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ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL (EEE) PARTS ASSURANCE STANDARD

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FOREWORD

This standard is published by the National Aeronautics and Space Administration (NASA) to provide uniform engineering and technical requirements for processes, procedures, practices, and methods that have been endorsed as standard for NASA programs and projects, including requirements for selection, application, and design criteria of an item.

This standard is approved for use by NASA Headquarters and NASA Centers, including Component Facilities and Technical and Service Support Centers, and is intended to be applied on NASA contracts.

This standard establishes a consistent set of requirements for electrical, electronic, and electromechanical (EEE) parts selection, management, and control for space flight and mission critical ground support equipment for NASA programs. The parts requirements described in this document are to be applied based on equipment grade and mission needs as specified in the Project Specification. Individual equipment needs should be evaluated to determine the extent to which each requirement should be applied.

This NASA standard was developed by NASA Headquarters Office of Safety and Mission Assurance and the EEE Parts Program. Requests for information, corrections, or additions to this standard should be submitted to the NASA, Office of Safety and Mission Assurance (OSMA), by email to Agency-SMA-Policy-Feedback@mail.nasa.gov, or via the "Email Feedback" link at https://standards.nasa.gov/.

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ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL (EEE) PARTS MANAGEMENT AND CONTROL REQUIREMENTS FOR SPACE FLIGHT HARDWARE

1. SCOPE

1.1 Purpose

1.1.1 The purpose of this standard is to establish a consistent set of requirements to control risk and enhance reliability in NASA space flight hardware and critical ground support equipment, in part, by managing the selection, acquisition, traceability, testing, handling, packaging, storage, and application of EEE parts as required by NASA Policy Directive (NPD) 8730.2, NASA Parts Policy. The requirements contained in this standard are not applicable to aeronautics systems, unless specifically cited in governing documents.

1.1.2 While this document may give guidance with respect to processes and selection criteria associated with EEE parts, it is generally not the intent of this standard to mandate specific reliability grade parts in particular applications, rather to allow programs and projects to make these decisions based on the guidance contained herein, Center EEE Parts input, and program and project requirements. Sections 4.2 (including table 2) and 5.2.4 are included as qualitative guidance and are not to be considered requirements.

1.2 Applicability

1.2.1 This standard is approved for use by NASA Headquarters and NASA Centers, including Component Facilities and Technical and Service Support Centers, and may be cited in contract, program, and other Agency documents as a technical requirement. This standard may also apply to the Jet Propulsion Laboratory or to other contractors, grant recipients, or parties to agreements only to the extent specified or referenced in their contracts, grants, or agreements.

1.2.2 This standard is applicable to space flight hardware, launch vehicles, critical ground support equipment (GSE), projects governed by NPR 7120.5, NASA Space Flight Program and Project Management Requirements.

1.2.3 This standard does not apply to institutional projects as defined by NPR 7120.7, NASA Information Technology and Institutional Infrastructure Program and Project Requirements, or to Research and Technology Development Programs and Projects as defined by NPR 7120.8, NASA Research and Technology Program and Project Management Requirements unless explicitly specified in project requirements documents.

1.2.4 All mandatory actions (i.e., requirements) are denoted by statements containing the term "shall." The terms: "may" or "can" denote discretionary privilege or permission, "should" denotes a good practice and is recommended but not required, "will" denotes expected outcome, and "are/is" denotes descriptive material.

1.3 Tailoring

1.3.1 Tailoring of the requirements contained in this standard for application to a specific program or project per Center requirements, risk classification or acceptable risk posture shall be formally documented in the Program and Project EEE Parts Management and Control Plan (EPMCP), or equivalent, and approved by the Parts, Materials, and Processes Control Board (PMPCB), or equivalent, and the SMA Technical Authority.

2. APPLICABLE DOCUMENTS

2.1 General

2.1.1 The documents listed in this section contain provisions that constitute requirements of this standard as cited in the text. Use of more recent issues of cited documents may be authorized by the responsible Technical Authority. The applicable documents are accessible via the NASA Technical Standards System at https://standards.nasa.gov or may be obtained directly from the Standards Developing Organizations or other document distributors.

2.2 Government Documents

NASA-STD-8739.4	Crimping, Interconnecting Cables, Harness, and Wiring
NASA-STD-8739.6	Implementation Requirements for NASA Workmanship Standards

2.3 Non-Government Documents

ANSI/ESD S20.20	Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
SAE AS5553A	Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition Verification Criteria

2.4 Order of Precedence

2.4.1 This standard establishes requirements to control risk and enhance reliability in NASA space flight and critical ground support/test systems, in part, by managing the selection, acquisition, traceability, testing, handling, packaging, storage, and application of EEE parts but does not supersede nor waive established Agency requirements found in other documentation.

2.4.2 Conflicts between this standard and other requirements documents shall be resolved by the Technical Authority.

3. ACRONYMS AND DEFINITIONS

3.1 Acronyms and Abbreviations

AIP	Acquisition Integrity Program
CAGE	Commercial and Government Entity
CI	Configuration Item
CCP	Counterfeit Control Plan
COTS	Commercial Off The Shelf
DDD	Displacement Damage Dose
DMSMS	Diminishing Manufacturing Sources and Material Shortages
DPA	Destructive Physical Analysis
EEE	Electrical, Electronic, and Electromechanical
ELDRS	Enhanced Low Dose Rate Sensitivity
EPARTS	Electronic Parts Applications Reporting and Tracking System
EPMCP	EEE Parts Management and Control Plan
EOL	End of Life
ESA	European Space Agency
ESD	Electrostatic Discharge
FRL	Failure Rate Level
GEIA	Government Electronics & Information Technology Association
GIDEP	Government Industry Data Exchange Program
GSE	Ground Support Equipment
HI-REL	High Reliability
JAN	Joint Army Navy
JAXA	Japan Aerospace Exploration Agency
LDC	Lot Date Code

LFCP	Lead-Free Control Plan
MIL-PRF	Military Performance
MTBF	Mean Time Between Failure
NASA	National Aeronautics and Space Administration
NEPP	NASA Electronic Parts and Packaging Program
NPSL	NASA Parts Selection List (maintained on the Internet by NEPP/NEPAG) (https://nepp.nasa.gov/npsl/)
OCM	Original Component Manufacturer
OSMA	Office of Safety and Mission Assurance
PAPL	Program or Project Approved Parts List
Pb	Lead
PCB	Parts Control Board
PCN	Product Change Notice
PDR	Preliminary Design Review
PDN	Product Discontinuance Notification
PEM	Plastic Encapsulated Microcircuit
PIN	Part or Identifying Number
PIND	Particle Impact Noise Detection
PMPCB	Parts, Materials, and Processes Control Board
QML	Qualified Manufacturers List
QPL	Qualified Product List
RHA	Radiation Hardness Assurance
RHAE	Radiation Hardness Assurance Engineer
RHAP	Radiation Hardness Assurance Plan
RPCP	Red Plague Control Plan
SAE	SAE International

SCD	Source Control Drawing
SEE	Single Event Effect
Sn	Tin
STD	Standard
TID	Total Ionizing Dose

3.2 Definitions

Commercial and Government Entity (CAGE) Code: An identifying code assigned by the Government that unambiguously identifies EEE part sources. A CAGE Code is required in order to conduct business with the Federal Government.

Commercial: A classification for an assembly, part, or design for which the item manufacturer or vendor establishes performance, configuration and reliability, including design, materials, processes, and testing pursuant to market forces rather than by enforceable compliance to a government or industry standard.

Critical: The condition where failure to comply with prescribed requirements can potentially result in loss of life, serious personal injury, loss of mission, or loss of a significant mission resource.

Derating: Derating of a part is the intentional reduction of its electrical, mechanical and thermal stresses for the purpose of providing a margin between the applied stress and the actual demonstrated limit of the part capabilities.

Destructive Physical Analysis (DPA): A series of inspections and tests performed on samples of an EEE part and resulting in damage to the samples. Usually part of a failure analysis or quality conformance inspection.

Desiccant: A hygroscopic substance that induces or sustains a state of dryness (desiccation) in its vicinity. A drying agent.

Deviation: A specific written authorization, granted prior to the manufacture of a Configuration Item (CI), to depart from a particular requirement of a CI's current approved configuration for a specific number of units or a specified period of time.

Displacement Damage Dose (DDD): Dose of radiation capable of causing displacement damage. Refers to the cumulative degradation resulting from the displacement of nuclei from their lattice position in a material due to ionizing or non-ionizing radiation.

Enhanced Low Dose Rate Sensitivity (ELDRS): The characteristic of a device that exhibits an enhanced total dose response at dose rates below 50 rad(Si)/s.

Failure Mode Effects and Criticality Analysis: Analysis of a system and the working interrelationships of its elements to determine ways in which failures can occur (failure modes) and the effects of each potential failure on the system element in which it occurs, on other system elements, on the mission, and the study of the relative mission significance or criticality of all potential failure modes.

Fault Tree Analysis: A deductive system reliability tool that provides both qualitative and quantitative measures of the probability of failure. It estimates the probability that a top-level event will occur, systematically identifies all possible causes leading to the top event, and documents the analytic process to provide a baseline for future studies of alternative designs.

Franchised Distributor: A source authorized by the original component manufacturer to distribute parts.

Free Space Environment: The natural space radiation environment present in the absence of any man-made structures or objects. This definition only applies above the Kármán Line (100 km altitude).

Government Industry Data Exchange Program (GIDEP): An organization through which users and suppliers of products (EEE parts, mechanical parts, materials, software, etc.) and the government may exchange information, such as part design changes and failure experiences.

Grade : A classification which designates EEE parts in terms of reliability , quality or screening level based on military or industry standards. Interchangeable with terms “level” and “class” when used in this context.

Ground Support Equipment (GSE): Non-flight equipment, systems, or devices specifically designed and developed for a direct physical or functional interface with flight hardware.

Heritage Hardware: Hardware whose design has been previously qualified and used in space applications, and was accepted for use by a NASA program or project.

Lot Date Code (LDC): An identification code, usually marked on a EEE part and prescribed by the applicable specification, to identify parts which have been processed as a batch.

Obsolete Part: A part that is no longer being manufactured.

Off-The-Shelf Hardware: Assembly, part, or design that is readily available for procurement, usually to catalog specifications, without the necessity of generating detail procurement specifications for the item.

Projected Obsolete Part: A part for which a manufacturer has issued a Product Discontinuance Notification (PDN) or other notification stating that the part will no longer be manufactured after some future date.

Qualification: Tests consisting of mechanical, electrical, and environmental intended to verify that materials, design, performance, and long-term reliability of the part are consistent with the specification and intended application, and to assure that manufacturer processes are consistent from lot to lot.

Qualified Manufacturers List (QML): A classification issued by a qualifying agency that identifies manufacturers (along with other information) that have met certain standards for qualification.

Qualified Parts List (QPL): A classification issued by a qualifying agency that identifies products (along with other information) that have met certain standards for qualification.

Quality Conformance Inspection: Inspection or test, used to verify conformance with requirements.

Radiation Hardened (EEE Parts): EEE components designed to operate in man-made or natural space radiation environments and show complete immunity up to a designated level of total ionizing dose (TID) and immunity to one or more classes of single event effects (SEE). Note that standard radiation hardness assurance (RHA) designators are available on many MIL-STD marked parts; however, it is important to note that the designator may not include important areas of performance such as SEE or enhanced low dose rate susceptibility (ELDRS).

Red Plague (Cu_2O): The sacrificial corrosion of copper in a galvanic interface between silver and copper, resulting in the formation of red cuprous oxide (Cu_2O). Continued exposure to an oxygen rich environment can then lead to black cupric oxide (CuO). Galvanic corrosion is promoted by the presence of moisture and oxygen at an exposed copper-silver interface (i.e., conductor end, pinhole, scratch, nick, etc.).

Source Control Drawing (SCD): A drawing that provides an engineering description (including configuration, part number, marking, reliability, environmental, and functional/performance characteristics), qualification requirements, and acceptance criteria for commercial items or vendor developed items procurable from a specialized segment of industry that provides for application critical or unique characteristics.

Screening: Tests, typically applied to 100% of parts in a lot, intended to remove nonconforming parts (parts with random defects that are at increased risk of resulting in early failures, known as infant mortality) from an otherwise acceptable lot and thus increase confidence in the reliability of the parts selected for use.

Single Event Effect (SEE): A generalized category of anomalies that result from a single ionizing particle. This term includes such effects as single event upsets, transients, latch–up, permanent upset, and device burnout.

Single Event Upset (SEU): An unintentional change in the state of a digital device, resulting in erroneous data or control induced by ionizing radiation. The change of a state is not permanent in that complete functionality can be restored by reprogramming.

Technical Authority: Individuals at different levels of responsibility who maintain independent authority to ensure that proper technical standards are utilized.

Total Ionizing Dose (TID): The cummulative energy deposited in a material causing a long-term degradation of electronics. Typical effects include parametric failures or variations in device parameters such as leakage current, threshold voltage, etc., or functional failures.

Traceability: The ability to verify the history, location, or application of an item by means of documented recorded identification.

Vendor Hi-Rel: A term used to describe parts that have been screened and qualified to requirements that have been enhanced from the manufacturer's normal flow, as determined solely by the manufacturer and offered as high reliability parts.

Waiver: A written authorization, granted after manufacture, to accept a CI that is found to depart from specified requirement(s) of the CI's current approved configuration for a specific number of units or a specified period of time.

White plague: Reaction occuring when excess fluorine outgasses from fluoropolymer insulations combines with water in the form of humidity to create hydrofluoric acid, which reacts with any surrounding metal.

4. EEE PARTS CLASSIFICATION

4.1 General

4.1.1 Programs and projects shall establish and implement processes in accordance with the requirements and guidance in this standard to ensure that:

a. Every Electrical, Electronic and Electromechanical (EEE) part intended for use in space flight is reviewed and approved for compatibility with the intended environment and mission life,

b. Parts are selected so that space flight hardware meets all performance and reliability requirements in the worst-case predicted mission environment, including radiation, thermal, vacuum, and vibration stresses over mission life, and

c. Parts intended to be used in critical ground support equipment are selected to meet program specific performance and reliability requirements.

4.1.2 The EEE part type categories covered by this document are listed in Table 1, EEE Part Types. In addition to these part types, Commercial Off-The-Shelf (COTS) assemblies and sub-assemblies containing EEE parts are within the scope of this standard. Additionally, these requirements also apply to EEE parts in sensor assemblies where basic sensing/transducer pieces (e.g. resistance temperature detector, strain gauge, etc.) are packaged in an assembly with other electrical part types such as wire, connector, resistor, etc.

Table 1. EEE Part Types

Part Types	Federal Stock Classes	Part Types	Federal Stock Classes
Capacitors	5910		
Circuit Breakers	5925	Hybrid microcircuits (including dc/dc converters, opto-electronics, RF, and microwave devices)	5962
Connectors	5935	Magnetics, Inductors & Transformers	5950
Crystal & Crystal Oscillators	5955	Monolithic Microcircuits	5962
Diodes	5961	Relays	5945
Fiber Optic Accessories	6070	Resistors	5905
Fiber Optic Cables	6015	Switches	5930
Fiber Optic Conductors	6010	Thermistors	5905
Fiber Optic Devices	6030		
Fiber Optic Interconnects	6060	Transistors	5961
Filters	5915	Wire and Cable	6145
Fuses	5920		

4.2 EEE Part Classification

The terms “grade” and “level” and “part class” are considered synonymous; i.e., a grade 1 part is consistent with reliability level 1. The intention of this standard is not to mandate locally used terms such as level, grade or part class to be changed to match this document. Table 2 qualitatively describes each of the part grades in relative terms for different properties. Table 3 lists classification designations for different part types found in their respective military specification. Note for Table 3: This table only includes examples and is not all-inclusive. Certain military specifications only pertain to a single reliability grade and are not listed in the table (e.g. MIL-PRF-123 applies only to space grade ceramic capacitors). References to “reliability” apply to the individual part, and may not apply to the system. Additionally, a reliability value obtained from a manufacturer (e.g. MTBF, FRL) applies to the part as manufactured and may not apply to its use in a system. Additional information regarding system reliability considerations can be found in NASA-STD-8729.1.

4.2.1 Grade 1

Grade 1 EEE parts typically meet the highest reliability standards, and have been subjected to independent verification. Additionally, Grade 1 parts are manufactured with the greatest amount of element evaluation, traceability, in-process testing and final screening as compared to other parts of the same type, but different reliability grades. Military specification documents (e.g.

MIL-PRF 19500P, Semiconductor Devices, General Specification For) describe the Grade 1 designation level as being intended for space applications.

4.2.2 Grade 2

Grade 2 EEE parts typically meet rigorous (but not the highest) military or industry reliability standards, and have been subjected to independent verification. Grade 2 parts may be manufactured at facilities that also manufacture Grade 1 parts, but typically with less element evaluation, traceability, in-process testing and final screening as compared to Grade 1 parts of the same type.

4.2.3 Grade 3

Grade 3 EEE parts typically meet military or industry standards for reliability, but there may be significant exceptions, such as omitted tests or reduced temperature ranges. Manufacturing and testing of parts may not have been independently verified. Traceability to manufacturing lot may not be available.

4.2.4 Grade 4

Grade 4 EEE parts typically meet vendor standards for self-defined or commercial market place reliability criteria, but have not been independently verified. Grade 4 EEE parts can also be referred to as COTS. Traceability to manufacturing lot or testing data may not be available. Additionally, homogeneity cannot be assumed in terms of manufacturer facility, manufacturing lot, die origin, etc., when purchasing multiples of a specific part. Finally, most aspects of COTS part manufacturing are subject to change by the manufacturer without notice to the customer, potentially nullifying any previous qualification efforts.

Table 2. EEE Part Grade Description

GRADE	SUMMARY	LEVEL OF IN-PROCESS CONTROLS AND SCREENING	COST/ PART	POTENTIAL UPSCREEN COST	TYPICAL USE
1	Space quality class qualified parts or equivalent.	Highest	Highest	Low	Space flight.
2	Full Military quality class qualified parts or equivalent.	High	High	Medium	Space flight or critical ground support equipment.
3	Low Military quality class parts and Vendor Hi-Rel or equivalent. Screened automotive grade EEE parts.	Medium	Moderate	High	Space flight experiments, cube-sats noncritical space flight, critical ground support equipment, test demonstrations and ground support systems.
4	“Commercial" quality class parts. Qualification data at manufacturer’s discretion. No government process monitors incorporated during manufacturing.	Variable	Lowest	Highest	Cube-sats, noncritical space flight, noncritical ground support equipment, ground support systems, test demonstrations and prototypes. Limited critical GSE.

4.2.5 Qualified Manufacturer List (QML) and Qualified Product List (QPL)

4.2.5.1 Use of the QMLs can greatly aid in the selection and procurement of qualified EEE parts. The QML is comprised of manufacturers who have had their products and assembly facilities examined, tested and audited by the Defense Logistics Agency (DLA) and who have satisfied all applicable qualification requirements for that product according to manufacturer requirements and military specifications.

4.2.5.2 The QPL contains parts that have met specific standards for qualification and are identified by unique part numbers, also known as a Part Identifying Number (PIN). This PIN is generated from the appropriate military performance (MIL-PRF) specification or military detail specification (MIL-DTL) for the desired federal stock class and part grade. Parts procured using this specific PIN have passed all qualification and screening tests required by the part type’s military specification, based on the part grade. Table 3 lists the different part classes, as specified in the respective military specification for each part type, for the different reliability grades.

Table 3. EEE Part Classes for Each Grade

Item	Grade 1	Grade 2	Grade 3	Grade 4
Typical Minimum Quality Class	Microcircuit: **Class S, V (hermetic) and Y (nonhermetic)** Hybrid Microcircuit: **Class K** Discrete Semiconductor: **JANS (Joint Army-Navy, Class S)** Capacitor or Resistor: **Failure Rate Level (FRL) T, S, R and tantalum caps: C & D** Other: Various	Microcircuit: **Class B or Q** Hybrid Microcircuit: **Class H** Discrete Semiconductor: **JANTXV** Capacitor or Resistor: **FRL R, P, or B-tantalum caps** Other: Various	Microcircuit: **Class M, N, T, or /883** Hybrid: **Class G, D, or E** Discrete Semiconductor: **JANTX** Capacitor or Resistor: **P or B**, and Other Other: Various, Vendor Hi-Rel Automotive Grade	Commercial (Often is PEM)

4.2.5.3 Information on QML, QPL, MIL-PRF, MIL-DTL and other military standards can be found on the Defense Logistics Agency website: https://landandmaritimeapps.dla.mil/programs/qmlqpl/

4.2.6 European Space Agency and the Japan Aerospace Exploration Agency Part Qualification Programs

The European Space Agency (ESA) and the Japan Aerospace Exploration Agency (JAXA) have extensive qualification programs for manufacturers and individual parts along with QPL. Similar to the QML and QPL programs, these space agencies also differentiate parts into reliability categories such as “high reliability” and “space grade,” with individual screening and qualification testing requirements for each. These internationally recognized EEE space part qualification programs include periodic audits of manufacturers, and review of manufacturing process documents and test data. Programs and projects should review these screening and qualification test program standards prior to approving parts based on ESA or JAXA qualification.

4.2.7 Manufacturer’s High Reliability Designation

The classification term manufacturer “(MFR) HI-REL,” often referred to as high-reliability or “space grade” parts on the manufacturer’s website or part data sheet, applies to parts that are procured to a manufacturer-controlled flow as described in the manufacturer’s catalog. The part manufacturing flow is controlled only by the manufacturer and subject to change at their discretion. A Certificate of Compliance is furnished by the manufacturer, certifying that the parts have been tested and will perform according to advertised specifications. In some cases, manufacturers perform thorough qualification and screening testing in accordance with the military specifications (without DLA certification) or other criteria. In other cases, manufacturers add very little to their commercial process flows, and yet call their product “high reliability.” Projects are strongly encouraged to obtain test procedures and data to verify that the screening and qualification requirements specified in requirement documents are met or should perform the screening and qualification themselves.

5. EEE PARTS SELECTION REQUIREMENTS

5.1 General

5.1.1 The selection requirements shall be in accordance with Center, program and project requirements and the following sections:

5.1.1.1 Centers, programs and projects may choose a selection process such as using a Parts Control Board or incorporation of a Parts Selection List and Nonstandard Parts Approval Requests.

5.1.1.2 Whereas the selection of lower grade parts may initially conserve financial and schedule resources, these parts are rarely designed to endure rigorous environmental stresses or to survive corresponding testing. Additionally, obtaining design specifications, configuration control, traceability information or test data from the manufacturer may be extremely challenging. This issue is especially true with respect to radiation testing/analysis of lower grade parts. Predicted resource savings for parts used in critical applications usually diminish after additional testing, analysis and redesign costs are factored in.

5.1.1.3 Parts that do not meet any specific requirement shall require additional documented review and approval before use in hardware on a waiver, deviation or other form of non-conformance documentation in accordance with program and project requirements. This documentation will list the details of the non-conformance, along with any additional testing that is required.

5.1.1.4 In situations where an application requires the use of a COTS or inherited device or assembly, the designated EEE parts authority (e.g. Parts Control Board (PCB) or SMA Technical Authority) shall determine if any mitigating actions are required for approval based on the requirements stated in the program or project EEE Parts Management and Control Plan. Example issues include the lack of internal parts list, derating analysis, use of Pb-free solder, etc., while mitigating actions may include performing a Destructive Physical Analysis (DPA), qualification testing, or approval to use “as-is.” Reliability and SMA experts should be consulted to determine the assembly’s effect on the entire system.

5.2 Reliability Selection

5.2.1 Parts selection shall be driven by safety, performance and environmental requirements, and an assessment of criticality (e.g. Failure Mode Effects and Criticality Analysis or Fault Tree Analysis) of the circuit functions in the space flight and GSE hardware design.

5.2.2 Based on the requirements and analyses listed in section 5.2.1, each EEE part shall be selected at an appropriate grade and possibly with additional screening and qualifications tests that will reduce the risk that mission objectives are not met. The feasibility of repairs or component replacement in the mission environment can be taken into consideration to determine EEE part requirements.

5.2.3 The following are additional guidelines for selecting appropriate reliability grades for EEE Parts:

a. Grade 1

(1) Equipment supporting functions of critical mission objectives and safety such as life support or launch abort systems, requiring maximum feasible reliability.

(2) Project having very high visibility both within and outside of NASA.

(3) Projects involving objectives which may be difficult to repeat in another mission.

b. Grade 2

(1) Equipment that requires high reliability, but for which a low risk of failure can be tolerated to meet cost or schedule constraints.

(2) Multiple or single purpose, with a repeat mission possible.

(3) Critical ground support equipment.

c. Grade 3

(1) Equipment where high reliability is desired, but is not mandatory.

(2) Single purpose or routine mission with repeat missions possible.

(3) Application is usually space flight experiments or ground support equipment.

d. Grade 4

(1) Equipment where high reliability is secondary to affordability.

(2) Mission is not critical.

(3) Repeat mission is possible.

(4) Typical choice for space flight experiments and ground support equipment.

5.2.4 NASA Parts Selection List and Databases

5.2.4.1 The NASA Parts Selection List (NPSL) (https://nepp.nasa.gov/npsl) has been developed to serve as a parts selection tool for NASA space flight programs. In general, parts listed in the NPSL have established procurement specifications, have available source(s) of supply, are capable of meeting a wide range of application needs, and have been assessed for quality, reliability, and risk. Parts listed in the NPSL are recommended for use in space flight hardware when they meet the program and project’s needs and should be considered for inclusion in standard or preferred parts lists.

5.2.4.2 NASA parts databases such as the Electronic Parts Applications Reporting and Tracking System (EPARTS) database (https://eparts.nasa.gov/) may also be used for additional part selection guidance, provided that the part selected meets the qualification and screening criteria for the intended application. Caution must be used when comparing specific mission and design requirements from a previous project to a current project before approving a part based on its previous use in space flight hardware.

5.3 Application Selection

5.3.1 Derating

5.3.1.1 Derating is the reduction of electrical, mechanical and thermal stresses applied to a part during normal operation with respect to the part's design limits in order to decrease the degradation rate and prolong the part's expected life.

5.3.1.2 Project documentation shall specify derating requirements for all EEE part types in the design of the hardware.

5.3.1.3 A derating analysis shall be conducted by the design organization and submitted for project/Center review and approval (see section 8.3.1).

5.3.1.4 A part that does not meet the derating requirements shall require additional review and approval before use in space flight hardware.

5.3.1.5 The use of parts where the predicted worst case parameters exceed the part manufacturer's absolute design limits shall be prohibited.

5.3.2 Operating Environment

EEE parts shall be evaluated to determine if the parts will perform nominally in the proposed operating environment, or if analysis or testing is required, in accordance with Center, program or project requirements. The operating environmental conditions include, but are not limited to, the temperature, humidity, shock, vibration, electromagnetic compatibility and radiation to which the parts will be exposed. This requirement can be accomplished by manufacturer's screening or qualification testing (or both if specified).

5.3.2.1 Ionizing Radiation

5.3.2.1.1 EEE parts intended for use in space flight hardware shall be qualified (in accordance with subsequent paragraphs) to operate with acceptable performance during and after exposure to the part-level radiation environment specified in the program or project environmental requirements documents.

5.3.2.1.2 In accordance with program and project and Center requirements, the effects of the projected ionizing radiation on each part and assembly shall be determined by analysis, test or both.

5.3.2.1.3 The program's and project's radiation evaluation shall address all threats appropriate for the technology, application, and environment, including TID, ELDRS, SEE, and DDD as defined in the program's and project's ionizing radiation control documents (e.g. Radiation Hardness Assurance Plan (RHAP)), etc.).

5.3.2.1.4 SEE are divided into non-destructive (e.g., single event upsets, transients, functional interrupts, etc.) and destructive (e.g., single event latch-ups, burnouts, gate ruptures, snapbacks, etc.) effects. The destructive effects involve permanent damage to the affected part. They may involve latent damage, in which the part may continue to function but with a drastically shortened lifetime.

5.3.2.1.5 Safety-critical functions shall be designed so that they will not fail because of SEE.

5.3.2.1.6 The radiation environment analysis and EEE part hardness requirements shall be the responsibility of a lead Radiation Hardness Assurance Engineer (RHAE).

5.3.2.1.7 The duties of the RHAE include, with respect to program and project:

a. Acts as prime interface on technical and programmatic issues (e.g., contractor tasks, funding, schedule, deliverable tracking, requirements, etc.) related to ionizing radiation.

b. Leads environment and EEE parts scrubbing analysis.

c. Resolves design and application specific issues related to radiation.

d. Approves all radiation documents including requirements.

e. Coordinates radiation testing and analysis.

5.3.2.1.8 If a program or project does not have a "full-time" RHAE due to constraints or risk posture, the responsibilities shall be delegated to one or more appropriate engineers assigned to the program or project with the understanding that engagement of external subject matter expertise may be necessary. The prime points of contact for the lead RHA engineer may include, but are not limited to:

a. Program or project manager and designees.

b. Systems engineers.

c. EEE parts engineers.

d. Mission assurance personnel.

e. Reliability engineers.

f. Electrical and optical systems designers.

g. Mechanical and thermal engineers.

h. Science team (when ionizing radiation may impact science performance).

i. Center subject matter experts.

5.3.2.1.9 The program and project radiation hardness requirements should be defined in a program or project RHAP. Refer to section 8.1.3 for additional information regarding the RHAP.

5.3.2.1.10 Low-cost space flight experiments and projects that do not require radiation hardened parts should consider the following:

a. Analyze parts for radiation susceptibility, considering environment and project lifetime.

b. Identify critical parts. Use the highest grade feasible for critical parts.

c. Implement redundancy.

d. Utilize over-current detection, watchdog timers and software resets.

5.4 Plastic Encapsulated Microcircuits (PEMs)

Within the constraints of the appropriate Center controlling documents, individual programs and projects shall decide whether the use of Plastic Encapsulated Microcircuits is allowed in their respective space flight applications. This decision should be based on a thorough evaluation for thermal, mechanical, and radiation implications of the specific application with respect to mission requirements. The use of PEMs should be restricted to applications where no similar high reliability hermetically sealed device is available. Due to significant lot-to-lot variability that can occur in the fabrication processes and technology, each procurement of PEMs requires a separate evaluation that includes radiation effects. The use of plastic encapsulated semiconductor devices and hybrids should follow similar guidelines as for PEMs.

5.5 Material and Corrosion Concerns

5.5.1 Restricted Materials

5.5.1.1 The following guidelines apply to EEE parts used in space flight hardware including, but not limited to, packages, terminals, leads, mounting hardware, solder, solder lugs, electromagnetic interference (EMI) shields, and structures.

5.5.1.2 For some service conditions, use of Pb-free solder may compromise electronic interconnection performance due to differences in fatigue characteristics under thermal cycling and vibration, relative to traditional solders. Note: Tin(Sn)-Silver(Ag) and Tin(Sn)-Antimony(Sb) solders of ratios Sn96/Ag4 and Sn95/Sb5 (and similar) are standard solder-attach materials used in high temperature and other special soldering applications and are acceptable for those applications only.

5.5.1.3 Whiskers are electrically conductive, crystalline structures that can grow from surfaces of metal plating and finishes and can result in various levels of product and system failure. Metals that form whiskers include pure tin, tin alloys, zinc, cadmium, indium, antimony and silver. Use of Pb-free surface finishes (i.e., finishes with <3% lead by weight) can lead to the formation of metal whiskers that in turn can result in various levels of product and system failure.

5.5.1.4 The restrictions pertaining to tin (Sn), cadmium (Cd), zinc (Zn), mercury (Hg), polyvinylchloride (PVC), and other materials used in spacecraft are defined in NASA-STD-6016.

5.5.1.5 The use of Pb-free tin alloy soldering processes and materials to manufacture space flight equipment shall be justified by technical need, meet the program's requirements for reliability, mission life, parts compatibility, rework, thermal, vibration, and shock environments and receive approval from the Center, program or project Parts Control Board or equivalent authority.

5.5.1.6 Lead-Free Control Plan

Requirements regarding the creation of a Lead-Free Control Plan (LFCP), documenting the controls and processes for reducing the risk of harmful effects relating to tin whiskers and avoiding premature solder-joint failure are defined in IPC J-STD-001 ES. Additionally, SAE GEIA-STD-0005-1 and associated documents, and the NASA Tin and Other Metal Whisker Web site, https://nepp.nasa.gov/whisker are recommended for guidance.

5.5.2 Red Plague

5.5.2.1 Cuprous/cupric oxide corrosion (red plague) can develop in silver-coated soft or annealed copper conductors (component leads, single and multi-stranded wires and printed circuit board conductors) when a galvanic cell forms between the copper base metal and the silver coating in the presence of moisture (H_2O) and oxygen (O_2). Once initiated, the sacrificial corrosion of the copper base conductor can continue indefinitely in the presence of oxygen. The color of the corrosion by-product (cuprous oxide crystals) may vary depending on the different levels of oxygen available, but is commonly noted as a red/reddish-brown discoloration on the silver coating surface.

5.5.2.2 Requirements regarding the use of silver-coated copper conductors including the implementation of a Red Plague Control Plan (RPCP) to reduce and control exposure to environmental conditions and contamination that promote the development of red plague and latent damage are defined in IPC J-STD-001 ES.

5.5.3 White Plague

5.5.3.1 White plague occurs when fluoropolymer insulations, especially ETFE and XL-ETFE, outgasses excess fluorine. This fluorine combines with humidity to create hydrofluoric acid which reacts with any surrounding metal, e.g., conductors, connectors, and contacts.

5.5.3.2 ETFE-insulated wire and cable shall be stored in packaging that is vented to prevent buildup of hydrogen fluoride inside the packaging. The packaged ETFE-insulated wire or cable should be stored in a humidity-controlled environment.

5.5.3.3 All fluoropolymer-insulated wire and cable shall be procured in accordance with the wire procurement specification and the following additional requirements:

a. Fluorine Outgassing – The rate of fluorine evolution (outgassing) of the insulation jacket(s) shall not exceed 20 PPM when tested in accordance with AS4373 Method 608, Fluoride Offgassing.

b. ETFE (Tefzel) – ETFE and XL-ETFE insulated wire and cable shall be subjected to a full or partial vacuum bake at +125 °C [+257 °F] for a period of 24 hours, or a dry nitrogen-purge oven bake at +66 °C to +125 °C [+194 °F to +257 °F] for a minimum of 24 hours, prior to Fluorine Outgassing test in accordance with AS4373 Method 608, Fluoride Offgassing.

6. EEE PARTS ASSURANCE AND CONTROL REQUIREMENTS

6.1 Scope

6.1.1 The focus of this section is at the EEE "part" level. All attempts to screen, qualify and analyze parts individually versus at the assembly level should be made to ensure adequate performance in the mission environment. An exception to this practice is in the procurement of a complete assembly where access to the individual parts or parts list documentation is not available.

6.1.2 General screening and qualification at the assembly level, versus the part level may be an acceptable risk, depending on the risk posture of the project and Center/project requirements.

6.2 Qualification

6.2.1 Qualification tests are intended to validate that a specific part design and assembly can survive the stresses endured throughout a mission. These tests are performed on sample parts and include electrical, mechanical, environmental and life tests.

6.2.2 Grades 1 and 2 EEE parts shall be qualified at the piece part level. For applications using Grades 3 & 4 EEE parts, assembly level qualification may be sufficient.

6.2.3 The program and project shall determine the appropriate level of qualification required for Grades 3 & 4 EEE parts based on project classification, criticality, and input from the parts engineer.

6.2.4 The circumstances where assembly level qualification is acceptable shall be listed in the project EEE parts control document or approved by the program and project Parts Control Board.

6.2.5 Piece Part Level

6.2.5.1 Qualification at the piece part level shall be achieved by meeting designated military, NASA Center EEE, or program and project requirements for the part type and grade level.

6.2.5.2 Requirements for qualification of parts not meeting the required grade level shall be equivalent to the requirements imposed on similar parts, or otherwise satisfactorily demonstrate that the part has an approved margin of performance beyond the stresses expected in the application.

6.2.6 Assembly Level

6.2.6.1 The circumstances where assembly level screening is acceptable shall be listed in the project EEE parts control document or approved by the program and project Parts Control Board.

6.2.6.2 Assembly level qualification shall be based upon qualification testing of the assembled fully functional equipment. An assembly (and all parts within it) will be considered qualified for a given application by successful performance in equipment qualification testing.

6.2.6.3 A part within an assembly qualified at the assembly level shall not be considered qualified for any other use unless it goes through additional part or assembly level qualification, as determined by the project.

6.3 Screening

6.3.1 Screening tests are intended to remove nonconforming parts with random defects induced during the manufacturing process that are likely to result in early failures (known as infant mortality), from an otherwise acceptable lot and thus increase confidence in the reliability of the parts selected for use.

6.3.2 EEE parts intended to be installed in space flight hardware shall be subjected to screening in accordance with project requirements. Any required test that is already performed by the procurement specification (military or SCD) or that is normally performed by the manufacturer need not be repeated. However, if lot specific testing is a program or project requirement, data must be provided by the manufacturer or testing facility to show that tests were performed with acceptable results. The project is responsible for specifying and documenting device-unique requirements, if any.

6.3.3 The program and project shall determine the appropriate level of screening required based on project classification, criticality of assembly function, and input from the parts engineer. It is recommended that lower grade EEE parts that are procured in lieu of higher grade parts due to budgetary or scheduling limitations receive additional screening tests normally conducted on higher grade parts, such as Particle Impact Noise Detection (PIND) and X-ray.

6.4 Government-Industry Data Exchange Program (GIDEP) Review

6.4.1 EEE Parts shall be reviewed for applicable GIDEP Alerts, GIDEP Safe-Alerts, GIDEP Problem Advisories, GIDEP Agency Action Notices and NASA Advisories during part selection and throughout all design and development phases. Review of Product Change Notices (PCN), Diminishing Manufacturing Sources and Material Shortages (DMSMS) notices, and other GIDEP data is recommended, but optional. The GIDEP evaluation-disposition process is defined in NPR 8735.1, Procedures for Exchanging Parts, Materials, and Safety Problem Data Utilizing the Government-Industry Data Exchange Program (GIDEP) and NASA Advisories.

6.4.2 Serious manufacturing defects, non-conformances, or other identified problems will be handled in accordance with NPR 8735.1, using appropriate documentation (e.g. NASA Advisory or GIDEP Notice) and submitted to the Center Alert Coordinator for review.

6.4.3 Required actions for parts affected by NASA Advisories, GIDEP Alerts, Safe-Alerts, Problem Advisories or Agency Action Notices shall be in accordance with Center and project requirements. Recommended actions include:

a. Follow requirements in NPR 8735.1.

b. Identifying LDC and location of parts.

c. Removing and quarantining the parts, if prudent.

d. Identifying mitigating actions such as part substitution.

e. Further research.

6.5 Receiving Inspection

6.5.1 A receiving inspection system shall be developed and implemented in accordance with Center, program and project requirements that ensure purchased parts comply with procurement documents. The receiving inspection system should verify that:

a. Documentation is reviewed, along with a physical inspection, to verify that specific part types (e.g. part numbers and description) and quantities comply with purchase requirements.

b. Inspections and tests are performed in accordance with written procedures for selected parts.

c. Identification of acceptance or nonconformance status of parts and records is maintained.

d. Receiving inspection and test records are maintained.

e. Protective measures for cleanliness, electrostatic discharge, moisture, handling, packaging, and shipping are implemented. See section 6.6.

f. All nonconforming items shall be segregated for disposition.

6.5.2 The acquiring activity shall subject all parts to a timely receiving inspection upon receipt to verify compliance with the procurement documents (including test data), along with a manufacturer's certificate of compliance (if applicable).

6.5.3 Personnel performing receipt/inspection should be trained in counterfeit parts detection, other risk factors and the methods they are responsible for performing in accordance with program and project or Center requirements.

6.6 Environmental Control and Storage Requirements

6.6.1 General Requirements

6.6.1.1 Environmental conditions such as temperature, humidity, and particulate contamination shall be identified and appropriately controlled for parts handling, packaging, and storage in accordance with Center, program or project requirements. Temperature and humidity requirements are defined in NASA-STD-8739.6.

6.6.1.2 The use of parts that have been in storage for an extended period of time (typically 5 years from date of manufacture) shall be reviewed in accordance with Center or project requirements to determine the need for rescreening, "re-lifing," qualification or prohibition.

6.6.1.3 Parts stored in conditions where moisture or ESD are not controlled shall not be used unless project approval is granted and detailed justification documented.

6.6.2 Limited Life of Silver-Coated Copper Conductors

6.6.2.1 Due to the potential of cuprous/cupric oxide corrosion formation, silver-coated copper conductors that have exceeded a shelf life of 10 years from the manufacturing date shall not be used on assemblies fabricated to this standard.

6.6.2.2 Completed assemblies incorporating silver-coated copper conductors with a storage or use-life exceeding 10 years from the date of assembly shall be identified, inspected and tested, and tracked as a limited-life article.

6.7 Electrostatic Discharge (ESD) Control

6.7.1 Electrostatic Discharge (ESD) Control is required in accordance with NPD 8730.5, NASA Quality Assurance Program Policy, Attachment A 3.b, and as defined in ANSI/ESD S20.20 Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices).

6.8 Reuse of EEE Parts

6.8.1 EEE parts unsoldered or otherwise removed from printed circuit boards or assemblies shall not be reused unless approved by the program and project Parts Control Board.

6.8.2 If connectors are reused, the connectors shall be thoroughly cleaned, inspected, and tested per NASA-STD-8739.4 Crimping, Interconnecting Cables, Harness, and Wiring or equivalent, prior to reuse.

6.8.3 No parts shall be reused from previously flown hardware without project approval.

7. EEE PARTS PROCUREMENT, OBSOLESCENCE AND COUNTERFEIT PART AVOIDANCE

7.1 Procurement Management

7.1.1 Parts shall be procured from Original Component Manufacturers (OCM) or authorized distributors unless unavailable and in accordance with federal procurement regulations. This minimizes the risk of receiving parts that have been mismarked, misrepresented or subjected to substandard storage or handling conditions.

7.1.2 Procurements shall be made in accordance with Centers' supplier approval process.

7.1.3 Requirements for surveys and audits of supply sources are defined in NPD 8730.2, NASA Parts Policy.

7.1.4 Authorized distributors should be compliant to SAE AS6496 (2014) or equivalent. If other distributors are used, they shall be assessed with respect to their ability to provide parts with proper traceability and without adversely affecting their quality and integrity.

7.1.5 It is recommended to use only independent distributors compliant to SAE AS6081 (2012) or equivalent.

7.1.6 Storage conditions for components should be evaluated for humidity and ESD controls. Humidity control is of particular concern when procuring PEMs. Temperature and humidity requirements are defined in NASA-STD-8739.6.

7.1.7 Overall distributor assessment is required, whether procuring standard military parts or commercial parts.

7.1.8 Procurements shall clearly identify the specification for items being purchased and request certification of conformance to the required specifications.

7.1.9 Procurement of parts should be coordinated among programs and Centers, whenever feasible.

7.2 Obsolescence Management

7.2.1 Projects with extended product life cycles, such as GSE, and those that plan to utilize heritage hardware are exposed to high risk of being affected by parts obsolescence. To mitigate this risk, EEE parts should be assessed prior to selection to ensure part availability meets or exceeds production milestones and mission duration. In addition, parts should be monitored throughout the system life cycle to identify and mitigate obsolescence issues before they occur.

In the event a system is retained in service beyond its original life expectancy, spare parts might be required for repairs and maintenance operations. Obsolescence monitoring provides notification of part discontinuance to allow projects sufficient time to procure spares.

7.2.2 Program and project management, and in accordance with Center requirements, shall determine the extent to which Obsolescence Management will be implemented. Projects that do not implement a full Obsolescence Management Plan should still avoid obsolete or projected obsolete parts.

7.2.3 Any program or project of sufficient duration that could be negatively impacted by parts obsolescence shall maintain a process for monitoring their parts for and mitigating the effects of parts obsolescence. Mitigation may include the selection of parts that have multiple sources, part substitution, or life-time buy practices.

7.2.4 Obsolete and projected obsolete EEE parts shall not be selected for hardware design unless approved by the program or project. EEE part availability should coincide with project life-cycle requirements to avoid obsolescence impacts.

7.2.5 Project As-Designed EEE Parts Lists shall be analyzed prior to preliminary design review (PDR) and the critical design review (CDR) to screen for potential obsolescence issues. This process ensures obsolescence is not incorporated into hardware designs and eliminates DMSMS risks to system production.

7.2.6 The planned steps to be taken regarding component obsolescence shall be listed in the program and project EEE Parts Management and Control Plan (EPMCP). If necessary, a separate stand-alone document may be generated.

7.2.6.1 The plan shall list the specific measures that will be taken to minimize and resolve obsolete part occurrences, such as the continuous monitoring of product end-of-life (EOL) notifications, manufacturer’s PDN, GIDEP PCN, or a GIDEP DMSMS Notice. These notifications are typically provided six months to one year in advance of the actual obsolescence date. Advanced notification allows the project ample time to plan for product obsolescence and to budget for part procurement.

7.2.6.2 The plan shall also list the requirements of the Parts Obsolescence Analysis. The purpose of this analysis is to identify manufacturing status and part availability projections for each part on the program and project parts lists in order to reduce obsolescence impacts throughout system life cycles. Refer to section 8.3.2 for additional information regarding the Parts Obsolescence Analysis.

7.3 Counterfeit EEE Parts Avoidance

7.3.1 All NASA space flight programs and projects shall take appropriate steps to mitigate entry of suspect counterfeit EEE parts into the NASA supply chain while maximizing the availability of authentic, originally designed and qualified parts throughout the product’s life cycle.

7.3.2 The programs and projects shall document the required actions with a Counterfeit Control Plan (CCP).

7.3.2.1 The CCP can be a stand-alone document, part of the program or project Mission Assurance Document or the EEE Parts Control and Management Plan.

7.3.2.2 The CCP shall specify controls in the selection, procurement, acquisition, and inspection of EEE parts used in both space flight and ground support hardware. Further guidance is available in SAE AS5553 and Center documents.

7.3.2.3 The controls shall cover all reliability grades of parts, including commercial grade, to prevent entry of suspect counterfeit parts. Table 4 lists the recommended processes the CCP should include.

7.3.2.4 Refer to Section 8.1.6 for additional information on the CCP.

Table 4. Counterfeit Control Document Processes

PROCESS	CONTENTS
Part Availability	To address obsolescence, sparing plans and lead times.
Procurement	To address required assessments of supply sources, mitigation plans when using sources other than OCM's or authorized vendors and contract/purchase order quality requirements.
Product Assurance	To address the required verification of authentic conforming parts.
Material Control and Disposition	To address required actions to identify and quarantine suspect or confirmed counterfeit parts, along with subsequent actions.
Reporting	To address the required actions for the reporting of nonconforming, defective, and suspected counterfeit parts in accordance with NPR 8735.1, and for all cases involving counterfeit parts or other potential fraud to the NASA Office of Inspector General and the NASA Director, Acquisition Integrity Program (AIP).

8. EEE PARTS DOCUMENTATION AND ORGANIZATION

8.1 Program and Project EEE Parts Management and Control Documents

The listed documents shall control EEE parts activities from the design and development phase through use and maintenance of the hardware systems and instruments.

8.1.1 Program and Project EEE Parts Management and Control Plan (EPMCP)

8.1.1.1 Program and Project management shall approve and oversee the implementation of the EPMCP. The plan may either be a separate document or part of one of the approved project plans such as the Project Mission Assurance Document.

8.1.1.2 The EPMCP shall document the processes that will be used by the program and project to meet the following requirements with respect to EEE Parts, as described in previous sections and in accordance with Center, program and project requirements:

a. Selection
   (1) Reliability
   (2) Derating
   (3) Operating Environment
   (4) Radiation Environment
   (5) Restricted Materials and Corrosion Control
b. Assurance and Control
   (1) Qualification
   (2) Screening
   (3) GIDEP Review
   (4) Receiving Inspection
   (5) Environmental Control and Storage
c. Procurement Management
d. Obsolescence Management
e. Counterfeit Part Avoidance

8.1.1.3 The EPMCP shall be organized in such a manner that each of the requirements contained herein are addressed clearly, concisely and unambiguously. Larger sections, such as the RHAP, LFCP, CCP, may be included in the Project EPMCP or controlled as separate documents.

8.1.1.4 The document shall list all requirements pertaining to EEE parts activities from the design and development phase through the use and maintenance of hardware systems and instruments.

8.1.1.5 The EPMCP shall specify the grade level of parts to be selected with respect to criticality or other categorization.

8.1.1.6 It shall document the requirements with respect to all sections contained herein.

8.1.1.7 Special requirements for COTS devices and assemblies shall also be listed.

8.1.2 Program and Project EEE Parts Control Organization

8.1.2.1 The EPMCP shall identify the authority or organization that will serve as the focal point EEE parts organization.

8.1.2.2 If a PCB or a PMPCB, or equivalent, serves as the focal point EEE parts organization, the project, along with Center level requirements shall determine the membership of the board. Recommended participants include representation from the Offices of Chief Engineer, EEE Parts Engineering, EEE Parts Assurance, and Safety and Mission Assurance. Representation from contractors is also recommended, if applicable. Conversely, project management, along with Center level requirements shall determine NASA representation on contractor control boards in accordance with contract or procurement documentation.

8.1.2.3 The EPMCP or a subset of requirements of the EPMCP shall be imposed on each sub-tier organization in accordance with contract, procurement or project documentation.

8.1.3 Radiation Hardness Assurance Plan

8.1.3.1 The program and project environmental requirements should be defined in a RHAP specific for the program or project. An independent document is recommended for efficient tailoring and implementation. The RHAP shall clearly define the scope of the radiation effects effort for the target program and project including both, a design- or specialist-level and system-level perspective.

8.1.3.2 The RHAP shall provide for planning and validation of:

a. Free space environment exposure external to the spacecraft/instrument.

b. Transport of the free space environment internal to the spacecraft/instrument.

  (1) This is typically done at a high level (e.g. dose-depth analysis) early in the program or project life cycle, but may require a more thorough analysis of spacecraft/instrument geometry.

  (2) Normally negotiated with the program and project based on the high-level results.

c. Ionizing radiation requirements definition and specifications if not included elsewhere.

d. Electrical/optical component and design review procedures, which should include:

  (1) Radiation tolerance/susceptibility metrics

  (2) Risk identification

(3) Test requirements and recommendations

(4) Design mitigation recommendations (when applicable)

(5) Degradation and event rate prediction methodologies.

8.1.3.3 Additional information regarding radiation hardness assurance can be found in Section 5.3.2.1.

8.1.4 Lead-Free Control Plan

8.1.4.1 Requirements regarding the creation of a LFCP, documenting the controls and processes for reducing the risk of harmful effects relating to tin whiskers and avoiding premature solder-joint failure are defined in IPC J-STD-001ES. The plan shall state the process controls required during system development such as:

a. special design considerations

b. material selection

c. manufacturing process controls

d. test and qualification requirements

e. quality inspection and screening

f. marking and identification

g. workmanship requirements and inspection

h. maintenance and repair processes

i. other steps taken to mitigate risks and to ensure the reliability of hardware for the intended application.

8.1.4.2 SAE GEIA-STD-0005-1 and associated documents, and the NASA Tin and Other Metal Whisker Web site https://nepp.nasa.gov/whisker are recommended for guidance in preparing the LFCP.

8.1.4.3 Refer to section 5.5 for more information regarding the lead-free controls and other restricted materials.

8.1.5 Red Plague Control Plan

Requirements regarding the use of silver-coated copper conductors and the implementation of a User-approved RPCP to reduce and control exposure to environmental conditions and contamination that promote the development of cuprous/cupric oxide corrosion (Red Plague) and latent damage are defined in IPC J-STD-001 ES.

8.1.6 Counterfeit Control Plan

The program and project shall document the implementation of their EEE parts Counterfeit Control Plan (CCP) for the avoidance, detection, mitigation, disposition, control, and reporting of counterfeit EEE parts. The recommended format for plan implementation is in regards to the parts availability, procurement, assurance, control, and reporting processes:

8.1.6.1 Parts Availability Process

This section describes the program's and project's plan to maximize availability of authentic, originally designed, and qualified parts throughout the product's life cycle, including, for example:

a. Control of parts obsolescence.

b. Alternate/multiple sources.

c. Acceptable product substitutions.

d. System redesign.

e. Inventory control, parts sparing, and lifetime buy practices.

f. Planning for adequate procurement lead times in support of manufacturing and delivery schedules.

8.1.6.2 Procurement Process

This section describes the program's and project's plan to:

a. Assess potential sources of supply to determine the risk of receiving non-authentic parts. OCM, OCM-authorized suppliers (e.g. franchised distributors), and authorized aftermarket manufacturers are considered to have low risk of supplying non-authentic parts. Assessment actions include surveys, audits, review of product alerts (e.g. GIDEP Notices and NASA Advisories), and analysis of supplier quality data to determine past performance. (Note: GIDEP Notices and NASA Advisory product alerts are accessible through NASA's Supplier Assessment System http://sas.nasa.gov).

b. Mitigate risks of procuring counterfeit parts from sources other than OCMs or authorized suppliers.

c. Factor risk of receiving non-authentic parts into the source selection process.

d. Ensure that approved/ongoing sources of supply are maintaining effective processes for mitigating the risks of supplying counterfeit EEE parts.

e. Include applicable contract/purchase order quality requirements related to counterfeit parts prevention. Examples of quality requirements are provided in SAE AS5553, including:

(1) Certificate of Compliance.

(2) Mandatory Product Tests and Inspections.

(3) Supply Chain Traceability.

(4) Federal Penalties Associated with Fraud and Falsification.

(5) Specify contractor flow down of applicable counterfeit parts prevention requirements to their subcontractors.

8.1.6.3 Product Assurance Process

This section describes the program's and project's plan to verify receipt of authentic conforming parts, commensurate with product risk. Product risk is determined by the criticality of the part and the assessed likelihood of receiving a non-authentic part. Product assurance actions include review of data deliverables, verification of purchase order quality clause compliance, visual inspection, measurements, non- destructive evaluation (e.g., x-ray, hermeticity, marking permanency), destructive testing (e.g., destructive physical analysis (DPA), thermal cycling, and construction analysis).

8.1.6.4 Material Control and Disposition Process

This section describes the program's and project's plan to:

a. Identify and quarantine suspect or confirmed counterfeit parts.

b. Whenever possible, confirm conclusively whether the parts are authentic or counterfeit. This may include further part-level testing or communication with the parts' (supposed) OCM.

c. Upon confirmation that a part is counterfeit, identify and place on "Hold" all potential additional counterfeit parts in storage and identify installed counterfeit parts pending disposition by appropriate authorities.

d. Actions pertaining to confirmed counterfeit parts shall be in accordance with direction received from investigative authorities.

e. Counterfeit parts should only be returned to suppliers under controlled conditions so as to prevent their re-entry into the supply chain.

8.1.6.5 Reporting Process

This section describes the program's and project's plan to report nonconforming, defective, and suspected counterfeit parts in accordance with NPR 8735.1, and for all cases involving counterfeit parts or other potential fraud, to the NASA Office of Inspector General and the NASA Director, AIP.

8.1.6.5.1 Additional information regarding counterfeit part controls can be found in Section 7.3.

8.2 EEE Parts Lists

8.2.1 The equipment design activity shall submit EEE Parts Lists as described below, along with updates throughout the hardware design and development for EEE parts organization approval.

8.2.2 The lists shall account for parts within all subassemblies, including subcontracted or procured subassemblies, unless exempt by specific project agreement.

8.2.3 The data shall be submitted in an electronic database format for review. The use of the single NASA EEE Parts Database, EPARTS (https://eparts.nasa.gov), is strongly encouraged for all lists and updates.

8.2.4 Program and Project Approved Parts List

Once requirements for EEE parts to be used in space flight and critical GSE hardware are established, the program and project may elect to establish a Program and Project Approved Parts List (PAPL). The purpose of this document is to list approved parts with respect to each of the required part reliability levels or function criticality levels for the program and project. The goal of this list is to provide design engineers with a choice of approved parts that have been selected on the basis of knowledge about their technology, specification controls, manufacturing processes and controls, supplier performance, testing, and screening and qualification methods while minimizing the number of styles and generic part types that are used in hardware. If not contained in other documents, the PAPL may also define the process for the selection and screening of parts. The content of the PAPL is intended to be consistent with the Program and Project EEE Parts Management and Control Plans and under the technical control of the Program and Project Parts Control Boards. The PAPL shall meet all program and project configuration management requirements.

8.2.5 As-Designed EEE Parts List

8.2.5.1 The As-Designed EEE Parts List shall identify the equipment containing the individual parts, part description, EEE part number and specification, generic part number, EEE part qualification method and status, part approval status, and part manufacturer(s) as applicable and in accordance with program and project requirements. The order of information is not a requirement and may be tailored.

8.2.5.2 A preliminary As-Designed EEE Parts List shall be submitted for PDR.

8.2.5.3 Changes to the baseline As-Designed EEE Part List shall be monitored and controlled at all levels of procurement, test, and fabrication to ensure the prompt identification, reporting, review, and disposition (approval/disapproval) of any changes.

8.2.6 Part Approval Documentation

8.2.6.1 The approval for parts that meet all requirements shall be documented on the parts lists as specified above.

8.2.6.2 Parts that do not meet a specific requirement shall require identification and additional review and approval before use in hardware. This additional effort is typically documented on a waiver, deviation or other form of non-conformance documentation, in accordance with Center or project requirements. This documentation will list the details of the non-conformance along with any additional testing that is required.

8.2.7 As-Built EEE Parts List

8.2.7.1 The equipment manufacturing activity shall submit an As-Built EEE Parts List for each deliverable end item.

8.2.7.2 The As-Built EEE Parts List shall identify the EEE parts actually used in fabricating each unit.

8.2.7.3 The As-Built EEE Parts List shall account for parts within all subassemblies, including subcontracted or procured subassemblies, unless exempt by specific project agreement.

8.2.7.4 In accordance with project requirements, the As-Built EEE Parts List shall identify the using end item and serial number, the using assembly and serial number, EEE part description, part number, generic part number, part serial number if applicable, EEE part circuit location or reference designation (R1, CR2, etc.), EEE part manufacturer's CAGE code or equivalent identification, and EEE part LDC or equivalent lot identification, as applicable and in accordance with program and project requirements.

8.3 EEE Parts Analyses

8.3.1 EEE Parts Application (Derating) Analysis

8.3.1.1 As described in Section 5.3.1, the equipment design activity shall submit a EEE parts application analysis for each deliverable end item to verify each EEE part (or assembly where part level information is unobtainable) meets the program and project derating requirements, even in worst case environments, operating conditions, and duty cycles.

8.3.1.2 The analysis shall address the EEE parts actually used in fabricating each unit and include electrical reference designator for individual part identification.

8.3.1.3 The analysis shall address parts within all subassemblies, including subcontracted or procured subassemblies, unless exempt by specific project agreement.

8.3.1.4 Individual cases where the derating limits cannot be met shall be dispositioned by the appropriate subject matter experts for the program and project.

8.3.2 EEE Parts Obsolescence Analysis

8.3.2.1 An Obsolescence Analysis of EEE parts should be performed during the early design stages when the design engineer is selecting parts for their design. The NASA EPARTS EEE parts database tool may be used to conduct the Obsolescence Analysis. This tool generates EEE part manufacturing status and part availability projections to reduce obsolescence impacts throughout system life cycles. This analysis should be ongoing throughout the project life cycle, monitoring for product EOL notifications. These advanced notifications should allow the project ample time to plan for product obsolescence and to budget for part procurement. The notifications can also be distributed as a manufacturer's PDN, or a GIDEP PCN. Project EEE parts lists loaded into EPARTS are automatically analyzed for obsolescence risk.

8.3.2.2 Refer to section 7.2 for more information regarding parts obsolescence.

APPENDIX A. REFERENCES

A.1 Purpose

The purpose of this appendix is to provide guidance and is made available in the reference documents below. The following documents are considered to be useful as background information for the reader in understanding the subject matter but do not constitute requirements of this standard.

A.1.1 Government Documents

NPD 8730.5	NASA Quality Assurance Program Policy
NPR 8705.4	Risk Classification for NASA Payloads
NASA-STD-6016	Standard Materials and Processes Requirements for Spacecraft
NASA-STD-8729.1	NASA Reliability and Maintainability (R&M) Standard for Spaceflight and Support Systems
MIL-PRF-19500P	Semiconductor Devices, General Specification For

A.1.2 Non-Government Documents

IPC J-STD-001ES	Space Applications Electronic Hardware Addendum to IPC J-STD-001E Requirements for Soldered Electrical and Electronic Assemblies
SAE AS6081 (2012)	Fraudulent/Counterfeit Electronic Parts: Avoidance, Detection, Mitigation, and Disposition – Distributors Counterfeit Electronic Parts; Avoidance Protocol, Distributors
SAE AS6496 (2014)	Fraudulent/Counterfeit Electronic Parts: Avoidance, Detection, Mitigation, and Disposition - Authorized/Franchised Distribution
SAE-GEIA-STD-0005-1	Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-Free Solder