of life device design capability	Validates that the device processing and design end of life are outside the Thermo-Mechanical and Operational boundaries established for useful life.

Table 500-11 Recommended Electrical Parameters

Device Type	Parameter	Measurement Point	Measurement Temperature (1)
Rectifiers Small Signal, Switching, Silicon & Schottky Rectifiers	Forward Voltage (Vf)	At rated I_F	At room, hot, and cold.
	Leakage Current (I_R)	At 80% of rated B_{VR}	At room and hot temp.
	Breakdown Voltage (V_{RB})	At 10x I_R	At room and cold
	ΔV_F and ΔI_R	Post HTRB, Burn-In, Life Tests, and Temperature Cycling	Room Temperature
	Surge and Reverse Energy	Peak Rated Current	Room Temperature
	Junction Capacitance C_J	At specified Voltage and frequency	Room Temperature
	Reverse Recovery Time	At specified V_R, I_R load resistance, load capacitance.	Room Temperature
Varactors	Forward Voltage (Vf)	At rated I_F	At room, hot, and cold.
	Leakage Current (I_R)	At 80% of rated B_{VR}	At room and hot temp.
	Breakdown Voltage (V_{RB})	At 10x I_R	At room and cold
	ΔV_F and ΔI_R	Post HTRB, Burn-In, Life Tests, and Temperature Cycling	Room Temperature
	Quality factor Q	At specified voltage and frequency	Room Temperature
Photodiode	Forward Voltage (Vf)	At rated I_F	At room, hot, and cold.
	Leakage Current (I_R)	At 80% of rated B_{VR}	At room and hot temp.
	Power Output (P_O) ΔV_F, ΔI_R , and ΔP_O	Post HTRB, Burn-In, Life Tests, and Temperature Cycling	Room Temperature
Transient Suppressers	Forward Voltage (Vf)	At rated I_F (Zeeners)	At room, hot, and cold.
	Leakage Current (I_Z)	At 80% of rated B_Z	At room and hot temp.
	Breakdown Voltage (V_Z)	At specified I_Z	At room, hot, and cold
	ΔV_F, ΔI_Z, ΔV_Z	Post HTRB, Burn-In, Life Tests, Surge, and Temperature Cycling	Room Temperature
	Reverse Surge Capability	At rated peak current	Room Temperature

Table 500-11 Recommended Electrical Parameters (cont.)

Device Type	Parameter	Measurement Point	Measurement Temperature (1)
Zener, Temperature Compensated	Forward Voltage (Vf)	At rated I_F (Zener)	At room, hot, and cold.
	Leakage Current (I_Z)	At 80% of rated B_Z	At room and hot temp.
	Breakdown Voltage (V_Z)	At specified I_Z	At room, hot, and cold
	Zeener Impedance (Z_Z)	At 25% and 125% of specified IZ	Room Temperature
	ΔV_F, ΔI_Z, ΔV_Z, and ΔZ_Z	Post HTRB, Burn-In, Life Tests, and Temperature Cycling	Room Temperature
	Temperature Coefficient (a V_z)	V_Z value over temperature	At room, hot, and cold

NOTES: 1. Room Temperature =25±5°C, Cold Temperature = Low rated Temperature (-55°C or -65°C typically), Hot Temperature = High Rated Temperature (above 125°C typically)

Reliability Suspect designs The following designs have been determined from past experience to be reliability suspect. However, with improved materials, process controls, and through sound engineering the problems associated with these designs could be alleviated. For each of these see Table 500-7, 500-8, and 500-10 Assembly, Screening, and Quality Conformance for possible validation:

a) Hot welded cans
b) Nonpassivated dice
c) Bimetallic bonds at the die
d) Point contact (whisker) devices
e) Silver bump, ramrod construction
f) Nonmetallurgically bonded construction (except schottky devices), unless supported by operational thermal cycle life data
g) Germanium devices
h) Gallium Arsenide devices
I) Flip chip units
j) Glass or silver filled epoxy die attach
k) Parts containing organic materials, unless supported by HTRB and Life Test data
l) All plastic encapsulated devices, unless supported by full design application validation and qualification
m) Pure and unfused tin coated packages and leads.

SECTION 600 - EMI AND RF FILTERS

1. ORGANIZATION: This section covers RF and EMI filters.

2. APPLICATION

Table 600-1 - RF and EMI Derating

DEVICE TYPE	PARAMETER	DERATING FACTOR	COMMENTS
All	Applied Voltage DC Current Tj Surge Current(Is)	.50 .75 80% of Tj Max $(t_S)x(I_S)<1.4I_R$	At the specified Temperature At the specified Temperature Not to exceed 105°C With no load current flowing and where t_S is the surge duration and I_R is the Rated DC current.

Table 600-2 End-of Life Design Limits

Device Type	Parameter	Parameter Design Value
All	Capacitance	± 20% from the original maximum limit
	Insulation Resistance	50 percent of specification limit
Ceramic discoidal capacitors using BX and X7R Dielectric	Capacitance	Allow for a 2 - 4% decrease per decade hour.

Table 600-3 Design Applications

Style	Typical Applications	Application Considerations	Possible Mitigation
All	General Purpose	Under certain conditions, the current parameters of the filter are governed by the transient surge current (I_s). I	To determine whether a filter can withstand a know surge current, the following analysis should be used. A filter should not be exposed to a transient current that could damage the device. **1.2** Transient Current With no load current flowing: I_S = surge current (amps) I_R = Rated DC current (amps)t t_S = Duration of I_S (µs) Then, if tS multiplied by IS is less than 1.4 I_R, the filter should not be damaged. **2.2** Rated Load Current With rated load current I_R flowing:

			Then, if t_S multiplied by I_S is less than 0.4 IR, the filter should not be damaged.
Stud Mounted	General Purpose	Insulation and Soldering	Follow the established procedures for the specific application to provide adequate Insulation and to prevent device degradation during soldering operation.
		Connecting wires	Heat sink the filter stud lead to prevent damage to the high temperature solder seals in stud leads.
		Mounting torque	Do not exceed specified torque; Do not hold on to filter body to keep filter from turning under torque; Use tooth stile lockwasher between filter and mounting surface only. Insulation resistance or DWV should be performed after torquing.

3. DESIGN AND CONSTRUCTION

The Class S rules of MIL-F-28861 have traditionally been followed for most of the space level applications of EMI and RF filters. In addition the Class S rules for the individual piece parts used in the manufacture of these filters have also been followed very successfully to the extent possible. The Table 600-4 below provides a quick application reference.

Table 600-4 Design Application Considerations

Typical Applications	Design & Considerations
Low power EMI filters with low RF currents	Ceramic capacitors; Follow the individual governing specification and section 200 herein.
High power EMI filters.	L, C, Pi, or T sections of toroidal wound or ferrite bead inductors and capacitors. Feedthrough capacitors. Follow the individual governing specification and appropriate sections herein

3.1 Space & Launch Vehicles Recommended Designs: Follow the information provided in individual Capacitor, Inductor, and MIL-F 28861.

3.2 Known Reliability Suspect Designs: Follow the information provided in individual Capacitor, Inductor, and MIL-F 28861.

Table 600-5 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Built with suspect piece parts.	Individual sub-components such as capacitors, inductors etc. are reliability suspect; See individual sections.
Non-hermetic filters (polymeric seals)	Filters without glass end seals are not hermetically sealed and are both subject to corrosion and may outgas significantly.
Gold plated polymeric sealed devices	Gold-plated parts with polymeric end seals are especially subject to moisture penetration and outgassing.
Tubular Ceramic Elements	EMI or RF filters containing tubular ceramic elements are not recommended for use in space applications unless proven that the design application is robust and can accommodate the use of these devices without failure.
Unfused Tin plated packages and terminals	Unfused Tin plating has been proven to develop whisker growth under certain conditions and is not recommended for use in space applications.
External tooth locking hardware	Not recommended for high shock and vibration environments.

3.3 Known Material Hazards: Follow the information provided in individual Capacitor, Inductor, and MIL-F 28861.

3.4 Produceability and Baseline Controls A product baseline should be established for all filters not purchased as a QPL MIL-F-28861 device. Areas which need to be specified and controlled in the drawing and baseline are:

Table 600-6 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to MIL-F-28861 for Class S
Production Lot	Refer to MIL-F-28861 for Class S
Serialization	Refer to MIL-F-28861 for Class S
Traceability Control (Parts, Materials, & Processes)	Refer to MIL-F-28861 for Class S
Rework Provisions	Refer to MIL-F-28861 for Class S
Solder Dip/Retinning Option	Use a qualified process; Perform specified 100% subsequent testing per MIL-F-28861.
Process Controls verification & validation	Refer to MIL-F-28861 for Class S
Screening Tests (100%)	Refer to MIL-F-28861 for Class S
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to MIL-F-28861 for Class S
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-F-28861 for Class S

Note: A manufacturing baseline should be developed and maintained by the manufacturer in accordance with MIL-F-28861, and controlled and verified by the procuring organization.

4. QUALITY ASSURANCE

4.1 The following table outlines the minimum areas which should be considered and verified when purchasing QPL MIL-F-28861 or Company specific filter drawings.

Table 600-7 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of MIL-F -28861.	Lot Homogeneity Production Lot formation Device Serialization Traceability Control Rework Provisions I.A.W. approved procedures Process Controls and their verification & validation elements Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)
Screening (100 percent): refer to MIL-F-28861 for Class S.	Review screening data (Attributes & Variables). Verify test equipment correlation, repeatability, test windows were met, test conditions, and PDA compliance.
Lot Conformance: refer to MIL-F-28861 Group B for class S.	Review lot conformance data (Attributes & Variables).
Supplier DPA: should be in accordance with MIL-F-28861.	Review supplier DPA and compare to incoming DPA.
Qualification Testing: refer to the requirements of MIL-F-28861 for class S.	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: should be in accordance with MIL-STD-1580.	Review incoming DPA and compare to supplier DPA.
Sample and Data Retention: Data retention information is found in Section 4 of this handbook.	Maintain samples and data for further use.

SECTION 700 Fuses (MIL-F-23419)

1.0 Scope

This section contains detailed information for fixed, high reliability sealed fuses.

2.0 Application

The following tables contain information about fixed, high reliability sealed fuses to assist in the decision making process of selection and documentation for Design Engineers and Parts Engineers.

Table 700-1 Derating

Device Type	Parameter	Derating Factor	Comments
Link or similar fuses and molded	Current ratings	0.70	For atmospheric conditions @ +25°C.
	2 A	0.50	For vacuum conditions @ +25°C. Decrease linearly 0.5%/C (for Link or similar fuses) and 0.2% (for solid molded fuses) above 25C or the manufacturer suggested derating factor up to maximum allowed temperature
	1 A	0.45	
	½ A	0.40	
	3/8 A	0.35	
	¼ A	0.30	
	1/8 A	0.25	

TABLE 700-2 Design Applications

Style	Typical Applications	Application Considerations	Possible Mitigation
	Electrical overload protection	The current ratings of the fuses should be determined at specified operating conditions.	Consideration should be given to the following areas for each application: 1. Ambient temperature 2. Connections to the circuit 3. Ventilation 4. Vacuum adhere to the derating criteria.
		Electrical Considerations	Factors to be considered should 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
		Do not use in t applications where open circuit voltage exceeds the max specified voltage rating for the fuse.	Adhere to derating .
		Mounting environments including heat sinking should be considered.	Heat sinking is recommended for all fuses.

3.0 Design and Construction

3.1 Recommended Design for Space and Launch Vehicles Fuses designed and qualified to MIL-F-23419 and the additional screening documented in this handbook. And the following information:

Table 700-3 Design and Construction Considerations

Construction	Information
General	Designs should be considered for space use only if they can be demonstrated to not alter current ratings more than 10% when used under vacuum (i.e., loss of pressure within fuses) or if hermeticity can be demonstrated to provide the above stability over a 10 year period in vacuum. (Extrapolations from leak rate measurements may be used.)

3.2 Known Reliability Suspect Designs The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 700-4 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Intermittent contact	Fuses requiring fuse holders. These fuses were documented as a prohibited part in MIL-STD-1547.
Tin Whiskers	Fuses with plated tin package or leads. These fuses were documented as a prohibited part in MIL-STD-1547.

3.3 **Lessons Learned** Fuses which are not hermetic used in a non hermetic environment fail standard visual assembly inspection due to oxidation. The oxidation will cause a change in electrical resistance.

3.4 **Known Material Hazards** The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 700-5 Known Material Hazards

Material	Precaution
Tin plated packages or leads	100% tin plate has caused tin whiskers which have the potential of causing a short or arc. This material was documented as a prohibited part in MIL-STD-1547.

3.4 Produceability and Baseline Controls A product baseline should be established for all fuses purchased as a QPL MIL-F-23419 device, with the additional screening tests documented in this handbook. Areas which need to be specified and controlled in the drawing and baseline are:

Table 700-6 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to Section 4
Production Lot	Refer to Section 200
Serialization	Refer to Section 4
Traceability Control (Parts, Materials, & Processes)	Refer to Section 4
Rework Provisions	Refer to MIL-F-23419
Process Controls Verification & Validation	Refer to MIL-F-23419
Screening Tests (100%)	Refer to MIL-F-23419 and Table 600-8, in this handbook.
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to MIL-F-23419 quality conformance tests, Subgroup 1, 2, and 5 of Group C inspections.
Lot conformance tests for critical applications or where more predictable results in alien environments are needed, and/or vibration and shock applications.	Refer to Table 700-9 in this handbook.
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-F-23419.

Note: A manufacturing baseline should be developed and maintained by the manufacturer and controlled and verified by the procuring organization for (company unique drawings).

4.0 Quality Assurance Provisions

The following table outlines the minimum areas which should be considered and verified when purchasing QPL MIL-F-23419 fuses with the additional screening documented in this handbook.

Table 700-7 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of the applicable manufacturing baseline.	Homogeneity Production Lot Serialization Traceability Control for Parts, Materials, & Processes Rework Provisions Process Controls verification & validation Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests) The following verifications are essential for this product: 1. Fuse element attachment is visually inspected on all items at 10X mag. Min. 2. Radiographic inspection on all opaque body fuses (in-lieu of visual), viewed at 7X min. Should be acceptable at a min. Of 2 orthogonal views or 360° turn.
Screening (100 percent): Refer to MIL-F-23419 and Table 700-8, in this handbook.	Review screening data (Attributes & Variables).
Lot Conformance: Refer to MIL-F-23419 quality conformance tests, Subgroup 1, 2, and 5 of Group C inspections.	Review lot conformance data (Attributes & Variables).
Lot Conformance Tests: for critical applications or where more predictable results in alien environments are needed, for vibration and shock applications. Refer to Table 700-9 in this handbook.	Review lot conformance data (Attributes & Variables).
Qualification Testing: Refer to the requirements of MIL-F-23419	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: Materials and construction is verified upon receipt of each lot of fuses.	Review incoming DPA and compare to historical DPA data.
Sample and Data Retention: Data retention information is found in Section 4 of the this handbook.	Maintain samples and data for further use.

Table 700-8 Screening Table

MIL-F-23419 Screens	Additions and Exceptions to the Methods and Criteria of MIL-F-23419
Thermal Shock	MIL-STD-202, Method 107, Condition B; Monitor for continuity during last cycle.
Seal, Hermetic	MIL-STD-202, Method 112. Gross Leak per Test Condition A, or equivalent. Not applicable to non-hermetic devices.
Terminal Strength and DC Resistance	1. Simultaneous dc resistance measurement. 2. Test current used should be 10% of rated value during strength measurement. 3. Test at +25°C. 4. Resistance data within spec at all times during strength measurement.
Burn-In	Test @ +85°C +0°C -3°C for 168 hours, at rated DC voltage, with 50% rated DC current.
DC Resistance	Test @ +25°C, Current is 10% of rated value. Resistance data within spec at all times, and Resistance data to be within +8% of initial reading at all times.
Voltage Drop	Test @ 50% rated current, measurement taken after 5 minutes, Accept fuses within +2 standard deviation of lot average.
Visual/Mechanical (External)	Marking and identification Defects and damage; i.e., body finish, lead finish, misalignment, cracks.
Radiographic Inspection	1. Per MSFC-STD-355; 2 views 90 deg. Apart by x-ray, or 360 deg. View by real-time x-ray. Use of “real-time” x-ray systems capable of viewing through 360 deg rotation is encouraged. 2. Test is not required except for ceramic and molded body devices.

Table 700-9 Lot Conformance Tests

Tests	Additions to the Methods and Criteria of MIL-F-23419
Vibration and Shock	The shock level is 500, +50 g for ½ second sinewave input, the vibration level is per MIL-STD-202, Method 214, Condition IIK. (Monitor continuity during shock and vibration). 1. Measure resistance by current plots in excess of monitored display for elimination of unusual characteristics. 2. Record parameters over various temperatures 3. Thermal vacuum testing

SECTION 800 Magnetic Devices (Transformers, Inductors, & Coils

1.0 Scope

This section contains detailed information for transformers, inductors, & coils.

2.0 Application

The following tables contain information about transformers, inductors, & coils to assist in the decision making process of selection and documentation for Design Engineers and Parts Engineers.

Table 800-1 Derating

Device Type	Parameter	Derating Factor	Comments
All magnetics	Voltage	.050 of min. rated wire insulation voltage	Maximum winding-to-winding and winding-to-case voltages are derated.
	Temperature	Max. operating temp not to exceed T_I - 30°C	T_I is the insulation class temperature of the lowest temperature insulation material used in the device. The max. operating temperature is the same as the sum of the ambient temperature and the device temperature rise.

Table 800-2 End-of Life Design Limits

Temperature Exposure	Organic Insulating Materials
The operational life of a magnetic device is limited by the various temperatures to which the insulation may be exposed.	The design service life is reduced 50% for each 10°C increase in hot-spot temperature.

TABLE 800-3 Design Applications

Specifications	Typical Applications
Mil-T-27	Audio, Power, & High-Power Pulse Transformers & Inductors
MIL-T-21038	Low-Power Transformers
MIL-C-15305 & MIL-C-39010	Fixed & Variable Radio Frequency Coils
MIL-STD-981	Custom Magnetic Devices
MIL-C-83446/5	Fixed Chip Radio Frequency Coils

3.0 Design and Construction

3.1 **Recommended Design for Space and Launch Vehicles** Design and construction should be in accordance with the applicable specification and the recommendations of this handbook.

Table 800-4 Design and Construction Considerations

Construction	Information
< 200 V devices	Minimum magnetic wire size should be as defined for Class S parts in Table I of MIL-STD-981.
≥ 200 V devices	Minimum wire size is AWG size #36.

3.2 Known Reliability Suspect Designs The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 800-5 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Inadequate design for reliable operation	Wire size less than the size specified in Table I of MIL-STD-981.
Inadequate design for reliable operation	Wire size < # 36 for > 200 V devices.
Shorting and Arcing	Tin plated devices or leads.

3.3 **Known Material Hazards** The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 800-6 Known Material Hazards

Material	Precaution
Tin plating	100% tin causes tin whiskers.

3.4 Produceability and Baseline Controls A product baseline should be established for all custom magnetics. Areas which need to be specified and controlled in the drawing and baseline are:

Table 800-7 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to Section 4
Production Lot	Refer to Section 200
Serialization	Refer to Section 4
Traceability Control (Parts, Materials, & Processes)	Refer to Section 4
Rework Provisions	Refer to MIL-STD-981 for Class S.
Process Controls Verification & Validation	Refer to MIL-STD-981 for Class S.
Screening Tests (100%)	Refer to MIL-STD-981 for Class S. The 96 hour burn-in under no load conditions should be omitted from screening.
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to MIL-STD-981 for Class S.
Qualification Tests (Destructive & Non-destructive tests)	Refer to Lot Conformance Tests.

4.0 Quality Assurance Provisions

The following table outlines the minimum areas which should be considered and verified when purchasing Magnetic devices to company specific Magnetic drawings.

Table 800-8 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of the applicable manufacturing baseline.	Homogeneity Production Lot Serialization Traceability Control for Parts, Materials, & Processes Rework Provisions Process Controls verification & validation Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)
Screening (100 percent): refer to the requirements of the company unique drawings, MIL-STD-981 and this handbook.	Review screening data (Attributes & Variables).
Lot Conformance: refer to the requirements of the company unique drawing, MIL-STD-981 and this handbook.	Review lot conformance data (Attributes & Variables).
Qualification Testing: refer to the requirements of company unique drawing, MIL-STD-981 and this handbook.	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: should be in accordance with MIL-STD-1580.	Review incoming DPA and compare to supplier DPA.
Sample and Data Retention: Data retention information is found in Section 4 of the this handbook.	Maintain samples and data for further use.

SECTION 900 - MICROCIRCUITS

1 ORGANIZATION: This section covers Digital and Linear monolithic microcircuits (Integrated Circuits).

2 APPLICATION

Electrical Considerations. The circuit design should make allowances for worst case variations in output voltage or current, and propagation delays. All strategic parameters used in the application (all Subgroups) should be verified, and any radiation effects on those parameters over the life of the application considered.

TABLE 900-1 DIGITAL MICROCIRCUITS DERATING

PARAMETER	DERATING FACTOR (Nominal)/	DERATING FACTOR (Worst Case)	COMMENTS
Total Output Load Current	.80	.90	Not Applicable to single fanout devices.
Vcc specified nominal supply voltage	1.1Vcc	1.1Vcc	
Transients	1.2 Vcc	1.2 Vcc	Transient peaks not to exceed the specified value.
Propagation Delay	110 %	110 %	
Fanout			Derate by one load or to 80 percent of maximum rating (whichever is greater), except where fanout is rated as one
Power Dissipation, PD	.80	.90	
Max. Junction or “Hot-Spot” Temperature	+105 Degrees C	+125 Degrees C	Tj = Not to exceed +105 degrees Centigrade
Supply Voltage for CMOS	.70	.80	Tj = Not to exceed +105 degrees Centigrade

TABLE 900-2 LINEAR MICROCIRCUITS DERATING

PARAMETER	DERATING FACTOR (Nominal)	DERATING FACTOR (Worst Case)	COMENTS
Input Signal Voltage	.70	.80	
Output Current	.75	.85	
Operating Frequency (application)	.75	.85	
Transients (4.)	1.20Vcc	1.4Vcc	Transients not to exceed the specified value
Gain (application)	.75	.85	
Power Dissipation, PD	.75	.85	
Max. Junction or "Hot-Spot" Temperature	+105 Degrees C	+125 Degrees C	Tj = Not to exceed +105C

TABLE 900-3 LINEAR VOLTAGE REGULATOR MICROCIRCUIT DERATING

PARAMETER	DERATING FACTOR (Nominal)	DERATING FACTOR (Worst Case)	COMENTS
Input Current	.80	.90	
Input Voltage	.80	.85	
Output Current	.75	.85	
Power Dissipation, PD	.75	.85	
Max. Junction or "Hot-Spot" Temperature	+105 Degrees C	+125 Degrees C	

3. DESIGN AND CONSTRUCTION

3.1 Background: Microcircuit devices Design and Construction have traditionally been maintained in accordance with the requirements of the applicable specifications (MIL-M-38510 and its Slash Sheets). The JAN Class S design rules within the specifications were applied where available. However, with the push for the use of plastic encapsulated devices, and replacement of traditional JAN Class S controls with the more cost effective high volume production line process controls the designer has to evaluate the acceptability of the proposed design and construction for the application (including Radiation Effects).

The new approaches such as Surface Mount package, Multi Chip Module (MCM) technology, and Power Module technology that are currently beginning to be employed in the space application designs are often based on old technology, either old die designs, old package types etc., that are modified and supplied as Surface Mount, MCM, and Power Modules. As such the modifications are often performed after the discrete devices were screened and the final product is rarely verified and validated for the intended application. Therefore, the designer or the component engineer needs to ensure that the supplied components meet the application requirements. Table 900-4 provides some of the known Design and Construction Considerations.

3.2 Reliability Suspect designs The following designs have been determined from past experience to be reliability suspect. However, with improved materials, process controls, and through sound engineering the problems associated with these designs could be alleviated:

- Hot welded cans
- Nonpassivated devices
- Plastic encapsulated units
- Packages other than those defined in MIL-STD-1835
- Programmable units which do not program with a single pulse
- Internal organic / polymeric materials (lacquers, varnishes, coatings, adhesives, or greases)
- Internal desiccants
- Flip chips
- Beam leaded devices
- Bimetallic lead bond at die
- Ultrasonic cleaned parts
- All tin coated packages or leads

Table 900-4 Design and Construction Considerations

Device Type	Design & Construction Considerations	Possible Mitigation
Cavity Devices	Lead solder based compounds used for die attach medium.	Maintain the moisture levels below 5000/ppm to prevent solder decomposition.
	Silver filed Epoxy or Silver glass die attach mediums.	Maintain under 5000/ppm moisture, perform Die Shear Monitors (beginning of shift / every 2 hours / end of shift) and qualify process to Temperature Cycling.
	Organic passivating or conformal coating materials.	Qualify process to 1000 hr HTRB, perform extended vacuum bake prior to device sealing, maintain low moisture levels.
	Gold wire bonds on Aluminum die metalization and aluminum wire on gold substrates.	Qualify wire bond process to survive 300°C without Au-Al intermetalic formation.
	Aluminum wire bonds on Silver die metalization and on Ni plated Au flash posts.	Qualify process to survive an acceptable number (to the design application) of Intermittent Operating Life Cycles followed by wire pull test without any wire lifts.
	Au flash on Ni plated posts.	Maintain gold to 5 - 10/µin over Ni plating on posts.
Hot Welded Cans	A high potential for loose conductive particles inside the cans.	Monitored cap welding and PIND test.
Glass to metal seals	High probability of developing glass cracks during testing and handling of devices.	Qualify packages to survive acceptable number of Temperature Cycles for the proposed application followed by die penetrant.

3.3 Produceability and Baseline Controls A product baseline should be established for all devices not purchased as a MIL-PRF-38535 QPL device. Areas which need to be specified and controlled in the drawing and baseline are:

Table 900-5 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to MIL-PRF-38535 for Class S
Wafer Lot	Refer to MIL-PRF-38535 for Class S
Wafer Lot Acceptance	Refer to MIL-PRF-38535 for Class S
Radiation Hardness	Refer to MIL-PRF-38535 for Class S
Assembly Lot accumulation period	Refer to MIL-PRF-38535 for Class S
Manufacturing Location	Refer to MIL-PRF-38535 for Class S
Assembly processes and their verification	Refer to MIL-PRF-38535 for Class S
Inspection Lot formation	Refer to MIL-PRF-38535 for Class S
Test equipment validation	Refer to MIL-PRF-38535
Serialization	Refer to MIL-PRF-38535 for Class S
Traceability Control (Parts, Materials, & Processes)	Refer to MIL-PRF-38535 for Class S
Rework Provisions	Refer to MIL-PRF-38535 for Class S
Process Controls verification & validation	Refer to MIL-PRF-38535 for Class S
TRB and Change Control Authority	Refer to MIL-PRF-38535
Screening Tests (100%)	Refer to MIL-PRF-38535 for Class S and Detail Specification as applicable
Quality Conformance Inspection (Destructive & Non-destructive tests)	Refer to MIL-PRF-38535 for Class S and Detail Specification as applicable
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-PRF-38535 for Class S and Detail Specification as applicable

Note: The manufacturing baseline should be developed and maintained by the manufacturer in accordance with MIL-PRF-38535, and controlled and verified by the procuring organization.

4. QUALITY ASSURANCE

There are four major areas to be covered under the Quality Assurance provisions. These are the Wafer Fabrication, Assembly, 100% Test or Screening, and Quality Conformance Inspection and Qualification. MIL-PRF-38535 has provided guidance for both the device manufacturers and designers in all of the four areas. The designer and component engineer has to understand the device application, the need for and application tolerance of device to device performance variation and how the device manufacturer controls in each of the four areas impact the performance. Table 900-6 provides a summary of the recommended controls for space level devices.

Table 900-6 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
Wafer Fabrication: In process controls should be per MIL-PRF-38535, Appendix A.	Wafer Lot formation (mask revision), (5.) Wafer Fabrication rework control (5.) Wafer Lot Acceptance Wafer Fab Location (5.)
Assembly: In process controls should be per MIL-PRF-38535, Appendix A	Lot Homogeneity Production Lot formation Traceability Control Rework Provisions I.A.W. approved procedures Process Controls, their verification & validation elements Assembly Location
Screening Tests (100%): Screening should follow the MIL-PRF-38535 Table IA or IB, and detailed specification.	Electrical parameters and performance specified (including Radiation Effects) meets application.
Quality Conformance Inspection (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)	Screening Temperature Range, QCI and Qualification specified meet application Test equipment accuracy and repeatability Accept and Reject criteria Failure Analysis and Corrective action.
Screening (100 %): Refer to the requirements of MIL-PRF-38535 for Class S and the detailed specification.	Review screening data (Attributes & Variables). Verify test equipment correlation, repeatability, test-period windows were met, test parameters / conditions, and PDA compliance.

NOTES: (5.) To assure characterized electrical performance and characterized radiation hardness immunity for flight hardware (and future procurement).

Table 900-7 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
Quality Conformance Inspection: refer to the requirements of MIL-PRF-38535 for Class S, and the detailed specification.	Review lot conformance data (Attributes & Variables), sampling techniques, and stress levels.
Qualification Testing: refer to the requirements of MIL-PRF-38535 for Class S, and the detailed specification.	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: should be in accordance with MIL-STD-1580.	Review incoming DPA and compare to supplier documentation.
Sample and Data Retention: Data retention information is found in Section 4 of the this handbook.	Maintain samples and data for further use.

5.0 Lessons Learned

Wafer Fabrication: This is probably the most critical area that determines the device reliability and performance. Traditionally this area has been downplayed in its importance to the reliability of the end product and consequently controlled by OEMs through a "flow chart" at best. With the change from "screening of devices to meet quality requirements" to "building of quality into devices" this area becomes the only area that builds quality into the die. Homogeneity of the wafer fabrication process (with regard to exact process, exact mask set, exact fabrication module / equipment, etc.) as characterized, is paramount for known electrical and radiation performance. Many semiconductor companies are contracting-out wafer fabrication (in efforts to reduce costs), the component engineer should ascertain that the flight hardware was manufactured on the same line as the characterized product to assure electrical performance over the life of the program, including radiation effects. Table 900-8 outlines some of the areas that need specific attention.

Assembly: This is the area where the die, or chips, after being processed through wafer fabrication, are put in packages or assembled so that they can used in systems. The packages and assembly materials used determine in most cases, where the die ratings outperform the package ratings. Sound engineering process monitors, SPC, and continuous qualification feedback to assembly is important in controlling process variations. Many semiconductor companies are contracting-out package assembly (in efforts to reduce costs), the component engineer should ascertain that the flight hardware is assembled in the same certified facility as the characterized/qualified product to protect the Program schedule from surprises. Table 900-9 outlines some of the areas that need specific attention.

Screening: This area covers the 100% testing (electrical, mechanical, and environmental) that is applied to devices in order to eliminate the defects associated with infant mortality portion of the "Bathtub" reliability curve (see Figure 900-10). The Percent Defect Allowable (PDA), test windows post HTRB and Burn-In, and other controls determine the number of random defects expected when using the lot of devices. The implementation of effective process controls in the front areas, wafer fabrication and assembly, makes device to device performance variability more consistent, and therefore, could allow lots to be evaluated on a sample basis rather than screened on 100% basis. The intended design application requirements provide the basis for device performance valuation. Table 900-10 outlines some of the areas that need specific attention.

Quality Conformance Inspection (QCI): This area covers the sample verification of the lot integrity to be used in the application. The stress levels applied traditionally have been at the levels established, for the particular technology and product type, to simulate the end of life characteristics under accelerated conditions. Table 900-11 outlines some of the areas that need specific attention.

Table 900-8 - Wafer Fabrication

Area of Concern	Effect on Performance	Potential Remedy
Wafer Lot formation	Determines die lot performance homogeneity	Use wafers from single batches and manufacturers.
Wide resistivity and thickness, epi and epi thickness specifications	Allows wide range of electrical characteristics which lead to new device types and/or product downgrading.	Use only the devices for which the target specifications of the raw wafers were designed and not the downgraded by-products.
High defect count per cm^2.	Increase of device to device variation, risk of premature device failure, lower yields.	Lower the acceptable number of defects per cm on the incoming wafers.
Wafer Fab. Processing	Determines the device performance	
Particle size and count allowable in the clean room.	Depending on the device type, geometry, and technology may impact device reliability and electrical performance. Ionic contamination.	Use positive air flow interlocks and entries, air filters, process only devices for which the clean room characteristics were proven to be acceptable.
Water purity and Diffusion cleanness	Potential for ionic contamination.	Use water filters, test for bacteria, C-V plots.
Rework	Increase of device to device variation, risk of premature device failure, lower yields.	If allowed, verify that the rework did not have adverse effects on device performance in the intended application.
Wafer Fab Location	Use of foundries and other manufacturer's die leads to loss of visibility into wafer fab processing and controls may impact device performance.	Verify the supplier of devices has visibility and control over the wafer fabrication processes, changes, and implementation. Recharacterize.
Wafer Lot Acceptance	Data provided does not correlate or tie into the wafer fab process controls for oxide, die, metalization, and passivation layer thickness. Sampling may not be valid.	Ensure wafer lot acceptance provides meaningful data to ascertain the wafer fabrication process and controls (MIL-STD-883, Method 5007).
Radiation Tolerance	Process, design & layout can impact radiation performance.	Use design techniques & process methods that are minimally impacted (affected) by radiation influences.

Table 900-9 - Assembly

Area of Concern	Effect on Performance	Potential Remedy
Die attach is not consistent	Devices fail prematurely due to voids which cause overheating or current crowding effects	Implement die attach monitors such as die shear.
Attach materials are not optimized for the package and design application.	Devices fail prematurely due to die attach degradation when operated under simulated and accelerated application conditions.	Qualify and validate the attach process and materials for the intended design application.
Multiple Lots formation and loss of Lot Traceability	Increase potential for lot failure due to loss of traceability to individual lots.	Maintain traceability to individual lots.
Rework Provisions	Allowing rework on the production line may not enforce corrective action implementation and promote loose process controls.	If rework was allowed, maintain traceability to the reworked portion of the lot for future valuation of adverse rework effects.
Purple Plague (Au wire on Al metalization)	Open circuit, or degraded electrical performance.	Validate process through extensive High temperature storage; subject lot to 300°C.
Purple Plague (Al wire on Au metalization	No impact if Gold is thin and the bonding is to the Ni under plate. Otherwise will lead to open circuit.	Validate process through Temperature and Operating Cycles; peel wire to verify bond.
Al wire bonds on Ag metalization.	Open circuit due to operating and Thermal cycles.	Validate process through Temperature and Operating Cycles;
Particles inside cavity	Potential short due to conductive particle such as Die attach slag, weld splash, etc.	Validate the processes to ensure loose particles are not introduced. Institute PIND.

Table 900-10 100% Screening

Screening Test	Effect on Performance	Rationale for Test Conditions
Pre-Cap Visual Inspection	Ensures the devices are free of defects prior to encapsulation	Depending on the manufacturer's process controls this may be done on a sample basis.
High Temperature Storage	Some device technologies require this to stabilize the junction characteristics.	Select the max. device rated temperature storage.
Temperature Cycling	Intended to screen out infant mortality defects due to die attach and other package mismatch defects.	20 cycles were initially established as sufficient to pass the infant mortality stage. Devices should reach temperature extremes.
Constant Acceleration	Test designed to stress the wire bonds and die attach areas.	The G-force level is determined by the package capability and should be above the application requirements.
PIND	Developed to screen out devices with loose particles inside the cavity.	Set-up sensitivity, location and tester mounting, shock/ co-shock and vibration levels, and transducer couple medium are important to effective PIND screening.
Pre-HTRB electrical tests	Electrical parameters (at T_A=25°C) established for each technology and device type to be indicative of a good device.	Parameters most likely to change if ionic contamination is present such as Leakage currents, Forward Voltage, Breakdown Voltage

Table 900-10 100% Screening (cont.)

Screening Test	Effect on Performance	Rationale for Test Conditions
HTRB	Stress test designed to screen out ionic contaminated devices using DC Bias Voltage and Temperature to accelerate the effects. Ions are made mobile through Temperature exposure while the DC Bias Voltage acts as dipole magnet attracting the ions on each positive and negative side of the power supply.	The applied Temperature should be that of the Max. Operating Ambient without heat sink, and the applied voltage should be 80% of the rated breakdown voltage of the stressed junction. The magnitude of the exposing temperature and applied bias directly affect the result. Applying AC Voltage or removal of the bias before devices reached approx. 35°C will negate the test.
Post-HTRB electrical tests	Repeat of Pre-HTRB electrical tests to validate devices did not drift outside the established limits. Test should be performed within 16 hrs of bias removal.	Ionic contamination, if free to move around will cause a change in the device electrical characteristic. Depending on the contaminant type and level the ions will eventually return to original state.
Percent Defective Allowable (PDA)	Establishes the random failure rate expected during the useful life of the devices.	Typical PDA is 5% max. with a one time resubmission if Percent Defective (PD) < 20%. Lots failing this criteria are should be considered reliability suspect.
Power Burn-In	Test designed to screen out assembly defects.	Test conditions are typically established such that device junction temperature approaches that of the maximum Operating Junction Temperature Ratings.

Table 900-10 100% Screening (cont.)

Screening Test	Effect on Performance	Rationale for Test Conditions
Post Power Burn-In electrical tests	Verify that devices still meet the established electrical characteristics.	Repeat the Post HTRB (Pre Burn-In) electrical tests plus the rest of the DC characteristics including those at high and low temperatures.
Percent Defective Allowable (PDA)	Establishes the random failure rate expected during the useful life of the devices.	Typical PDA is 5% max. with a one time resubmission if Percent Defective (PD) < 20%. Lots failing this criteria are should be considered reliability suspect.
X-Ray	Test was developed for workmanship verification (it does not replace Pre-Cap Visual Inspection).	Criteria and level of inspection is based on the package and defect type.

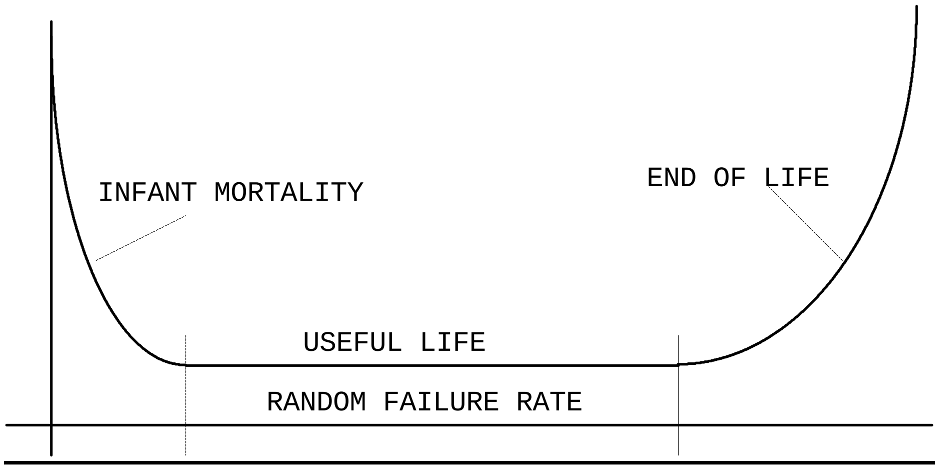


Figure 900-10: Reliability Bathtub Curve

Table 900-11 - Quality Conformance Inspection

Test Name	Effect on Performance	Test Rationale
Group A	Verifies device electrical performance under DC, AC or transient conditions, and over the Rated temperature range.	Validates device capability to meet its electrical characteristics. Usually performed on each lot on a sample basis after 100% screening was completed.
Group B	Verifies device operational performance within the useful life portion of the bath tub curve. This includes package design integrity verification (Temperature Cycling, Intermittent Operating Life, and Thermal Resistance Subgroups), device operational performance (Accelerated Life Test).	Validates lot homogeneity and process/design operational performance capability on a lot by lot basis. Validates screening was performed correctly and no defects were introduced.
Group C	Verifies device mechanical performance and operational performance up to 1000 hrs. Operational Life or 6000 Intermittent Operation Cycles.	Validates the processing and device design provide up to 1000 hrs. and or 6000 cycles of useful life under accelerated conditions. Most military and space design applications reliability predictions use this as basis for predictions.
Group D	Verifies package end of life device design.	Validates that the device processing and design end of life are outside the Thermo-Mechanical and Operational boundaries established for useful life.
Group E	Verifies the device design capability to withstand the radiation effects environment in which some applications may operate during their useful life.	Validates wafer fabrication, device design, and processing are capable of meeting the total radiation exposure of the system operating life without degradation .

SECTION 960 - HYBRIDS

1. ORGANIZATION: This section covers hybrid microcircuits, multi-chip-modules (MCM), and power modules.

2. APPLICATION

TABLE 960-1 HYBRID MICROCIRCUIT DERATING

DEVICE TYPE	DERATING FACTOR
HYBRID	Use the appropriate Derating Factor for each element covered in this Handbook

2.1 Verification. Verification of junction-case thermal resistance by testing and thermal mapping is recommended for new designs and use of new technology.

2.2 Electrical Considerations. The circuit design for each die should make allowances for worst case variations of the actual output logic “L” state sink current, actual logic “H” state sink current, propagation delays, gain, offset voltage, and bias current. The temperature range of Space Quality Hybrids is -55 to +125 Degrees C, however, application specific temperature range lower than this can be used with appropriate application qualification and verification. All strategic parameters used in the application (Dynamic and Static parameters) should be verified and should include any radiation and storage environments degradation effects on those parameters over the life of the application.

3. DESIGN AND CONSTRUCTION

BACKGROUND: Hybrid microcircuit devices Design and Construction have traditionally been maintained in accordance with the requirements of the applicable specifications (MIL-M-38510, MIL-H-38534, and MIL-STD-883, Method 5009). The Class K (previously Class “S”) design rules within the specifications were applied where available. However, with the push for the use of plastic encapsulated devices, and replacement of traditional Class K controls with the more cost effective high volume production line process controls, the designer has to evaluate the acceptability of the proposed design and construction for the application (including radiation effects).

The new approaches such as Surface Mount components, Multi Chip Module (MCM) technology, and Power Module technology that are currently beginning to be employed in the space application designs are often based on old technology, either old die designs, old package types, etc., that are modified and supplied as Surface Mount, MCM, and Power Modules. As such, the modifications are often performed after the discrete devices were screened and the final product is rarely verified and validated for the intended application. Therefore, the designer or the component engineer needs to ensure that the supplied components meet the application requirements. Table 960-2 provides some of the known Design and Construction Considerations.

Table 960-2 Design and Construction Considerations

Device Type	Design & Construction Considerations	Possible Mitigation
Hybrid Packages	Lead solder based compounds used for die attach medium.	Maintain the moisture levels below 5000ppm to prevent solder decomposition.
	Silver filed Epoxy or Silver glass die attach mediums.	Qualify process meet mechanical, environmental (i.e. Temperature Cycling), and thermo-electrical application requirements (i.e. Hot spots, power distribution, etc.) Maintain under 5000 ppm moisture, maintain process monitors such as Die attach monitors (beginning of shift / every 2 hours / end of shift).
	Organic passivating or conformal coating materials.	Qualify process to 1000 hr HTRB, perform extended vacuum bake prior to device sealing, maintain low moisture levels.
	Gold wire bonds on Aluminum die metalization and aluminum wire on gold substrates.	Not recommended, if used, qualify wire bond process to survive 300°C without Au-Al intermetalic formation.
	Aluminum wire bonds on Silver die metalization and on Ni plated Au flash posts.	Qualify process to survive an acceptable number (to the design application) of Intermittent Operating Life Cycles followed by wire pull test without any wire lifts.
	Au flash on Ni plated posts.	Maintain gold to 5 - 10µin over Ni plating on posts.

Table 960-2 Design and Construction Considerations

Device Type	Design & Construction Considerations	Possible Mitigation
Welded, Brazed, or Soldered Lids	A high potential for loose conductive particles inside the package.	Monitored lid welding/sealing, and PIND test.
Hard Glass or Ceramic to metal seals	High probability of developing glass/ceramic cracks during testing and handling of devices.	Qualify packages to survive acceptable number of Temperature Cycles for the proposed application followed by die penetrant.

Produceability and Baseline Controls A product baseline should be established for all devices not purchased as a MIL-PRF-38534 QPL device. Areas which need to be specified and controlled in the drawing and baseline are:

Table 960-3 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to MIL-PRF-38534 for Class K
Wafer Lot	Refer to MIL-PRF-38534 for Class K
Element Evaluation / Wafer Lot Acceptance	Refer to MIL-PRF-38534 for Class K
Radiation Hardness	Refer to MIL-PRF-38534 for Class K
Assembly Lot accumulation period	Refer to MIL-PRF-38534 for Class K
Manufacturing Location	Refer to MIL-PRF-38534 for Class K
Assembly processes and their verification	Refer to MIL-PRF-38534 for Class K
Inspection Lot formation	Refer to MIL-PRF-38534 for Class K
Test equipment validation	Refer to MIL-PRF-38534
Serialization	Refer to MIL-PRF-38534 for Class K
Traceability Control (Parts, Materials, & Processes)	Refer to MIL-PRF-38534 for Class K
Rework Provisions	Refer to MIL-PRF-38534 for Class K
Process Controls verification & validation	Refer to MIL-PRF-38534 for Class K
MRB and Change Control Authority	Refer to MIL-PRF-38534
Screening Tests (100%)	Refer to MIL-PRF-38534 for Class K and Detail Specification as applicable
Quality Conformance Inspection (Destructive & Non-destructive tests)	Refer to MIL-PRF-38534 for Class K and Detail Specification as applicable
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-PRF-38534 for Class K and Detail Specification as applicable

Note: A manufacturing baseline should be developed and maintained by the manufacturer in accordance with MIL-PRF-38534, and controlled / verified by the procuring organization.

4. QUALITY ASSURANCE There are four major areas to be covered under the Quality Assurance provisions. These are: the Element Evaluation, Assembly, 100% Test or Screening, and Quality Conformance Inspection and Qualification. TraMIL-H-38534 Appendix A required the manufacturers to develop a comprehensive Quality Assurance Plan covering all of the four areas. The designer and component engineer needs to understand the device application, the application need, the device to device performance variation impact to the application, and how the device manufacturer established controls in each of the four areas impact the device performance. Table 960-4 provides a summary of the recommended controls for space level devices.

Table 960-4 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
Element Evaluation: In process controls should be per MIL-PRF-38534, Appendix A.	Microcircuit & Semiconductor Dice (1.) & (2.) Passive Elements (2.) Saw Elements (2.) Substrates (3.) Packages
Assembly: In process controls should be per MIL-PRF-38534, Appendix A	Lot Homogeneity Production Lot formation Traceability Control Rework Provisions I.A.W. approved procedures Process Controls, their verification & validation elements Assembly Location
Screening Tests (100%): Screening should follow the MIL-PRF-38534 Table X, and detailed specification.	Electrical parameters and performance specified (including Radiation Effects) meets application.
Screening (100%): Refer to the requirements of MIL-PRF-38534 for Class K and the detailed specification.	Review screening data (Attributes & Variables). Verify test equipment correlation, repeatability, test-period windows were met, test parameters / conditions, and PDA compliance.
Quality Conformance Inspection (Destructive & Non-destructive tests)	Screening Temperature Range, QCI and Qualification specified meet application. Test equipment accuracy and repeatability.
Qualification Tests (Destructive & Non-destructive tests)	Accept and Reject criteria Failure Analysis and Corrective action.

NOTES: (1.)Data to be representative of the devices to be used (i.e. Same manufacturer, same wafer fabrication module, same mask revision, same process) to assure characterized performance including potential processing, storage, and radiation degradation effects for flight hardware (and future procurement).

(2.) Was element designed to meet military temperature range (-55 to +125° C) or was it screened for the operation?

(3.) If coupons are used, are they representative of process? Exact metal, etc.?

Table 960-5 Qualification Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
Quality Conformance Inspection: refer to the requirements of MIL-PRF-38534 for Class K, and the detailed specification.	Review lot conformance data (Attributes & Variables), sampling techniques, and stress levels.
Qualification Testing: refer to the requirements of MIL-PRF-38534 for Class K, and the detailed specification.	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: should be in accordance with MIL-STD-1580.	Review incoming DPA and compare to supplier documentation.
Sample and Data Retention: Data retention information is found in Section 4 of the this handbook.	Maintain samples and data for further use.

5.0 Lessons Learned

Element Evaluation:

Wafer Fabrication of microcircuit and semiconductor dice: This is probably the most critical area that determines the device reliability and performance. The circuit designer should assure that all elements used were designed to and meet the full temperature range and the full radiation environment(s) at end of life. Historically, hybrid manufacturers do not manufacture the die (active and passive elements) used in the finished hybrid. Traditionally this area has been downplayed in its importance to the reliability of the end product and consequently controlled by OEMs through a “flow chart” at best. With the change from “screening of devices to meet quality requirements” to “building of quality into devices”, this area becomes the only area that builds quality into the die, and therefore, the hybrid device. Homogeneity of the wafer fabrication process (with regard to exact process, exact mask set, exact die manufacturer, exact fabrication module / equipment, etc.) as characterized, is paramount for known electrical and radiation performance. Assuring that the die (and other components) are military grade (i.e.: probed to function in the -55 to +125 Degree C environment) saves time and money prior to assembly. Since many semiconductor manufacturers are contracting-out wafer fabrication (in efforts to reduce costs), the component engineer should ascertain that the flight hardware die / elements were manufactured on the same line as the characterized product to assure electrical performance over the life of the program, including radiation effects. Table 960-6 outlines some of the areas that need specific attention.

Preselection of passive elements and SAW elements to function over the full temperature range (-55 to +125 degrees C) and environment often saves expensive assembled device failures later.

Substrate evaluation by the use of coupons (where approved) should be representative of the actual substrate. Assuring same exact materials assures representative wire bond evaluations and die shear evaluations.

Assembly: This is the area where the active and passive elements are put in packages or assembled so that they can used in systems. The packages and assembly materials used determine, in most cases, where the die ratings outperform the package ratings. Sound engineering process monitors, SPC, and continuous qualification feedback to assembly is important in controlling process variations. Many hybrid companies are contracting-out package assembly (in efforts to reduce costs) and the component engineer should ascertain that the flight hardware is assembled in the same certified facility as the characterized/qualified product to protect the Program schedule from failures / surprises. Table 960-7 outlines some of the areas that need specific attention.

Screening: This area covers the 100% testing (electrical, mechanical, and environmental) that is applied to devices in order to eliminate the defects associated with infant mortality portion of the "Bathtub" reliability curve (see Figure 960-8). The Percent Defect Allowable (PDA), test-period windows post Burn-In, and other controls determine the number of random defects expected when using the lot of devices. The implementation of effective process controls in the front areas (wafer fabrication and assembly), makes device to device performance variability more consistent, and therefore, could allow lots to be evaluated on a sample basis rather than screened on 100% basis. The intended design application requirements provide the basis for device performance valuation. Table 960-8 outlines some of the areas that need specific attention.

Quality Conformance Inspection (QCI): This area covers the sample verification of the lot integrity to be used in the application. The stress levels applied traditionally have been at the levels established, for the particular technology and product type, to simulate the end of life characteristics under accelerated conditions. Table 960-9 outlines some of the areas that need specific attention.

Table 960-6 Element Evaluation Semiconductor Wafer Fabrication

Area of Concern	Effect on Performance	Potential Remedy
Wafer Lot formation	Determines die lot performance homogeneity	Use wafers from single batches/ & manufacturers.
Wide resistivity and thickness, epi and epi thickness specifications	Allows wide range of electrical characteristics which lead to new device types and/or product downgrading.	Use only the devices for which the target specifications of the raw wafers were designed and not the downgraded by-products.
High defect count per cm^2.	Increase of device to device variation, risk of premature device failure, lower yields.	Lower the acceptable number of defects per cm on the incoming wafers.
Wafer Fab. Processing	Determines the device performance	Evaluate devices for application performance.
Particle size and count allowable in the clean room.	Depending on the device type, geometry, and technology may impact device reliability and electrical performance. Ionic contamination.	Use positive air flow interlocks and entries, air filters, process only devices for which clean room characteristics were proven to be acceptable.
Water purity and Diffusion cleanness	Potential for ionic contamination.	Use water filters, test for bacteria, C-V plots.
Rework	Increase of device to device variation, risk of premature device failure, lower yields, loss of radiation effects immunity.	If allowed, verify that the rework did not have adverse effects on device performance in the intended application, including radiation effects.
Wafer Fab Location	Use of foundries and other manufacturer's die leads to loss of visibility into wafer fab processing and controls; may impact device performance.	Verify the supplier of devices has visibility and control over the wafer fabrication processes, changes, and implementation. Recharacterize electrical and radiation performance.
Wafer Lot Acceptance	Data provided does not correlate or tie into the wafer fab process controls for oxide, die, metalization, and passivation layer thickness. Sampling may not be valid.	Ensure wafer lot acceptance provides meaningful data to ascertain the wafer fabrication process and controls (MIL-STD-883, Method 5007). Verify homogeneity of wafer process/masks/fab.
Radiation Tolerance	Process design & layout can impact radiation performance.	Use design techniques & process methods that are minimally impacted (affected) by radiation influences.

Table 960-7 - Assembly

Area of Concern	Effect on Performance	Potential Remedy
Die attach is not consistent	Devices fail prematurely due to voids which cause overheating/or current crowding effects	Implement die attach monitors such as die shear.
Attach materials are not optimized for the package and design application.	Devices fail prematurely due to die attach degradation when operated under simulated and accelerated application conditions.	Qualify and validate the attach process and materials for the intended design application.
Multiple Lots formation and loss of Lot Traceability	Increase potential for lot failure due to loss of traceability to individual lots.	Maintain traceability to individual lots.
Rework Provisions	Allowing rework on the production line may not enforce corrective action implementation and promote loose process controls.	If rework was allowed, maintain traceability to the reworked portion of the lot for future valuation of adverse rework effects.
Purple Plague (Au wire on Al metalization)	Open circuit, or degraded electrical performance.	Validate process through extensive High temperature storage; subject lot to 300°C.
Purple Plague (Al wire on Au metalization	No impact if Gold is thin and the bonding is to the Ni under plate. Otherwise will lead to open circuit.	Validate process through Temperature and Operating Cycles; peel wire to verify bond.
Al wire bonds on Ag metalization.	Open circuit due to operating and Thermal cycles.	Validate process through Temperature and Operating Cycles;
Particles inside cavity	Potential short due to conductive particle such as Die attach slag, weld splash, etc.	Validate the processes to ensure loose particles are not introduced. Institute PIND.
Assembly Location	Use of contract facilities leads to loss of visibility into the assembly processes and change controls; may impact device performance.	Verify that Contractor has visibility into assembly processes, changes, and implementation. Recharacterize / requalify.

Table 960-8 100% Screening

Screening Test	**Effect on Performance**	**Rationale for Test Conditions**
Internal Visual Inspection	Insures the devices are free of defects prior to encapsulation	Depending on the manufacturer's process controls this may be done on a sample basis.
Temperature Cycling	Intended to screen out infant mortality defects due to die attach and other package mismatch defects.	20 cycles were initially established as sufficient to pass the infant mortality stage. Devices should reach temperature extremes.
Constant Acceleration	Test designed to stress the wire bonds and die attach areas.	The G-force level is determined by the package capability and should be above the application requirements.
PIND	Developed to screen out devices with loose particles inside the cavity.	Set-up sensitivity, location and tester mounting, shock/ co-shock and vibration levels, and transducer couple medium are important to effective PIND screening.
Pre Burn-in electrical tests	Electrical parameters (at T_A=25°C) established for each technology and device type to be indicative of a good device.	Parameters most likely to change if ionic contamination is present such as Leakage currents, Forward Voltage, Breakdown Voltage

Table 960-8 100% Screening (cont.)

Screening Test	Effect on Performance	Rationale for Test Conditions
Burn - In Test	Stress test designed to screen out ionic contaminated devices using DC Bias Voltage and Temperature to accelerate the effects. Ions are made mobile through Temperature exposure while the DC Bias Voltage acts as dipole magnet attracting the ions on each positive and negative side of the power supply.	Test conditions are typically established such that device junction temperature approaches that of the maximum Operating Junction Temperature Ratings.
Post Burn-In electrical tests	Repeat of Pre Burn-In electrical tests to validate devices did not drift outside the established limits. Test should be performed within 96 hours of bias removal.	Ionic contamination, if free to move around will cause a change in the device electrical characteristic. Depending on the contaminant type and level the ions will eventually return to original state.
Percent Defective Allowable (PDA)	Establishes the random failure rate expected during the useful life of the devices.	Typical PDA is 2% maximum. Lots failing this criteria are should be considered reliability suspect.
X-Ray	Test was developed for workmanship verification (it does not replace Internal Visual Inspection).	Criteria and level of inspection is based on the package and defect type.

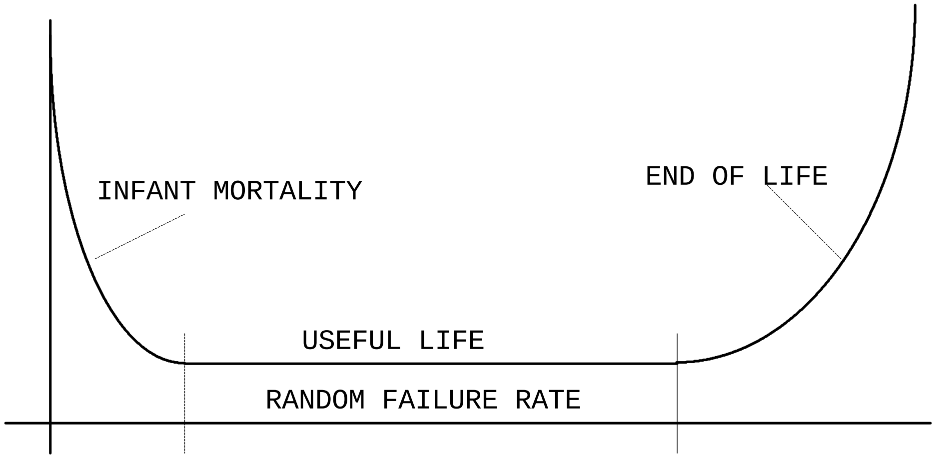


Figure 960-8: Reliability Bathtub Curve

Table 960-9 Quality Conformance Inspection

Test Name	Effect on Performance	Test Rationale
Group A	Verifies device electrical performance under DC, AC or transient conditions, and over the Rated temperature range.	Validates device capability to meet its electrical characteristics. Usually performed on each lot on a sample basis after 100% screening was completed.
Group B	Verifies workmanship and package homogeneity and capability.	Validates lot homogeneity and process/design operational performance capability on a lot by lot basis. Validates screening was performed correctly and no defects were introduced.
Group C	Verifies device mechanical performance and operational performance up to 1000 hours Operational Life.	Validates the processing and device design provide up to 1000 hours of useful life under accelerated conditions. Most military and space design applications reliability predictions use this as basis for predictions.
Group D	Verifies package end of life device design.	Validates that the device processing and design end of life are outside the Thermo-Mechanical and Operational boundaries established for useful life.
Group E	Verifies the device design capability to withstand the radiation effects environment in which some applications may operate during their useful life.	Validates wafer fabrication, device design, and processing are capable of meeting the total radiation exposure over the system operating life without degradation .

6.0 Reliability Suspect designs The following designs have been determined from past experience to be reliability suspect. However, with improved materials, process controls, and through sound engineering the problems associated with these designs could be alleviated:

- Hot welded cans
- Nonpassivated die
- Plastic encapsulated units
- Packages other than those defined in MIL-STD-1835
- Programmable units which do not program with a single pulse
- Internal organic / polymeric materials (lacquers, varnishes, coatings, adhesives, or greases)
- Internal desiccants and getters
- Flip chips
- Uninspectable surface mount devices
- Bimetallic lead bond at die
- Any internal parts, packages, or leads with tin coating

SECTION 1000 - RELAYS (CURRENT RATING OF 25A OR LESS)

1. ORGANIZATION: This section covers electromechanical relays with current rating of 25 amperes or less.

2. APPLICATION

TABLE 1000-1 - RELAY DERATING

DEVICE TYPE	PARAMETER	DERATING FACTOR	COMENTS
Relays	Coil Voltage (Steady State conditions) 1/	100% of rated	Operation at less, or higher than rated coil voltage compromises relay operating life cycles
	Coil Voltage (Pulsed conditions) 1/	<150% of rated	Duty Cycle < 10%, Max. on time 50ms
	Resistive Load	.75 of rated Resistive load	
	Inductive Load	.40 of rated Resistive load	
	Motor Load	.20 of rated Resistive load	Or .75 of rated Inductive Load
	Filament Load	.10 of rated Resistive load	Or .75 of rated Motor Load
	Capacitive Load	.75 of rated Resistive load	Or .75 of rated Filament Load
	Tj	.50 80% of Tj Max	Not to exceed 105°C

NOTE 1: The caution is specified by both MIL-R-6106 and MIL-R-39016:

Table 1000-2 End-of Life Design Limits

Parameter	End of Life Values)
Contact Resistance	Same as the specified Life Test endpoints
Pick-up and Drop out voltages	Same as the specified Life Test endpoints

TABLE 1000-3 Design Applications

Typical Applications	Application Considerations	Possible Mitigation
Capacitive Load	Currents may exceed Dc rated resistive loads levels	Use series resistance to limit current levels
General	Protect the coil against transient voltages of greater than twice the rated voltage.	Use external diodes to protect the coil as needed.
	Low or Intermediate loads (relative to the rated load) applications.	Qualify the relays at these levels as well to insure relay performance.
	Operating with current loads in excess of the rated resistive loads.	Relay is qualified at the operating current levels with twice the number of cycles of the actual application. Lot-by Lot verification of this performance is maintained through testing.

3. DESIGN AND CONSTRUCTION

3.1 Recommended Design for Space and Launch Vehicles Relays designed and qualified to MIL-R-6106, MIL-R-28776, MIL-R-39016, and MIL-R-83726 and are processed to Table 1000-8 (manufacturing), Table 1000-9 (screening), Table 210-10 (lot conformance).

Table 1000-4 Design and Construction Considerations

Design & Construction Considerations	Possible Mitigation
Electronic components such as diodes, transistors, capacitors, and hybrids used in the manufacture of the relays.	Follow the applicable Military Specifications for Space level devices and applicable sections in this handbook.
Magnet Wire	Coil wire should be 44 AWG or larger and use a polyimide (or equivalent) insulation
Teflon strands used as an integral part and extension of the Teflon coil wrap or coil lead insulation are acceptable	Insure no loose Teflon strands are inside which can interfere with the normal actuation and operation of the relay.

3.2 Known Reliability Suspect Designs: The information in Table 1000-5 describes products which have caused reliability problems in the past. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 1000-5 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Uncontrolled critical processes and procedures that have critical effect on the fabrication, function, reliability, or service life of the article	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 are considered critical to the performance of relays.
Uncontrolled critical materials	Critical materials are: coil assembly, carrier assembly, contact assembly (contacts), armature assembly, coil core, pole piece assembly, motor assembly, wires, and header
Loose particles inside the relays	Relays were not canned and final assembly was not performed in clean environment (Class 100), were not properly cleaned, etc.
Use of outgassing materials inside the relays.	Vacuum bake the Relay coil assemblies to ensure no film buildup on the contacts and increase in contact resistance.
Loose or partially attached Weld splatter or weld expulsion balls	Weld splatter or weld expulsion balls should not be allowed, if not capable of withstanding a probing force of 125 ± 5 grams applied using a force gage calibrated for a range of 110 to 135 grams pressure force. Probe each suspect weld one time only during pre-cap.
Scratches and Burns	Scratches or tool marks wholly below the surface of the metal are acceptable. Burrs protruding above the surface are not acceptable.
Cracks in greater than .1” glass seals. Soldered-sealed cases Units not subjected to a vibration miss test External dielectric coatings Plug-in devices Internal suppression diode Tin plated packages or terminals	Screen out the relays with cracks in the header pin glass seals, if the crack length from the pin or outer edge is more than one-third the radius of the seal. Use of clear coating materials on the glass seal (if not fully qualified as required in MIL-R-6106, MIL-R-28776, MIL-R-39016, and MIL-R-83726) will hide the seal cracks without any added benefit.

Table 1000-6 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	See NOTE 1.
Control of critical processes, materials, and components	Table 1000-5, and NOTE 1.
Production Lot	See NOTE 1.
Serialization	See NOTE 1.
Traceability Control (Parts, Materials, & Processes)	See NOTE 1.
Rework Provisions	See NOTE 1.
Process Controls verification & validation	See NOTE 1.
Screening Tests (100%)	See NOTE 1.
Lot conformance Tests (Destructive & Non-destructive tests)	See NOTE 1.
Qualification Tests (Destructive & Non-destructive tests)	See NOTE 1.

NOTE 1: Follow MIL-R-6106, MIL-R-28776, MIL-R-39016, and MIL-R-83726

4.0 Quality Assurance Provisions

4.1 The following table outlines the minimum areas which should be considered and verified when purchasing QPL MIL-R-6106, MIL-R-28776, MIL-R-39016, and MIL-R-83726 or custom relays purchased under Source, Selected Item, and Specification Control Drawing.

Table 1000-7 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: Follow MIL-R-6106, MIL-R-28776, MIL-R-39016, MIL-R-83726, and the following:	Critical components and materials Lot formation, Traceability, and Homogeneity. Production Lot formation Device Serialization Traceability Control Rework Provisions I.A.W. approved procedures Process Controls and their verification & validation elements Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)
Visual Inspection criteria: Perform in a Class 100 environment per FED-STD-209 using a minimum of 10X magnification on relays prior to final clean prior to capping.	Inspect contact assembly, contact surfaces, stationary and movable contacts, springs, coil, pole piece, armature, header. Inspect the entire relay assembly for scratches, burns, particulate, etc. (See Table 1000-8 for details)
Screening (100 percent): refer to the requirements of MIL-R-6106, MIL-R-28776, MIL-R-39016, MIL-R-83726.	Review screening data (Attributes & Variables). Verify test equipment correlation, repeatability, test windows were met, test conditions, and PDA compliance.
Lot Conformance: refer to the requirements of MIL-R-6106, MIL-R-28776, MIL-R-39016, MIL-R-83726.	Review lot conformance data (Attributes & Variables).
Supplier DPA: should be in accordance with MIL-STD-1580.	Review supplier DPA and compare to incoming DPA.
Qualification Testing: refer to the requirements of MIL-R-6106, MIL-R-28776, MIL-R-39016, MIL-R-83726 and application requirements.	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: should be in accordance with MIL-STD-1580.	Review incoming DPA and compare to supplier DPA.
Sample and Data Retention: Data retention information is found in Section 4 of the this handbook.	Maintain samples and data for further use.

Table 1000-8 Visual Inspection

Visual Inspection Criteria	Rationale
Moving Contact Assembly and Springs. Inspect the moving contact assembly for proper installation and position. The springs should 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).	Insure that Moving Contact Assembly and Springs operation is not hindered.
Contact Surfaces (Fixed and Movable). Inspect surfaces for scratches or burrs in contact mating area and cracked or peeling plating. Inspect mating contact surfaces for proper alignment for both positions of the armature, underside of contact supports for tool marks, fibers and other contaminants, and weld splatter.	Insure contacts have optimum performance characteristics and provide the expected cycling life.
Coil Inspection. Inspect and probe the coil lead welds for adequate quality and evidence of weld on each coil lead wire; weld splatter at coil terminals; Verify coils are not kinked, nicked, proper lead coil dress with clearance to all moving and conductive surfaces, and the teflon insulation is not loose or frayed.	To avoid future latent broken, open, or shorting of the coil wires.
Armature and Pole Piece. Inspect armature and pole piece gap for weld splatter and contamination.	Prevent loose particles from developing and affect future relay operation.
Header. Inspect header for Tool marks that affect reliability, glass seal defects, weld splatter, cracked or peeling plating, misalignment of header and frame.	

5.0 Lessons Learned Relays are electromechanical devices that require very careful magnetic and mechanical adjustments to for optimum operation. Therefore, their manufacturing and testing should be documented and verified for each procurement.

Cleaning. All electromechanical relays should be cleaned. To insure cleaning is effective is recommended to be performed in a Class 100 environment. and that relays are degaussed and the permanent magnets demagnetized if they can be re-magnetized and stabilized after canning. The relays are typically demagnetized with a Thomas and Skinner Model DM 35 or equivalent equipment. Cleaned relays should be stored in Class 100 environment. There are various methods for cleaning: Ultrasonic, Vacuum, and Millipore Cleaning which are outlined below.

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.

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.

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. First obtain Freon (or equivalent EPA approved) from a 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 Freon and turn vacuum pump on. Repeat until flask is filled. Fill a pressurized container with cleaned Freon. Clean filter by blowing both surfaces with ionized air. Using the pressurized container, wash both sides of the filter with clean filtered Freon. Observe filter under 30X magnification; if any particles 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 Freon, pour the Freon into the funnel, covering the parts to be cleaned. Cover funnel. Turn on vacuum pump. When all the Freon has passed through the filter, turn off vacuum pumps. Remove filter and examine under 30X magnification. If one or more particles 2.5 micrometers (0.001 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). Screen (100 percent) of MIL-R-39016 type relays in accordance with the "M" level of the Group A inspections in MIL-R-39016 and ER level for MIL-R-6106 with the addition and exceptions in Table 1000-9

Table 1000-9 Screening Table

MIL-R-39016 &6106 Level M and ER GRP. A Respectively	Additions/Exceptions to MIL-R-39016 and 6106
Monitored Vibration	MIL-STD-202, Method 214, Test Condition II, K; Perform Random Vibration to the requirements of the application onto 3 orthogonal planes for 3 minutes each; Monitor for contact chatter or transfer greater than 10μs per MIL-STD-202, Method 310, Circuit B with equipment capable of detecting closures of 1μs and greater. No contact transfer is allowed. Mounting fixture cannot add or remove energy from the relay. Energize/latch the non-latching/ latching relays during 1st half of the test and de-energize/latch the other during the second half for non-latching and latching relays respectively.
Thermal Shock	Per MIL-R-6106, Group A, operational reliability requirements perform five thermal shocks and record pickup and dropout voltage; For relays with coil gauge wire of AWG 44 or smaller, continually monitor coil continuity with 350 μA (maximum current) during last temperature cycle. Monitor relay for Miss Test during fifth cycle of thermal shock
PIND	Perform Particle Impact Noise Detection (PIND) per MIL-STD-202, Method 217 with the following criteria: 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 should be removed after each run. Lots which do not meet the 1% PDA on the fifth run, or exceed 25% defectives cumulative, should be rejected. Substitute 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. Vibrate relay with a 10 g peak sine wave at a fixed frequency of 10 Hz for 3 ± 0.1 minutes on an axis perpendicular to the motion of the contacts. Operate the relay at 9.9 Hz while monitoring the contacts for any misses. Reject all relays with misses.
Electrical Characteristics	Determine in accordance with the requirements in MIL-R-39016: Contact Resistance, Operating Voltage, Release Voltage, Hold Voltage, Operate and Release Times, Contact Bounce, Coil Resistance, Transient Suppression, and Reverse Polarity Protection.
Insulation Resistance	
Dielectric Withstanding-Voltage	Sea Level Only
Radiographic	Per MSFC-STD-355; 2 views 90° apart by X-ray inspection, or 360°. view by Vidicon. Use of "real-time" X-ray systems capable of viewing through 360 deg rotation is encouraged.
Hermetic Seal	Per MIL-R-6106 or MIL-R-39016 (as applicable)

External Visual and Mechanical Examination	Per MIL-R-6106 or MIL-R-39016 (as applicable)

Table 1000-10 Lot Conformance TestsTable

MIL-R-39016 &6106	Additions/Exceptions to MIL-R-39016 and 6106
Random Vibration and Shock	Perform per Table 1000-9 herein
Resistance to solder heat	Per MIL-R-39016
Internal moisture	Per MIL-R-6106
Qualification Tests	Per MIL-R-39016 and application requirements

SECTION 1100 RESISTORS, INTRODUCTION

1.0 **ORGANIZATION:** This section covers the common information for resistors and thermistors. Table 1100-1 lists, the types and style included in this section and the applicable section in this handbook where the specific detailed information is located.

Table 1100-1 Types and Style Included in Section 1100

Section	Resistor Type	Ref. Specification	Style
1110	Fixed Carbon Composition	MIL-R-39008	RCR
1120	Fixed Film	MIL-R-39017	RLR
1125	Fixed Film Chips	MIL-R-55342	RM
1130	Fixed Metal Film	MIL-R-87254	RSC
1140	Variable, Nonwire-Wound) & Wire-Wound	MIL-R-39035, 39015	RJR, RTR
1160	Wire-Wound, Accurate	MIL-R-39005	RBR
1170	Wire-Wound, Power-Type & Chassis-Mounted		RWR, RER
1190	Resistor Network	MIL-R-874	RZR
1195	Thermistor	MIL-T-23648	RTH

2.0 Application

For use of resistors refer to MIL-STD-199 and the information contained in the applicable section of this handbook.

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.

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.

Table 1100-2 Electrical Considerations

Electrical Considerations	Information for the designer and selector.
Power Ratings	Selection of resistor types and power ratings should be used based on intended application and allowable failure rate.
Pulse Applications	In applications where pulse voltages are present, the maximum pulse amplitude (including any steady-state voltage) should not exceed the value established by derating, regardless of resistance value.
Repetitive pulses	The average power should 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
Nonrepetitive pulses	The thermal time constant of the resistor in the particular application should 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 should be listed in Company documentation.

3.0 Design and Construction

The design and construction paragraph within the detailed part section provides information specific to the resistor for recommended designs, known design and construction problems, known reliability suspect designs, known material hazards, and recommended topics to be addressed in a company unique drawing to control produceability and controlling a baseline from a vendor.

TABLE 1100-3 Design and Construction Considerations

Design and Construction	Information
Solder Dip/Retinning Option	When solder dip/retinning is exercised, the subsequent 100% testing, as specified in the applicable military specification should be performed. The supplier should have been previously qualified to perform the process to the applicable military specification.

Table 1100-4 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Significant change of resistance value in a short period of time, regardless of storage conditions.	All carbon film
Has changed resistance value during operation.	All variable types.
	Films over solid cores without initial undercoating
Silver migration	Chip devices with silver or silver/palladium terminations that have no barrier metallization
	Film chips with films < 350 Angstroms thick
	Non-hermetic film resistors with aluminum terminations
	Wirewound resistors with crimped or soldered terminations
	Wirewound resistors with wire size < 0.001 inch
Nichrome migrates and causes opens	Nichrome film networks
	Network resistors using tantalum nitride films < 350 Angstroms thick.
	Non-welded networks
Corrosion	Nonhermetic resistor networks
	Non-hermetic hollow core (ceramic) film types. This construction was prohibited by MIL-STD-1547.
	All hermetic hollow ceramic core film resistors with internal metallization. This construction was prohibited by MIL-STD-1547.
Tin plate causes tin whiskers, which carries current to short or arc devices on a PWB.	Parts with tin-plated leads. This construction was prohibited by MIL-STD-1547.

4.0 Quality Assurance

The quality assurance section contains the recommended verification and validation during the procurement process, screening tests, lot conformance tests, and qualification tests for each resistor type.

4.1 Production Lot

The recommended production lot for high reliability resistors is, resistors of a single resistance and voltage rating of one design, from the same material batch, and processed as a single lot through all manufacturing steps on the same equipment, to the same baseline documentation, and identified with the same date and lot code designation. The lot may contain all available resistance tolerances for the nominal resistor value.

5.0 Lessons Learned

This paragraph has been inserted into this handbook to document information which from past experience and history which is not addressed in any other paragraph. This information was gained during failure reviews, incoming inspection history and any other source available which will give insight into problems which can be rectified.

SECTION 1110 FIXED COMPOSITION, INSULATED, CARBON COMPOSITION RCR (MIL-R-39008)

1.0 Scope

This section contains detailed information for fixed composition resistors (commonly called carbon comp resistors).

2.0 Application

The following tables contain information about fixed, composition resistors to assist in the decision making process of selection and documentation for Design Engineers and Parts Engineers.

Table 1110-1 Derating

Device Type	Parameter	Derating Factor	Comments
COMPOSITION RCR	POWER HOT-SPOT TEMPERATURE	.50 .80 of Max Rated	Nor recommended for space applications Above 70°C derate linearly to 0 Power at 98°C Ambient Temperature

TABLE 1110-2 End-of Life Design Limits

Resistance	
± 15 % for approved application	± 20% for worst case application

TABLE 1110-3 Design Applications

Style	Typical Applications	Application Considerations	Possible Mitigation
RCR		Changes in resistance of ± 15% due to moisture and temperature effects.	When closer tolerance or higher accuracy is needed, metal film or precision wire-wound devices are preferred.

3.0 Design and Construction

3.1 Recommended Design for Space and Launch Vehicles Carbon composition resistors are not recommended for any application requiring a resistor tolerance of 20% or less. Design and construction information is found in MIL-R-39008, and the following information of this handbook:

3.2 Known Reliability Suspect Designs The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 1110-4 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
	Carbon film types (prolitic carbon film deposited on glass or ceramic core).
Change of resistance value in excess of ±20%	Carbon composition (RCR) resistors should be limited to applications where a resistance accuracy (excluding initial tolerance) in excess of ±20% is allowed by the design.

4.0 Quality Assurance Provisions

Quality Assurance provisions should be in accordance with the requirements of MIL-R-39008 unless other wise specified.

Table 1110-5 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
Incoming Inspection: Verification of resistor received on a sample basis.	Review incoming data for accuracy of test.
Sample and Data Retention: Data retention information is found in Section 4 of this handbook.	Maintain samples and data for further use.

5.0 Lessons Learned

5.1 In coastal areas of U.S. these resistors can change as much as 50% and cannot be baked out after normal storage. Carbon comps will absorb moisture from organics during vacuum bake of hermetically sealed assemblies.

5.2 Performing DPA on this type of resistor has no added value.

SECTION 1120 Fixed Film Resistor RLR (MIL-R-39017)

1.0 Scope

This section contains detailed information for fixed film resistors (style RLR).

2.0 Application

The following tables contain information about fixed film (thick), resistors to assist in the decision making process of selection and documentation for Design Engineers and Parts Engineers.

Table 1120-1 Derating

Device Type	Parameter	Derating Factor	Comments
ALL	Steady State Power Peak Power	0.5 of rated 0.7	Derate linearly above 60C to zero at 100C Derate linearly above 70C to zero at 125C
RLR 05	Maximum continuous W V DC 200V	0.80 of the maximum continuous working voltages	
RLR 07	Maximum continuous W V DC 250V	0.80 of the maximum continuous working voltages	
RLR 20	Maximum continuous W V DC 350V	0.80 of the maximum continuous working voltages	
RLR 32	Maximum continuous W V DC 500V	0.80 of the maximum continuous working voltages	

TABLE 1120-2 End-of Life Design Limits

Resistance	Resistance
± 2 % for approved application	± 3 % for worst case application

TABLE 1120-3 Design Applications

Style	Typical Applications	Application Considerations	Possible Mitigation
RLR		Peak Power (Watt-seconds) should be limited to: RLR 05 1 RLR 07 3 RLR 20 15 RLR 32 40	
		Outgassing The resistor encapsulation is organic materials	The application must be tolerant of moisture and outgassing.
		These devices are susceptible to ESD damage.	Precautions against ESD should be used in packaging, handling, storage and kitting.

3.0 Design and Construction

3.1 Recommended Design for Space and Launch Vehicles Resistors designed and qualified to MIL-R-39017, failure level "S".

3.2 Known Reliability Suspect Designs The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 1120-4 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Thin metal film	Devices constructed with a deposited thin metal film over solid core that do not have protective undercoating between the metal film and the outer jacket should not be used.
ESD Damage	Resistors not protected from electrostatic discharge during shipping and handling may experience permanent damage.
Corrosion	Resistors using aluminum terminations are susceptible to corrosion due to moisture penetration. These parts should not be used or procured, unless with protective undercoating.

3.3 Produceability and Baseline Controls A product baseline should be established for all fixed film resistors. Areas which need to be specified and controlled in the drawing and baseline are:

Table 1120-5 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to Section 4
Production Lot	Refer to Section 200
Serialization	Refer to Section 4
Traceability Control (Parts, Materials, & Processes)	Refer to Section 4
Rework Provisions	Refer to MIL-R-39017
Process Controls Verification & Validation	Refer to MIL- R-39017
Screening Tests (100%)	Refer to MIL-R-39017 and table 1120-7 herein.
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to MIL-R-39017
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-R-39017

4.0 Quality Assurance Provisions

Quality Assurance provisions should be in accordance with the requirements of MIL-R-39017 unless other wise specified.

Table 1120-6 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of the applicable manufacturing baseline.	Homogeneity Production Lot Serialization Traceability Control for Parts, Materials, & Processes Rework Provisions Process Controls verification & validation Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)
Screening (100 percent): Refer to MIL-R-39017 Group A and Table 1120-7, in this handbook.	Review screening data (Attributes & Variables).
Lot Conformance: Refer to MIL-R-39017 Group B tests	Review lot conformance data (Attributes & Variables).
Qualification Testing: Refer to the requirements of MIL-R-39017	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: Materials and construction is verified upon receipt of each lot of devices, by performing DPA in accordance with MIL-STD-1580.	Review incoming DPA and compare to historical DPA data.
Sample and Data Retention: Data retention information is found in Section 4 of this handbook.	Maintain samples and data for further use.

Table 1120-7 Screening Table

MIL-R-39017	Additions to the Methods and Criteria of MIL-R-39017
Subgroup 1 100% Thermal Shock	
DC Resistance	Read and record
Overload	24 hours min. @ 25°C ± 5°C with 1.5 X rated power
Power conditioning	96 hours min. @ max. rated temperature with full rated power; do not exceed max. voltage specified in the spec.
DC Resistance (after Power Conditioning)	a) Change in DC resistance should not exceed 0.5 % +0.05Ω or ± 3 standard deviation, whichever is less, for the combined overload and power conditioning tests b) DC resistance should be within initially specified tolerance limits; lots having more than 10% out-of-tolerance rejects should not be used
Subgroup 2 100% Resistance Noise	(Optional for applications that are not noise-sensitive) Procedure and accept/reject criteria should be per MIL-R-87252
Subgroup 3 Solderability	
Subgroup 4 Visual and Mechanical Examination	

SECTION 1125 **Fixed Film Resistor Chips** RM (MIL-R-55342)

1.0 Scope

This section contains detailed information for fixed film resistor chips.

2.0 Application

The following tables contain information about fixed, film resistor chips to assist in the decision making process of selection and documentation for Design Engineers and Parts Engineers.

Table 1125-1 Derating

Parameter	Derating Factor	Comments
Power	Nominal < 70°C 50% of rated power Worst Case < 70°C 75% of rated power	70 to 125°C linearly derate to zero power 70 to 125°C linearly derate to zero power
Voltage	Should be limited to 0.8 times maximum voltage values shown in MIL-R-55342	Steady-state voltage applied to resistors

TABLE 1125-2 End-of Life Design Limits

Resistance	Resistance
± 4 % for approved application	± 7% for worst case application

3.0 Design and Construction

3.1 Recommended Design for Space and Launch Vehicles Fixed film resistor chips, which meet the design and construction requirements of MIL-R-55342, and have had the additional testing in table 1125-7 herein.

3.2 Known Reliability Suspect Designs The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

3.3 Produceability and Baseline Controls A product baseline should be established for all fixed film resistor chips. Areas which need to be specified and controlled in the drawing and baseline are:

TABLE 1125-3 Design Applications

Typical Applications	Application Considerations	Possible Mitigation
High Frequency	> 200Mhz, effective resistance is reduced as a result of shunt capacity between resistance elements and controlling circuits.	Perform design analysis before use in this application.
Operation under humid 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 film 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.
	The terminations of these chips (usually platinum or gold) are subject to leaching when exposed to molten solder at high temperatures.	Mounting Pre-tinning is recommended.
	Under low humidity conditions fixed film chip resistors, particularly those of smaller case sizes manufactured with high sheet resistance films, are subject to ESD damage and sudden shifts in resistance and the temperature coefficient of resistance.	Precautions against ESD should be used in packaging, handling, storage and kitting. These devices are not recommended for designs intolerant of sudden shifts in resistance and temperature coefficient of resistance under low humidity.

Table 1125-4 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Resistance to solder leaching	Silver and palladium terminations should not be used unless leach resistance barriers such as nickel or copper are utilized between the termination and the solder.
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 c) Other anomalies
Copper or Nickel film	Fixed film resistor chips with copper or nickel conductor film is a prohibited part in MIL-STD-1547.

Table 1125-5 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to Section 4
Production Lot	Refer to MIL-R-55342
Serialization	Refer to Section 4
Traceability Control (Parts, Materials, & Processes)	Refer to Section 4
Rework Provisions	Refer to MIL-R-55342
Process Controls Verification & Validation	Refer to MIL-R-55342
Screening Tests (100%)	Refer to MIL-R-55342 and Table 1125-7 herein.
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to MIL-R-55342
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-R-55342

4.0 Quality Assurance Provisions

Quality Assurance provisions should be in accordance with the requirements of MIL-R-55342 unless other wise specified.

Table 1125-6 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of the applicable manufacturing baseline.	Homogeneity Production Lot Serialization Traceability Control for Parts, Materials, & Processes Rework Provisions Process Controls verification & validation Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)
Screening (100 percent): Refer to MIL-R-55342 Group A and Table 1125-8, in this handbook.	Review screening data (Attributes & Variables).
Lot Conformance: Refer to MIL-R-55342 Group B tests	Review lot conformance data (Attributes & Variables).
Qualification Testing: Refer to the requirements of MIL-R-55342	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: Materials and construction is verified upon receipt of each lot of devices, by performing DPA in accordance with MIL-STD-1580.	Review incoming DPA and compare to historical DPA data.
Sample and Data Retention: Data retention information is found in Section 4 of this handbook.	Maintain samples and data for further use.

Table 1125-7 Screening Table

MIL-R-55342	Additions to the Methods and Criteria of MIL-R-55342
Subgroup 1 1/ Pre-glassivation visual inspection	Paragraph 3.19 of MIL-R-55342
DC Resistance	Read and record
Thermal Shock	
Power conditioning	a) 96 hours +4 -0, full rated power @ 70°C applied 90 minutes on, 30 minutes off b) Delta DC resistance should not exceed the limits specified for thermal shock test.
Subgroup 2 Solderability	When applicable
Subgroup 3 Visual and Mechanical Examination	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 should not be used.

SECTION 1130 Fixed Metal Film Resistor RSC (MIL-R-87254)

1.0 Scope

This section contains detailed information for fixed metal film resistors (style RSC).

2.0 Application

The following tables contain information about fixed metal film resistors to assist in the decision making process of selection and documentation for Design Engineers and Parts Engineers.

Table 1130-1 Derating

Device Type	Parameter	Derating Factor	Comments
RSC	Steady State Power Peak Power	0.5 0.7	Derate linearly above 70C to zero at 120C Derate linearly above 70C to zero at 140C
	Voltage	Steady-state voltage applied to RSC resistors should be limited to 0.80 of the maximum allowable voltage rating in MIL-R-87254	Applications at 71°C to 125°C
	Voltage	Steady-state voltage applied to RSC resistors should be limited to 0.80 voltage rating in MIL-R-87254	Applications at 70°C and below

TABLE 1130-2 End-of Life Design Limits

Resistance	Resistance
± 1 % for approved application	± 1.5% for worst case application

TABLE 1130-3 Design Applications

Style	Typical Applications	Application Considerations	Possible Mitigation
RSC		Temperature Coefficient MIL-R-87254 specifies resistance changes if ±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 not the environment. The temperature coefficient is nonlinear but can be approximated by as straight line for small temperature changes.	Use in applications tolerant of TC changes. Verify the resistor temperature in the application then use derating.
		These devices are susceptible to ESD damage.	Precautions against ESD should be used in packaging, handling, storage and kitting.

3.0 Design and Construction

3.1 Recommended Design for Space and Launch Vehicles Resistors designed and qualified to MIL-R-87254.

3.2 Known Reliability Suspect Designs The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 1130-4 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Non-hermetic	Non-hermetic resistors using thin film metallization without a corrosion-resistant precoat over the metal film.
ESD Damage	Resistors not protected from electrostatic discharge during shipping and handling may experience permanent damage.
Corrosion	Resistors using aluminum terminations are susceptible to corrosion due to moisture penetration. These parts should not be used or procured, unless with protective undercoating.
Hollow core	Non-hermetic hollow-core types are prohibited
Hollow core corrosion	Hermetic hollow-core types with internal (inside surface of the core) metallization (susceptible to film corrosion due to contamination from the manufacturing process). This is a prohibited part in MIL-STD-1547.

3.3 Produceability and Baseline Controls A product baseline should be established for all custom resistors. Areas which need to be specified and controlled in the drawing and baseline are:

Table 1130-5 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to Section 4
Production Lot	Refer to Section 4
Serialization	Refer to Section 4
Traceability Control (Parts, Materials, & Processes)	Refer to Section 4
Rework Provisions	Refer to MIL-R-87254
Process Controls Verification & Validation	Refer to MIL-R-87254
Screening Tests (100%)	Refer to MIL-R-87254
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to MIL-R-87254
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-R-87254

4.0 Quality Assurance Provisions

Quality Assurance provisions should be in accordance with the requirements of MIL-R-87254 unless other wise specified.

Table 1130-6 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
Incoming Inspection: Verification of resistor received on a sample basis.	Review incoming data for accuracy of test.
Incoming Inspection DPA: Materials and construction is verified upon receipt of each lot of devices, by performing DPA in accordance with MIL-STD-1580.	Review incoming DPA and compare to historical DPA data.
Sample and Data Retention: Data retention information is found in Section 4 of the this handbook.	Maintain samples and data for further use.

SECTION 1140 Variable, Nonwire-wound and Wire-wound Resistors RJR, RTR (MIL-R-39035, MIL-R-39015)

1.0 Scope

This section contains detailed information for two (2) resistors types, variable, nonwire-wound and wire-wound resistors. Where the requirements or information differ the resistor style will be noted.

2.0 Application

The following tables contain information about variable, non-wire wound and wire-wound resistors to assist in the decision making process of selection and documentation for Design Engineers and Parts Engineers.

Table 1140-1 Derating

<table>
<tr><th>Device Type</th><th>Parameter</th><th>Derating Factor</th><th colspan="2">Comments</th></tr>
<tr><td rowspan="3">RJR
(MIL-R-39035)</td><td>Steady State Power</td><td>0.5</td><td colspan="2">Derate linearly above 50C to zero at 90C</td></tr>
<tr><td>Peak Power</td><td>0.6</td><td colspan="2">Derate linearly above 60C to zero at 110C</td></tr>
<tr><td>Steady state applied voltage</td><td>0.80 of the values shown in Paragraph 3.3 of Section 402 of MIL-STD-199</td><td colspan="2"></td></tr>
<tr><td rowspan="13">RTR
(MIL-R-39015)</td><td>Steady State Power</td><td>0.5</td><td colspan="2">Derate linearly above 25C to zero at 100C</td></tr>
<tr><td>Peak Power</td><td>0.7</td><td colspan="2">Derate linearly above 25C to zero at 125C</td></tr>
<tr><td rowspan="11">Steady state applied voltage</td><td rowspan="11">0.80 of the values shown</td><td>Nominal Resistance</td><td>Maximum Rated Voltage Volts AC (rms) or DC</td></tr>
<tr><td>10</td><td>2.7</td></tr>
<tr><td>20</td><td>3.8</td></tr>
<tr><td>50</td><td>6.1</td></tr>
<tr><td>100</td><td>8.7</td></tr>
<tr><td>200</td><td>12.3</td></tr>
<tr><td>500</td><td>19.4</td></tr>
<tr><td>1000</td><td>27.4</td></tr>
<tr><td>2000</td><td>38.7</td></tr>
<tr><td>5000</td><td>61.3</td></tr>
<tr><td>10000</td><td>86.7</td></tr>
</table>

TABLE 1140-2 End-of Life Design Limits

Style	Resistance	Resistance
RJR	± 22 % for approved applications	± 30 % for worst case applications
RTR	± 10 % for approved applications	± 20 % for worst case applications

TABLE 1140-3 Design Applications

Style	Application Considerations	Possible Mitigation
RJR, RTR	These are non-hermetic resistors, which are susceptible to degrade performance due to ingress of solder flux, cleaning solvents, and conformal coatings during equipment fabrication. These parts are subject to resistance change during shock and vibration. Mounting brackets should be used.	Use in designs tolerant to resistance change while under vibration and shock
RTR	These parts are subject to resistance change during aging Pulse Power limitations of Wire wound resistors (See SECTION 1170) apply.	Use in designs tolerant to resistance chnage. Or in applications which will not age before use. Only if Wiper position is not less than 70 % of the maximum settings

3.0 Design and Construction

3.1 Recommended Design for Space and Launch Vehicles Variable resistors should be avoided whenever possible. They are not recommended for space use. If used variable, non-wire wound resistors, which meet the design and construction requirements of MIL-R-39035 for RJR types or wire-wound resistors in accordance with MIL-R-39015 for RTR types and the additional controls and testing herein.

3.2 Known Reliability Suspect Designs The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 1140-4 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Variable resistors	All variable resistors were documented as reliability suspect devices in MIL-STD-1547
Wire diameter	A minimum wire diameter of 25.4 micrometers (0.001”) zero negative tolerance should be used for RTR resistors
Internal connections	All internal connections should be welded for RTR resistors

3.3 Produceability and Baseline Controls A product baseline should be established for all variable, nonwire-wound and wire-wound resistors. Areas which need to be specified and controlled in the drawing and baseline are:

Table 1140-5 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to Section 4
Production Lot	Refer to Section 4
Serialization	Refer to Section 4
Traceability Control (Parts, Materials, & Processes)	Refer to Section 4
Rework Provisions	Refer to MIL-R-39035 for RJR, MIL-R-39015 for RTR
Process Controls Verification & Validation	**Refer to MIL- R-39035 and the following for RJR type:** Perform 100% Internal visual, using a binocular microscope at minimum 30x. Any resistor exhibiting any of the following defects should be marked and rejected: a) Foreign material b) Chips, spalls, cracks, or scratches in the resistor element c) Element misalignment or improper seating d) Incorrect or missing element stops e) Incorrect seating or damage to wiper arm f) Faulty termination of element or pins Reject lot if the number of rejects at internal visual exceeds 7.0 % of the lot. **Refer to MIL- R-39015 and the following for RTR type**: Perform 100% Internal visual, using a binocular microscope at minimum 30x. Any resistor exhibiting any of the following defects should be marked and rejected: a) Damage to resistance wire reducing its diameter by 1/3 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 ½ of tab width j) Cracks or fractures in welds k) Loose terminals l) Foreign material such as weld splatter, flux residue, or metallic particles The entire lot should be rejected if the number of rejects at internal visual exceeds 7.0 % of the lot.
Screening Tests (100%)	Refer to MIL- R-39035 and table 1140-7-1 herein for RJR and MIL-R-39015 and table 1140-7-2 herein for RTR.
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to MIL- R-39035 for RJR or MIL-R-39015 for RTR.
Qualification Tests (Destructive & Non-	Refer to MIL-R-39035 for RJR or MIL-R-39015 for RTR.

destructive tests)	

4.0 Quality Assurance Provisions

Quality Assurance provisions should be in accordance with the requirements of MIL-R-39035 for RJR types or MIL-R-39015 for RTR types unless other wise specified.

Table 1140-6 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of the applicable manufacturing baseline.	Homogeneity Production Lot Serialization Traceability Control for Parts, Materials, & Processes Rework Provisions Process Controls verification & validation Refer to MIL-R-39035 and the following for RJR types: 100% Internal visual, using a binocular microscope at minimum 30x and an integral light source should be performed. Any resistor exhibiting any of the following defects should be marked and rejected: a) Foreign material b) Chips, spalls, cracks, or scratches in the resistor element c) Element misalignment or improper seating d) Incorrect or missing element stops e) Incorrect seating or damage to wiper arm f) Faulty termination of element or pins The entire lot should be rejected if the number of rejects at internal visual exceeds 7.0 % of the lot. Refer to MIL- R-39015 and the following for RTR type: 100% Internal visual, using a binocular microscope at minimum 30x and an integral light source should be performed. Any resistor exhibiting any of the following defects should be marked and rejected: a) Damage to resistance wire reducing its diameter by 1/3 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 ½ of tab width j) Cracks or fractures in welds k) Loose terminals l) Foreign material such as weld splatter, flux residue, or metallic particles The entire lot should be rejected if the number of rejects at internal visual exceeds 7.0 % of the lot. Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)
Screening (100 percent): Refer to MIL-R-39035 Group A and Table 1140-7-1 herein for RJR type, or MIL-R-39015 Group A and Table 1140-7-2 herein for RTR type.	Review screening data (Attributes & Variables).
Lot Conformance: Refer to MIL-R-39035 Group B tests for RJR type or MIL-R-39015 Group B tests for RTR type	Review lot conformance data (Attributes & Variables).
Qualification Testing: Refer to the requirements of MIL-R-39035 for RJR type or MIL-R-39015 for RTR type	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: Materials and construction is verified upon receipt of each lot of devices, by performing DPA in accordance with MIL-STD-1580.	Review incoming DPA and compare to historical DPA data.
Sample and Data Retention: Data retention information is found in Section 4 of this handbook.	Maintain samples and data for further use.

Table 1140-7-1 Screening Table for RJR Type

MIL-R-39035	Additions to the Methods and Criteria of MIL-R-39035
Subgroup 1 100% 1/ Thermal Shock Conditioning Contact Resistance Variation Immersion	168 hours minimum @ +85°C ± 5°C
Subgroup 2 Vibration, random	a) 12 samples (6 highest, 6 lowest in resistance value) accept on 0 failures 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 (2) orthogonal planes d) Post vibration measurements should meet specification limits.
Subgroup 3 Visual and Mechanical Examination	

1/ Lots having more than 5% PDA for Subgroup 1 screening should not be used.

Table 1140-7-2 Screening Table for RTR Type

MIL-R-39015	Additions to the Methods and Criteria of MIL-R-39015
Subgroup 1 100% 1/ Thermal Shock Conditioning Peak Noise Total Resistance Immersion	168 hours minimum @ +85°C ± 5°C
Subgroup 2 Vibration, random	a) 12 samples (6 highest, 6 lowest in resistance value) accept on 0 failures 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 (2) orthogonal planes d) Measurements before, during and after test should be in accordance with MIL-R-39015 e) Change in total resistance and setting stability should 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/ Lots having more than 5% PDA for Subgroup 1 screening should not be used.

SECTION 1160 Wire-Wound, Accurate Resistors RBR (MIL-R-39005)

1.0 Scope

This section contains detailed information for fixed wire-wound (accurate) resistors

2.0 Application

The following tables contain information about fixed wire-wound (accurate) resistors to assist in the decision making process of selection and documentation for Design Engineers and Parts Engineers.

Table 1160-1 Derating

Device Type	Parameter	Derating Factor	Comments
RBR All Values	Power	 0.40 0.40 0.40 0.80	Resistance Tolerance 0.01% 0.05% 0.1% 1.0%
All Values	Voltage	0.80	Of the max voltages in Table 303-II of MIL-STD-199

TABLE 1160-2 End-of Life Design Limits

STRESS LEVEL	Resistance Tolerance
70% Power up to 125C	±1.00% plus initial tolerance
50% Power up to 125C	±0.51% plus initial tolerance
30% Power up to 125C	±0.30% plus initial tolerance
10% power up to 80C	±0.03% plus initial tolerance

TABLE 1160-3 Design Applications

Style	Application Considerations	Possible Mitigation
RBR	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 PPM. 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 the manufacturer for temperature and duration.)

3.0 Design and Construction

3.2 Recommended Design for Space and Launch Vehicles Wire-wound, accurate resistors, which meet the design and construction requirements of MIL-R-39005 and the additional controls and testing herein.

Table 1160-4 Recommended Design Characteristics

Construction Item	Description of Construction
Wire	Wire diameter of 25.4 micrometers (0.001") zero negative tolerance
Internal Connections	Welded internal connections

3.2 Known Reliability Suspect Designs The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 1160-5 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Internal connections	All designs using solder or crimped internal connections.
Wire diameter	Designs using a wire diameter of less than 25.4 micrometers (0.001") zero negative tolerance.

3.3 Produceability and Baseline Controls A product baseline should be established for all wire-wound, accurate resistors. Areas which need to be specified and controlled in the drawing and baseline are:

Table 1160-6 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to Section 4
Production Lot	Refer to Section 200
Serialization	Refer to Section 4
Traceability Control (Parts, Materials, & Processes)	Refer to Section 4
Rework Provisions	Refer to MIL-R-39005
Process Controls Verification & Validation	Refer to MIL- R-39005 and the following: 100% Internal visual, of all exposed inner surfaces at minimum 10x should be performed. Any resistor exhibiting any of the following defects should be marked and rejected: a) Less than 0.025" gap between leads b) Absence of a soft cushion coating over wire winding c) Burning at weld greater than 1/2 tab width d) Lack if indication weld tip indention at welds e) Cracks, breaks, or partial fracture at welds
Screening Tests (100%)	Refer to MIL- R-39005 Group A tests and table 1160-8 herein.
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to MIL- R-39005 Group B tests.
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-R-39005.

4.0 Quality Assurance Provisions

Quality Assurance provisions should be in accordance with the requirements of MIL-R-39005 unless other wise specified.

Table 1160-7 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of the applicable manufacturing baseline.	Homogeneity Production Lot Serialization Traceability Control for Parts, Materials, & Processes Rework Provisions Process Controls verification & validation 100% Internal visual, of all exposed inner surfaces at minimum 10x should be performed. Any resistor exhibiting any of the following defects should be marked and rejected: a) Less than 0.025" gap between

	leads b) Absence of a soft cushion coating over wire winding c) Burning at weld greater than 1/2 tab width d) Lack if indication weld tip indention at welds e) Cracks, breaks, or partial fracture at welds Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)
Screening (100 percent): Refer to MIL-R-39005 Group A and Table 1160-8 herein.	Review screening data (Attributes & Variables).
Lot Conformance: Refer to MIL-R-39005 Group B tests.	Review lot conformance data (Attributes & Variables).
Qualification Testing: Refer to the requirements of MIL-R-39005.	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: Materials and construction is verified upon receipt of each lot of devices, by performing DPA in accordance with MIL-STD-1580.	Review incoming DPA and compare to historical DPA data.
Sample and Data Retention: Data retention information is found in Section 4 of this handbook.	Maintain samples and data for further use.

Table 1160-8 Screening Table

MIL-R-39005	Additions to the Methods and Criteria of MIL-R-39005
Thermal Shock	
DC Resistance	
Conditioning	168 hours minimum
Short Time Overload	
Delta DC Resistance	R ± (0.01% +0.01Ω)
Radiographic Inspection	Per MSFC-STD-355; 2 views 90° apart by x-ray, or 360° view by using real-time x-ray systems capable of viewing through 360° rotation. (Test may be waived if in-process inspection is performed)
External Visual and Mechanical Examination	a) Marking and identification b) Defects and damage; i.e., body finish, lead finish, misalignment, cracks.

SECTION 1170 Wire-Wound, Power-Type, Chassis-Mounted Resistors RWR (MIL-R-39007), RER (MIL-R-39009)

1.0 Scope

This section contains detailed information for two (2) types of resistors, fixed wire-wound power-type (RWR) and chassis-mounted (RER) resistors. Where the requirements or information differ the resistor style will be noted.

2.0 Application

The following tables contain information about fixed wire-wound (power-type) (RWR) and chassis-mounted (RER) resistors to assist in the decision making process of selection and documentation for Design Engineers and Parts Engineers.

Table 1170-1 Derating

Device Type	Parameter	Derating Factor	Comments
RWR,RER	Steady State Power Peak Power	0.47 0.60	Derate linearly above 25C to 0 at 140C Derate linearly above 25C to 0 at 170C
	N/A		RWR resistors are relatively low ohmic devices, and voltage derating is normally not required.

TABLE 1170-2 End-of Life Design Limits

Style	Resistance	Resistance
RWR, RER	± 1% for approved application	± 5% for worst case application

TABLE 1170-3 Design Applications

Style	Typical Applications	Application Considerations	Possible Mitigation
RWR, RER		The temperature coefficient of resistance (due to wire variations) may be either negative or positive	The values for each style of RWR resistors are listed in the applicable MIL-R-39007 slash sheet. Follow application derating rules.
	High-Frequency	These resistors are not designed for high-frequency circuits where their ac characteristics are important	For high-frequency applications were ac characteristics are not important.
	Noise	The only source of noise is thermal agitation which can be neglected in most circuit applications	Assure circuit design is tolerant of noise from thermal agitation
		Voltage coefficient of resistance is not specified for wire-wound resistors.	

3.0 Design and Construction

3.3 Recommended Design for Space and Launch Vehicles Wire-wound, power-type and chassis-mounted resistors, which meet the design and construction requirements of MIL-R-39007 (RWR), MIL-R-39009 (RER) as applicable and the additional controls and testing herein.

Table 1170-4 Recommended Design Characteristics

Construction Item	Description of Construction
Wire	Wire diameter of 25.4 micrometers (0.001") zero negative tolerance
Internal Connections	Welded internal connections

3.2 Known Reliability Suspect Designs The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 1170-5 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Internal connections	All designs using solder or crimped internal connections.
Wire diameter	Designs using a wire diameter of less than 25.4 micrometers (0.001") zero negative tolerance.

3.3 Produceability and Baseline Controls A product baseline should be established for all. fixed wire-wound (power-type) (RWR) and chassis-mounted (RER) resistors. Areas which need to be specified and controlled in the drawing and baseline are:

Table 1140-6 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to Section 4
Production Lot	Refer to Section 200
Serialization	Refer to Section 4
Traceability Control (Parts, Materials, & Processes)	Refer to Section 4
Rework Provisions	Refer to MIL-R-39007 for RWR and MIL-R-39009 for RER types
Process Controls Verification & Validation	Refer to MIL- R-39007 for RWR or MIL-R-39009 for RER and the following: 100% Internal visual, of all exposed inner surfaces at minimum 10x should be performed. Any resistor exhibiting any of the following defects should be marked and rejected: a) RWR, End cap misalignment greater than 5° b) RER, End cap misalignment greater than 10° c) Cracks, excessive bends, incomplete wire weld, or loose wire at end cap d) Split, distorted, or cracked end caps e) Space between wire turns more than 5 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) f) Cracks or surface holes in core which exceed 0.025" in greatest dimension
Screening Tests (100%)	Refer to MIL- R-39007 Group A tests for RWR types or MIL-R-39009 Group A tests for RER types and table 1170-8 herein.
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to MIL- R-39007 Group B tests for RWR types or MIL-R-39009 Group A tests for RER types
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-R-39007 for RWR types or MIL-R-39009 for RER types.

4.0 Quality Assurance Provisions

Quality Assurance provisions should be in accordance with the requirements of MIL-R-39007 for RWR types or MIL-R-39009 for RER types unless other wise specified.

Table 1170-7 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of the applicable manufacturing baseline.	Homogeneity Production Lot Serialization Traceability Control for Parts, Materials, & Processes Rework Provisions Process Controls verification & validation Perform 100% Internal visual, of all exposed inner surfaces at minimum 10x. Any resistor exhibiting any of the following defects should be marked and rejected: a) RWR, End cap misalignment greater than 5° b) RER, End cap misalignment greater than 10° c) Cracks, excessive bends, incomplete wire weld, or loose wire at end cap d) Split, distorted, or cracked end caps e) Space between wire turns more than 5 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) f) Cracks or surface holes in core which exceed 0.025" in greatest dimension Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)
Screening (100 percent): Refer to MIL-R-39007 Group A for RWR types or MIL-R-39009 Group A for RER types and Table 1170-8 herein.	Review screening data (Attributes & Variables).
Lot Conformance: Refer to MIL-R-39007 Group B tests for RWR types or MIL-R-39009 Group B tests for RER types.	Review lot conformance data (Attributes & Variables).
Qualification Testing: See MIL-R-39007 for RWR types or MIL-R-39009 for RER types.	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: Verify materials and construction upon receipt of each lot of devices, through DPA per MIL-STD-1580.	Review incoming DPA and compare to historical DPA data.
Sample and Data Retention: Data retention information is found in Section 4 of this	Maintain samples and data for further use.

handbook.	

Table 1170-8 Screening Table

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

1/ PDA for Subgroup1 tests is 5%, or one resistor, for rejects due to exceeding resistance change limits and DWV failures

SECTION 1190 Fixed Film Resistor Networks RZR (MIL-R-874)

1.0 Scope

This section contains detailed information for fixed film resistor networks.

2.0 Application

The following tables contain information about fixed film resistor networks to assist in the decision making process of selection and documentation for Design Engineers and Parts Engineers.

Table 1190-1 Derating

Device Type	Parameter	Derating Factor	Comments
RZR	Power, Approved Applications	0.50 of the power ratings values shown in Table 1190-2	Temperature below +70°C, power applied is linearly reduced to zero power from +70°C to +125°C
	Power, Worst Case	0.75 of the power ratings values	Temperature below +70°C, power applied is linearly reduced to zero power from +70°C

	Applications	shown in Table 1190-2	to +125°C
	Steady-State Voltage	0.80 of the maximum voltage values shown in Table 1190-2	

Table 1190-2 Manufacturer's Element Power, Network Power and Voltage Ratings

Style	Schematic Type*	Element Power Rating @ +70°C in watts	Network Power Rating @ +70°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°C for total network and up to +90°C per element. Rating shown here is for thick film.				

TABLE 1190-3 End-of Life Design Limits

Style	Resistance	Resistance
RZR	± 1% for approved application	± 2% for worst case application

TABLE 1190-4 Design Applications

Style	Application Considerations	Possible Mitigation
RZR	The resistance temperature coefficient (TC) can be either characteristic H (± 50 ppm per deg. C) or characteristic K (± 100 ppm 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 ppm.	

3.0 Design and Construction

3.4 Recommended Design for Space and Launch Vehicles Fixed film network resistors, which meet the design and construction requirements of MIL-R-874 and the additional controls and testing herein. The resistance temperature coefficient (TC) should be either characteristic H (+ 50 ppm per deg. C) or characteristic K (+ 100 ppm per deg. C). All resistors in a network should be manufactured from the same batch at the same time.

Table 1190-5 Recommended Design Characteristics

Construction Item	Description of Construction
Film	Tantalum nitride, deposited onto substrate, and protected by tantalum pentoxide passivation.
Surface	The surface should be anodized for moisture protection or laser-trimmed and subsequently glassivated.
Internal Connections	Welded internal connections.
Hermeticity	Hermetically sealed units.

3.2 Known Reliability Suspect Designs The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 1190-6 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Thick film designs	Resistor networks manufactured by thick film technology with internal solder connections.
Nichrome	Thin film resistors manufactured with nichrome as the resistive element are prone to potential opening of nichrome traces in the presence of moisture and bias, even in hermetically sealed packages.
Excessively thin tantalum nitride	Designs requiring tantalum nitride thickness' below 35 nanometers have increased susceptibility to (a) mechanical handling damage, (b) opens resulting from "hot spots" at surface defects and (c) nonohmic behavior at low voltages.
Nonhermetically sealed packages	Parts in nonhermetically sealed packages are reliability suspect.

3.3 Produceability and Baseline Controls A product baseline should be established for all fixed film resistor networks. Areas which need to be specified and controlled in the drawing and baseline are:

Table 1190-7 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to Section 4
Production Lot	Refer to Section 4
Serialization	Refer to Section 4
Traceability Control (Parts, Materials, & Processes)	Refer to Section 4
Rework Provisions	Refer to MIL-R- 874 and MIL-R-83401.
Process Controls Verification & Validation	Refer to MIL- R-83401 and Precap visual specified in Table 1190-9 herein.
Screening Tests (100%)	Refer to MIL- R-874 Group A tests and Table 1190-9 herein.
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to MIL- R-874 Group B tests.
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-R-874.

4.0 Quality Assurance Provisions

Quality Assurance provisions should be in accordance with the requirements of MIL-R-874 unless other wise specified.

Table 1190-8 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of the applicable manufacturing baseline.	Homogeneity, Production Lot, Serialization Traceability Control for Parts, Materials, & Processes, Rework Provisions Process Controls verification & validation Screening Tests (100%) Lot conformance Tests and Qualification Tests (Destructive & Non-destructive tests)
Screening (100 percent): Refer to MIL-R-874 Group A and Table 1190-9 herein.	Review screening data (Attributes & Variables).
Lot Conformance: Refer to MIL-R-874 Group B tests.	Review lot conformance data (Attributes & Variables).
Qualification Testing: Refer to the requirements of MIL-R-874.	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: Materials and construction is verified upon receipt of each lot of devices, by performing DPA in accordance with MIL-STD-1580.	Review incoming DPA and compare to historical DPA data.
Sample and Data Retention: Data retention information is found in Section 4 of this handbook.	Maintain samples and data for further use.

Table 1190-9 Screening Table

MIL-R-83401 100% 1/	**Additions to the Methods and Criteria of MIL-R-874**
Precap Visual Inspection	A binocular microscope with at least 100X mag. And a coaxial illuminated or fiber optic light ring should be used. The resistor side visual inspection should be performed at 100X min. mag. Perpendicular to the die surface, with illumination normal to the die surface. Any die exhibiting one or more of the following defects should be marked and rejected: 1) **Metallic Particles** a)Unattached There should be no more than 3 unattached metallic particles. Unattached particles should be less than 0.005" or the width of the spiral cut in dimension, whichever is less. Particles should not be joined. b)Attached Attached metallic particles should not exceed 0.005" in major dimension. Particles should not touch nor extend over the metal film. Particles should be considered attached when they cannot be removed with 20 psig gas blow of dry nitrogen or dry, oil-free air. c)Residue There should be no residue from the spiral cutting operation at 100X mag. Within the enclosure. 2) **Nonmetallic Particles** Glass, fibers, and other nonmetallic materials within the enclosure should not exceed 0.005" in their major dimension. 3) **Metallization Defects** Any of the following anomalies in the active circuit metallization should be cause for rejection. a) Metallization Scratches 1. Any scratch in metallization through which the underlying resistor material also appears to be scratched. 2. 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% of its original width. 3. A scratch is defined as any tearing defect that disturbs the original surface of the metallization. b) Metallization Voids 1. Any void in the interconnecting metallization, which leaves less than 50% of the original width undisturbed. 2. 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 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) Mettalization Bridging Bridged metallization defect that reduces the distance between any two metallization areas to less than 0.0003". Bridging between metallization and resistor pattern not intended by design that reduces the distance between the two to less than 0.0001". f) Metallization Alignment Any misalignment between the resistor

pattern and the metallization such that more than 0.0005” of resistor on a side is exposed.

   g) Metallization Corrosion Any evidence of localized heavy stains, metallization corrosion, discoloration or mottled metallization.

4) **Resistor Defects** Any of the following anomalies within the active resistor area should be caused 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% of the original width. Any void or necking down in the active resistor path for a line width design of less than 0.0002” which reduces its 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 strips. A partial bridging defect is that which reduces the distance between adjacent active resistance stripes to less than 0.1 mil or 50% 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” design width, visual separation (evident @ 40X) is sufficient for acceptance.

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 should 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 cause for rejection.

6) **Resistor Bonding Pad Defects** Any resistor containing one or more bonding pads with one or more of the following anomalies should 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. 7) **Oxide Defects** Any resistor having excessive oxide defects or voids should 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 should 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 then 0.0005" oxide visible between active metallization and edge of a die. Excluded from this are any inactive metallization lines. 8) **Scribing and Die Defects** Any resistor having the following scribing or die anomalies should be rejected: a) Any chipout or crack in the active resistor or metal area. b) Any crack that exceeds 0.005" in length or come closer than 0.001" to an active circuit area. c) Any crack in a die that exceeds 0.001" 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% of area intact or a crack or chip under a bonding pad.
Thermal Shock	
Power Conditioning	a) The network should be mounted to attain the test temperature condition noted below. Leads should be mounted by means other than soldering or welding to avoid stress or damage to the leads. Networks should be so arranged that the temperature of one network can not appreciably affect the temperature of any other network. b) Operating conditions should be in accordance with MIL-R-83401. The supply voltage should be regulated and controlled to maintain a tolerance ±5% of the maximum voltage specified. c) With the dc voltage applied, the ambient temperature should be adjusted to obtain a case temperature of +70°C, +5°C, -0°C. d) Initial and final resistance should be At room ambient. e) Test duration should be 168 hours, min.
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 max. of 5 times. 1. If less than 1% of the lot fails during any of the 5 runs, the lot may be accepted. 2. All defective devices should be removed after each run, no retesting of failed devices allowed. 3. Lots, which do not meet the 1% PDA on the fifth run, or cumulatively exceed 25% defectives, should be rejected. 4. Applicable to cavity devices only.
Visual and Mechanical Examination	a) Marking and identification. b) Defects and damage; i.e., body finish, lead finish, misalignment, cracks.

1/ Resistor networks that are out of resistance tolerance, or which exhibit a change in resistance greater than that permitted, should be removed from the lot. Lots having more than 5% total rejects due to resistance tolerance or resistance change should be rejected

SECTION 1195 Thermistors RTH (MIL-T-23648)

1.0 Scope

This section contains detailed information 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).

2.0 Application

The following tables contain information about thermistors both positive TC and negative TC to assist in the decision making process of selection and documentation for Design Engineers and Parts Engineers.

Table 1195-1 Derating

Device Type	Parameter	Derating Factor	Comments
PTC	Rated Power	50% at any given temperature as provided in the thermal derating curve of a given slash sheet.	Positive temperature coefficient thermistors are generally operated in the self-heat mode (heated as a result of current passing through).
NTC	Dissipation Constant		

TABLE 1195-2 End-of Life Design Limits (for 5 years)

Style	Resistance
Glass Bead NTC	± 1.3% + initial tolerance
Bead Encapsulated PTC	± 1.8% + initial tolerance
Disc PTC, NTC	± 5% + initial tolerance
	EOL resistance factor is the total RSS (root sum square) design tolerance: $\text{Total Design Tolerance} = \left[(\text{Aging} + \text{initial tolerance})^2 + (\text{environments})^2 \right]^{1/2}$

TABLE 1195-3 Design Applications

Style	Typical Applications	Application Considerations	Possible Mitigation
NTC		Use 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 runway.	
RTH		Never exceed the maximum current or power rating, even for short time periods.	
		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 runway.	
		Accurate thermistors (+ 1%) 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.	
		Mounting considerations: 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 resistance of the thermistor.	
		Handling during assembly: Heat sinks should be used when soldering to thermistor leads.	

3.0 Design and Construction

3.5 Recommended Design for Space and Launch Vehicles Thermistors, which meet the design and construction requirements of MIL-T-23648 and the additional controls and testing herein.

Table 1195-4 Recommended Design Characteristics

Construction Item	Description of Construction
Style	Glass bead style
Hermeticity	Hermetically sealed where appropriate. (The only hermetically sealed thermistor available in MIL-T-23648 is the -/19, a PTC device type.)

3.2 Known Reliability Suspect Designs The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 1195-5 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Moisture	Some disc-type thermistors should be avoided because they can absorb water.
Fragility	Some thermistors are mechanical fragile and can easily be broken.
Tin slivers	Tin coated case or leads

3.3 Produceability and Baseline Controls A product baseline should be established for all thermistors. Areas which need to be specified and controlled in the drawing and baseline are:

Table 1195-6 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to Section 4
Production Lot	Refer to Section 4
Serialization	Refer to Section 4
Traceability Control (Parts, Materials, & Processes)	Refer to Section 4
Rework Provisions	Refer to MIL-T-23648.
Process Controls Verification & Validation	Refer to MIL-T-23648
Screening Tests (100%)	Refer to MIL-T-23648 Group A tests and Table 1195-8 herein.
Lot conformance Tests (Destructive & Non-destructive tests)	Refer to MIL-T-23648 Group B tests.
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-T-23648.

4.0 Quality Assurance Provisions

Quality Assurance provisions should be in accordance with the requirements of MIL-T-23648 unless other wise specified.

Table 1195-7 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of the applicable manufacturing baseline.	Homogeneity Production Lot Serialization Traceability Control for Parts, Materials, & Processes Rework Provisions Process Controls verification & validation Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)
Screening (100 percent): Refer to MIL-T-23648 Group A and Table 1195-8 herein.	Review screening data (Attributes & Variables).
Lot Conformance: Refer to MIL-T-23648 Group B and Table 1195-8 herein.	Review lot conformance data (Attributes & Variables).
Qualification Testing: Refer to the requirements of MIL-T-23648.	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: Materials and construction is verified upon receipt of each lot of devices, by performing DPA in accordance with MIL-STD-1580.	Review incoming DPA and compare to historical DPA data.
Sample and Data Retention: Data retention information is found in Section 4 of this handbook.	Maintain samples and data for further use.

Table 1195-8 Screening Table

MIL-T-23648	Additions to the Methods and Criteria of MIL-T-23648
Zero Power Resistance (Initial)	At + 25°C
Thermal Shock	NTC devices only – Max. of 1.0% change.
Bake (High temperature exposure)	100 hours at max. specified operating temperature.
Burn-in	PTC devices only – 168 hours @ +25°C with 1.5 times rated power.
Zero Power Resistance	
Resistance Ratio Characteristic	
Insulation Resistance	Min. of 500 megohms
External Visual and Mechanical	a) Marking and identification

Examination	b) Defects and damage; i.e., body finish, lead finish, misalignment, cracks.

Table 1195-9 Lot Conformance Table

MIL-T-23648	Additions to the Methods and Criteria of MIL-T-23648
Short Time Load	Max. delta Zero Power Resistance: 1%
Dielectric Withstanding Voltage	
Low Temperature Storage	Max. delta Zero Power Resistance: 1%
Dissipation Constant	
Terminal Strength	a) Min. 1.0 lb. Strength b) Max. delta Zero Power Resistance: 0.5%

SECTION 1200 SWITCHES (Sensitive & push) MIL-S-8805, (Thermostatic) MIL-S-24236, (Pressure) MIL-S-9395

1.0 **Scope** This section contains multiple types of switches, where the switch information is not common the type of switch will be indicated. The military specifications and the type of switches are presented in the following table:

Table 1200-1 Switch Types

Switch Type	Military Specification	Comments
Sensitive and Push	MIL-S-8805	Snap action
Thermal	MIL-S-24236	
Pressure	MIL-S-9395	

2.0 **Application** For the selection and use of switches and associated hardware MIL-STD-1132 and requirements contained herein are recommended for use. 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 Handbook for applicable information.

Table 1200-2 Derating

Switch Type	Parameter	Derating Factor	Comments
All	Contacts	See Section 1000	Operation at ambient temperatures
Typical	Current		

TABLE 1200-3 Design Applications

Type	Application Considerations	Possible Mitigation
All	Contact Current: Current during make, break, and continuous duty is to be carefully considered. Rating of contacts are usually given for room temperature. As the ambient temperature increases, switching current rating are reduced.	Observe established derating criteria.
	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.	Highlight this operational caution in testing and operational manuals or documents when using Thermal or Pressure switches.
	Load Considerations: For inductive loads, low level loads, intermediate range loads, parallel contacts,	Refer to MIL-STD-1132 and MIL-STD-1346 as applicable to determine these load considerations.

	series contacts, dry switching, transformer switching, transient suppression, and dynamic contact resistance.	
	Environmental Conditions: The environmental conditions need to be considered when using the leaf type actuator. Uncontrolled forces due to shock, vibration and acceleration can result in inadvertent plunger actuation.	Verify construction features during the selection process. Establish controls for shock, vibration and acceleration within the design.
	Cold environment applications.: Slow working contacts.	The use of high contact pressures is recommended
Sensitive and Push	This style is recommended for space applications.	
Thermal	These switches have the advantage of being lightweight, sturdy (withstands high shocks of 750 g & vibration of 60 g rms random), and require no external power.	Bimetallic disc (BMD) thermal switches.
	These switches can exhibit anomalous switch behaviors in both the 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	This failure anomaly usually occurs during acceptance tests. See mitigation. This anomaly is far more consequential, since 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.
	Thermal switches should not be used for applications where the temperature rate of change is > 0.11°C per minute, or the thermal deadband is > +2.2°C	Mitigation - One possible mitigation to alleviate the possibly, is to require a 2.2°C min. for the thermal deadband (temperature separation between the thermal switch "on" position and the switch "off" position) and require a temperature rate of change < 0.11°C per minute. Switches exhibiting a contact current rating of 5 Amps. max.
		When the application exhibits these considerations Solid state temperature

		sensing and controls are preferred.
Pressure	See All	

3.0 Design and Construction

3.1 Recommended Design for Space and Launch Vehicles Design and construction are documented in the applicable specifications and this handbook.

Table 1200-4 Design and Construction Considerations

Construction	Information
Corrosion resistant material	It is recommended the switch shaft and housing be made of corrosion resistant material.
Positive break	Recommended for Space applications
Hermetically sealed package	Hermetically sealed packages are highly recommended to reduce contact failure from oxidation caused by moisture.
Panel seal	Recommended for Space applications
Thermal switches	Recommended for Space application - Snap action, switches with current rating of 5 Amps max., temperature rate of change accommodated, 0.11°C per minute min., deadband +2.2°C min.

3.2 Known Reliability Suspect Designs The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product and known manufacturing controls needed.

Table 1200-5 Known Reliability Suspect Designs

Problem	Description of Product that is Reliability Suspect
Particles greater than 25.4 micrometers (0.001") in maximum dimension.	1. Switches during assembly processing and before package closure which are not stored in a dust free atmosphere. 2. Switches being worked on following final cleaning and assembly in an environment which exceeds Class 100 per FED-STD-209. 3. Switches which are not millipore cleaned at pre-closure. (refer to Section 1000 of this handbook for millipore clean information)
Nonhermetic units	Switches designed using materials for encapsulation which allow moisture and atmosphere to enter the device body after closure. Documented in MIL-STD-1547B as a Registered PMP.
Slide devices	Documented in MIL-STD-1547B as a Registered PMP.
Thermal Switches	The application considerations of these switches cause these switches to be reliability suspect unless totally mitigated in the design.

3.3 Known Material Hazards_ The following table describes design and manufacturing problems which have been identified as the cause of reliability problems. This information was taken from MIL-STD-1547 as reliability suspect and prohibited product.

Table 1200-6 Known Material Hazards

Material	Precaution
Noncorrosion resistant material	The use of materials which are non corrosion resistant causes oxidation which will cause switch failure.
100% tin	100% tin causes tin whiskers to grow which can short a switch out internally or when mounted. It is recommended that another metal be added to the tin, at least 10% making a tin alloy.
Snap-action - thermoplastic dielectric or packaging.	Documented in MIL-STD-1547B as reliability suspect parts.

3.4 Produceability and Baseline Controls A product baseline should be established for all switches not purchased as a QPL MIL-S-8805 Sensitive and push style, MIL-S-24236 Thermostatic style and MIL-S-9295 style device. Areas which need to be specified and controlled in the drawing and baseline are:

Table 1200-7 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to Section 4
Production Lot	Refer to Section 4
Serialization	Refer to Section 4
Traceability Control (Parts, Materials, & Processes)	Refer to Section 4
Rework Provisions	Refer to MIL-S-8805, MIL-S-24236 and MIL-S-9395
Process Controls Verification & Validation All	Refer to MIL- S-8805, MIL-S-24236 and MIL-S-9395 and the following: a. Storage of switches during assembly and inspection prior to closure is a clean dust-free environment. b. Subsequent to final cleaning and assembly, all open switches should be worked on under a Class 100 environment per FED-STD-209. c. Pre-closure wash (millipore) should be accomplished per Section 1000. Description of Millipore clean - Obtain freon from pre-filtered supply. Assembly pre-cleaned 1000 milliliter flask, vacuum pump, filter holder, pre-cleaned 0.080-micrometer filter, and pre-cleaned funnel. Fill funnel with pre-filtered freon and turn vacuum pump on. Repeat until flask is filled. Fill a pressurized container with cleaned freon. Clean filter by blowing both surfaces with ionized air. Using the pressurized container, wash both sides of the filter with clean filtered freon. Observe filter under 30X mag., 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 freon, pour the freon into the funnel, covering the parts to be cleaned. Cover funnel. Turn on vacuum pump. When all freon has passed through the filter, turn off vacuum pumps. Remove filter and examine under 30X mag. If one or more particles 2.5 micrometers (0.001”) or larger are

	present, or three or more visible particles under 2.5 micrometers (0.001”) 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 storage in a class 100 environment. d. 100% Internal visual inspection at 10X min. under a laminar flow hood, for the following : 1. Particles greater than 25.4 micrometers (0.001 inch) in maximum dimension 2. Solder and weld joints. 3. Proper alignment 4. Feedthroughs with contamination, debris damage or misalignment. 5. Each switch should have its contact closure or opening force setting checked. 6. Check critical internal dimensions for correctness 100%. 7. All switches that utilize different materials for movable and stationary contacts should have the contacts identified as + and -, and the life verified by tests with voltage applied in the polarity specified. 8. No plating defects such as flaking or blistering. e. The following additional controls apply: 1. Inspect seals and encapsulation 100% at 10 X minimum for cracks. 2. Leads and terminals are clean, straight, and free of tin.
Snap-action	Refer to MIL-S-8805 for in-process controls and this handbook the following defects should be removed from space level switches: a. Switches which have adhering conductive or nonconductive particles visible at 10X min. (metal burrs or flashing. b. Switches with incomplete swaging or staking of assembly components (not 360°). c. Scratches or nicks on the contact surface areas.
Thermal switches	Refer to MIL-S-24236 and the following: 100% internal (Pre-cap)visual for the following defects: a. No loose oxide film on surface of bimetallic disc. b. No organic compounds or films on contacts or header base. c. Actuator tips free of sharp peaks, cracks, chips, and flakes. d. No radial cracks in the glass seal extending greater than ½ the distance from the center post to outside edge.
Screening Tests (100%) - All	Refer to MIL- S-8805, MIL-S-24236 and MIL-S-9395 and the following: 1. 500 cycles of run-in testing with contacts monitored for misses at 6 volts dc, 100 µA maximum. Refer to table 1200-9 of this handbook.
Snap-action	Refer to table 1200-10 of this handbook.
Thermal Switches	Refer to table 1200-11 of this handbook.
Pressure	
Lot conformance Tests (Destructive & Non-destructive	Group B of these applicable documents MIL- S-8805.

tests) Thermal Switches Pressure Switches	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 Refer to MIL-S-9395 and Table 1200-12 in this handbook.
Qualification Tests (Destructive & Non-destructive tests)	Qualification of these applicable documents MIL- S-8805, MIL-S-24236 and MIL-S-9395 and the application requirements.

Note: A manufacturing baseline should be developed and maintained by the manufacturer and controlled and verified by the procuring organization for (company unique drawings), for QPL reliability level S the manufacturing baseline should be verified by the procuring organization.

4.0 Quality Assurance Provisions

4.1 The following table outlines the minimum areas which should be considered and verified when purchasing QPL MIL- S-8805, MIL-S-24236 and MIL-S-9395 and company specific switch drawings.

Table 1200-8 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
In-Process Controls: should be in accordance with the requirements of the applicable manufacturing baseline.	Homogeneity, Production Lot, Serialization Traceability Control for Parts, Materials, & Processes, Rework Provisions Process Controls verification & validation Screening Tests (100%) Lot conformance Tests (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests) Specifically the following verifications are essential for this product: a. Storage of switches during assembly and inspection prior to closure is a clean dust-free environment. b. Subsequent to final cleaning and assembly, all open switches should be worked on under a Class 100 environment per FED-STD-209. c. Verify Pre-closure wash (millipore-clean) was performed per Section 1000. d. 100% Internal visual inspection at 10X

	min. for the following : 1. Particles greater than 25.4 micrometers (0.001 inch) in maximum dimension 2. Solder and weld joints. 3. Proper alignment 4. Feedthroughs with contamination, debris damage or misalignment. 5. Normal contacts. 6. Check critical internal dimensions for correctness 100%. e. The following additional controls apply: 1. Inspect seals and encapsulation 100% at 10 X minimum for cracks. 2. Leads and terminals are clean, straight, and free of tin.
Screening (100 percent): refer to the requirements of the company unique drawing and MIL- S-8805, MIL-S-24236 and MIL-S-9395	Review screening data (Attributes & Variables).
Lot Conformance: refer to the requirements of the company unique drawing and MIL- S-8805, MIL-S-24236 and MIL-S-9395	Review lot conformance data (Attributes & Variables).
Qualification Testing: refer to the requirements of company unique drawing and MIL- S-8805, MIL-S-24236 and MIL-S-9395	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: should be in accordance with MIL-STD-1580.	Review incoming DPA and compare to supplier DPA.
Sample and Data Retention: Data retention information is found in Section 4 of the this handbook.	Maintain samples and data for further use.

Table 1200-9 Screening Table Snap-Action type

MIL-S-8805	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 systems position and test to the requirements of the application). b. 3 orthogonal planes, 1 minute each. c. Mounting fixture should not add or remove energy from the switch under test. d. Monitor for chatter, 10 µsec max. per MIL-STD-202, Method 310, Circuit B. e. No contact transfer (monitor equipment must be capable of detecting closures <1µsec. f. If more than one critical system position exists, repeat steps a through e, with the switch in each critical position.
Thermal Shock	During last cycle (5th) measure contact resistance at temperature extremes.
Particle Impact Noise Detection (PIND)	MIL-STD-202, Method 217 Detection, Percent Defective Allowable (PDA) criteria: a. The lot may be tested a maximum of 5 runs, during testing of the 5 runs the lot exhibits > 1% failures the lot is acceptable at that point. b. Lots which do not meet the 1% PDA by the fifth run or exceed 25% defectives cumulative should be rejected. All defective devices should be removed after each run. (No device should be tested more than once.)
Insulation Resistance	
Mechanical Run-in	a. 500 cycles @ 10 cycles per minute @ +25°C. b. Monitor all make and break contacts at 6 VDC 100mA max.
Seal	
Dielectric Withstanding Voltage	
Insulation Resistance	
Operating Characteristics	
Radiographic Inspection	MSFC-STD-355, 2 views 90° apart by x-ray, or 360° view by Real Time X-ray system capable of viewing through 360° rotation.
Visual & Mechanical Examination (External)	a. Inspect seals and encapsulation 100% at 10 X minimum for cracks. b. Leads and terminals are clean, straight, and free of tin. c. Marking and identification d. Defects and damage, i.e., body finish, lead finish, misalignment, cracks.

Table 1200-10 Screening Table Thermal Switches

MIL-S-24236	Additions and Exceptions to the Methods and Criteria of MIL-S-24236
Vibration (Sine) 1/	a. MIL-STD-202, Method 204, @ 30g, 10-2,000Hz (switch in critical system position). b. Electrical load of 110 MA max. @ 6 Vdc. c. Monitored for contact chatter 10µsecs. Max. per MIL-STD-202, Method 310, Circuit B. d. No contact transfer (monitor equipment should be capable of detecting closures greater than 1 µsec. e. Duration of 1 frequency sweep per contact position.
Vibration (Random) 1/	a. MIL-STD-202, Method 214, except use the following spectrum: 1. 20 Hz. $0.01g^2$ per Hz. 2. 20 - 90 Hz +9db per Octave 3. 90 - 350 Hz $0.9g^2$ per Hz. 4. 350 - 2,000 Hz -6db per Octave b. 3 Orthogonal planes. c. Duration should be 1 minute per axis per contact position. d. Monitored for contact chatter, 10µsecs. Max. per MIL-STD-202, Method 310, with 110 µA max. at 6 Vdc. e. No contact transfer (monitor equipment greater than 1 µsec.)
Calibration	
Mechanical Run-in	a 500 cycles. b. Monitor all make and break contacts @ 6 Vdc 100 mA max. c. Miss test monitoring equipment to measure contact resistance required
Particle Impact Noise (PIND)	MIL-STD-202, Method 217 Detection, Percent Defective Allowable (PDA) criteria: a. The lot may be tested a maximum of 5 runs, during testing of the 5 runs the lot exhibits > 1% failures the lot is acceptable at that point. b. Lots which do not meet the 1% PDA by the fifth run or exceed 25% defectives cumulative should be rejected. All defective devices should be removed after each run. (No device should be tested more than once.)
Creepage	a. Temperature rate of change should be 0.11°C per minute min. b. Three runs. c. Arc duration of 5 µsec. Max. @ 500 - 600 Vdc with current limited to 1µA max.
Seal	Per MIL-S-24236 for hermetic switches.
Dielectric Withstanding Voltage	
Insulation Resistance	
Contact Resistance	
Radiographic Inspection	MSFC-STD-355, 2 views 90° apart by x-ray, or 360° view by Real Time X-ray system capable of viewing through 360° rotation
Visual & Mechanical Examination (External)	a. Marking and identification. b. Defects and damage, i.e., body finish, lead finish, misalignment, cracks.

NOTES: 1/ Vibration method used should be based on the application.

Table 1200-11 Screening Table Pressure Switches

MIL-S-9395	Additions and Exceptions to the Methods and Criteria of MIL-S-9395
Contact Resistance	
Dielectric Withstanding Voltage	
Seal	
Radiographic Inspection	MSFC-STD-355, 2 views 90° apart by x-ray, or 360° view by Real Time X-ray system capable of viewing through 360° rotation
Visual & Mechanical Examination (External)	a. Marking and identification. b. Defects and damage, i.e., body finish, lead finish, misalignment, cracks.

Table 1200-12 Lot Conformance Table Pressure Switches

MIL-S-9395	Additions and Exceptions to the Methods and Criteria of MIL-S-9395
Group I	a. 3 Samples. Note: Because this sampling plan is different that MIL-S-9395, the group samples must be unique and can not be used in more than 1 group test.
Solderability Shock Moisture Resistance Overload Cycling Seal	If applicable.
Group II Mechanical Endurance Electrical Endurance Contact Resistance Seal Dielectric Withstanding Voltage	a. 3 Samples
Group III	b. 2 Samples
Burst Pressure Explosion	If applicable

SECTION 1400: TRANSISTORS

1 Organization:

This section covers the following device types: Unijunction, Switching, Power, General Purpose, Field Effect (FET), Metal Oxide Semiconductor Field Effect (MOSFET), and Injection Gate Bipolar Junction (IGBT).

2 APPLICATION: .

It is recommended that the locus of the I-V operating point for applications such as in line or relay drivers, power inverters, converters, or amplifiers, and other circuits involving reactive loads should 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 provides the recommended derating criteria for transistors in space applications and Table 1400-2 provides the recommended end of life design limits.

TABLE 1400-1 - TRANSISTOR DEVICES DERATING

DEVICE TYPE	PARAMETER	DERATING FACTOR	COMENTS
Small Signal, Switching and General Purpose Transistors	P_D	.50	Based on the SOA at operatir point
	BVCBO	.70	
	BVCEO	.70	
	BVEBO	.75	
	IC	.75	
	Tj	80% of Tj Max	Not to exceed .75 of SOA IC limit the specified operating conditions. Not to exceed 105^{o}C
POWER TRANSISTORS	P_D	.50	Based on the SOA at operatir point
	BVCBO	.70	
	BVCEO	.70	
	BVEBO	.75	
	IC	.75	
	Tj	80% of Tj Max	Not to exceed .75 of SOA IC limit the specified operating conditions. Not to exceed 105^{o}C
FETS	P_D	.50	
	VDS	.75	
	Tj	80% of Tj Max	Not to exceed 105^{o}C
MOSFETS	P_D	.50	
	BVDSS	.75	
	BVGSS	.50	
	ID	.75	
	Tj	80% of Tj Max	Not to exceed 105^{o}C
RF TRANSISTORS	P_D	.50	
	BVCBO	.70	
	BVCEO	.70	
	IC	.75	
	f_T	.75	
	Tj	80% of Tj Max	Not to exceed 105^{o}C
OPTICALY COUPLED ISOLATORS	IO	.50%	
	BVCBO	.70	
	BVCEO	.70	
	Tj	80% of Tj Max	Not to exceed 105^{o}C
IGBTS	P_D	.50	
	Brkdown Voltage	.70	
	IC	.75	
	Tj	80% of Tj Max	Not to exceed 105^{o}C

Table 1400-2 End-of Life Design Limits

Device Type	Parameter	Parameter Design Value
Small Signal, Switching and General Purpose Transistors	I_{CBO}	10% of initial maximum limit
	h_{FE}	25% of initial maximum limit
	V_{BE}(sat)	50mV from initial maximum limit
	V_{CE}(sat)	50mV from initial maximum limit
	I_{EBO}	10% of initial maximum limit
POWER TRANSISTORS	I_{CBO}	10% of initial maximum limit
	I_{CEO}	10% of initial maximum limit
	h_{FE}	25% of initial maximum limit
	V_{BE}(sat)	50mV from initial maximum limit
	V_{CE}(sat)	50mV from initial maximum limit
	I_{EBO}	10% of initial maximum limit
FETS	I_{DS}	15% of initial maximum limit
	I_{GSS}	10% of initial maximum limit
	V_{GS}(off)	100mV from the original maximum limit
MOSFETS and IGBTS	I_{DSS}	10% of initial maximum limit
	I_{GSS}	10% of initial maximum limit
	V_{GS}(th)	100mV from the original maximum limit
	R_{DS}(on)	25% of the initial maximum limit
	g_{FS}	25% of the initial maximum limit
OPTICALY COUPLED ISOLATORS	I_{CBO}	10% of initial maximum limit
	h_{FE}	25% of initial maximum limit
	V_{BE}(sat)	50mV from initial maximum limit
	V_{CE}(sat)	50mV from initial maximum limit
	I_{EBO}	10% of initial maximum limit
	I_O	25% of initial maximum limit
RF Transistors (bipolar & FETS)	Apply all parameters for the Bipolar or FET as applicable and the following.	Apply all parameters for the Bipolar or FET as applicable and the following
	D $I_{DS'}$	± 15% of specified value
	D Gm Transductance	± 10% of specified value
	D Pout	± 0.5 dB output power
	NF	± 10 percent where appropriate
	D C_{obo}	± 25% of specified value

Electrical Parameters Definitions:

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 Bipolar Junction Transistor

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,$V_{(BR)CBO}$
Breakdown voltage, emitter to base, collector open, $V_{(BR)EBO}$

3 Unijunction

Emitter to base two reverse current, I_{EB20}
Interbase resistance, r_{BBO}
Intrinsic standoff ratio, n

4. Power Bipolar Junction Transistors

Same as General Purposes (see Note 2)

5. Switching

Same as General Purposes (see Note 2)

6. MOSFET

Same as FET above (see Note 1) plus
Forward transconductance, g_{FS}
Forward body drain - to- source diode voltage drop, V_{SD}

3. DESIGN AND CONSTRUCTION

BACKGROUND: Semiconductor device Design and Construction has traditionally been maintained in accordance with the requirements of the applicable specifications (MIL-S-19500 and its Slash Sheets). The JANS design rules within the specifications were applied where available. With the push for the use of plastic encapsulated devices, and replacement of traditional JANS controls with the more cost effective high volume production line process controls, the designer has to evaluate the acceptability of the proposed design and construction for the application. In addition, some of the old Bipolar junction and Unijunction technologies were never designed to meet the high reliability applications needs and application of the JANS rules was often limited to just screening the quality in. Other new technologies such as MOSFET and IGBT require a high degree of process controls and advanced equipment and facilities for their manufacture.

The new approaches such as Surface Mount package, Multi Chip Module (MCM) technology, and Power Module technology that are currently beginning to be employed in the space application designs are often based on old technology, either old die designs, old package types, etc., that are modified and supplied as Surface Mount, MCM, and Power Modules. As such the modifications are often performed after the discrete devices were screened and the final product is rarely verified and validated for the intended application. Therefore, the designer or the component engineer needs to ensure that the supplied components meet the application requirements. Table 1400-3 provides some of the known Design and Construction Considerations.

Table 1400-3 Design and Construction Considerations

Device Type	Design & Construction Considerations	Possible Mitigation
Small Signal, Switching and General Purpose Transistors, & FETS	Gold wire bonds on Aluminum die metalization.	Qualify wire bond process to survive 300°C without Au-Al intermetalic formation.
	Electron Irradiation post wafer fabrication for gain targeting.	Establish time & temperature needed to stabilize die characteristics and prevent annealing.
	Use of Unglassivated die.	Validate assembly cleaning and vacuum bake processes to minimize contamination.
	Silver filed Epoxy or Silver glass die attach mediums.	Maintain under 5000 ppm moisture, perform Transient Thermal Response and qualify process to 1000hrs. Power Burn-In.
POWER TRANSISTORS, MOSFETS, & IGBTS	Lead solder based compounds used for die attach medium.	Maintain the moisture levels below 5000ppm to prevent solder decomposition.
	Organic passivating or conformal coating materials.	Qualify process to 1000 hr HTRB, perform extended vacuum bake prior to device sealing, maintain low moisture levels.
	Aluminum wire on gold substrates.	Qualify wire bond process to survive 300°C without Au-Al intermetalic formation.
	Aluminum wire bonds on Ni plated Au flash posts.	Qualify process to survive an acceptable number (to the design application) of Intermittent Operating Life Cycles followed by wire pull test without any wire lifts.
	Au flash on Ni plated posts.	Maintain gold to 5 - 10µin over Ni plating on posts.

Table 1400-3 Design and Construction Considerations (cont.)

Packaging	Design & Construction Considerations	Possible Mitigation
Gallium Arsenide Transistors	Potential for thermo-mechanical stress induced cracking.	Adequate heat sinking and monitored Temperature Cycling.
Optically Coupled Isolators	Open circuit and high transfer loss due to optical couple material shape and processing.	Monitored Temperature Cycling, and qualification of process through extended Life tests (1000 hrs. min)
Hot Welded Cans	A high potential for loose conductive particles inside the cans.	Monitored cap welding and PIND test. Use of alternate materials for packages such as Ni caps etc.
Solder Sealed packages	A high potential for loose conductive particles inside the cans, loss of inert atmospheric content and of hermetic seal.	Validate the sealing process through extended temperature cycles, liquid to liquid temperature shock, PIND tests, RGA, and Hermetic Seal.
Electrically Isolated packages	Use of Beryllium Oxide materials for package isolation	Handle with caution; BeO is a carcinogenic material.
	Loss of isolation due to subsequent processes and thermal mismatch caused cracks during device operation.	Perform package isolation tests after Solder Dip, qualify attachment process to minimize header to substrate voiding.
Glass to metal seals materials	Use of glass seals on Kovar and Stainless Steel headers.	Qualify packages through extended temperature cycling and liquid-to-liquid thermal shock.
	High probability of developing glass cracks during testing and handling of devices.	Qualify packages to survive acceptable number of Temperature Cycles for the proposed application followed by die penetrant.

Produceability and Baseline Controls A product baseline should be established for all devices not purchased as a MIL-PERF-19500 QPL device. Areas which need to be specified and controlled in the drawing and baseline are provided in Table 1400-4.

Table 1400-4 Produceability & Baseline Controls

Produceability Controls	References
Homogeneity	Refer to MIL-PERF-19500 for JANS
Wafer Lot	Refer to MIL-PERF-19500 for JANS
Wafer Lot Acceptance	Refer to MIL-PERF-19500 for JANS
Radiation Hardness	Refer to MIL-PERF-19500 for JANS
Assembly Lot accumulation period	Refer to MIL-PERF-19500 for JANS
Manufacturing Location	Refer to MIL-PERF-19500 for JANS
Assembly processes and their verification	Refer to MIL-PERF-19500 for JANS
Inspection Lot formation	Refer to MIL-PERF-19500 for JANS
Test equipment validation	Refer to MIL-PERF-19500 for JANS
Serialization	Refer to MIL-PERF-19500 for JANS
Traceability Control (Parts, Materials, & Processes)	Refer to MIL-PERF-19500 for JANS
Rework Provisions	Refer to MIL-PERF-19500 for JANS
Process Controls verification & validation	Refer to MIL-PERF-19500 for JANS
MRB and Change Control Authority	As agreed with Contracting Activity
Screening Tests (100%)	Refer to MIL-PERF-19500 Table II and Detail Specification as applicable
Quality Conformance Inspection (Destructive & Non-destructive tests)	Refer to MIL-PERF-19500 for Tables III, IVa, V, and Detail Specification as applicable
Qualification Tests (Destructive & Non-destructive tests)	Refer to MIL-PERF-19500 for Table VI and Detail Specification as applicable

Note: A manufacturing baseline should be developed and maintained by the manufacturer in accordance with MIL-PERF-19500, and controlled and verified by the procuring organization.

4. QUALITY ASSURANCE

There are four major areas to be covered under the Quality Assurance provisions. These are the Wafer Fabrication, Assembly, 100% Test or Screening, and Quality Conformance Inspection and Qualification. MIL-S-19500 has provided guidance for both the device manufacturers and designers in all of the four areas. The designer and component engineer has to understand the device application, the need for and application tolerance of device to device performance variation and how the device manufacturer controls in each of the four areas impact the performance. Table 1400-5 provides a summary of the recommended controls for space level devices.

Table 1400-5 Quality Assurance

Quality Assurance Consideration	Recommended Verifications and Validations
Wafer Fabrication: In process controls should be per MIL-PERF-19500 Appendix D. **Assembly:** In process controls should be per MIL-PERF-19500 Appendix D **Screening Tests (100%)**: Screening should follow the MIL-PERF-19500 Table II and detailed specification. Quality Conformance Inspection (Destructive & Non-destructive tests) Qualification Tests (Destructive & Non-destructive tests)	Wafer Lot formation Wafer Fab rework Wafer Lot Acceptance Wafer Fab Location Lot Homogeneity Production Lot formation Traceability Control Rework Provisions I.A.W. approved procedures Process Controls, their verification & validation elements Assembly Location Electrical parameters and performance specified meets application. Screening Temperature Range, QCI and Qualification specified meet application Test equipment accuracy and repeatability Accept and Reject criteria Failure Analysis and Corrective action.
Screening (100 percent): refer to the requirements of MIL-PERF-19500 for JANS and the detailed specification.	Review screening data (Attributes & Variables). Verify test equipment correlation, repeatability, test windows were met, test conditions, and PDA compliance.

Table 1400-5 Quality Assurance (cont.)

Quality Assurance Consideration	Recommended Verifications and Validations
Quality Conformance Inspection: refer to the requirements of MIL-PERF-19500 for JANS and the detailed specification.	Review lot conformance data (Attributes & Variables), sampling techniques, and stress levels.
Qualification Testing: refer to the requirements of MIL-PERF-19500 and the detailed specification.	Review qualification data (Attributes & Variables).
Incoming Inspection DPA: should be in accordance with MIL-STD-1580.	Review incoming DPA and compare to supplier documentation.
Sample and Data Retention: Data retention information is found in Section 4 of the this handbook.	Maintain samples and data for further use.

5.0 Lessons Learned

Wafer Fabrication: This is probably the most critical area that determines the device reliability and performance. Traditionally this area has been downplayed in its importance to the reliability of the end product and consequently controlled by OEMs through a flow chart at best. With the change from “screening of devices to meet quality requirements” to “building of quality into devices” this area becomes the only area that builds quality into the die. Table 1400-6 outlines some of the areas that need specific attention.

NOTE: For most of the older semiconductor device technologies the wafer fabrication process is typically designed to a nominal level that would produce a range of device types and device families on the same line and may not be cost effective target the process for only one device type.

Assembly: This is area where the die or chips, processed through wafer fabrication, are put in packages or assembled so that they can used in systems. These packages and assembly materials used determine in most cases, where the die ratings outperform the package ratings, the final device ratings such as Power Dissipation, Operating and Storage Temperature Ranges, Output Steady State Current, and Thermal Resistance. It is very important that the assembly processes are closely monitored and controlled so that defects are not introduced. MIL-S-19500 Appendix D has traditionally provided the guidelines for process controls for semiconductor devices. Table 1400-7 outlines some of the areas that need specific attention.

Screening: This area covers the 100% testing (electrical, mechanical, and environmental) that are applied to devices in order to eliminate the defects associated with infant mortality portion of the “Bathtub” reliability curve (see Figure 1400-9). The Percent Defect Allowable (PDA), test windows post HTRB and Burn-In, and other controls determine the number of random defects expected when using the lot of devices. The implementation of effective process controls in the front areas, wafer fabrication and assembly, makes device to device performance variability more consistent, and therefore, could allow lots to be evaluated on a sample basis rather than screened on 100% basis. The intended design application requirements provide the basis for device performance valuation. Table 1400-8 outlines some of the areas that need specific attention.

Quality Conformance Inspection (QCI): This area covers the sample verification of the lot integrity to be used in the application. The stress levels applied traditionally have been at the levels established, for the particular technology and product type, to simulate the end of life characteristics under accelerated conditions. Table 1400-10 outlines some of the areas that need specific attention.

Table 1400-6 - Wafer Fabrication

Area of Concern	Effect on Performance	Potential Remedy
Wafer Lot formation	Determines die lot performance homogeneity	Use wafers from single batches/ manufacturers.
Wide resistivity and thickness, epi and epi thickness specifications	Allows wide range of electrical characteristics which lead to new device types and or product downgrading.	Use only the devices for which the target specifications of the raw wafers were designed and not the downgraded by products.
High defect count per cm^2.	Increase of device to device variation, risk of premature device failure, lower yields.	Lower the acceptable number of defects per cm on the incoming wafers.
Wafer Fab. Processing	Determines the device performance	
Particle size and count allowable in the clean room.	Depending on the device type, geometry, and technology may impact device reliability and electrical performance. Ionic contamination.	Use positive air flow interlocks and entries, air filters, process only devices for which clean room characteristics were proven to be acceptable.
Water purity and Diffusion cleanness	Potential for ionic contamination.	Use water filters, test for bacteria, C-V plots.
Rework	Increase of device to device variation, risk of premature device failure, lower yields.	If allowed, verify that the rework did not have adverse effects on device performance in the intended application.
Wafer Fab Location	Use of foundries and other manufacturer's die leads to loss of visibility into wafer fab processing and controls may impact device performance.	Verify the supplier of devices has visibility and control over the wafer fabrication processes, changes, and implementation.
Wafer Lot Acceptance	Data provided does not correlate or tie into the wafer fab process controls for oxide, die, metalization, and passivation layer thickness. Sampling may not be valid.	Ensure wafer lot acceptance provides meaningful data to ascertain the wafer fabrication process and controls.
Radiation Tolerance	Process, design & layout can impact radiation performance.	Use design techniques & process methods that are minimally impacted (affected) by radiation influences.

Table 1400-7 - Assembly

Area of Concern	Effect on Performance	Potential Remedy
Die attach is not consistent	Devices fail prematurely due to voids which cause over heating/ or current crowding effects	Implement die attach monitors such as Transient Thermal Response, ΔVBE, SOA, and die shear.
Attach materials are not optimized for the package and design application.	Devices fail prematurely due to die attach degradation when operated under simulated and accelerated application conditions.	Qualify and validate the attach process and materials for the intended design application.
Use of Organic material coatings and desiccants.	Devices may intermittently open during temperature transitions while under operation.	Validate and monitor the process through Monitored Temp Cycle and extended life tests.
Multiple Lots formation and loss of Lot Traceability	Increase potential for lot failure due to loss of traceability to individual lots.	Maintain traceability to individual lots.
Rework Provisions	Allowing rework on the production line may not enforce corrective action implementation and promote loose process controls.	If rework was allowed maintain traceability to the reworked portion of the lot for future valuation of adverse rework effects.
Purple Plague (Au wire on Al metalization)	Open circuit.	Validate process through extensive High temperature storage; subject lot to 300°C.
Purple Plague (Al wire on Au metalization	No impact if Gold is thin and the bonding is to the Ni under plate. Otherwise will lead to open circuit.	Validate process through Temperature and Operating Cycles; peel wire to verify bond.
Al wire bonds on Ag metalization.	Open circuit due to operating/ Thermal cycles.	Validate process through Temperature and Operating Cycles;
Particles inside cavity	Potential short due to conductive particle such as Die attach slag, weld splash, etc.	Validate the processes to ensure loose particles are not introduced. Institute PIND.
Irradiation Device	Targets h_{FE} and V(sat) selection; Devices may return to original values if not annealed properly.	Validate the annealing process and monitor the hFE and V(sat) drift over HTRB, Power Burn-In, and Life tests.

Table 1400-8 - 100% Screening

Screening Test (MIL-S-19500 Table II)	Effect on Performance	Rationale for Test Conditions
Pre-Cap Visual Inspection	Ensures the devices are free of defects prior to encapsulation	Depending on the manufacturer's process controls this may be done on a sample basis.
High Temperature Storage	Some device technologies require this to stabilize the junction characteristics.	Select the max. device rated temperature storage.
Temperature Cycling	Intended to screen out infant mortality defects due to die attach and other package mismatch defects.	20 cycles were initially established as sufficient to pass the infant mortality stage. Devices should reach temperature extremes.
Constant Acceleration	Test designed to stress the wire bonds and die attach areas.	The G-force level is determined by the package capability and should be above the application requirements.
Transient Thermal Response	Non-destructive die attach screen for voids outside the process capabilities.	Applicable only to devices with negative voltage temperature coefficient. Limits should track back to maximum $R_{\theta JC}$, P_D, and or Surge characteristics.
SOA1 (Low Voltage High Current)	Developed to screen out devices with die attach, junction, and or bulk silicon defects.	SOA should not exceed the max. designed capability of the die under DC conditions.
SOA2 (High Voltage -Low current)	Developed to screen out devices with junction, and or bulk silicon defects	SOA should not exceed the max. designed capability of the die under DC conditions.
PIND	Developed to screen out devices with loose particles inside the cavity.	Set-up sensitivity, location and tester mounting, shock/ co-shock and vibration levels, and transducer couple medium are important to effective PIND screening.

Table 1400-8 - 100% Screening (cont.)

Screening Test (MIL-S-19500 Table II)	Effect on Performance	Rationale for Test Conditions
Pre-HTRB electrical tests	Electrical parameters (at T_A=25°C) established for each technology and device type to be indicative of a good device.	Parameters most likely to change if ionic contamination is present such as Leakage currents, DC gains, Breakdown Voltages
HTRB	Stress test designed to screen out ionic contaminated devices using DC Bias Voltage and Temperature to accelerate the effects. Ions are made mobile through Temperature exposure while the DC Bias Voltage acts as dipole magnet attracting the ions on each positive and negative side of the power supply.	The applied Temperature should be that of the Max. Operating Ambient without heat sink, and the applied voltage should be 80% of the rated breakdown voltage of the stressed junction. The magnitude of the exposing temperature and applied bias directly affect the result. Applying AC Voltage or removal of the bias before devices reached approx. 35°C will negate the test.
Post-HTRB electrical tests	Repeat of Pre-HTRB electrical tests to validate devices did not drift outside the established limits. Test should be performed within 16 hrs of bias removal.	Ionic contamination, if free to move around will cause a change in the device electrical characteristic. Depending on the contaminant type and level the ions will eventually return to original state.
Percent Defective Allowable (PDA)	Establishes the random failure rate expected during the useful life of the devices.	Typical PDA is 5% max. with a one time resubmission if Percent Defective (PD) < 20%. Lots failing this criteria are should be considered reliability suspect.
Power Burn-In	Test designed to screen out assembly defects.	Test conditions are typically established such that device junction temperature approaches that of the maximum Operating Junction Temperature Ratings.

Table 1400-8 - 100% Screening (cont.)

Screening Test (MIL-S-19500 Table II)	Effect on Performance	Rationale for Test Conditions
Post Power Burn-In electrical tests	Verify that devices still meet the established electrical characteristics.	Repeat the Post HTRB (Pre Burn-In) electrical tests plus the rest of the DC characteristics including those at high and low temperatures.
Percent Defective Allowable (PDA)	Establishes the random failure rate expected during the useful life of the devices.	Typical PDA is 5% max. with a one time resubmission if Percent Defective (PD) < 20%. Lots failing this criteria are should be considered reliability suspect.
X-Ray	Test was developed for workmanship verification (it does not replace Pre-Cap Visual Inspection).	Criteria and level of inspection is based on the package and defect type.

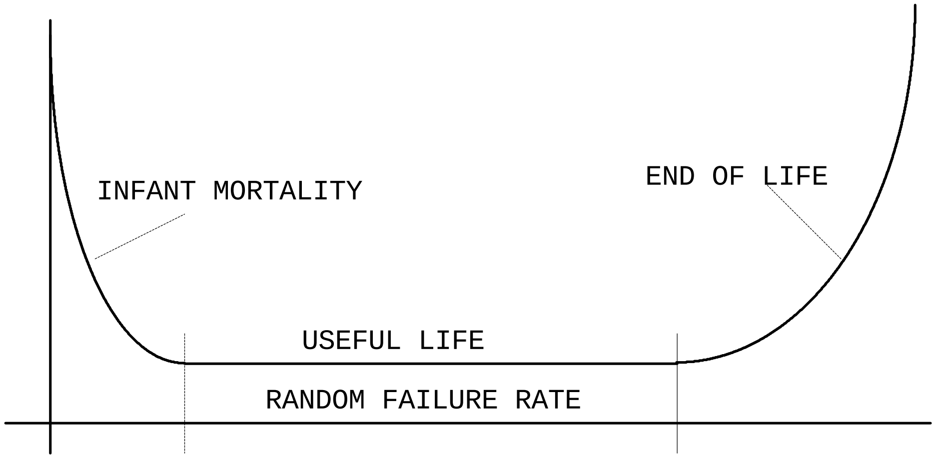


Figure 1400-9: Reliability Bathtub Curve

Table 1400-10 - Quality Conformance Inspection

Test Name	Effect on Performance	Test Rationale
Group A	Verifies device electrical performance under DC, AC or transient conditions, and over the Rated temperature range.	Validates device capability to meet its electrical characteristics. Usually performed on each lot on a sample basis after 100% screening was completed.
Group B	Verifies device operational performance within the useful life portion of the bath tub curve. This includes package design integrity verification (Temperature Cycling, Intermittent Operating Life, and Thermal Resistance Subgroups), device operational performance (Accelerated Life Test).	Validates lot homogeneity and process/design operational performance capability on a lot by lot basis. Validates screening was performed correctly and no defects were introduced.
Group C	Verifies device mechanical performance and operational performance up to 1000 hrs. Operational Life or 6000 Intermittent Operation Cycles.	Validates the processing and device design provide up to 1000 hrs. and or 6000 cycles of useful life under accelerated conditions. Most military and space design applications reliability predictions use this as basis for predictions.
Group D	Verifies the device design capability to withstand the radiation effects that some applications may require to operate under.	Validates wafer fabrication, device design, and processing are capable of meeting the total radiation exposure over the system operating life without degradation.
Group E	Verifies end of life device design capability	Validates that the device processing and design end of life are outside the Thermo-Mechanical and Operational boundaries established for useful life.

Table 1400-11 Recommended Electrical Parameters

Device Type	Parameter	Measurement Point	Measurement Temperature (1)
Small Signal, Switching and General Purpose Transistors, Power Transistors	I_{CBO}	At 80% of rated BV_{CBO}	At room, hot, and cold.
	h_{FE}	At specified DC conditions	At room, hot, and cold.
	V_{BE}(sat)	At specified DC conditions	At room, hot, and cold.
	V_{CE}(sat)	At specified DC conditions	At room, hot, and cold.
	I_{EBO}	At 80% of rated BV_{CBO}	At room, hot, and cold.
	I_{CES}	At 80% of rated BV_{CEO}	At room, hot, and cold.
	BV_{CBO}	At 10x I_{CBO}	At room and cold
	BV_{CEO}	At 10x I_{CEO}	At room and cold
	BV_{EBO}	At 10x I_{EBO}	At room and cold
	ΔI_{CBO}, ΔI_{CES}, Δh_{FE}, ΔV_{BE}(sat), ΔV_{CE}(sat)	Post HTRB, Burn-In, Life Tests, Temperature Cycling, Operating Cycling.	Room Temperature
	SOA1 and SOA2	Peak Rated Current At rated DC SOA curve points	Room Temperature
	Junction Capacitance C_J	At specified Voltage and frequency	Room Temperature
	Switching Times	At specified V_{CB}, I_B, I_C, load resistance, and load capacitance.	Room Temperature
FETS	I_{GSS}	At ±80% of rated BV_{GSS}	At room, hot, and cold.
	Y_{FS}	At specified DC conditions	At room, hot, and cold.
	I_{DSS}	At 80% of rated BV_{CBO}	At room, hot, and cold.
	V_{GS}(off)	At specified current	At room, hot, and cold
	BV_{DSS}	At 10x I_{CBO}	At room and cold
	BV_{GSS}	At 10x I_{GSS}	At room and cold
	ΔI_{GSS}, ΔI_{DSS}, ΔY_{FS},	Post HTRB, Burn-In, Life Tests, Temperature Cycling, Operating Cycling.	Room Temperature
	SOA1 and SOA2	At rated DC SOA curve points	Room Temperature
	C_{ISS}, and C_{OSS},	At specified Voltage and frequency	Room Temperature
	Switching Times	At specified V_{GS}, I_D, load resistance, and load capacitance.	Room Temperature

Table 1400-11 Recommended Electrical Parameters (cont.)

Device Type	Parameter	Measurement Point	Measurement Temperature (1)
MOSFETS and IGBTS	I_{GSS}	At ±80% of rated BV_{GSS}	At room, hot, and cold.
	g_{FS}	At specified DC conditions	At room, hot, and cold.
	V_{SD}	At specified DC conditions	At room, hot, and cold.
	r_{DS}(on)	At specified DC conditions	At room, hot, and cold.
	I_{DSS}	At 80% of rated BV_{CBO}	At room, hot, and cold.
	BV_{DSS}	At 10x I_{CBO}	At room and cold
	BV_{GSS}	At 10x I_{GSS}	At room and cold
	ΔI_{GSS}, ΔI_{DSS}, Δg_{FS}, ΔV_{SD}, Δr_{DS}(on)	Post HTGB, HTRB, Burn-In, Life Tests, Temperature Cycling, Operating Cycling.	Room Temperature
	SOA1 and SOA2	At rated DC SOA curve points	Room Temperature
	C_{ISS}, C_{OSS}, C_{RSS} and or Gate Charges	At specified Voltage and frequency	Room Temperature
	Switching Times	At specified V_{GS}, I_D, V_{DS}, load resistance, and load.	Room Temperature
Optically Coupled Isolators	Forward Voltage (V_f)	At rated I_F	At room, hot, and cold.
	Leakage Current (I_R)	At 80% of rated B_{VR}	At room and hot temp.
	Power Output (P_O)	At specified DC conditions	Room Temperature
	ΔV_F, ΔI_R , and $\Delta P_{O,}$ ΔI_{CBO}, ΔI_{CES}, Δh_{FE}, ΔV_{BE}(sat), ΔV_{CE}(sat	Post HTRB, Burn-In, Life Tests, Temperature and Operating Cycling	Room Temperature
	I_{CBO}	At 80% of rated BV_{CBO}	At room, hot, and cold.
	h_{FE}	At specified DC conditions	At room, hot, and cold.
	V_{BE}(sat)	At specified DC conditions	At room, hot, and cold.
	V_{CE}(sat)	At specified DC conditions	At room, hot, and cold.
	I_{EBO}	At 80% of rated BV_{CBO}	At room, hot, and cold.
	I_{CES}	At 80% of rated BV_{CEO}	At room, hot, and cold.
	BV_{CBO}	At 10x I_{CBO}	At room and cold
	BV_{CEO}	At 10x I_{CEO}	At room and cold
	BV_{EBO}	At 10x I_{EBO}	At room and cold
	Junction Capacitance C_J	At specified Voltage and frequency	Room Temperature
	Switching Times	At specified V_{CB}, V_f, I_f, I_B, I_C, load resistance, and load	Room Temperature

Table 1400-11 Recommended Electrical Parameters (cont.)

Device Type	Parameter	Measurement Point	Measurement Temperature (1)
RF Transistors (Bipolar &FET)	Apply all parameters for the Bipolar or FET as applicable and the following.	Same as for Bipolar and FET as applicable.	Same as for Bipolar and FET as applicable
	$I_{DS'}$, Gm, Pout, NF, C_{obo}	Post HTRB, Burn-In, Life Tests, Temperature and Operating Cycling	Room temperature.

Table 1400-12: Reliability Suspect Parts.

Part Type	Potential Problem	Remedy
Hot welded cans	Short due to conductive particles	100% PIND and Weld monitors
Non-Glassivated Die	Short due to particles, moisture and contamination	Extended vacuum bake prior to seal, 100% PIND, RGA < 5000ppm moisture, 1000 hrs. Life test.
Bimetallic bonds at die	Open due to bond lift.	300C bake, bond pull post IOL and Life Test on samples.
Internal Organic materials	Open due to lifted bonds; Short due to moisture and contamination.	Extended vacuum bake prior to seal, monitored Temp. Cycling, 1000 hrs. Life test with wire pull.
Silver glass/ epoxy die attach.	Open and or short due to lack of die attach	Mechanical shock, transient thermal response post extended Temperature cycles, IOL, 1000 hrs. Life test.
Mesa Design	Old technology	Use in non-critical applications only.
Alloy junction	Old technology	Use in non-critical applications only.
Plastic encapsulated	Not proven reliable for applications outside commercial and industrial environments.	Conduct extensive qualification for the application prior to use.
Flip chips	Not recommended for high vibration/shock and power management applications.	Provide system level design solutions.
Beam leaded	Not recommended for high vibration/shock applications	Provide system level design solutions.
Third party assembled	Lower reliability	Qualify and validate all processing as necessary to ensure device reliability for the applications.
Chip on board	Not proven reliable for applications outside commercial and industrial environments.	Provide system level design solutions

SECTION 1500 - WIRE AND CABLE

1. SCOPE This section covers the common requirements which should be taken into account for wire and cables for use in space applications

2. APPLICATION

2.1 External. Use the requirements of MIL-W-83575 for external wiring to electronic enclosures

2.2 Internal. Use MIL-STD-454, Requirement 61 for wiring internal to the electronic enclosures.

2.3 Coaxial Cable. Use MIL-C-17 for all flexible and semi-rigid coaxial cables.

2.4 Derating. Derating factors and wire current should be based on the individual specification or MIL-W-5088 and should take into account the wire size, wire insulation, and the number of wires used in a cable or harness.

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

2.5.1 Ethylene Tetrafluoroethylene (Tefezel - ETFE). Tefezel, a Du Pont trade name, is a high temperature resin consisting of 75% TFE by weight and its balance or properties is well suited for space applications. It can withstand an unusual amount of physical abuse during and after the 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 200C. 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 material meets the outgassing requirements of NASA SP-A-0022. This wire insulation 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 Tefezel. Its nominal service temperature is -65C to + 135C. 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 material exhibits good properties for thinner-walled, lighter weight wire construction. This insulation meets 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 (nominal service temperature is 200C with some up to 250C) and electric properties, and solvent resistance except when exposed to concentrated acids and alkalies. It is the lightest weight wire insulation material and meets outgassing requirements of NASA SP-A-0022 and flammability and toxicity requirements of MSFC-HDBK-527. The drawbacks are its inflexibility (stiffness), water absorption, lack of abrasion and cut through resistance. It is prone to both wet-arc and dry-arc tracking especially from abrasions and cuts in the insulation material exposing the conductors, and the failure results in an explosive (rapid) carbonization of the insulation materials. Naval Air Development tests have shown this insulation material to cause fires, explosions, and other damage to the host vehicle when the insulation fails. This 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, NK, and NL. **This material is a reliability suspect PMP item**.

2.6 Electrical and Handling Considerations - Conductors. Use the characteristics of the conductors used on wire as an aid when selecting the proper wire for each application. Conductor strands should made of soft annealed copper, high strength copper alloy, or beryllium-copper alloy, and coated with either silver, nickel, or tin alloy.

2.6.1 Silver Coated Wire. Temperature range is above 150C to about 200C, and is good for high frequency applications due to its higher conductivity. 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 should be used. All beryllium - coper wire should be silver coated.

2.6.2 Nickel Coated Wire. Good for crimp applications (if the MIL-C-39029 crimp values are used) and has good finish up to 260C. For solder applications, solder does not wick under the insulation beyond the joint, leaving a good flexible area.

2.6.3 Tin Coated Wire. Tin or tin alloy is the least expensive, but is susceptible to oxide formation and corrosion when exposed to traces of clorine, oxides of nitrogen, or humidity. Tin whisker formation is possible but very rare due to alloying of the thin tin coating with the copper wire. Tin or tin alloy finish may be used with solder terminations, but they are not recommended with crimp terminations.

2.7 Stripping. Thermal stripping of the wire insulation is the preferred method for most wire insulation types. Mechanical stripping is acceptable if adequate workmanship precautions are taken to avoid quality problems such as nicks due to improper tools use.

3.0 DESIGN AND CONSTRUCTION

3.1 General Purpose Wire. Use Quality Conformance Inspection tests of MIL-W-22759 Table VI for all non military specification wire. Use Quality Conformance Inspection tests of MIL-C-27500 Table VII for all non military specification cable.

3.2 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

g. MIL-W-16878 wire types

h. All Polyvinyl chloride (PVC) insulated wire and cable.

3.3 Radiation Hardness Assurance. Verify that the selected insulation material can withstand greater than 105 rads(Si) total ionizing dose.

4 QUALITY ASSURANCE Follow the guidance of this handbook Section 4 and the applicable military specification.

SECTION 2000 - MATERIALS REQUIREMENTS

1. SCOPE This section covers the common requirements which should be taken into account for non-electronic materials. Materials fall into two main categories: Metals and Non-metals (which include Organics).

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

3. SPECIAL CONSIDERATIONS All materials used should meet the requirements listed in Section 4.3.2 of this handbook.

4. PROHIBITED MATERIALS LIST FOR SPACE FLIGHT ITEMS

   a. Items with exposed surfaces of cadmium or zinc.

   b. Mechanical and electronic parts within electronic boxes with pure unfused tin coated internal or external surfaces not including drawn wire products (see section 4of this handbook).

   c. Alloys or compounds containing mercury.

   d. Parylene (paraxylylene) coatings containing chlorine.

   e. Corrosive (acetic acid evolving) silicone sealants, adhesives, or coatings.

   f. Wood should not be used.

   g. Combustible materials, or materials that can generate toxic outgassing or toxic products of combustion.

SECTION 2100 - METALS

1. SCOPE This section provides the common requirements for the use of metals in space and launch vehicles.

2 APPLICATION MIL-HDBK-5 should be used as the basic document for defining strength allowables and other mechanical / 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 Forging

3.1.1 Forging Design. Forgings should 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 should 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 should 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 should be free from reentrant and sharply folded flow lines. After the forging technique, including degree of working is established, the first production forging should be sectioned to show the grain flow patterns and to determine mechanical properties and fracture toughness values at control areas. The procedure should be repeated after any significant change in the forging technique. The information gained from this effort should be utilized to redesign the forging as necessary. The data, material samples, and the results of the tests on redesign, should be retained by the contractor for the life of the Program for future reference.

3.1.2 Forging Surfaces. Surfaces of structural forgings in regions identified by analysis as fatigue critical or in regions of major attachment should 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 should 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 should be make 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, MSFC-SPEC-522 and the references contained therein should 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 should be utilized in all structural, load-carrying applications. Particular emphasis should 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 should be classified and inspected in accordance with MIL-STD-2175. Structural castings should be procured to guaranteed property, premium quality specifications including MIL-A-21180, AMS 5343, or other document(s) in accordance with the contractor's approved PMP control plan.

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

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

2. APPLICATION In structural applications requiring the selection of aluminum alloys, maximum use should 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 should not be used for structural applications. The use of 7075-T6, 2024-T3, 2024-T4, and 2014-T6 sheet (<0.25” thick) material should 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 should be heat-treated to the -T73 temper.

3. SPECIAL CONSIDERATIONS

3.1 Aluminum Heat Treatment. Heat treatment of aluminum alloy parts should 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 should be retained by the contractor and is subject to review.

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

3.3 Stress Corrosion Cracking. Aluminum alloys should not be used where assembly or assembly-induced stresses are greater than 75% if the stress corrosion threshold for that alloy (including consideration of the grain direction, 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 Degrees F

c. Aluminum alloy 5083-H38, where temperature > 150 Degrees F

d. Aluminum alloy 5086-H34, where temperature > 150 Degrees F

e. Aluminum alloy 5086-H38, where temperature > 150 Degrees F

f. Aluminum alloy 5456-H32, where temperature > 150 Degrees F

g. Aluminum alloy 5456-H38, where temperature > 150 Degrees F

SECTION 2120 - BERYLLIUM

1. SCOPE This section sets forth the common requirements for the use of beryllium and it's alloys.

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

3. SPECIAL CONSIDERATION

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

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

3.3 Design. Design of beryllium parts should 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 it's alloys.

2. APPLICATION Magnesium alloys should not be used for structural applications in areas subject to wear, abrasion, erosion, or where fluid entrapment is possible. Magnesium alloys should 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 should be treated after forming to avoid stress corrosion cracking.

3.2 Corrosion. Magnesium and magnesium alloy products should not be used without a corrosion protection system that can be maintained with ease and 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, should 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 should 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 should be considered. Steels heat-treated to strength levels at or above 200 ksi UTS should be used in accordance with the contractor's approved PMP Control Plan.

3. SPECIAL CONSIDERATIONS

3.1 Heat Treatment of Steels. Steel parts should 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 should 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 is available that assures the heat treatment improves the mechanical and/or physical properties of the specific steel without altering susceptibility to degradation. This data should 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 should be avoided. When such drilling or machining is unavoidable, carbide tipped tooling and other techniques necessary to avoid formation of untempered martensite should be used. Microhardness and metallurgical examination of test specimens typical of the part should be used to determine if martensite areas are formed as a result of drilling or machining operations. The surface roughness of finished holes should not be greater that 63 RHR, and the ends of the holes should 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 should be performed in accordance with MIL-STD-866. Grinding of chromium plated martensitic steels hardened to 180 ksi UTS and above should 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 should be avoided. Sulfur or selenium additions improve machinability but lower fatigue life.

3.4.2 Precipitation Hardened Stainless Steels. These steels should be aged at temperatures not less than 1000 degrees F. Exception is made for castings which may be aged at 935 degrees F ± 15 degrees 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 should be taken to minimize warping during heat treatment of steel parts. Steel parts should be formed or straightening 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 should be hot formed or straightened within a temperature range from the tempering temperature to 50 degrees 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, exception can be made 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 should be shot peened prior to finishing.

3.7 Stress Corrosion Cracking. The assembly stresses of low alloy steel heat treated above 200 ksi UTS should 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 it's alloys.

2. APPLICATION Titanium sheet and plate stock should be procured to meet the requirements of MIL-T-9046, and supplemented by contractor specifications, drawing notes, or other approved documents which reflect the quality properties and processing to provide material suitable for it's intended use. All titanium extruded bars, rods or special shaped sections should 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 should be in accordance with MSFC-SPEC-469. For titanium alloy products not covered in MSFC-SPEC-469, heat treatment should 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 should not be used in sections which exceed their specified limits. The surfaces of titanium parts should be machined or chemically milled to eliminate all contaminated zones formed during processing.

3.2 Titanium Forgings. All titanium bar and forging stock should 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 should 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 it's manufacturing should be prohibited.

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

3.5 Titanium Corrosion Considerations.

3.5.1 Surface Considerations. The surfaces of titanium and titanium alloy mill products should 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 should not be cadmium or silver plated. Cadmium plated clamps, tools, fixtures and jugs should 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 handbook.

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 application should 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 paragrpah 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 should develop and use threshold values similar to those listed for other alloys based on the ability to withstand exposure to alternate immersion test 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 covers the common requirements for the use of nonmetallic materials (including organics).

2. APPLICATION Nonmetallic materials should 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, state and local regulation

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

2.2 Compatibility. Nonmetallic materials should 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 should 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 should be controlled by a shelf-life control program and should not be used beyond expiration dates unless based on test information supplied by the manufacturer (or test information 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 should 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 should be limited.

3. SPECIAL CONSIDERATIONS

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

3.2 Non-cured Elastomers. Materials that are procured in non-cured state such as sealants and potting compounds should be held in controlled temperature storage not to exceed 26.7 degrees C (80 degrees F). Some specific materials require storage at reduced temperatures and should be stored as recommended by the manufacturer. A first in first out system is recommended as the most effective method for tracking and maintaining adequate storage times. Overage materials may be used if testing can insure that the material is adequate for the intended uses.

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 Foamed plastics should be applied in a manner as to preclude damaging fragile components or exerting undue stress on adjacent surfaces. They should be hydrolytically stable and should not be subject to reversion.

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

3. SPECIAL CONSIDERATONS

3.1 Application Documents. Application documents for dry film lubricants should 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 should consider life cycles, including installation, test, and utilization, as well as a design margins.

SECTION 2240 - ADHESIVES, SEALANTS, COATING, & 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 should be qualified to MIL-A-46146. Adhesives for structural applications should be qualified to MIL-A-83377 for the specific materials to be bonded.

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

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

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 form mechanical damage should 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 should be associated with one or more documents describing its application and usage. Each application document should detail the specific cleaning procedure for all surfaces to be coated (or bonded) and a maximum time period between surface preparation and coating (or bonding), after which, surfaces should be reprocessed. Materials covered by this section should 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 of cryogenic temperatures during test or usage should be a minimum of 30 degrees 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 should only be used.

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

3.4 Asbestos. Asbestos-containing materials should 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 handbook, composite materials are divided into three broad categories: conventional composites, advanced composites, and metal matrix composites. Conventional composites are fiberglass reinforced organic resins. Advanced composites are organic resins reinforced with high strength and or 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 environments, system requirements, structural and functional requirements, electrical or dielectric requirements, serviceability, and reparability.

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 polyimide, 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, Volume I - Volume 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 should 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 , Ohio43214, 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 should be vented and designed to prevent entrance and entrapment of water or other contaminants in the core structure. Sandwich assemblies should satisfy the requirements of MIL-HDBK-23 and be tested in accordance with MIL-STD-401. Aluminum honeycomb core sandwich assemblies should 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 should 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 the use of processes.

2. APPLICATION Processing specifications herein represent minimum standards of quality required for space and launch vehicles and associated hardware. The manufacturing, installation, and inspection processes are controlled by the contractor through their own controls and specifications. The contractor should control the processes to ensure that these minimum requirements are met.

3. SPECIAL CONSIDERATIONS

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

3.2 Statistical Process Control (SPC) All continuous with automated, or semiautomated product lines and or processes should be controlled through a formal and 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 should be kept and maintained. Certification of compliance are not acceptable proofs without the associated results of analyses or documentation showing successful processing or testing.

3.4 Cleaning and Storage The materials, parts, and assemblies should be cleaned and maintained clean between processing, installation, testing, steps as needed. Where appropriate, such as for clean room environment, chemical solutions etc., verification of appropriate levels of cleanliness and freedom from contamination should be performed.

SECTION 3100 - ADHESIVE BONDING

1. SCOPE This section sets forth the common requirements for adhesive bonding.

2. APPLICATION Structural bonding should meet the requirements of MIL-S-83377

3. SPECIAL CONSIDERATIONS All bonding processes and materials selected for structural components should be validated and verified to meet the desired properties for the entire life of the component. This has been accomplished through the test of tag-end test specimens under the simulated service conditions, except for high temperature nozzle bonds, or through hardware qualifications and acceptance tests plus lap shear witness coupons processed concurrently using the same material cleaning method and cure cycles.

SECTION 3200 - WELDING

1. SCOPE This section outlines the common requirements for welding operations, welding filler material, and welding rework in space applications.

2. APPLICATION Welding procedures and supplies should be selected to provide optimum weld quality with minimum weld energy input and maximum protection of heated metal from contaminants. The design and selection of parent materials and weld methods should consider the weldments, including the adjacent heat affected zones, as they affect the operational capability of the parts. The suitability of the process, equipment and equipment set-up, welding supplies and supplementary treatments selected should be validated through qualification tests. As a minimum, qualification should be in accordance with MIL-STD-1595. For optimum results, the contractor should only use operators trained and qualified for the applicable welding equipment and specific tasks.

2.1 Critical Weld Areas The following are considered critical to space flight hardware: pressure vessel weldments, tubing weldments, and other primary structural components.

2.2 Electronic Circuit Modules Resistance welding of electronic circuit module should meet MIL-W-8939 requirements.

3. SPECIAL CONSIDERATIONS

3.1 Weld Filler Material The weld rod or wire used as filler metal on structural parts should be traceable and have certified documentation for composition, type, heat number, manufacturer, supplier, etc. In addition, the quality of each filler rod segment, or of each weld filler metal on a lot by lot basis with testing of each structural weldment to simulated service or proof of loading, should be verified through qualitative and or quantitative analysis, and nondestructive testing as applicable.

3.2 Weld Rework Weld rework of high performance or critical parts should not be permitted. Weld rework should 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. Weld rework does not include the correction of dimensional deficiencies by weld build-up or “buttering” of parts in areas where the design did not provide for a weld joint. All weld rework should be fully documented and should include weld procedures and schedules, location of rework, nature of problem, and the appropriate inspection and qualification requirements. The quality of rework should be confirmed by 100% inspection of both surface and subsurface, using visual, dimensional, and non destructive techniques.

SECTION 3300 - BRAZING

1. SCOPE This section outlines the common requirements for brazing operations.

2. APPLICATION Brazing should meet the requirements of MIL-B-7883. Brazed joints should be designed for shear loading and should not be used to provide tension strength for structural parts. Allowable shear strength and design limitations are specified in MIL-HDBK-5.

3. SPECIAL CONSIDERATIONS Fusion welding operations in the vicinity of brazed joints or other operations involving high temperatures which may affect the brazed joint are prohibited.

4. Prohibited Materials List

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

   b. Cadmium and zinc alloys that are not plated as to preclude the material hazards in section 4 of this handbook.

SECTION 3400 - FASTENER INSTALLATION

1. SCOPE This section outlines the common 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, should meet MSFC-SPEC-250 and MIL-STD-403 a appropriate.

3. SPECIAL CONSIDERATIONS Zinc and or cadmium platings/coatings are prohibited materials in accordance with section 2170 af this handbook and should not be used on space flight hardware. Unfused tin coatings on space flight hardware is also prohibited.

SECTION 3500 - PRINTED CIRCUIT ASSEMBLY

1. SCOPE This section outlines the common requirements for printed circuit assemblies.

2. APPLICATION

2.1 Rigid Printed Circuit Assemblies The design of printed circuit assemblies should be in accordance with MIL-STD-275 for feed through designs, and ANSI/IPC-D-275 for surface mount designs.

2.2 Flexible Printed Circuit Assemblies The design of flexible printed circuit assemblies should be in accordance with MIL-STD-2118.

2.3 Installation and Mounting Appendix B of MIL-STD-2000 should be used for installation and mounting. For through-hole mounting NASA NHB 5300.4 (3A-2) may also be used.

2.3.1 Fragile Parts Fragile parts should be protected through sleeving, buffer coating, etc. to prevent damage.

2.3.2 Lead Formation Lead formation operation should be controlled so it does not mechanically damage devices or cause the loss of hermetic seal. Adequate inspection points and hermetic seal testing should be inserted after the lead form operation to monitor either on a sample or 100% basis the integrity of the operation.

2.4 Soldering MIL-STD-2000, and NASA NHB 5300.4 (3A-2) for through-hole only, should be used for soldering.

2.4.1 Terminal Soldering Step-soldering mounting of terminals to the printed circuit boards should be per MIL-STD-2000 using high temperature solder per QQ-S-571.

2.4.2 Solder in Bend Radius Solder in the bend radius should be allowed on axial leaded components with body diameter less than .125” and with lead formed to a 90° bend.

2.5 Cleanliness Testing All uncoated printed wiring assemblies (circuit card assemblies) should be verified through test that are free from ionic contaminants using the testing outlined in MIL-STD 2000 or equivalent. All cleaned printed wiring assemblies (PWA) should be protected from the environment.

2.6 Conformal Coatings Conformal coatings materials should be selected from MIL-I-46058 and the guidelines provided in TABLE 3500-1 and 3500-2. The conformal coating operation should follow MIL-STD-275. Conformal coating should coat the underside of components spaced off the PWA. A flexible polymeric coating should be used to bridge the gap between the underside of components and substrate. When rigid coating is used, it should not bridge the PWA surface and the parts or parts leads.

2.6.1 Visual Criteria The coated assemblies should not have any blisters, cracking, crazing, peeling, wrinkles, measling, or evidence of reversion or corrosion. A pin-hole, bubble, or combination thereof should not bridge more than 50% of the distance between the nonconnecting conductors wile maintaining the minimum dielectric spacing. Bridging of greater than 50% cannot be reworked more than twice.

3. SPECIAL CONSIDERATIONS Special considerations should be given to designs using leadless ceramic chip carriers (LCCC), surface mount components, grid arrays etc. whenever the following exist:

a. The body size is greater than 0.400 square inches

b. The difference between PWA and component Coefficient of Thermal Expansion (CTE) is more than a factor of 2.

c. The device operating power is greater than 300mW

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

Conformal Coatings	General Physical Properties	Application Methods
Paraxylylene	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.
Epoxies	Excellent chemical resistance, good mechanical properties, low permeability to moisture, high dielectric strength and volume resistivity, brittleness at low temperatures.	Material can be applied by either dipping or flow coating. Brush coating is used 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 either dipping, spraying, brushing, or flow coating. Dilute as necessary to achieve the desired thickness.
Urethanes	Good mechanical, chemical and moisture resistance properties, excellent electrical insulating properties, relatively poor thermal stability.	Material can be supplied with viscosities appropriate to their applications such as dipping, spraying, brushing, or flow coating.
Fluoropolymers	Excellent electrical properties, good thermal stability, water repellent, resistant to high energy radiation.	Materials can be used as received or diluted to a 0.1 to 5% solution with suitable solvents. Apply by either dipping or spraying. Best film properties achieved at film thickness of 5mills.
Acrylics	Excellent moisture resistance and dielectric properties, poor chemical and solvent resistance, poor resistance to mechanical abrasion.	Material can be applied by spray, roller or curtain coating methods. For high production applications, automated spraying methods are recommended.

TABLE 3500-2: General Physical Properties of selected Conformal Coatings

Property	Paraxylylene	Epoxies	Silicones	Urethanes	Pluoropolymers	Acrylics
Dielectric Strength Volt/MII(ASTM D149-64)	5400-7000	4000-5000	5400	4500-5000	2500-3000	3500
Dielectric Constant	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 1MHz	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 & 50%RH, Ω-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 (°C)	60-100	110	-130	-10	-------	-------
Thermal Conductivity 10^{-4} Cal/s/cm/°C/cm	2.0-3.0	4.5	3.5-7.5	5	-------	-------
Pot Life	-------	Good-Poor	Good-Poor	Good-Poor	Excellent	Excellent
Reparability (Solder-Through)	Fair	Poor	Poor	Good	Excellent	Good
Reparability (Removal by Solvent)	No	No	Poor	No	Excellent	Excellent
Reparability (Physical Removal)	Fair	Poor	Good	Good	---------	Good

APPENDIX 1

FOREWORD

Parts, Materials, and Processes Control Program for

1. This Appendix is the previous MIL-STD-1546B (USAF) which was the latest Military Appendix approved for use by the Department of the Air Force for Space and Launch Vehicles prior to Acquisition Reform implementation. Minimal modifications have been made to allow its use as an appendix to MIL-HDBK-1547 instead of a stand alone Military handbook.

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

USAF Space and Missile Systems Center, SMC/SDFC

P.O. Box 92960

Worldway Postal Center

Las Angeles, CA. 90009-2960

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

3. The requirements of this Appendix were developed for long life and/or high reliability space and launch vehicles and equipment. To ensure successful operation of space equipment, attention to every detail is required at every level of assembly throughout development, manufacturing, 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.

4. Analysis of space mission failures and on orbit anomalies by USAF Space and Missile Systems Center revealed that the non-availability of reliable space quality electronic piece parts was a serious deterrent to achieving space mission success. In responding to this problem, the USAF Space and Missile Systems Center 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 Appendix was developed to document the management requirements for parts, materials, and Processes for space and launch vehicles.

5. The objective of this parts, materials, and processes control program Appendix is to ensure integrated and coordinated management of the selection, application, procurement, control and Appendixization 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. The requirements in this Appendix revise the Parts Control Program requirements stated in MIL-STD-965 by expanding particular requirements to satisfy space and launch vehicle acquisitions and extend the requirements to apply to materials and processes.

TABLE OF CONTENTS

SECTION 1

SCOPE

1.1 Purpose

This Appendix establishes the requirements for the preparation, implementation, and operation of a parts, materials, and processes control program for use during the design, development, and production of space and launch vehicles. The implementation of these requirements is intended to:

a. Assure integrated management of the selection, application, procurement, control, and standardization of parts, materials, and processes (PMP).

b. Improve the reliability of program PMP to reduce PMP failures at all levels of integration, assembly, and test.

c. Reduce program life cycle costs.

d. Improve procurement and test of small quantities of piece parts and materials that meet system requirements.

1.2 Application

This Appendix is intended for use in acquisition of space and launch vehicles. This Appendix differentiates between space vehicle and expendable launch vehicle requirements in selected applications. Unless otherwise stated in the contract statement of work, the unique launch vehicle requirements are applicable to launch and upper stage systems. This Appendix may be tailored by the acquisition activity for the specific application or program.

1.3 Compliance with System Requirements.

The requirements of this Appendix should not relieve the contractor of the responsibility for complying with all the equipment, system performance, and reliability requirements as set forth in the applicable specification and contract

SECTION 2

APPLICABLE DOCUMENTS

NONE

SECTION 3

DEFINITIONS AND ACRONYMS

3.1 DEFINITIONS

3.1.1 Acquisition Activity. The acquisition activity is the Government office or the contractor acquiring the equipment, system, or subsystem.

3.1.2 Categories of Contractor. The term "contractor” signifies a producer of modules or higher level items of equipment. A contractor that provides items to another contractor can be identified as a subcontractor. Some system programs have one major contractor identified as a “prime contractor", who is responsible directly to the acquisition activity. Other programs may have two or more major contractors, each responsible directly to the acquisition activity (neither one subordinate to the other), which are called associate contractors". In the case of programs with associate contractors, the acquisition activity may designate one associate contractor as responsible for managing the program Parts, Materials, and Processes Control Program. In this Appendix, when the term contractor is used, it applies to the prime, the associate, or the subcontractor, whichever is applicable.

3.1.3 Commercial Off-The-Shelf (COTS) Item. A commercial off-the-shelf (COTS) item is an item which has been developed and produced to military or commercial standards and specifications, is readily available for delivery from an industrial source, and may be acquired without change to satisfy a military requirement

3.1.4 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.

3.1.5 Destructive Physical Analysis. 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.

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

3.1.7 Electrostatic Discharge (ESD). A transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by an electrostatic field.

3.1.8 Expendable Launch Vehicle (ELV) Quality Baseline. The expendable launch vehicle space quality baseline defines the Electronic Parts, Materials, and Processes which are approved for use in expendable launch vehicle systems. (See Appendix 1C).

3.1.9 Long Lead PMP. Long lead PMP are those PMP items that require special procurement actions to assure program schedules are met

3.1.10 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, pan, or material. The manufacturing baseline includes all associated documentation with respective revision levels 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 tide, number, date of issue, applicable revision, and date of revision.

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

3.1.12 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.

3.1.13 Mechanical Parts. The term mechanical parts (non-electrical parts) is used in a broad sense in this Appendix and includes such simple mechanical parts as nuts, bolts, washers, pins, and terminals, as well as more complex assemblies such as, clamps and glass-to-metal seals. Such mechanical parts have a single, nonelectrical function (other than electrical grounding), and contain one or more necessary material items. Formed, shaped or otherwise processed portions of packages used by electronic assemblies, such as substrates and lids, should be considered as mechanical parts.

3.1.14 Military Parts Control Advisory Group (MPCAG). The MPCAG is a Department of Defense organization which provides advice to the military departments and military contractors on the selection of parts in assigned commodity classes, and collects data on non standard parts for developing or updating military specifications and standards.

3.1.15 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.

3.1.16 Parts. Materials. and Processes Control Board (PMPCB). The PMPCB is a formal contractor organization previously established by contract to manage and control the selection, application, procurement, and documentation of parts, materials, and processes used in equipment, systems, or subsystems.

3.1.17 Part/Material and Process Approval Request (PAR/MAR) A documented analysis or assessment which provides technical justification for adding parts (PAR), or materials and processes (MAR) to the PMPSL.

3.1.18 Parts. Materials. and Processes Lists.

3.1.18.1 Parts. Materials. and Processes Selection List (PMPSL). The PMPSL is a list of all parts, materials, and processes which are approved for design use in a specific contract. (See DI-MISC-81277)

3.1.18.2 As Designed Parts. Materials and Processes List (ADPMPL). The ADPMPL consists of all the parts, materials and processes (including the quantity for each part and material) selected to be used in end-item hardware. (See DI-MISC-81276)

3.1.18.3 As Built PMP List. The As Built PMP List identifies all the PMP used in each deliverable end item. The list includes the PMP types listed for each next assembly.

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

3.1.20 Production Lot. A production lot of parts refers (Unless otherwise specified in the detail specification) 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, and the same manufacturing and quality. controls; and tested within the same period of time. All parts in the same lot have the same lot date code, batch number or equivalent identification.

3.1.21 Program Technical Requirements. These requirements an either stated directly or derived from the System Performance Specification (SPS) or listed as technical compliance documents in the contract The SPS is sometimes refereed to as the "A" or "B" level prime item development specification. Examples of PMP requirements stated or derived from the SPS are: natural space environments, radiation hardness performance levels, reliability requirements. etc. Examples of technical compliance documents are: DOD-PRF-8983. MIL-A-83577, MIL-STD-975. and MIL-HDBK-1547.

3.1.22 Reliability Suspect PMP. Reliability Suspect PMP are those items which have been determined to cause space systems performance anomalies.

3.1.23 Redundant System/Circuit A redundant system/circuit is any system/circuit consisting of two or more independent paths performing the same function, which can function normally with the failures of all but one path.

3.1.24 Registered 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 application specific integrated circuits, customized or specially designed parts, new part types or technologies not having prior space flight usage, reliability suspect PMP, limited application PMP, and PMP involving restricted or specially controlled usage. storage, or handling due to safety or environmental concerns.

3.1 25 Space Quality PMP Baseline. The Space Quality PMP Baseline defines the standard parts, materials, and processes which are approved for space and launch vehicle use. See Appendix A

3.2 ACRONYMS

ADPMPL	As Designed Parts, Materials and Processes List ([)I-MISC-81276)
COTS	Commercial Off the shelf equipment.
DPA	Destructive Physical Analysis
EEE	Electrical, Electronic, and Electromagnetic parts
ELV	Expendable Launch Vehicle
ESD	Electrostatic Discharge
FSAR	Failure Summary and Analysis Report QI-REU-80255)

MAR	Material and Process Approval Request
MPCAG	Military Parts Control Advisory Group (See 3.1.14)
PAR	Part Approval Request (0ata Item Description, DI-MISC-80071)
PMP	Parts, Materials, and Processes
PMPCB	Parts, Materials, and Processes Control Board
PMPSL	Parts, Materials, and Processes Selection List (Data Item Description, DIMISC-81277)
QML	Qualified Manufacturers List
QPL	Qualified Parts List
RHA	Radiation Hardness Assurance
SQ	Space Quality

SECTION *5*.0

DETAILED REQUIREMENTS

5.1 Parts. Materials. & Processes Control Program. Planning The contractor should establish and conduct a parts, materials, and processes standardization, management and control program plan. The program plan requirements outlined in this Appendix have been proven to be effective for space vehicle applications and could be used as a guide. Existing contractor in-house documentation equivalent with (Data Item Description, DI-MISC-80526) may be used and referenced in the plan as applicable to addresses how the requirements of this Appendix are to be met and should be made available for review by the acquisition activity. All appropriate subcontractors should also participate in the parts, materials, and processes control program to the extent required by the prime contractor and acquisition activity in order to meet the requirements of this Appendix. The plan should address how the contractor ensures the flow down of the applicable parts, materials, and processes control program requirements to the subcontractors. The plan should include:

a. PMPCB operating procedures, membership, responsibilities, authority, meeting schedules, PMP review procedures, PMP approval/disapproval procedures, acquisition activity involvement, and plans for updating the operating procedures; the definition of the role and authority of each PMPCB member; and relationships with various groups within the prime, associate, and subcontractor organizations. (see 5.2).

b. Definition of the Program PMP Baseline, procedures for approving PMP not included in the SQ Baseline or the ELV quality baseline, and the requirements for listing PMP in the Program Parts, Materials and Processes Selection List (PMPSL).

c. Procedures for identification and control of long lead, registered, and prohibited PMP. (See 3.1.9, 3.1.24 and 3.1.22)

d. Shelf life control plan. (See 5.4.6)

e. Parts and materials application derating. (See 5.4.3).

f. PMP vendor surveillance and audit plan. (See *5.5.2)*

g. PMP qualification plan that describes how new PMP should be qualified for the intended end item application. (See *5.*10)

h. Incoming inspection and test plan. (See 5.4.5)

i. Destructive Physical Analysis (DPA) plan. This plan should include a list of those part types that require DPA as part of incoming inspection. (See 5.4.5)

j. Defective parts and components controls program. (See 5.11)

k. PMPCB coordination and interactions with other program control boards; i.e., configuration (CCB), failure review (FRB), mass properties (MPCB), and material review (MRB).

l. Coordinated procurement plan. if applicable. (See 5.5.3).

m. Radiation hardness assurance program plan as required. (See 5.6).

n. Electrostatic discharge ESD) control plan.

o. Corrosion prevention and control plan.

p Contamination Prevention and Control Plan, as required

q. Implementation plan for using the Defense Electronics Supply Center (DESC) JAN class S Operating Stock Program for the procurement of JAN Class S parts (See 5.5.4).

r. Subcontractor PMP management plan.

s. Standardization of program PMP.

t. VLSI qualification and procurement plan

u. Alternate QCI and small lot sample plans, as required- (See 5.4.7*).*

5.2 Parts. Materials. and Processes Control Board (PMPCB)

A Parts, Materials and Processes Control Board (PMPCB) when instituted and operated by the contractor should be responsible for the planning, management, and coordination of the selection, application, and procurement requirements of all parts, materials and processes intended for use in the deliverable end item(s). PMPCB findings, decisions, and directions should be within the contractual requirements, and should be binding on all applicable contractors and subcontractors. Participation of the acquisition activity at PMPCB meetings is encouraged to ensure real-time approval/disapproval of PMPCB decisions and actions. When necessary, the acquisition activity decisions should be provided within a mutually agreed upon period.

5.2.1 Chairmanship. The PMPCB Chairman should be responsible for preparation and distribution of PMPCB meeting agenda and minutes, conduct PMPCB meetings, and manage the PMPCB.

5.2.2 Membership. The PMPCB membership should include at least one member from each appropriate contractor and subcontractor. The acquisition activity should appoint a representative to be an active member of the PMPCB. Other members may be designed by the acquisition activity or the PMPCB chairman. Each member should be supported in technical matters as required. Each member should have the authority to commit his activity, organization, or company to PMPCB decisions within the scope of the applicable contract. Representation at individual meetings should be required, consistent with the scheduled subject matter on the agenda. The acquisition activity representative should be afforded the opportunity for attendance at all PMPCB meetings.

5.2.3 Delegation. The authority to conduct PMPCB may be delegated by the prime contractor PMPCB chairman to major contractors/subcontractors. Each organization so delegated should supply the responsible activity PMPCB with meeting minutes documenting decisions in a timely manner. All information should be made available to each higher acquisition activity. Each higher acquisition activity retains the right of disapproval of delegated PMPCB decisions.

5.2.4 Meetings. The PMPCB should conduct meetings as follows:

a. A post award organizational PMPCB meeting should be convened by the contractor. The chairman should coordinate the date and location of the meeting with the acquisition activity, and inform proposed member activities of the schedule and meeting agenda. The purpose of this initial meeting is to establish responsibilities, procedures, and working relationships to allow the rapid transition to an operational PMPCB.

b - Regularly scheduled meetings should be held as determined necessary by the PMPCB chairman. These meetings should address, as a minimum, predefined agenda items for discussion.

c. Special PMPCB meetings may be called by the PMPCB chairman to discuss special items which may require expeditious resolution. Adequate notification should be provided to all PMPCB members.

d. PMPCB meetings may be accomplished either in person, via telephone, or other media such as tele/video conference.

5.2.5 PMPCB Responsibilities

a. The PMPCB should establish operating procedures in accordance with this Appendix

b. The PMPCB should establish and maintain a Parts, Materials and Processes Selection List PMPSL). The PMPCB should review and approve the initial version and subsequent revisions to the PMPSL. The PMPCB should review and approve all Parts (Materials or Processes) Approval Requests (PARs) (MARs), with supporting details.

c. Through interface with design activity, the PMPCB should ensure the design selection and use of PMP which meets the technical program requirements. The order of precedence should be the basis of PMP selection. (See 5.5.5).

d. The PMPCB should ensure the procurement of PMP in the orders of precedence as specified in the contractual program requirements. (See 5.5.5).

e. The PMPCB should ensure derating of all electronic parts and adequate design margins for mechanical parts used in deliverable end items. The PMPCB should review and approve any proposed deviations from the technical program requirements.

f. The PMPCB should ensure the establishment of Destructive Physical Analysis (DPA) policies, procedures and reporting formats. DPA problems and anomalies of concern should be reviewed by the PMPCB.

g. The PMPCB should ensure the review of the results of DPA, Material Review Board (MRB) actions, failure analyses, and any other details pertaining to PMP. All PMP problems should require disposition by the PMPCB.

h. The PMPCB should ensure the timely identification of long lead PMP items and other problem procurements.

i. The PMPCB should ensure the identification and configuration control of any changes to PMPCB approved documentation.

j. The PMPCB should ensure that laboratories and analysis facilities used for evaluation of PMP are viewed for capabilities of equipment and personnel before performing analyses in compliance with this Appendix.

k The PMPCB should ensure that all screening and testing of parts is conducted by laboratories with personnel, equipment and software that are capable and controlled.

5.2.6 PMPCB Authority. The PMPCB should ensure that all PMP items approved for use meets system performance and reliability requirements. All PMPCB decisions should be documented in the meeting minutes. All supporting technical analysis should be provided and any additional analysis and tests in accordance with PMPCB direction attached to the meeting minutes. The PMPCB should have the authority to approve technical changes to the detail PMP requirements when baseline changes fall into one or more of the categories specified below without impact to the item performance in the intended application:

1. Variation from design and construction requirements of the detail specification
2. Screening and lot acceptance tests and acceptance criteria deviations from the detail specifications.

5.3 Management of PMP Selection. The contractor should manage the selection of PMP in accordance with criteria specified in this Appendix. PMP should be selected to meet the system established performance over the required useful life. The contractor should develop a Parts, Materials, and Processes Selection list (PMPSL) (Data Item Description, DI-MISC-81277) and an As-designed Parts, Materials, and Processes list (ADPMPL) (Data Item Description, DI-MISC-81276) to be used by all contractors and subcontractors on the program for design and manufacture of flight and qualification hardware. The initial version of the PMPSL should be submitted to the acquisition activity for approval. Subsequent revisions to the PMPSL should be reviewed and approved by the PMPCB if the revisions are deemed equivalent to the original PMPSL and there is no impact to the contracted system performance requirements. The PMPSL should include all PMP identified in the Space Quality PMP Baseline (3.1.25) as tailored for the program's use or the ELV Quality PMP Baseline (3.1.8). PMP not included in the PMPSL should be documented on a Parts Approval Request (PAR) or Material Approval Request (MAR) and submitted to the PMPCB for review and approval.

5.3.1 Parts. Materials. and Processes Selection List (PMPSL). The PMPSL should be in accordance with the requirements specified in Appendix D herein and Data Item Description, DI-MISC-81277. Limited application and registered PMP should include information on applicable restrictions and reasons in the PMPSL.

5.3.2 Part/Material and Process Approval Request (PAR/MAR). The use of PMP, not approved for use must be technically justified and added to the PMPSL. A PAR/MAR should be prepared and submitted to the PMPCB for approval. The PAR/MAR must include appropriate justification that shows that no existing PMPSL item nor any other space qualified PMP is satisfactory, and that the reliability analysis supports the use of the non-standard PMP. When required by a Contract Data Requirements List (CDRL), the PAR/MAR should be in accordance with DI-MIS C-8007 1. An exception to this requirement is where a part is procured to program technical requirements and processed on a space qualified line by a supplier maintaining current and using all processes for space quality Class S QPL, or Classes V or K QML product lines. Additional exceptions for unique ELV requirements are included in Appendix C.

5.3.3 As-designed Parts. Materials and Processes List (ADPMPL). The ADPMPL should be in accordance with Appendix E and DI-MISC-81276. An as-built parts, materials and processes list has been traditionally substituted for the ADPMPL, however, this practice may add system performance variations.

5.4 Management of PMP Engineering Requirements.

5.4.1 System Design. The PMPCB is responsible to ensure that PMP used throughout the system meets the application, reliability, quality, and survivability requirements as derived from the System level requirements. PMP selected for use should be selected from the PMPSL. PMP engineering should review and approve all drawings and specifications (A level, B level, device detail specifications, etc.) to ensure that PMP requirements are met. The requirements of Appendix B herein, paragraph 20.6, should be considered for all PMP with radiation hardness requirements; however, the general provisions of paragraph 20.6 should be considered for all PMP selection.

5.4.2 Reuse or Parts and Materials. Parts and materials which have been installed in an assembly, and are then removed from the assembly for any reason, should not be used again in any item of flight or spare hardware without proven methodology that this practice does not degrade the system performance and prior approval of the PMPCB.

5.4.3 Derating. A uniform derating policy to meet the system requirements should be established by the PMPCB and used by all contractors in the program. Exceptions to this derating policy should require the approval of the PMPCB. The derating policy should address degradation sensitive parameters and maximum rated variations expected over the program mission life including storage environments and radiation effects.

5.4.4 Traceability and Lot Control. The contractor should develop and maintain a traceability and lot control plan in accordance with the requirements specified below and approved by the PMPCB. When given a lot date code or batch number, the contractor should be capable of determining the unique piece of equipment (black box level) by serial number in which the part or material is installed or used. Traceability to the serial number of an individual device or to a lower level of assembly should be as determined and specified by the PMPCB.

5.4.4.1 Electronic Parts. All EEE parts and cable assemblies should have 100% lot traceability to the production lot. Any other parts not included in the above which require traceability should be identified in the traceability lot control plan.

5.4.4.2 Mechanical Parts and Materials. One hundred percent (100%) lot traceability is required for parts and materials used in applications where a failure could jeopardize component or mission success.

Traceability and production or batch lot control for parts and materials used in other applications should be maintained where risk and cost so dictate.

5.4.5 Incoming Inspection Requirements. Each contractor should perform, or be responsible for the performance of applicable incoming tests and inspections including DPA of parts and materials to ensure that they meet the requirements of the procurement specification. Unless previously accomplished and accepted by government or contractor field personnel, incoming testing and inspections should be accomplished upon receipt of the parts or materials. The inspection and testing of parts and materials should be conducted in accordance with a plan approved by the PMPCB.

5.4.6 Shelf-Life Control. The contractor should develop a shelf life control program that identifies the shelf life limitations for all parts and materials to be stored. This plan should specify the length of time required and minimum requirements for reinspection, retest, & any other action required to ensure maintenance of space flight quality and reliability. The plan should be reviewed and approved by the PMPCB and controls should be identified to ensure that the plan is followed before parts and materials are issued to assembly. Separate plans for material shelf life control and parts shelf life control are permissible.

5.4.6.1 Material Shelf Life Control. In addition to general age limitation considerations, the plan should identify any specific temperature and humidity requirements for storage and any associated limitations on life. Any special environmental requirements (e.g., storage in dry nitrogen) should be identified.

5.4.6.2 Parts Shelf Life Control. A plan which requires the automatic retesting of all part types is not required. The plan should identify those part types considered to be potentially age sensitive. The plan should identify specific actions necessary in association with the potentially age sensitive parts. In general, the plan should consider a pedigree review and actions similar to that shown below for parts older than 5 years (suggested limit). The plan should define the specific limit for each part based upon logistical considerations of parts procurement schedules, program manufacturing schedules, and required program life. When parts exceed specified age limits in storage, actions should be taken as specified in the control plan or the PMPCB should provide direction based upon the following considerations:

a. Assess original part quality (Class S, SCD, Class B, etc.)

b. Assess lot history (suppliers percent defective, quantity used to date, number of failures, etc.).

c. Review of original screening/test data.

d. Review of problem/GIDEP Alerts.

e. Review of original DPA.

f. Review storage environment controls (temperature, ESD protection, handling, etc.).

g. When possible, consider application criticality, redundancy, etc.

h. When retest/ rescreen appears warranted, assess availability of retest equipment, outside rescreen facilities, potential for part damage during rescreening, etc.

i. Program technical requirements for screening should be used as guidance for any planned rescreening of product due to shelf life limitations.

5 4.7 Use of Alternate Quality Conformance Inspection and Small Lot Sampling Plans. The contractor may implement an alternate Quality Conformance Inspection (QCI) plan and a small lot sample plan for small lot quantities in accordance with the program's technical requirements. The PMPCB should review and approve these plans. These plans may be used under the following conditions:

a. The product(s) being purchased is not listed in the program's space quality baseline.

b. The product(s) being purchased meets the order of precedence requirements of 5.5.5.1, 5.5.5.2.1, or 5.5.5.2.2 herein (except for the space quality baseline).

C. Implementation criteria as defined in the program's technical requirements is satisfied

5.5 Management of Parts. Materials and Processes Procurement.

5.5.1 Supplier and Vendor Selection and Surveillance. The PMPCB is responsible for the selection and qualification of PMP suppliers, vendors, laboratories and manufacturers.

5.5.2 PMP Supplier and Manufacturer Surveillance (Monitoring). The PMPCB should establish a policy and procedures for the periodic surveillance and auditing of suppliers, vendors, laboratories and manufacturers to ensure compliance to procurement, quality, reliability and survivability requirements. Contractor surveillance of laboratories, suppliers, vendors, and manufacturers which have been approved as a part of QPL or QML program for products listed in the space quality baseline is not required. When surveillance/audit data is available from other sources (e.g. other contractor programs, other contractors/s subcontractors, independent audits reports, etc.) the contractor may utilize the results of the data contingent on the review and approval by the PMPCB. Acceptability of the data should be based on technical considerations, as well as timeliness and confidence in the source of the data

5.5.3 Coordinated Procurements. Implementation of a coordinated Procurement program is highly encouraged. When appropriate, the PMPCB should establish policies for the use of coordinated procurements for all contractors and subcontractors use. This may include the use of common specifications, management responsibilities, purchase agreements, monitoring, and quality assurance. The PMPCB (and procurement organizations) may ensure that a master purchase agreement allows authorized subcontractors to initiate their own procurements within the scope and framework of the master purchase agreement.

5.5.4 JAN Class S Operating Stocking Program. A JAN class S Operating Stock has been initiated by the Defense Logistics Agency (DLA) to allow contractors to procure JAN Class S parts that are readily available from stock (inventory). This reduces procurement lead times, and allows small quantity ordering. Contractors are encouraged to procure from the JAN Class S Operating Stock. The PMPCB should provide a forecast semi-annually (when requested) for the expected JAN Class S parts usage to USAF/Space and Missile Systems Center (S MC).

5.5.5 Electronic Parts Procurement Order or Precedence. EBB parts should be procured in the order of precedence defined for space vehicle or expendable launch vehicle programs as applicable:

5.5.5.1 Space Vehicle Programs. The procurement order of precedence should be as follows:

1st Order: Space Quality Baseline

2nd Order: Parts procured to contractor prepared drawings meeting program technical requirements. The contractor is encouraged to place orders with manufacturers willing to pursue qualification to space quality baseline QPL/QML.

3rd Order: Parts procured to QPL/QML not listed in the SQ baseline (e.g., Class B microcircuits and JANTXV semiconductors) and screened to program technical requirements.

Order of precedence #3 is intended for use on a very limited basis and only in cases where there is a major threat to the program schedule. Parts procured to the requirements in #3 may be approved by the PMPCB for use under the following circumstances:

a. Parts procured to #1 or #2 cannot be accomplished in time to satisfy program schedules.

b. Order of precedence #3 should be used on a limited basis until parts meeting the requirements of #1 or #2 are available. A purchase order to the requirements of #1 or #2 should be awarded prior to the use of parts procured to the requirements of #3. Exceptions to this requirement should be approved by the PMPCB.

5.5.5.2 Expendable Launch Vehicle Programs. The procurement order of precedence should be as follows:

5.5.5.2.1 Single String Systems/Circuits. Parts for use in non-redundant systems/applications should be procured in the order of precedence below:

a. Microcircuits, semiconductors and hybrids:

1st Order. Space vehicle space quality baseline or ELV quality baseline

2nd Order. Parts procured to contractor prepared drawings meeting program technical requirements; or

Parts procured to QML/QPL not listed in Appendices A and C (e.g., Class B microcircuits and JANXV semiconductors) and screened to program technical requirements

5.5.5.2.2. Redundant Systems/Circuits. Parts for use in redundant applications should be procured in the order of precedence as -fled below:

Space or ELV quality baseline; or,

Parts procured to contractor prepared drawings meeting program technical requirements;

or

Parts procured to QML/QPL not listed in Appendices A and C (e.g., class B microcircuits and JANTXV semiconductors) and screened to program technical requirements

5.6 Radiation Hardness Assurance (RHA). When required, the contractor, through the PMPCB, should develop and conduct a hardness assurance program in accordance with Appendix B. The hardness assurance program plan should address all phases of the flight hardware program including the design, test, and production.

5.7 Government Furnished Equipment PMP contained in unmodified government furnished equipment used in the end item of the contract should not be subject to PMP control.

5.8 Commercial Off.-the-Shelf Item Equipment (COTS). The requesting user should demonstrate to the PMPCB that the COTS items meet the reliability, environmental and survivability (if required) requirements of the contract end item for the intended application.

5.9 USAF SMC Space Parts Working Group (SPWG). The contractor is encouraged to provide representation to the USAF SMC Space Parts Working Group meetings. These meetings are usually held periodically (approximately annually) at or near the USAF SMC. The purpose of these meetings is to provide a forum for the exchange of information relating to technical, procurement, application, and status issues of interest involving space programs and especially space quality parts, materials and processes. The primary focus is on general PMP issues or items including their selection and procurement

5.10 PMP Qualification.

5.10.1 General. All PMP, including any processes developed to accomplish rework or retrofit, should be qualified for program use. Only qualified PMP should be used on flight hardware. For each non-qualified PMP, the contractor(s), through the PMPCB, should prepare a qualification plan and procedure. For electronic parts, the qualification plans and procedures should be based on the application or program technical requirements. The qualification plan should identify all conditions and testing necessary to meet the program and mission reliability and qualification requirements. These plans and procedures should be reviewed and approved by the PMPCB. A summary report of qualification test results should be submitted to the PMPCB. The PMPCB should maintain an up-to-date listing of the qualification status of all program PMP. Test methods used for qualification of PMP should be in accordance with applicable specifications and should include test methods for any additional tests necessary to fully qualify the part for its intended use in the system.

Qualification of PMP may be expedited by the following:

a. Initial selection of PAM using applicable military specified PAM previously qualified for use on space and launch vehicle programs.

b. Proof testing of all parts and materials to the program requirement levels.

c. Vendor audits and certification

d. Satisfactory completion of tests on engineering models that use the PAM.

5.10.1.1 Manufacturing Baseline. As part of the qualification plan for each non-qualified PMP item, the contractor(s) should insure that the non-qualified PMP item supplier has an established manufacturing baseline (3.1.10) as determined by the PMPCB and review the manufacturing baseline for compliance to the program's technical requirements. The manufacturing baseline for all other PMP should be reviewed and controlled as determined by the PMPCB.

5.10.2 Qualification by Extension. Parts, materials, or processes may be qualified by extension when supporting data is available and shows that either of the following criteria are met:

a. The part, material, or process was successfully used in a prior but recent space application in which the application environment conditions of use and test were at least as severe as those required of the candidate PMP for qualification

b. The part or material design and construction is the same as the previously qualified part or material. The part or material is manufactured by the same manufacturing facility to the same manufacturing baseline as the previously qualified part or material, and the utilization of the part or material does not result in critical stresses or mechanical strain (such as due to thermal mismatch) greater than the previously qualified part or material.

5.11 Defective Parts and Components Control Program. The PMPCB should review and evaluate Government Industry Data Exchange Program Alerts (GIDEP ALERTS), industry problem alert bulletins, and other available information relating to defective PMP to ensure that defective PMP are not selected for use unless the indicated defects or failures have been corrected or identified, and approved preventions implemented to eliminate the cause of the defects or failures in the parts to be used in the flight hardware. PMP indicated as defective in GIDEP AIJERT, industry problem alert bulletins, industry problem notices or alerts, or other sources of problem information should not be approved

5.12 Failure Analysis. As determined by the PMPCB, failure analysis should be performed on part and material failures experienced during assembly and testing. Failures should be analyzed to the extent necessary to understand the failure mode and cause, to detect and correct out-of-control processes, to determine the necessary corrective actions, and to determine lot disposition. When required, a Failure Summary and Analysis Report (FSAR) in accordance with DI-RELI-80255 and Appendix F herein, should be prepared and reviewed by the PMPCB. Determine and implement appropriate corrective action for each PMP failure. All failures, and the results of final failure analysis, should be reported to the PMPCB. Failure analysis reports should be retrievable for the duration of the contract, and should be available to the acquisition activity. When required, a Failed Item Analysis Report in accordance with DI-RBU-80253 should be prepared and reviewed by the PMPCB. Failure of parts procured from the DSCC JAN class S Operating Stock Program require immediate notification to DESC, the PMPCB, and the acquisition activity.

5.13 Preservation and Packaging. Preservation, packaging, and packing should be in accordance with the item and the system requirements. All parts which are subject to degradation by electrostatic discharge should be packaged in accordance with the approved ESD procedures.

5.14 Handling. Handling (including storage) procedures should be instituted to prevent part and material degradation. The handling procedures should be retained through inspection, kitting, and assembly and should be identified on “build to" documentation. The following criteria should be used as a minimum for establishing handling and storage procedures for parts and materials:

a. Control of environment, such as temperature, humidity, contamination, and pressure.

b. Measures and facilities to segregate and protect parts and materials routed to different locations such as, to the materials review crib, or to a laboratory for inspection, or returned to the manufacturer from unaccepted shipments.

c. Easily identifiable containers to identify space quality parts should be used.

d. Control measures to limit personnel access to parts and materials during receiving inspection and storage.

e. Facilities for interim storage of parts and materials.

f. Provisions for protective cushioning, as required, on storage area shelves, and in storage and transportation containers.

g. Protective features of transportation equipment design to prevent packages from being dropped or dislodged in transit

h. Protective bench surfaces on which parts and materials are handled during operations such as test, assembly, inspection, and organizing kits.

i. Required use of gloves, finger cots, tweezers, or other means when handling parts to protect the parts from contact by bare hands.

j. Provisions for protection of parts susceptible to damage by electrostatic discharge.

k. Unique parts and materials criteria.

5.15 Data Retention. The program should maintain records or incoming inspection tests, lot qualification and acceptance test data, radiation hardness assurance test data, traceability data and other data as determined by the PMPCB for a period of time specified by the acquisition activity.

SECTION 6

NOTES

The contents of this section are intended for guidance and information only.

6.1 Intended Use

The Appendix is intended for use as a guide in acquisition contracts for space vehicles, upper stage vehicles**,** payloads, launch vehicles, and for their subtier equipment. Note that this Appendix is not an appropriate reference in any specification since it is a management Appendix and does not contain technical requirements for the parts, materials, and processes to be used in the equipment. All requirements for data delivery must be listed in the Contract Data Requirements List of the acquisition contract.

There may be acquisition contracts for other types of equipment requiring high reliability where the special parts, materials, and processes control requirements stated in this Appendix could be applied. For those acquisition contracts, this Appendix may be cited to specify the applicable requirements. However, a statement should be included in the contract or the statement of work indicating that the words "space and launch vehicle" in this Appendix are to be interpreted as the applicable equipment. The requirements in this Appendix should therefore be interpreted as applying to the parts, materials, and processes control program requirements for the acquisition of the applicable equipment.

The requirements in the text of this Appendix expand the applicable Parts Control Program requirements as previously stated in MIL-STD-965 in order to satisfy space and launch vehicle acquisition requirements. This Appendix also expands the requirements to apply to materials and processes.

Contracts for ground equipment (e.g., control segments and user segments of space systems) could apply MIL-STD-965 for those segments unless it is determined that a tailored application of this Appendix 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 if both MIL-STD-965 and this Appendix are referenced, care should be taken to ensure that the applicability of each document is clear.

6.1.1 Related Management Requirements. In addition to this Appendix other critical management requirements to be implemented in the statement of work may include requirements for:

a. Quality program (MIL-STD-1586, MIL-STD-1535, MIL-STD-1520, and MIL-Q-9858)

b. Reliability program (MIL-STD-1543)

c. Contamination Prevention and Control program (MIL-STD-1246)

d. Safety program (ML-STD-882 and MIL-STD-1574)

e. Hardness and Survivability program, if applicable (DOD-STD-1766)

f. Program reviews (MIL-STD-1521)

6.1.2 Related Technical Requirements. Critical technical requirements to be implemented in the equipment specifications may include:

a. PMP technical requirements for space and launch vehicles (MIL-STD-1547)

b. DPA technical requirements for parts (MIL-STD-1580)

c. Corrosion control requirements for materials (MIL-STD-1568)

d. Electrostatic discharge control program (MIL-STD-l686 and DOD-HDBK-263)

e. Electrical and electronic equipment design DOD-E-8983, DOD-W-83575, and MIL-STD-454)

f. Moving mechanical assembly design (MIL-A-83577)

6.2 Tailored Application The parts, materials, and processes control program requirements in each contract may be tailored to the needs of that particular acquisition. Military specifications and standards need not be applied in their entirety. All tailored applications of this Appendix should be clearly identified in the compliance document section of the statement of work of the contract

6.3 Tailoring to Contract Phase This Appendix contains a comprehensive management program that requires reliability and standardization considerations be applied during all phases of the program. When this Appendix 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 technical requirements and management procedures apply to anything other than qualification and flight hardware (e.g. they do not apply to ground demonstration models). Contracts for the demonstration and validation phase are encouraged to require the development of a parts, materials, and processes control program plan and at least a first draft of the PMPSL. The contractor should, therefore$_1$ have a complete understanding of the entire PMP program to successfully transition into subsequent phases of the contract The Appendix is intended to be "self tailoring" in this respect so that -specific tailoring to each phase of the contract would not be required.

6.4 Data Item Descriptions Data requirements of this document 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. When the provisions of the DOD FAR clause on data requirements (currently DOD FAR Sub Part 27.475-1) are invoked and the DD Form 1423 is not used, the data specified below should be delivered by the contractor in accordance with the contract or purchase order requirements. Deliverable data required by this Appendix is cited in the following paragraphs:

Paragraph No.	Data Requirement 'ride	Applicable DID No.
3.1.18.1, 5.3, 5.3.1, App D	PMP Selection List	DI-MISC-81277
3.1.18.2,5.3.3, & App B	As Designed PMP List	DI-MISC-81276
5.1	Parts Control Program Plan	DI-MLSC-80526
5.2.1	Conference Minutes	DI-A-7089
5.3.2	Parts Approval Requests	DI-MISC-8OW1
5.12 & App F	Failure Summary and Analysis Report	DI-RELI-80255
5.12	Failed Item Analysis Report	DI-RELI-80253

(Data item descriptions related to this Appendix are listed in DOD 5O1O.12-L., AMSDL. Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the Naval Publications and Forms Center or as directed by the contracting officer)

a. Parts, Materials, and Processes Control Plan. Data Item Description, DI-MISC-80526, Parts Control Program Plan. The preliminary parts, materials, and processes control program plan should be provided to the PMPCB for review and to the acquisition activity for approval within the specified days after contract award, or as decided by the PMPCB. The final parts, materials, and processes control program should be provided to the PMPCB for review and to the acquisition activity for approval prior to the Preliminary Design Review.

b. Parts, Materials, and Processes Selection List (PMPSL). Data Item Description, DI-MISC-81277, Parts, Materials and Processes Selection List PMPSL). It is important to require that the contractor list the industry generic number on the PMPSL to allow independent computer searches for suspect parts. The initial issue of the PMPSL should be provided to the PMPCB for review and to the acquisition activity for approval shortly after contract award and always prior to the Preliminary Design Review.

c. Electromagnetic Medium. Delivery of data in electromagnetic medium is preferred . The PMPSL (see Appendix D), ADPMPL (See Appendix E), and FSAR (see Appendix F) DIDs require data to be generated and delivered on an electromagnetic medium; however, they are designed to allow flexibility by the contractor for determining format. For existing programs where a contractor's in-house data management system is not electromagnetic medium based and it may not be cost effective to transfer the data to electromagnetic medium, the acquisition activity may approve acceptance of paper submittals. This should be done on a case by case basis.

6.5 Contractor Proposal The contractor proposal should clearly set forth the plans and procedures for implementing a cost effective high reliability PMP management program. The proposed plan should define the scope and depth of the contractors efforts including his management approach, organization, staffing planning, technical aspects, and the relationship of the PMP program to the contractors other technical and management programs. This should cover the technical and management requirements of the Appendix.

6.5.1 Application of PMP Baseline. Compliance with the Space Quality PMP Baseline, Appendix A, to the maximum extent practicable. Note that on contracts for follow-on production of existing designs, the Space Quality PMP Baseline may be the as designed parts and materials list for the earlier production, updated to account for recommended PMP improvements

6.6 MPCAG Functions The function of the MPCAG is to act as an advisor to the acquisition activities and contractors in its assigned commodity classes. The MPCAG would recommend Appendix parts or inventory parts that meet the design requirements of the equipment or system in which the part is to be used. Moreover, the MPCAG 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 MPCAG is responsible as well as a listing of contact points with addresses and telephone numbers, see MIL-STD-965.

6.7 Reference Documents The following specifications. Appendixs, handbooks and data item descriptions are for reference purposes only. They do not add PMP management requirements beyond the scope of this document, however, they can be used to aid in the development of the various PMP plans and procedures stated herein.

DI-A-7089
MIL-A-83577
MIL-Q-9858
MIL-W-83575
MIL-STD-454
MIL-STD-965
MIL-STD-975
MIL-STD-882
MIL-SID- 1246
MIL-STD-1520
MIL-STD-1521
MIL-STD-1535
MIL-STD-1543
MIL-STD-1547
MIL-STD-1568
MIL-STD-1574
MIL-STD-1580
MIL-STD-1586
DOD-STD-1686
DOD-STD-1766
DOD-HDBK-263
DOD-E-8983

Unless otherwise indicated, copies of federal and military specifications, Appendixs, handbooks, and data item descriptions are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.

6.8 SUBJECT TERM (KEY WORD) LISTING

Baseline
Class S
control board
JAN Class S
lot
materials
MPCAG
operating stock
space
parts
PMP
PMP baseline
PMPCB
PMPSL
processes
registered
selection list

SPACE QUALITY BASELINE

This appendix is part of this handbook. The information contained is intended for guidance. This section lists those PMP items that are approved for use in space systems by the acquisition activity and should be listed in the PMPSL.
PMP space quality baseline is listed in three sections:

I. Approved Parts

II. Approved Materials

III. Approved Processes

Section I
Approved Parts

a.	Microcircuits	MIL-M-385l0, Class S, Part I & Part II of QPL
	Integrated Circuits	MIL-PRF-38535, Class V QML.
	Hybrid circuits	MIL-H-38534, Class K.
b.	Diodes	MIL-S-19500, JANS, QPL, Part I or II
c.	Transistors	MIL-S-19500, JANS, QPL, Part I or II
d.	Ceramic Capacitors	MIL-C-123, QPL
d.	Tantalum (solid) Capacitors	MIL-PRF-39003/10, failure rate level C, QPL
e.	Mica Capacitors	MIL-C-87164, QPL
f.	Fixed Film Capacitors	MIL-C-87217/1, /3, and /4, QPL
g.	Metal-Film Resistors	MIL-R-87254, QPL
h.	Low pass RF/EMI Filters	MIL-F-28861, Class S, QPL
i.	Connectors:	
	Circular	MIL-C-38999: For Series I and II: Classes G & H For Series Ill and IV: Classes G & H
	Rectangular D	MIL-C-24308: Classes: D, K, and M.
	Rectangular Microminiature	MIL-C-83513 Class M, Finish N
	Printed Wiring Board	MIL-C-55302
	RF (Microwave)	MIL-C-39012

Section II
Approved Materials

a. Wire and Cable procured to:
   MIL-W-22759/33, 44.45, and 46
   MIL-C-275OO Types SC, SR, SS, and ST

b. Aluminum Alloys
   QQ-A-250 Plate and Sheet
   QQ-A-200 Bar and Rod, Extruded
   QQ-A-225Bar Rod and Wire
   QQ-A-591 Die Castings
   MIL-A-2118O Sand Castings
   QQA-367H(2) Hand Forging

c. Copper
   QQ-C-576
   QQ-C-502

d. Corrosion Resistant Steels
   MIL-S-5059
   QQS-763
   QQS-766
   MIL-S-2504

e. Magnesium
   QQ-M-44
   QQ-M-31

f. Tungsten
   MIL-T-21014

g. Nickels Alloys
   MIL-N-8550
   QQN-286

h. Steels
   MIL-T-6736
   MIL-S-6758
   MIL-S-5000
   MIL-S-8844
   MIL-S-18729
   MIL-S-5626

i. Solder
   QQ-S-571
   MIL-F-14256 Types R and RMA

NON-METALLICS

- a. Adhesives
  - MIL-A-2546
- b. Ceramics
  - MIL-174
- c. Coating, Foaming Molding and Potting Compounds
  - MIL-I-16923
  - MIL-I-46058
- d. Cord and Core
  - MIL-I-3158
  - MIL-C-7438
- e. Elastomers
  - MIL-R-83248
  - MIL-R-25988
- f. Gas and Liquids
  - MIL-A-18455
  - MIL-C-81302
  - MIL-P-27401
  - MIL-P-27404
  - MIL-P-27407
- g. Lubricants
  - MIL-L-46010
- h. Marking, Primers Paints
  - MIL-I-43553
  - MIL-P-23377
  - MIL-C-83286
- i. Plastics, Laminates, and Fabrics Rubbers
  - MIL-P-2224l
  - MIL-P-81390
  - MIL-P-24074
  - MIL-P-46036
  - MIL-M-14
  - MIL-I-17205
  - MIL-P-18177
  - MIL-P-13949
  - MIL-R-83248
- j. Tapes
  - MIL-I-43435
  - MIL-I-15126
  - MIL-I-23594
- k. Thermal Control Materials
  - MIL-I-631
  - MIL-P-46112
  - MIL-F-21840
- l. Tubing
  - MIL-I-23053
  - MIL-Y-1140
  - MIL-S-85848

Section III
Approved Processes

a. Platings and coatings as follows:

Gold	MIL-G-45208
Nickel	QQN-290
Electroless Nickel	MIL-C-26074
Silver	QQ-S-365
Copper	MIL-C-14550
Chromium	QQ-C-320
Rhodium	MIL-R-46085
Tin-Lead	MIL-P-81728

b. Soldering in accordance with the follows:
MIL-STD-2000
NHB 5300.4 (3A)

c. Brazing, soldering (nonelectrical), and welding in accordance with the following:
MIL-W-6858
MIL-W-6873
MIL-B-7883

d. Heat Treating and Surface Hardening
MIL-H-81200
MIL-H-6875
MIL-A-22771
MIL-H-7199

e. Metal Fabrication Assembly
MIL-S-13165
MIL-A-21180

f. Metal Machining Chemical Milling
MIL-C-8l769

g. Adhesive Bonding

MIL-A-83376	Non-structural adhesive bonding
MIL-A-83377	Structural adhesive bonding

HARDNESS ASSURANCE

10. Scope

This appendix is part of this handbook. The information contained is intended for guidance. This appendix provides the detailed requirements for managing a PMP radiation hardness assurance program for space and launch vehicles.

20. Radiation Hardness Assurance Program

The contractor should develop and implement a Radiation Hardness Assurance (RHA) Program for the design, development and production of all space flight hardware. The hardness assurance program should be through the RHA Program Plan.

20.1 Radiation Hardness Assurance (RHA) Program Plan

The contractor should develop, document and maintain an RHA Program Plan that details radiation hardness assurance tasks and responsibilities for assuring parts and materials meet RHA requirements. The RHA Program Plan should include the following:

a. Organizational responsibility and lines of interaction

b. Prime contractor's interaction with subcontractors

c. Part/material selection and qualification

d. Alternative design and procurement considerations for risk assessment

e. Method for derivation of radiation requirements for parts and materials

f. Method for determining part and material specification requirements in consideration of radiation environments and system engineering applications.

g. Development and maintenance of a radiation characterization database for parts and materials

20.2 Hardness Assurance Design Documentation

The contractor should prepare a RHA Design Guidelines which details or references all radiation analysis procedures, test procedures, data formatting and reporting requirements for materials and for electronic piece parts. This document should include, but not be limited to:

a. Circuit schematic, functional description, pin-out, operation conditions, and application of each critical circuit. Only required for electronic piece parts.

b. Specification of worst case radiation environment for each critical material and for piece parts in each critical circuit.

c. Specification of end point electrical parameters, tolerances, recovery times following a nuclear event, and parameter values at the end of mission.

d. The list of piece parts for each critical circuit showing the radiation or parameter design margin between worst case circuit requirements and the degradation of piece parts due to radiation.

e. The list of materials subject to radiation degradation showing the radiation or parameter design margin between the worse case requirements and the anticipated degradation of the material over its life.

f. Part RHA categorization in each critical circuit and each environment.

g. Results of hardness verification analyses and tests.

h. Test requirements and description of hardness assurance test items/test structures and process monitors.

i. List of critical design, layout rules, and processing parameters in each radiation environment.

j. Lot acceptance criteria and test results.

k. Special controls, screening and testing specified for parts with inadequate design margin.

20.3 **Representation or RHA Issues at Audits and Design Reviews** The contractor should have an RHA representative at all applicable design reviews, including preliminary and critical design reviews. The contractor should ensure that all system design decisions are evaluated for their effect upon the hardness assurance of the system and its components. In addition, the representative should ensure that the RHA Program Plan, the RHA Design Document, and the detailed specification are updated to incorporate any hardness assurance critical decisions made at the design reviews.

20.4 **Integrating Subcontractor RHA Capabilities** The prime contractor should flow down the applicable RHA requirements, as determined by the PMPCB, to the subcontractors to ensure system hardening requirements are met This includes ensuring the subcontractors have the capability to meet program RHA requirements. Timely communication channels between the subcontractor’s RHA activity and the prime contractor's RHA organizations should be maintained.

20.5 **Hardness Assurance Requirements** The order of precedence of 5.5.5 should apply to radiation hardened parts. When hardness assured parts and materials in accordance with the space quality baseline (3.1.25) are unavailable or do not meet the program’s radiation requirements, the contractors may develop detailed specifications or contractor prepared drawings for parts and materials upon approval by the PMPCB. All technical requirements for radiation hardness should be included in the detail specifications or contractor documentation, either directly stated or by reference to other documents. In addition, the procurement document should include a list of approved radiation test facilities. The detail specification or contractor prepared drawings should include:

a. Radiation test methods and test circuits.

b. Sample size and sampling method.

c. Radiation types and specification level.

d. Pre- and post-radiation response parameters and failure criteria.

e. Data reporting and analysis.

f. Dosimetry requirements.

g. Special radiation tests such as electrical or radiation screening tests.

20.5.1 **Radiation Characterization Tests** The contractor should ensure radiation characterization of parts and materials for the specified radiation environments. The radiation characterization may be based upon existing data bases analyses and/or design margins with review and approval by the PMPCB.

20.5.2 **Hardness Assurance Verification Analyses** The contractor should perform and document radiation analyses based on the part or material radiation characterization data to ensure that under worst case conditions, critical circuits or materials are capable of meeting the RHA requirements.

20.6 **Consideration and Assessment of RHA Technologies** Consideration of various RHA technologies should be made prior to their selection for use. Trade studies that optimize performance, cost, schedule, power, weight, producibility, and technical risk should be accomplished. When possible, proven technologies should be chosen before emerging technologies to mitigate technical risk. Selection preference should also be given to those technologies produced by more than one supplier. Not only will competition effect the cost of hardware, but second source availability reduces the risk to program associated with supplier failures.

EXPENDABLE LAUNCH VEHICLE (ELV) QUALITY BASELINE

This appendix is part of this handbook. The information contained is intended forguidance. This section lists those PMP items that are approved for use in expendable launch vehicle applications by the acquisition activity. The ELV quality baseline may be tailored by the acquisition activity for each specific program.

The EL-V quality baseline is listed in three sections:

Section I	Approved Parts
Section II	Approved Materials and Processes
Section In	ELV PAR/MAR Additional Provisions

SECTION I
APPROVED PARTS

a.	Microcircuits	Same as Appendix A
b.	Semiconductors	Same as Appendix A
c.	Hybrids	Same as Appendix A
d.	Capacitors	MIL-C-123, QPL MIL-C-87164, QPL MIL-C-87217/1, /3, and /4, QPL MIL-C-39003/10 failure rate C, QPL MIL-C-20, failure rates S, C, D. or E, QPL MIL-C-l9976, failure rates S, C, D, or E, QPL MIL-C-23269, failure rates S, C, D, or E, QPL MIL-C-39006, failure rates S, C, D, or E, QPL MIL-C-39014, failure rates S.C, D, or E, QPL MIL-C-55365, failure rates S, C, D, or E, QPL MIL-C-55681, failure rates S, C, D, or E, QPL MILC-83421, failure rates S, C, D, or E, QPL
e.	Resistors	MIL-R-87254, QPL MIL-R-39005, failure rate S or R (if S not QPL), QPL MIL-R-39007, failure rate S or R (if S not QPL), QPL MIL-R-39009, failure rate S or R (if S not QPL), QPL MIL-R-39017, failure rate S or R (if S not QPL), QPL MIL-R-55182, failure rate S or R (if S not QPL), QPL MIL-R-55342, failure rate S or R (if S not QPL), QPL
f.	Relays	MIL-R-39016, failure rate P or R, QPL MIL-R-6106, failure rate P or R, QPL
g.	EMI Filters	MIL-F-22861, Class S QPL
h.	Fuses	MIL-F-23419, QPL

i.	Magnetics	MIL-STD-981, Class S QPL MIL-T-27, Class S QPL MIL-21O38, Class S QPL
j.	Connectors	MIL-C-38999, QPL MIL-C-24308, QPL MIL-C-26482, QPL MIL-C-55302, QPL MIL-C-83723, QPL MIL-C-83733, QPL MIL-C-3655, QPL MIL-C-5015, QPL MIL-C-39012, QPL
k.	Crystal Oscillator	MIL-O-55310, QPL
l.	Mechanical	Parts procured to military specifications listed in the Department of Defense Index of Specifications and Standards, (DODISS), QPL, selected per MIL STD-97O and listed in the program’s approved PMPSL.

SECTION II

APPROVED MATERIALS AND PROCESSES

a.	Wire and Cable	MIL-W-22759/16, /17, /18, /19, /32, /33, /34, /35, /41, /42, /43, /44, /45, and /46 MIL-W-81381/7,/8,/9,/10,/11,/12,/13,/14,/17, and /19. MIL-C-275()() (equivalent types listed above)
	Internal Box Only	MIL-W-22759/28, /29, /30, and /31.
b.	Soldering	MIL-STD-2000 NHB 5300.4
c.	PWB Assembly	MIL-P-55110 MIL-P-50884 MIL-C-28809
d.	EEE Component Mounting	MIL-STD-275 MIL-STD-2118 MIL-STD-45743
e.	Others	Materials and processes certifiable to specifications listed in the Department of Defense Index of Standards (DODISS) selected in accordance with MIL-STD-970 and listed on the program's approved PMPSL.

SECTION III
ELV PAR/MAR ADDITIONAL PROVISIONS

For ELV applications, product procured in accordance with program technical requirements or QML/QPL product screened in accordance with program technical requirements do not require preparation and approval of a PAR/MAR However, the detailed specification must be approved by the PMPCB.

PARTS, MATERIALS, AND PROCESSES SELECTION LIST (PMPSL)

10. **Scope** This Appendix provides the detail requirements for submitting a list of Parts, Materials and Processes (PMP) in electromagnetic format that are approved for design in a specific contract.

20. **Format** The PMPSL, as generated by the work task of paragraph 5.3, should comply with the format of Tables D-l thru D-5. The PMPSL should be in electronic medium to the requirements of paragraph 20.3.

The PMPSL should be divided into five sections (note: "DB" is abbreviation for database):

Section 1: General heading (Table -D5).

Section 2: General electronic parts including electromagnetic, electro-optical, optics, and motors (Table - D1)

Section 3: General materials (Table - D2).

Section 4: General processes (Table - D4).

Section 5: General mechanical parts including nuts, bolts, fasteners, valves, and hydraulic fluid fittings. Note: Subassembly/Assembly level devices should not be listed in the PMPSL. The PMP used in the design of the Subassembly/Assembly should be listed in the PMPSL (Table D-3).

A letter “L” should be placed in the "LTD” field column for each ITEM which has LIMITED APPLICATIONS.

20 1 **Contents** The PMPSL should include all items identified as being required in Tables D-1 thru D-5.

a. Part type should be in accordance with Federal Cataloging Handbook H6 and name modifiers. Related description data such as physical size, hardness assurance capability, and special handling or material requirements should be added to the part description field, and carried over to comments field if extra room is required.

b. The comment field need not be completed for each PMP entry. It should be used for QPL status, part qualification, part shortages, part restrictions part usage, special screening requirements, limited application, documentation status, long lead time, health and safety considerations, or any other appropriate remarks.

c. If identical parts from more than one manufacturer are approved for usage, the PMPSL should have a separate entry for each manufacturer.

d. All subcontractors parts should be included in the appropriate section of the PMPSL and be identified by their cage code number.
note: The word part refers to parts, materials, or processes.

20.2 **Revisions to the PMPSL**. When the contractor revises the PMPSL, a new copy should be in accordance to the same requirements as stated in par 20, 20.1, 20.3, and Table D-5 (herein).

20.3 **Procedures for Electromagnetic Medium**. The PMPSL should be in electromagnetic medium such as tape or floppy disk at the contractor's option. The submittal should be in accordance with the requirements below:

a. Disk submittal should be either:
   3.5" DOUBLE SIDED DOUBLE DENSITY (720 KBYTES) DISK
   3.5" HIGH DENSITY (1.44KBYTES) DISK

b. Documentation as shown in Table D-5 should accompany each disk.

c. Database file types should be either:
   LOTUS 123; FOCUS; EXCEL; QUATRO/QUATRO PRO; DATABASE 3+ OR 4; ALPHA 4; R:BASE; PARADOX; ORACLE; FOX PRO; OMNIS 5; OR OTHER TYPES WITH APPROVAL.

d. American National Standard Code for Information Interchange (ASCII) files may be used provided the fields are delimited or padded with spaces to maintain a constant record length. Each record should be terminated by a carriage return/line feed.

e. Magnetic tape is acceptable when the following criteria is met:
   Tape Structure: 1600, 6250 (REEL)/ 3480 (CARIRIDGE)
   Tape Type: Nine (9) Track
   Tape Labeled: Process (Standard/Non Standard) Describe

   File Structure:
      Name: Dsname
      Written Format (Code Formation): - ASCII / EBCDIC
      Record Format (RECFM): Fixed, Fixed Block, or Variable
      Logical Record Length (LRECL = n): Size of Record
      Block Size (BLKSIZE = n): Number of Records in the Block
      Density 1600 OR 6250 BPI

SAMPLE OF RECORD LAYOUT

FIELD #	FIELD NAME	CHARACTER WIDTH	SIZE	DESCRIPTION
I	PRTTYPE	10	01-10	
2	PARTCHAR	15	11-25	

20.4 **Part Classifications Codes** Parts should be classified according to the qualification codes as follows:

JANS or JAN CLASS S	A
JANB or JAN CLASS B	B
QML	C
JANTXV	D
JANTX	E
JAN (no longer available)	F
PASSIVE PARTS FAILURE LEVEL L (2% per 1000 hours)	L
PASSIVE PARTS FAILURE LEVEL M (1% per 1000 hours)	M
PASSIVE PARTS FAILURE LEVEL P or B (0.1% per 1000 hours)	P
PASSIVE PARTS FAILURE LEVEL R or C (0.01% per 1000 hours)	R
PASSIVE PARTS FAILURE LEVEL S or D (0.001% per 1000 hours)	S
PASSIVE PARTS FAILURE LEVEL T (0.0001% per 1000 hours)	T
CONTRACTOR SCD REQUIREMENTS	G
LOCKHEED (LMSC) MONITORED LINE PART	H
SOURCE CONTROL DRAWING IMPOSING MIL-STD-1547 REQUIREMENTS	J
SMD	K

TABLE D-1. **PMPSL DB field requirements for electronic parts**

Required fields and minimum field widths with a recommended format and structure

FIELD NUM	FIELD DATA DESCRIPTION	DB NAME	FIELD WIDTH	REQ'D
1	Part type (Resistor, Diode, etc.)(note 4)	PRTTYPE	10	YES
2	Part characteristic (Family type)(note 4)	PRTCHAR	15	YES
3	Part description (Voltage, Current, etc.)(note 4)	PRTDESC	40	OPT
4	Part usage (Where is the part used)(note 4)	PRTUSAGE	26	OPT
5	Contractor specification number	SPECNO	20	YES
6	Supplier/part manufacturer name	MFGNAME	20	YES
7	Part manufacture/cage code (Use Federal H4/H8 Cage Code Directory)	MFGCAGE	6	YES
8	Manufacturer part number	MFGPRTNO	26	OPT
9	Generic part number(Commonly accepted commercial part number)	GENERIC	20	YES
10	Military part number (As defined per applicable MIL SPEC)	MILPRTNO	20	YES
11	National stock number	NSN	20	OPT
12	Limited application for parts	LIMITED	1	YES
13	Part classification (See para 20.4)	CLASS	1	YES
14	Radiation Hardness Assurance (note 4)	RHA	1	YES
15	Comments (should be filled out for limited application or any other pertinent data)(note 2)	COMMENT	160	YES

NOTES

1. "OPT" found in the REQ'D field column indicates that data need not be entered for that field, but should be PART of the database structure.
2. Field # 15 (COMMENTS) may be left blank if no pertinent information exist.
3. Field # 14 to be left blank for non radiation hardened parts.
4. Sample inputs for part types.

PART TYPE	PART CHAR	PART DESCRIPTION	PART USAGE
MICROCIRCUIT	DIGITAL CMOS	DUAL FLIP/FLOP	HIGH SPD-CLOCK
RESISTOR	WIRE VARIABLE	1/8W 0-115K	PREC TIMING CKT
RESISTOR	FILM CHIP	1/16W 5K	HYBRID
CAPACITOR	TANTALUM SOLID	60V 32MF	FILTER
CAPACITOR	CERAMIC CHIP	50V .001MF	COUPLING

TABLE D-2. **PMPSL DB field requirements for materials**

Required fields and minimum field widths along with a recommended format and structure

FIELD NUM	FIELD DATA DESCRIPTION	DB NAME	FIELD WIDTH	REQ'D
1	Material (Metal, organic, composite, etc.)	MAT	10	YES
2	Material Type (Tin, gold, polymer, etc.)	TYPE	10	YES
3	Material Form (Bar, rod, sheet, wire, etc.)	FORM	10	YES
4	Trade Name (Common industry usage name)	TRNAME	20	YES
5	Supplier/Manufacturer (mfg.) Name	MFGNAME	20	YES
6	Supplier/Manufacturer Cage Code	MFGCAGE	6	YES
7	Contractor Specification Number	SPECNO	26	YES
8	Generic or Military (MIL) Part Number	MILPRTNO	20	YES
9	Hazardous Material (note 1)	CAUT	2	YES
10	Shelf-Life Control Item (note 2)	SHELF	1	YES
11	Qualification Status (note 5)	QUAL	1	YES
12	Limited Application for Material (note 3)	LIMITED	1	YES
13	Comments (note 4)	COMMENT	160	YES

NOTES:

1. The following codes should be used in hazardous material field number 9:
   a. Creates health hazard if not handled properly.
   b. Environmental hazard.
   c. Fire/explosive hazard.
   d. Other (explain in comment field).

2. If the material has limited shelf life add "L'" to field number 10.

3. If the material has a limited application for a specific function/job add 12 and specify application in comments field.

4. Comment field may be left blank if no applicable information is required.

5. If the material is qualified use '"Q" in field number 11 and state in comment field 13 how it is qualified.

TABLE D-3 **PMPSL DB field requirements for mechanical parts and assemblies**

Required fields and minimum field widths with a recommended format and structure

FIELD NUM	FIELD DATA DESCRIPTION	DB NAME	FIELD WIDTH	REQ'D
1	Part type/name (note 3)	PRTTYPE	20	YES
2	Part description (note 3)	PRTCHAR	15	YES
3	Part material (note 3)	PRTMAT	25	YES
4	Contractor specification number	SPECNO	26	YES
5	Generic or Military (MIL) Part Number	MILPRTNO	22	YES
6	Supplier/part manufacturer name	MFGNAME	20	YES
7	Supplier/part manufacturer cage code	MFGCAGE	6	YES
8	Supplier/part manufacturer part number	MFGPRTNO	26	YES
9	Limited application for parts (note 1)	LIMITED	1	YES
10	Qualification status (note 2)	QUAL	1	YES
11	Comments	COMMENT	160	YES

NOTES:

1. If the part has a limited application for a specific function/job, add “L” to field number 9 and specify application in Comment field number 11.

2. If part is qualified use the following codes to describe how it is qualified:

NAS STD	A
FED-STD	B
MIL-STD	C
DESIGN & TEST	D
SIMILARITY - State in comment field 11 the program and conditions for qualification.	S
OTHER - State in comment field 11 the program and the conditions for qualification.	O

3. Sample inputs for part types:

PART TYPE	PART DESCRIPTION	PART MATERIAL	COMMENTS
NUT	10X32, 1” DIAM.	CRES	
VALVE	FUEL	BRASS	HYDROGEN
CABLE TIES	¼ INCH	NYLON 66	120 lb. RATING

TABLE D-4 **PMPSL DB field requirements for processes**

Required fields and minimum field widths with a recommended format and structure

FIELD NUM	FIELD DATA DESCRIPTION	DB NAME	FIELD WIDTH	REQ'D
1	Process Title (Heat treatment, soldering, etc.)	TITLE	20	YES
2	Process number (MIL, Federal, Industry, Contractor, etc.)	NUM	20	YES
3	Process Description (Ag plating, quenching, soldering, etc.)	DESCR	40	YES
4	Qualification status	QUAL	1	OPT
5	Limited application (note 3, Table D-2)	LIMITED	1	YES
6	Hazardous Process (note 1, Table D-2)	HAZARD	1	YES
7	Need Code	NEED	1	OPT
8	Comments (note 4, Table D-2)	COMMENT	160	OPT

TABLE D-5 **PMPSL database documentation requirements for each submittal**

REQUIRED DATA TO BE SUPPLIED WITH EACH NEW OR REVISED PMPSL SUBMITTED
EACH ENTRY FOR INFORMATION TO BE ON A SEPARATE LINE

CONTRACTOR NAME __________

CONTRACTOR CAGE CODE __________

CONTRACTOR ADDRESS __________

CONTRACTOR CITY __________

CONTRACTOR STATE __________

CONTRACTOR ZIP __________

PMPSL CONTROL # __________

PMPSL REVISION # __________

CONTRACT # __________

USER (NASA, NAVY, SMC) __________

PROGRAM NAME (IUS, DSCS) __________

DATA ITEM TITLE __________

DATE OF LAST REVISION __________

RESPONSIBLE GROUP PHONE # __________

TOTAL NUMBER OF RECORDS __________

COMMENTS __________

Documentation paper should be furnished with each disk or tape containing the following:
Type of disk/tape, Name of file, Name of each field and its width, plus the electromagnetic medium requirements in para 20.3 herein.

AS-DESIGNED PARTS, MATERIALS, AND PROCESS LIST (ADPMPSL)

10. **Scope** This Appendix provides the detail requirements far submitting a list of Parts, Materials and Processes (PMP) in electromagnetic format that are approved for design in a specific contract.

20. **Format** The ADPMPL, as generated by the work task of paragraph 5.3, should comply with the format of Tables E-l thru E-5. The ADPMPL should be in electromagnetic medium to the requirements of paragraph 20.3.

The ADPMPL should be divided into five sections (note: "DB" is abbreviation for database):

Section 1: General heading (Table E-5).

Section 2: General electronic parts including electromagnetic, electro-optical, optics, and motors (Table E-I).

Section 3: General materials (Table E-2).

Section 4: General processes (Table E-4).

Section 5: General mechanical parts including nuts, bolts, fasteners, valves, and hydraulic and fluid fittings. Note: Subassembly/Assembly level devices should not be listed in the ADPMPL. The PMP used in the design of the Subassembly/Assembly should be listed in the ADPMPL (Table E-3).

A letter "L", should be placed in the "LTD" field column for each ITEM which has LIMITED APPLICATIONS.

20.1 **Contents.** The ADPMPL should include all the items identified as being required in Tables E-l through E-5.

a. Part type should be in accordance with Federal Cataloging Handbook H6 and name modifiers. Related description data such as physical size, hardness assurance capability, and special handling or material requirements should be added to the part description field, and carried over to comments field if extra room is required.

b. The comment field need not be completed for each PMP entry. It should be used for QPL status, part qualification, part shortages, part restrictions, part usage, special screening requirements, limited application, documentation status, long lead time, health and safety considerations, or any other appropriate remarks.

c. If identical parts from more than one manufacturer are approved for usage, the ADPMPL should have a separate entry for each manufacturer.

d. All subcontractors part should be included in the appropriate section of the ADPMPL and be identified by their cage code number.

note: The word part refers to parts, materials, or processes.

20.2 **Revisions to the ADPMPL**. When the contractor revises the ADPMPL, a new copy should be in accordance to the same requirements as stated in para 20, 20.1, 20.3, and Table E 5 (herein).

20.3 **Procedures for Electromagnetic Medium**. The ADPMPL should be in electromagnetic medium such as tape or floppy disk at the contractor's option. The submittal should be in accordance with the requirements below:

a. Disk submittal should be either:
3.5" DOUBLE SIDED DOUBLE DENSITY (720 KBYTES) DISK
3.5" HIGH DENSITY (1.44MBYTES) DISK

b. Documentation as shown in Table E-5 should accompany each disk.

c. Database file types should be either:
LOTUS 123; FOCUS; EXCEL; QUATRO/QUATRO PRO
DATABASE 3+ OR 4; ALPHA 4; R:BASE; PARADOX; ORACLE;
FOX PRO; OMNIS 5; OR OTHER TYPES WITH APPROVAL.

d. American National Standard Code for Information Interchange (ASCII) files may be used provided the fields are delimited or padded with spaces to maintain a constant record length. Each record should be terminated by a carriage return/ line feed.

C. Magnetic tape is acceptable when the following criteria is met:
Tape Structure: 1600, 6250 (REEL)/ 3480 (CARTRIDGE)
Tape Type: Nine (9) Track
Tape Labeled: Process (Standard/Non Standard) Describe.

File Structure:
Name: Dsname
Written Format (Code Formation): - ASCII/EBCDIC
Record Format (RECFM): Fixed Block, or Variable
Logical Record length (LRECL =n): Sire of Record
Block Sire (BLKSIZE = n): Number of Records in the Block
Density: 1600 OR 6250 BPI

SAMPLE OF RECORD LAYOUT

FIELD #	FIELD NAME	CHARACTER WIDTH	SIZE	DESCRIPTION
1	PRTTYPE	10	01 - 10	
2	PARTCHAR	15	11 - 25	

20.4 **Part Classifications Codes**. Parts should be classified according to the following codes:

JANS or JAN CLASS S	A
JANB or JAN CLASS B	B
QML	C
JANTXV	D
JANTX	E
JAN (no longer available)	F
PASSIVE PARTS FAILURE LEVEL L (2% per 1000 hours)	L
PASSIVE PARTS FAILURE LEVEL M (1% per 1000 hours	M
PASSIVE PARTS FAILURE LEVEL P or B (0.1% per 1000 hours)	P
PASSIVE PARTS FAILURE LEVEL R or C (0.01% per 1000 hours)	R
PASSIVE PARTS FAILURE LEVEL S or D (0.001% per 1000 hours)	S
PASSIVE PARTS FAILURE LEVEL T (0.0001% per 1000 hours)	T
CONTRACTOR SCD REQUIREMENTS	G
LOCKEED (LMSC) MONITORED LINE PART	H
SOURCE CONTROL DRAWING IMPOSING MIL-STD-1547 REQUIREMENTS	J
SMD	K
PASSIVE PARTS FAILURE LEVEL R or C (0.01% per 1000 hours)	R

TABLE E-1. **ADPMPL DB field requirements for electronic parts**

Required fields and minimum field widths with a recommended format and structure

FIELD NUM	FIELD DATA DESCRIPTION	DB NAME	FIELD WIDTH	REQ'D
1	Part type (Resistor, Diode, etc.)(note 4)	PRTTYPE	10	YES
2	Part characteristic (Family type)(note 4)	PRTCHAR	15	YES
3	Part description (Voltage, Current, etc.)(note 4)	PRTDESC	40	YES
4	Contractor specification number	SPECNO	20	YES
5	Supplier/part manufacturer name	MFGNAME	20	YES
6	Generic or Military (MIL) part number	PARTNUM	22	YES
7	Number parts used per vehicle	TOTQUANT	6	YES
8	Limited application add "L" for limited application and describe in Comment filed	LIMITED	1	YES
9	Radiation Hardened part (note 3)	RADHARD	1	YES
10	End item part number (black box part used in)	ITEMDWG	20	YES
11	End item name (black box part used in)	ITEMNAME	20	YES
12	Number parts used per black box	QUANTITY	6	YES
13	Comments (should be filled out for limited application or any other pertinent data)(note 2)	COMMENT	160	YES

NOTES

1. "OPT" found in the REQ'D field column indicates that data need not be entered for that field, but should be PART of the database structure.

2. Field # 13 (COMMENTS) May be left blank if no pertinent information exist.

3. Field # 9 add "R" for radiation hardened parts. If the part is rad hard and tested, the level may be added to Comment field 13.

3. Sample inputs for part types.

PART TYPE	PART CHAR	PART DESCRIPTION	PART USAGE
MICROCIRCUIT	DIGITAL CMOS	DUAL FLIP/FLOP	HIGH SPD CLOCK
RESISTOR	WIRE VARIABLE	1/8W 0-115K	PREC TIMING CKT
RESISTOR	FILM CHIP	1/16W 5K	HYBRID
CAPACITOR	TANTALUM SOLID	60V 32MF	FILTER
CAPACITOR	CERAMIC CHIP	50V .001MF	COUPLING

TABLE E-2. **ADPMPL DB field requirements for materials**

Required fields and minimum field widths along with a recommended format and structure

FIELD NUM	FIELD DATA DESCRIPTION	DB NAME	FIELD WIDTH	REQ'D
1	Material (Metal, organic, composite, etc.)	MAT	10	YES
2	Material Type (Tin, gold, polymer, etc.)	TYPE	10	YES
3	Material Form (Bar, rod, sheet, wire, etc.)	FORM	10	YES
4	Trade Name (Common industry usage name)	TRNAME	20	YES
5	Supplier/Manufacturer (mfg) name	MFGNAME	20	YES
6	Contractor Specification (SPEC) Number	SPECNO	26	YES
7	Generic or Military (MIL) part number	PARTNUM	22	YES
8	Hazardous Material (note 1)	CAUT	2	YES
9	Shelf-Life Control Item (note 2)	SHELF	1	YES
10	End Item part number (black box material (mat) used in)	ITEMDWG	20	YES
11	End Item name (black box mat used in)	ITEMNAME	20	YES
12	Total amount of mat used per black box	QUANTITY	6	YES
13	Total amount of mat used per spacecraft/launch vehicle	TOTQUANT	6	YES
14	Limited Application for Material (note 3)	LIMITED	1	YES
15	Qualification Status (note 5)	QUAL	1	YES
16	Comments (note 4)	COMMENT	160	YES

NOTES:

1. The following codes should be used in hazardous material field number 8:
   a. Creates health hazard if not handled properly.
   b. Environmental hazard.
   c. Fire/explosive hazard.
   d. Other (explain in comment field).

2. If the material has a limited shelf life add "L" to field number 9.

3. If the material has a limited application for a specific function/job add 'L" to field number 14 and specify application in comments field.

4. Comment field may be left blank if no applicable information is required.

3. If the material is qualified use "Q" in Qualification field number 15 and state in Comment field number 16 how it is qualified.

TABLE E-3 **ADPMPL DB field requirements for mechanical parts and assemblies**

Required fields and minimum field widths with a recommended format and structure

FIELD NUM	FILED DATA DESCRIPTION	DB NAME	FIELD WIDTH	REQ'D
1	Part type/name (note 4)	PRTTYPE	20	YES
2	Part description (note 4)	PRTCHAR	15	YES
3	Part material (note 4)	PRTMAT	25	YES
4	Contractor specification number	SPECNO	26	YES
5	Generic or Military (MIL) part number	PARTNUM	22	YES
6	Supplier/part manufacturer name	MFGNAME	20	YES
7	End Item part number (black box part used in)	ITEMDWG	20	YES
8	End Item name (black box part used in)	ITEMNAME	20	YES
9	Number of parts used per black box	QUANTITY	6	YES
10	Number of parts used per vehicle	TOTQUAN	6	YES
11	Limited Application for Parts (note 1)	LIMITED	1	YES
12	Qualification Status (note 3)	QUAL	1	YES
13	Comments (note 2)	COMMENT	160	YES

NOTES:

1. If the material has a limited application for a specific function/job add "L" to field number 11 and specify application in comment field 12.

2. Comment field 12 may be left blank if no applicable information is required.

3. If part is qualified use the following codes to describe how it is qualified:

NAS STD	A
FED-STD	B
MIL-STD	C
DESIGN & TEST	D
SIMILARITY-State in comment field 11 the program and conditions for qualification.	S
OTHER -State in comment field 11 the program and the conditions for qualification.	0

3. Sample inputs for part types

PART TYPE	PART DESCRIPTION	PART MATERIAL	COMMENTS
NUT	10X32, 1" DIAM	CRES	
VALVE	FUEL	BRASS	HYDROGEN
CABLE TIES	1/4 INCH	NYLON 66	120 lb. RATING

TABLE E-4. **ADPMPL DR field requirements for processes**

Required fields and minimum field widths with a recommended format and structure

FIELD NUM	FIELD DESCRIPTION	DB NAME	FIELD WIDTH	REQ'D
1	Process Title (Heat Treatment, Soldering, etc.)	TITLE	20	YES
2	Process number (MIL, Federal, Industry, Contractor)	NUM	20	YES
3	Process Description (Ag plating, soldering, etc.)	DESCR	40	YES
4	Limited Application (note 1)	LIMITED	1	YES
5	Hazardous Process (note 3)	HAZARD	1	YES
6	End Item part number (black box process used in)	ITEMDWG	20	YES
7	End Item name (black box process used in)	ITEMNAME	20	YES
8	Comments (note 2)	COMMENT	160	YES

NOTES:

1. If the material or process has limited application for a specific function/job add "L" to field number 4 and specify application in comment field 8.

2. Comment field 8 may be left blank if no applicable information is required.

3. The following codes should be used in hazardous material field number 8:
   a. Creates health hazard if not handled properly.
   b. Environmental hazard.
   c. Fire/explosive hazard.
   d. Other (explain in comment field).

TABLE E-5. **ADPMPL database documentation requirements for each submittal**

REQUIRED DATA TO BE SUPPLIED WITH EACH NEW OR REVISED ADPMPL SUBMITTED
EACH ENTRY FOR INFORMATION TO BE ON A SEPARATE LINE

CONTRACTOR NAME ______________
CONTRACTOR CAGE CODE ______________
CONTRACTOR ADDRESS ______________
CONTRACTOR CITY ______________
CONTRACTOR STATE ______________
CONTRACTOR ZIP ______________
ADPMPL CONTROL # ______________
ADPMPL REVISION # ______________
CONTRACT # ______________
USER (NASA, NAVY, SMC) ______________
PROGRAM NAME (IUS, DSCS) ______________
DATA ITEM TITLE ______________
DATE OF LAST REVISION ______________
RESPONSIBLE GROUP PHONE # ______________
TOTAL NUMBER OF RECORDS ______________
COMMENTS ______________

Documentation paper should be furnished with each disk or tape containing the following:
Type of disk/tape, Name of file, Name of each field and its width, plus the electromagnetic medium requirements in para. 2O.3 herein.

FAILURE SUMMARY AND ANALYSIS REPORT (FSAR)

10. **Scope** This appendix provides the detail requirements for submitting the parts and materials Failure Summary and Analysis Report (FSAR) in electromagnetic format over the life of a program for a specific contract. This appendix is used by the procuring activity to monitor/evaluate all program piece parts failures.

20. **Format** The FSAR as generated by the work task paragraph 5.12 should comply with the format of Tables F-l and F-2.

20.1 **Contents** The FSAR should include all the items identified as being required in Table F-1.

a. Part type should be per Federal Cataloging Handbook H6 and name modifiers.
b. Each part analyzed, should be a separate record.
c. A separate FSAR record should be required for each part or material number/type analyzed.

20.2 **Revisions to the FRAR** when the contractor revises the FSAR, a new copy should be in accordance to the same requirements as stated in para 20, 20.1, 20.3, 20.4 and Table F-2.

20.3 **Procedures for Electromagnetic Medium** The FSAR should be in electromagnetic medium such as tape or floppy disk at the contractor's option. The submittal should be in accordance with the requirements below:

a. Disk submittal should be either:
    3.5" DOUBLE SIDED DOUBLE DENSITY (720 KBYTES) DISK
    3.5" HIGH DENSITY (l.44 MBYTES) DISK
b. Documentation as shown in Table F-2 should accompany each disk
c. Database file types should be either:
    LOTUS 123; FOCUS; EXCEL; QUATRO/QUATRO PRO
    DATABASE 3+ OR 4; ALPHA 4; R:BASE; PARADOX; ORACLE;
    FOX PRO; OMNIS 5; OR OTHER TYPES WITH APPROVAL
d. American National Standard Code for Information Interchange (ASCII) files may be used provided the fields are delimited or padded with spaces to maintain a constant record length. Each record should be terminated by a carriage return/ line feed.
c. Magnetic tape is acceptable when the following criteria is met:
    Tape Structure: 1600,6250 (REEL)/ 3480 (CARTRIDGE)
    Tape Type: Nine (9) Track
    Tape Labeled: Process (Standard/Non Standard) Describe.
    File Structure:
        Name: Dsname
        Written Format (Code Formation): - ASCII / EBCDIC
        Record Format (RECFM): Fixed, Fixed Block, or Variable
        Logical Record length (1-RECL = n): Size of Record
        Block Size (13LKSIZE = n)t Number or Records in the Block
        Density: 1600 OR 6250 BPI

SAMPLE OF RECORD LAYOUT

FIELD #	FIELD NAME	CHARACTER WIDTH	SIZE	DESCRIPTION
1	PRTTYPE	10	01-10	
2	PARTCHAR	15	11-25	

TABLE F-1 **FSAR database field requirements**

Required fields and minimum field widths along with a recommended format and structure

FIELD NUM	FIELD DATA DESCRIPTION	DBASE NAME	FIELD WIDTH	REQ'D
1	Failure Analysis Report (FAR) number	FARNO	16	YES
2	Failed part type (Resistor, Diode, Capacitor, etc.)(para 20.4.5)	PRTTYPE	10	YES
3	Part characteristic (Film, Ceramic, Mica, etc.)	PRTCHAR	15	YES
4	Part description (Voltage, Current, etc.)	PRTDESC	40	OPT
5	Contractor specification number	SPECNO	20	YES
6	Part supplier/manufacturer name	MFGNAME	20	YES
7	Generic, Military or Industry part number	PARTNUM	22	YES
8	Program name where part failed	PRG	8	YES
9	Lot date code (LDC) start (note 4)	LDCSTRT	10	YES
9a	Lot date code (LDC) end (note 4)	LDCEND	10	YES
10	Serial number of end item (black box)	SN	10	YES
11	NR: Report number that caused FAR to be opened	NR	10	YES
12	Next assembly drawing (dwg) number of printed wiring board	PWBDWG	20	YES
13	End item usage (black box) dwg number	EIDWG	20	YES
14	End item usage name (Receiver)(name of black box)	EINAME	20	YES
15	Vehicle dwg/identification where box installed	VEHNUM	10	YES
16	Date failure occurred	DATEO	8	YES
17	Date FAR closed	DATEC	8	YES
18	Failure review board number that closed FAR	FRBNO	6	YES
19	Cause of part failure (summary in words)	CAUSE	160	YES
20	Corrective action summary	CA	60	YES
21*	Phase of manufacturing (mfg) when failure occurred (para 20.4.1)	PHASE	3	YES
22*	Test event when failure occurred (para 20.4.3)	TEST	5	YES
23*	Level of assembly when failure occurred (20.4.2)	LEVEL	3	YES
24*	Part defect caused by: see para 20.4.4	DEFECT	5	YES
25	Sub Contractor Name (mfg of black box)	SUBCONT	20	YES
26	Comment (note 3)	COMMENT	160	OPT

NOTES:

1. "OPT" found in the REQ'D (required) field column indicates that data need not be entered for that field, but should be part of the database structure.
2. "*" found in the Field Num column indicates that database field should be filled with the failure/defect codes identified in the applicable para referenced in the data description field.
3. The Comment field need only be used when appropriate.
1. Use Symbol ">" after LDC to indicate all subsequent LDCs are suspect. Use Symbol "<"after LDC to indicate all prior LDCs are suspect. Use symbol "S" after LDC to indicate a multiple of LDCs between LDCSTART and LDCEND are suspect.

20.4 Recommended code definitions for the applicable database fields. The contractor may use their own codes or add additional codes to describe when, where, and how the failure occurred. The contractor should provide documentation to describe these codes in accordance with para 20.4.4 (herein).

20.4.1 Phase of manufacturing when failure occurred (Table F-1 #21)

	NAME	CODE
a.	Assembly and Integration (A/I)	AI
b.	System	SYS
c.	Post System	POS
d.	Launch Preparations/OPS	OPS
e.	Other	OTH

20.4.2.1 Level of assembly when failure occurred (Table F-1 #23)

	NAME	CODE
a.	Destructive Physical Analysis	DPA
b.	Receiving Inspection	REC
c.	Lot Acceptance Test	LAT
d.	Printed Wiring Board	PWB
e.	Component (Black Box)	BOX
f.	Subsystem	SUB
g.	Vehicle	VEH
h.	Other	OTH

20.4.2.2 Testing event where failure occurred (Table F-1 #22)

	NAME	CODE
a.	Pre Acceptance Test Procedure (ATP)	PRATP
b.	1st Electrical	FSTEL
c.	Thermal Cycle Test	TC
d.	Thermal Vacuum Test	TV
e.	Shock Test	SHOCK
f.	Sine Vibration Test	VIBSI
g.	Random Vibration Test	VIBRA
h.	Acceleration Test	ACCEL
i.	Acoustic	ACUST
j.	Climatic (Humidity, Altitude, etc.)	CLIMA
k.	Burn-In Test	BURIN
l.	EMI Test	EMI
m.	Special Test	SPEC
n.	Leak Test	LEAK
o.	Pressure Test	PRESS
p.	Mechanical Test	MECH
q.	Final Electrical	FINEL
r.	Radiation Test	RAD
s.	Other	OTH

20.4.4 Cause code of part failure (Table F-1 #24)

	PART DEFECT CAUSED BY PART MANUFACIURE	CODE
a.	Contamination	MC
b.	Short	MS
c.	Open	M0
d.	Out Of Tolerance	MT
e.	Drift	MD
f.	Mechanical Damage	MM
g.	Friction	MF
h.	Wrong Material/Defective Material	MD
i.	Wrong Heat Treatment	MH
j.	Part Workmanship	MW
k.	Part anomaly could not be detected/duplicated	NP
l.	Manufacturer Other (added to comments Table F-l #26)	MOTH

PART DEFECT CAUSED BY CONTRACTOR

m.	Misapplication/Design	CM
n.	Mishandling	CH
o.	Planning Paper Error	CP
p.	Workmanship	CW
q.	Contractor Others (added to comments Table F-1 #26)	C0TH

20.4.3 Sample inputs for part types (see Table F-1, Field Num 1,2, & 3)

PART TYPE	PART CHAR	PART DESCRIPTION	PART USAGE
MICRO CKT CIRCUIT	DIGITAL CMOS	DUAL FLIP/FLOP	HIGH SPD CLOCK
RESISTOR	WIRE	VAR 1/8W 0-115K	PREC TIMING CKT
RESISTOR CHIP	FILM	1/16W 5K	HYBRID
CAPACITOR	TANTALUM SLUG	60V 32MF	FILTER
10 x32, 1" DIAM	CRES		
VALVE	FUEL	BRASS	HYDROGEN
CABLE TIES	1/4 INCH	NYLON 66	120 Lb. RATING

TABLE F-2 **FSAR database documentation requirements for each submittal**

REQUIRED DATA TO BE SUPPLIED WITH EACH NEW OR REVISED ADPMPL SUBMITTED
EACH ENTRY FOR INFORMATION TO BE ON A SEPARATE LINE

CONTRACTOR NAME ______________
CONTRACTOR CAGE CODE ______________
CONTRACTOR ADDRESS ______________
CONTRACTOR CITY ______________
CONTRACTOR STATE ______________
CONTRACTOR ZIP ______________
ADPMPL CONTROL # ______________
ADPMPL REVISION # ______________
CONTRACT # ______________
USER (NASA, NAVY, SMC) ______________
PROGRAM NAME (IUS, DSCS) ______________
DATA ITEM TITLE ______________
DATE OF LAST REVISION ______________
RESPONSIBLE GROUP PHONE # ______________
TOTAL NUMBER OF RECORDS ______________
COMMENTS ______________

Documentation paper should be furnished with each disk or tape containing the following:
Type of disk/tape, Name of file, Name of each field and its width, plus the electromagnetic medium requirements in para. 2O.3 herein.

APPENDIX A
RADIATION HARDNESS ASSURANCE REQUIREMENTS

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.
RMF	Is the geometric mean radiation failure value.
PDM	Is the parameter design margin.
PMD	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 should '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 should be accompanied by the mean and standard deviation of the critical parameters. These failure values should 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.

$$R_{DM} = \frac{R_{MF}}{R_{SPEC}} \qquad (1)$$

where

$$R_{MF} = \exp \overline{(\ln(R_{FAIL}))} \qquad (2)$$

$$\overline{\ln(R_{FAIL})} = 1/n \sum_{i=1}^{n} \ln(R_{FAILi}) \qquad (3)$$

where R_{FAIi} 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:

$$SR = \left\{ 1/(n-1) \sum_{i=1}^{n} \left\{ \ln(R_{FAILi}) - \overline{\ln(R_{FAILi})} \right\}^2 \right\}^{1/2} \qquad (4)$$

40.5 Part Categorization Methods. HCC-1M and HCC-2 piece parts should be categorized in each radiation environment using the following categorization method options:

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 should 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_1 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 should 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, should 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 Category1M. For total dose, the recommended acceptable minimum design margin is 3. Parts with an RDM of 2 or less, should not be used.

Unless otherwise specified, the survival probability should be 99 percent and the confidence level should 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-I), the data should be recorded.

From the data, the values of R_{FAIL} at PAR_{FAIL}I are obtained. (Annealing effects should be considered when applicable-) The lot is accepted when:

I $\quad RDM(Lot) \geq \exp(K_{TL}\ S_R(lot)) \quad$ (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 has 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, P_{DM}, 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-I).

The parameter mean value degradation P_{MD} is calculated from the radiation-induced parameter value PAR_{RAD} as follows:

$$\overline{\ln(PAR_{RAD})} = 1/n \sum_{i=1}^{n} \ln(PAR_{RADi}) \qquad (6)$$

where PAR_{RAD} is the radiation-induced parameter value for the i^{th} device.

The parameter mean value degradation is calculated as:

$$PMD = \exp\{\ln(\overline{PAR_{RAD}})\} \qquad (7)$$

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:

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

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

(b) For parameter value decreasing with radiation:

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

where

$$SR = \left\{1/(n-1) \sum_{i=1}^{n} \left\{\ln(R_{FAILi}) - \overline{\ln(R_{FAILi})}\right\}^2 \right\}^{1/2} \qquad (10)$$

50.3 Radiation Testing

50.3.1 Radiation Testing. The radiation test methods should 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 should be based on characterization data including post-irradiation effects, and latchup windows in latchup testing.

When 100% latchup screen is specified, testing should 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 at pre, during, and at post irradiation should be specified in the detailed specification.

FIGURE A-I. Lot Conformance Tests

Notes: A/Method 50.2.1: Multiple radiation levels

B/ Method 5022: Single radiation level

Microcircuits and semiconductor devices subjected to radiation testing should 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 should 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 should be selected from each wafer.

50.3.3 Lot Traceabilitv. Lot traceability should 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 should be tested in accordance with the applicable subgroup in Table A-1. Dice or hybrid circuits subjected to radiation testing should 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 Table A-1 can be applied as an alternate test plan.

50.3.5 Quartz Crystals. Radiation testing should be conducted in accordance with the applicable test methods in Table A-1. The minimum sample size should be 5 parts from a single lot. The same parts may be used for more than one environment. The frequency shift and resistance change should be measured per MILC-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 should be measured at pre and post irradiation with the time limit between irradiation and testing specified in Test Method 1019. For neutron irradiation, the test should be conducted in situ with the parts maintained at turnover temperature. Transient irradiation testing should be conducted with the parts kept at turnover temperature. The frequency and resistance changes should meet the specified 95 percent confidence level and 99 percent survival probability unless otherwise acceptable to the design activity.

50.3.6 Test Plans and Test Procedures. Radiation testing should be based on documented radiation test plans and procedures. The test plan should define the details of the testing to be; performed in each radiation environment for each part type. The test plans and procedures should 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 MIL-STD-883, Method 1019), 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 Combined Environments Damage. The parameters -degradation limit X_{LLC} or Parameter PAR due to the combined total ionizing dose and neutron fluence environments should be calculated as follows:

For a normal distribution:

$$X_{LLC} = PAR_{MPN} + PAR_{MPD} + \{(K_{TLN}S_N)^2 + (K_{TLD}S_D)^2\}^{1/2} \qquad (11)$$

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

PAR_{MPN} and PAR_{MPD} 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 should be selected based on radiation design margin equal to or greater than 10. When specific data is lacking, radiation testing should 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 should be specified.. The method of applying the metal shield should 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	
Upset	Methods 1021/1023	10
Latchup	Method 1020	As specified
Burnout	Detailed Specification	10
Single Event Upset	ASTM F-1192	4

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

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

3/ Sampling plan should be 4 parts per wafer for MSI and 2parts 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 should 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	4.722
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	3.66	1.119	1.366	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	7.50	---	---	---.	---	---
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	6.06	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	3.416	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	4.701

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 to provide interim space flight worthy devices whenever the JANS or Class S was not immediately available.

20. APPLICATION These requirements are applicable only to QPL/QML product and only to the product assurance levels specified. Application of this Appendix to other product assurance levels is unacceptable unless the manufacturer illustrates that the same or better controls as for the QPL/QML product.

30. CLASS B MICROCIRUIT UPSCREENING/LOT ACCEPTANCE TESTING

MIL-M-38510 microcircuits, Class B should 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 should 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, should be 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-Ia. MIL-M-38510 Class B Microcircuit Upscreening (Test 100%), Test Methods of MIL-STD-883

SCREEN	METHOD	REQUIREMENTS
1. Prescreen Electricals 3/ & 7/	5005	YLN of 2% optional but encouraged. 9/
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 (R & R) at 25°C
6. High Temperature Reverse Bias (HTRB) burn-in 6/ & 8/	1015	Test Condition A or C, 48 hr. minimum at +150°C or the device maximum operating limit, whichever is lower.
7. Post HTRB Electricals and deltas 3/ & 7/		R & R @ 25°C within 16 hr. of removal from bias. Percent Defective Allowable (PDA): 1st Pass: 5% or 1 whichever is greater 5/ 2nd Pass: 3% or 1 whichever is greater 6/
8. Power Burn-In Test 8/	1015 4/	240 hr. minimum at 125°C.
9. Post burn-in electrical parameters and deltas 3/ & 7/	_	R & R @ 25°C within 96 hr. of removal from bias. Percent Defective Allowable (PDA): 1st Pass: 5% or 1 whichever is greater 5/ 2nd Pass: 3% or 1 whichever is greater 6/
10. Final Electricals 3/ & 7 a. Static Tests Subgroups 1,2, and 3 of Table I, Method 5005 b. Dynamic Tests Subgroups 4, 5, and 6 or Subgroups 7 and 8 of Table I Method 5005 c. Switching Tests Subgroup 9 of Table I, Method 5005	 5005 5005 5005	All failures must be data logged Electrical testing performed at step 9 does not need to be repeated.
11. Seal Test a. Fine Leak b. Gross Leak 1. External Visual	1014 2009	Reject criteria per test method 100%

TABLE B-la. MIL-M-38510 Class B Microcircuit Upscreening 100%, Test Methods of MIL-STD-883

Notes

1/ Except as stated below, the requirements are per Class S of applicable MIL-M38510 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 S 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 Metho4 1015 do not apply.
i, 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% requires lot rejection.
6/ HTRB should 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/ Use two correlation samples to verify functionality of all Automatic Test Equipment (ATE) and bench testing equipment. Correlation units should be tested prior to any electrical testing. Read and Record all parameters specified in the applicable detail slash sheet, as determined in note 3/ above. If correlation units are not available, they may be removed from the lot being processed. Corre1ation units should be controlled by the contractor for future upgrade screen1ng.
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-lb. MIL-M-38510 Class B Microcircuit Lot Acceptance Testing (Sample as Specified), Test Methods of MIL-STD-883

SUBGROUP	METHOD	REQUIREMENTS 11/
SUBGROUP 1		3 devices sampled with 0 failures or 5 devices sampled with 1 failure.
(b) Internal Water Vapor 5/	1018	5000 ppm max. water content at 100°C
SUBGROUP 5		LTPD = 10 over subgroup 5. 9/
(a) Electrical Measurements 1/, & 2/ Subgroups 1,2 and 3 of Table I Method 5005	5005	R & R Data
(b) Steady State Life 4/, & 10/	1005	1000 hr. min. at 125°C
(c) Electrical Measurements 1/, & 2/ Subgroups 1,2 and 3 of Table I Method 5005	5005	R & R Data 8/
SUBROUP 6		LTPD = 15 over Subgroup 6 9/
(a) Temperature Cycling 3/	1010	Condition C, 100 cycles min.
(b) Constant Acceleration 6/	2001	Test Condition E, Y
(c) Hermetic Seal- Fine and Gross 7/	1014	Reject criteria per test method
(d) Electrical Measurements 1/, 2/, & 7/ Subgroups 1of Table I Method 5005	5005	R & R Data

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/ Use two correlation samples to verify functionality of all Automatic Test Equipment (ATE) and bench testing equipment. Test correlation units prior to any electrical testing and read and Record all parameters specified in the applicable detail slash sheet as determined in note 1/ above. If correlation units are not available, select two devices from the lot being processed

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.

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 i00% testing. If performed as part of 100% testing, constant acceleration should 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)$_1$ Temp cycling may be used in flight hardware with contractor's approved PMP Control plan

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

Notes (Cont.):

9/ Reference MIL-M-385i0, Table B-1for the number of samples required for each -specified LTPD. Resubmission of a failed lot should be permitted one time only. The resubmission sample size should 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 should not be included in the resubmission sample without contractor's approved PM&P 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 should. 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-158OA or approved procedure	Double the sample size All anomalies should be dispositioned as acceptable or rejectable
Internal water-vapor content 1/	Per NIL-STD-883, Method 1018. 3 devices sampled with 0 failures or 5 devices sampled with 1 failure. 5,000 ppm max. water content at 1OO^{0}C

Notes:

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

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

SCREEN	METHOD	REQUIREMENTS
1. Prescreen Electricals 3/ & 6/	5005	YLN of 2% optional but encouraged. 9/
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 (R & R) at 25°C
6. Power Burn-In test	1015	320 hr. at 125°C
7. Post burn-in Electricals and deltas 3/ & 6/		R & R @ 25°C within 96 hr. of removal from bias. Percent Defective Allowable (PDA): 1st Pass: 2% or 1 whichever is greater 5/
8. Final Electricals 3/ & 5/ a. Static Tests Subgroups 1,2, and 3 of Table X, Method 5008 b. Dynamic Tests Subgroups 4, 5, and 6 of Table X or Functional Subgroups 7 and 8 of Table X Method 5008 c. Switching Tests Subgroup 9, 10, and 11 of Table X, Method 5008	 5008 5008 5008	All failures must be data logged Electrical testing performed at step 7 does not need to be repeated.
9 Seal Test a. Fine Leak b. Gross Leak	1014	Reject criteria per test method
10 External Visual	2009	100%

Notes:

1/ Except as stated below, the requirements are per Class K of applicable MIL-H-38534 detail specifications.

2/ Test condition A, multiple pass criteria off MIL-STD-883, Method 2020.

3/ Parameters as called out in MIL-STD-883, Method 500& 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 the$_1$re 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 should 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% should require lot rejection.

6/ Use two correlation samples to verify functionality of all Automatic Test Equipment (ATE) and bench testing equipment. Test correlation units prior to any electrical testing and read and Record all parameters specified in the applicable detail slash sheet as determined in note 3/ above. If correlation units are not available, select two devices from the lot being processed

7/ Perform group A, subgroups 1 and 4. This test evaluates lots for continued upscreening or return to the vendor. A YLN is 2% or greater should be imposed as a flag for review and disposition.

TABLE B-2b. MIL-M-38534 Class H Hybrid Lot Acceptance Testing

(Sample as Specified), Test Methods of MIL-STD-883

SUBGROUP	METHOD	REQUIREMENTS 11/
SUBGROUP 1 (b) Internal Water Vapor 4/	1018	3 devices sampled with 0 failures or 5 devices sampled with 1 failure. Max. water content per MIL-H-38534
SUBGROUP 2		15 devices sampled with 0 failures 5/ & 6/
(a) Electrical Measurements 1/, & 2/ Subgroups 1,2 and 3 of Table X Method 5008	5008	R & R Data
(b) Steady State Life 3/, & 10/	1005	1000 hr. min. at 125°C
(c) Electrical Measurements 1/, & 2/ Subgroups 1,2 and 3 of Table X Method 5008	5008	R & R Data 5/
SUBROUP 3		LTPD = 15 over Subgroup 6 9/
(a) Temperature Cycling 7/	1010	Condition C, 100 cycles min.
(b) Constant Acceleration 8/	2001	Test Condition E, Y
(c) Hermetic Seal- Fine and Gross 9/	1014	Reject criteria per test method
(d) Electrical Measurements 1/, & 2/ Subgroups 1, 2, and 3 of Table X Method 5008	5008	R & R Data

Notes

1/ Parameters as called out in MIL-STD-S83, 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.

2/ Use two correlation samples to verify functionality of all Automatic Test Equipment (ATE) and bench testing equipment. Test correlation units prior to any electrical testing and read and Record all parameters specified in the applicable detail slash sheet as determined in note 1/ above. If correlation units are not available, select two devices from the lot being processed

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 should be permitted one time only using double the sample size with zero failures allowed. Parts passing the first test should 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. If performed as part of 100% testing, constant acceleration should be performed prior to seal leak testing.

TABLE B-2b. MIL-H-38534 Class H Hybrid Lot Acceptance Testing (Sample as Specified), Test Methods of MIL-STD-883

Notes (Cont.):

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 should 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-M-38534 Class H Hybrid Destructive Physical Analysis (DPA).

DPA per MIL-STD-158OA or approved procedure	Double the sample size All anomalies should 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 1OO^{0}C

Notes:

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

TABLE B-3a. MIL-S-19500 JANTXV Transistor and Diodes Upscreening (Test 100%), Test Methods of MIL-STD-750

SCREEN	METHOD	REQUIREMENTS
1. Prescreen Electricals 3/ & 9/	-	YLN of 2% optional but encouraged. 9/
2. Particle Impact Noise Detection (PIND)	1051	2/
3. Serialization	_	100%
4. Pre-HTRB Electrical Parameters 3/ & 9/	_	Read and Record (R & R) at 25°C
5. High Temperature Reverse Bias (HTRB) burn-in 10/ & 12/		Apply 80% of rated voltages (see below) for 48 hr. minimum @ +150°C or the device maximum operating limit, whichever is lower.
Transistors (bipolar junction)	1039	VCB
FET and JFET	1039	VGS
MOSFET	1042	VGS and VDS
Diodes and Rectifiers	1038	Except zeners with VZ ≤ 10V and rectifiers with < 10A @ Tc=100°C
1. Interim Electricals and deltas 3/ & 9/		R & R @ 25°C within 16 hr. of removal from bias. Percent Defective Allowable (PDA): 1st Pass: 5% or 1 whichever is greater 4/ 2nd Pass: 3% or 1 whichever is greater 5/
2. Power Burn-In Test 10/ &13/		240 hr. minimum per applicable slash sheet
Transistors (bipolar junction)	1039	
FET and JFET	1039	
MOSFET	1042	
Diodes and Rectifiers	1038	
1. Post burn-in electrical parameters and deltas 3/ & 9/	_	R & R @ 25°C within 96 hr. of removal from bias. Percent Defective Allowable (PDA): 1st Pass: 5% or 1 whichever is greater 4/ 2nd Pass: 3% or 1 whichever is greater 5/
2. Final Electricals 3/ & 9/ a. Static Tests Subgroups 2 and 3 of Table III, MIL-S-19500 b. Dynamic Tests Subgroups 4 through 7of Table III MIL-S-19500		All failures must be data logged Electrical testing performed at step 8 does not need to be repeated.
10 Radiographic	2076	Optional
11. Seal Test a. Fine Leak b. Gross Leak	1071	Reject criteria per test method
1. External Visual	2071	100%

TABLE B-3a. MIL-S-19500 JANTXV Transistor and Diode Upscreening (Test 100%) Test Methods of MIL-STD-750

Notes

1/ Except as stated below, the requirements are per Class S of 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 for JANS 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 HTRB or Power Burn-In one time if the 20%> PD>5%.

5/ A Percent Defective (PD) > 3% on the second HTRB or Power Burn-In should reject the lot.

6/ For all devices with internal cavity.

7/ Omit this test for painted glass body diodes.

8/ Omit this test for metallurgically bonded, double plug diodes.

9/ Use two correlation samples to verify functionality of all Automatic Test Equipment (ATE) and bench testing equipment. Correlation units should be tested prior to any electrical testing. Read and Record all parameters specified in the applicable detail slash sheet, as determined in note 1/ above. If correlation units are not available, they may be removed from the lot being processed. Corre1ation units should be controlled by the contractor for future upgrade screen1ng.

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.

13/ Test Condition B of the appropriate test method

TABLE B-3b. MIL-S-19500 JANTXV Transistor and Diode Lot Acceptance Testing (Sample as Specified) Test Methods of MIL-STD-750

SUBGROUP	METHOD	REQUIREMENTS 11/
SUBGROUP 1		3 devices sampled with 0 failures or 5 devices sampled with 1 failure.
(b) Internal Water Vapor 5/	1018	5000 ppm max. water content at 100°C
SUBGROUP 4		LTPD = 5 over subgroup 4. 8/
(a) Electrical Measurements 1/, & 2/ Subgroups 2 and 3 of Table III MIL-S-19500		R & R Data
(b) Steady State Life or Intermittent Operating Life	1037, 1042	340 hr. per the applicable slash sheet R & R Data 8/
(c) Electrical Measurements 1/, & 2/ Subgroups 2 and 3 of Table III MIL-S-19500		
SUBROUP 3		LTPD = 15 over Subgroup 3 8/
(a) Temperature Cycling 3/	1051	Condition C3, 100 cycles min.
(b) Constant Acceleration 5/ & 9/	2005	Y1 orientation
(c) Hermetic Seal- Fine and Gross 6/	1071	Reject criteria per test method
(d) Electrical Measurements 1/, 2/, & 6/ Subgroups 2of Table III MIL-S-19500		R & R Data

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/ Use two correlation samples to verify functionality of all Automatic Test Equipment (ATE) and bench testing equipment. Test correlation units prior to any electrical testing and read and Record all parameters specified in the applicable detail slash sheet as determined in note 1/ above. If correlation units are not available, select two devices from the lot being processed
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 testing may be performed as part of the DPA.
5/ Constant acceleration may be performed as part of i00% testing. If performed as part of 100% testing, constant acceleration should be performed prior to seal leak testing.
6/ Seal leak and electrical testing need not be performed if thermal 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 specified acceptance criteria, and not subjected to the destructive testing of Subgroup 1, test (b), Internal Water Vapor and/or Subgroup 6, test (a)$_1$ Temp cycling may be used in flight hardware with contractor's approved PMP Control plan

TABLE B-3b. MIL-S-19500 JANTXV Transistor and Diode Lot Acceptance Testing (Sample as Specified) Test Methods of MIL-STD-750

Notes (Cont.):

8/	Reference MIL-S-19500, Table IX for the number of samples required for each specified LTPD. Resubmission of a failed lot should be permitted one time only. The resubmission sample size should 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 should not be included in the resubmission sample without contractor's approved PM&P 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-158OA or approved procedure	Double the sample size All anomalies should be dispositioned as acceptable or rejectable
Internal water-vapor content 1/	Per NIL-STD-883, Method 1018. 3 devices sampled with 0 failures or 5 devices sampled with 1 failure. 5,000 ppm max. water content at 1OO^{0}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 guidelines 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 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 thls 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-N-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-fl-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 trans$_1$istors 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 the life test per 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 transistor 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~1950O 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 test per 3O.2.2.1 should still be performed.

TABLE C-1 Reduced Group B Sample Size

SUBGROUP & TEST 1/	MIL-STD-883 METHOD	QUANTITY			
		Use parts from previous. tests	New parts (Elect. Rej.)	New parts (Elect. 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			3		0
b) Internal Visual	2015, 2013, 2014	2			0
c) Bond Strength 4/	2011 Cond. D	3			0
d) Die Shear	2019	3			0
SUBGROUP 3					
Solderability	2003	3			0
SOUBGROUP 4					
a) Lead Integrity	2004 Cond. B2		2		0
b) Hermetic Seal 6/	1014	2			0
Fine Leak	Cond A or B				
Gross Leak	Cond C				
c) Lead Torque 5/	2024	2			0
SUBGROUP 5 7/, 8/, & 13/					
a) Electrical Parameters	Per Detail Spec	5		5	0
b) Steady State Life (1000 hr. min.) 11/	1005 Cond D	5			0
c) Electrical Parameters	Per Detail Spec	5			0
SUBGROUP 6 8/, 9/					
a) Electrical Parameters	Per Detail Spec	---		4	
b) Temperature Cycling	1010 Cond C 100 cycles	4			0
c) Constant Acceleration	2001 Cond E	4			0
d) Hermetic Seal 6/	1014	4			0
Fine Leak	Cond A or B				
Gross leak	Cond C				
e) Electrical Parameters	Per Detail Spec	4			0
TOTAL = 10 10/			8	9	

TABLE C-I. REDUCED GROUP B SAMPLE

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) should 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 should apply.

3/ Quantities stated represent minimum quantities. If larger sample sizes are used, the reject criteria should not change.

4/ Number of bonds to be pulled should 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 should apply only to glass-frit-sealed packages.

6/ Test Conditions D and E prohibited.

7/ Unless otherwise specified, all test conditions and end points should be per the Table I, Group B requirements of the detail specification.

8/ A minimum of 5 samples should 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 should 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 should apply here.

13/ Read and record.

TABLE c-2. REDUCED GROUP D SAMPLE SIZE. 1/

SUBGROUP & TEST 2/	MIL-STD-883 METHOD	QUANTITY 3/			
		Use parts from previous. tests	New parts (Elect . Rej.)	New parts (Elect. Good)	Rejects Allowed
SUBGROUP 1					
a) Physical Dimensions 4/, 6/	2016	---	3		0
SUBGROUP 2					
Lead Integrity Seal 6/	2004 Cond. B2	3 and	2		0
Fine Leak	1014	5			
Gross Leak	Cond A or B				0
	Cond C				0
SUBGROUP 3					
Temperature Cycling	1011-B, 15 cycles	5		5	0
Moisture Resistance	1010-C, 100 cycles	5			0
	1004				
Hermetic Seal 5/	1014	5			0
Fine	Cond A or B				
Gross	Cond C				
Visual Examination	1004/1010	5			0
End Point Electrical Parameters	per detail spec	5			0
SOUBGROUP 4					
Mechanical Shock	2302-B	5			0
Vibration, Variable Frequency	2007-A	5			0
Constant Acceleration	2001-E	5			0
Hermetic Seal 5/	1014	5			0
Fine	Cond A or B				
Gross	Cond C				
Visual Examination	1004/1010	5			0
End Point Electrical Parameters	per detail spec	5			0
SUBGROUP 6 4/, 6/					
Internal Water-Vapor Content	1018	---		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.

NOTES:

1/ Footnotes to MIL-STD-883, Method 5005 apply.
2/ Unless otherwise specified, all test conditions and end-points should 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 should 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 site requirement is ten (10) parts.
10/ See Table c-1, Note 12/.

APPENDIX D

The contents of this appendix are intended for guidance only

10 INTENDED USE

This Handbook when cited in the program peculiar specification for space or launch vehicles should 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 handbook is intended for use in all USAF space division acquisition contracts for. new or modified designs 'of space vehicles, upper stage vehicles, payloads, launch vehicles, and for their subtier equipment.

The requirements in the text of this handbook 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 .re1iability of the parts when used in space. equipment and critical launch equipment.

The requirements in this text 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$_1$ 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 handbook and also using either MIL-STD-965 or MIL-STD-1546, the definition of key terms that are common are the same in this handbook 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 handbook should be applied. For those acquisition contracts, this handbook 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 handbook are to be interpreted as the applicable equipment. The requirements in this handbook 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

26.1 TAILORED APPLICATION

The parts requirements in each acquisition should be tailored to the needs of that particular program to meet the mission needs. 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 implementing each requirement of this handbook 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 for entire life of the program.

20.2 TAILORING TO CONTRACT PHASE

This handbook contains comprehensive requirements for electronic parts that primarily apply during the design and production phases of a program. When this handbook 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 handbook 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 handbook 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. Additionally 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 implementation 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%screening requirements specified in the detailed requirements section of this handbook 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.

The lot conformance testing requirements specified in the detailed requirements section of this handbook 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.

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.

3.0 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 contract 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$_1$ 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:	PREPARING ACTIVITY
Army MI	Air Force 19
Navy AS	Project 1820-9808

REVIEW ACTIVITIES

Navy	CG
Air Force	33, 99, US
NASA	NA

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-HDBK-1547A	**2. DOCUMENT DATE (YYMMDD)** 980706

DOCUMENT TITLE **ELECTRONIC PARTS, MATERIALS, AND PROCESSESS FOR SPACE AND LAUNCH VECHICLES**

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 SPACE AND MISSILE SYSTEM CENTER	b. TELEPHONE *Include Area Code)* (1) Commercial ((310) 363-2406 (2) AUTOVON 833-2406
c. ADDRESS (include Zip Code) SMC/AXMP, 160 SKYNET STREET, SUITE 2315 EL SEGUNDO, CA 90245-4683	**IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT:** DEFENSE QUALITY AND STANDARDIZATION OFFICE 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22401-3466 Telephone (703) 756-2340 AUTOVON 289-2340

DD Form 1426, OCT 89 *Previous editions are obsolete* *198/290*