



AEROSPACE STANDARD

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Requirements for Plastic Encapsulated Discrete Semiconductors in Space Applications

RATIONALE

This document defines the requirements for screening, qualification, and lot acceptance testing for use of plastic encapsulated discrete semiconductors (PEDS) in space flight applications. The level of testing on PEDS should be dependent on a risk based approach, the application, reliability and radiation requirements of the mission. It shall be the responsibility of the user to have the tests conducted using the requirements specified herein. Reporting procedures shall be documented on how the tests are conducted and results obtained. This document addresses many of the concerns associated with PEDS, such as narrower operating temperature ranges and greater susceptibility to infant mortality and moisture absorption than space grade products.

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1. SCOPE

This document establishes the requirements for screening, qualification, and lot acceptance testing of Plastic Encapsulated Discrete Semiconductors (PEDS) for use in space application environments. The scope of this document is intended for standard silicon based technology only, but the process and methodology described within can be adopted for other technologies such as Silicon Carbide, Gallium Nitride, and Gallium Arsenide. However, when non-silicon based technology parts are being used, the device characterization shall be modified, and it is recommended to use available industry standards based upon published research/testing reports for those technology to address applicable physics of failure.

1.1 PURPOSE

Plastic encapsulated products have been used based on testing and analysis for high reliability applications such as those for medical, military hardware, and space applications. There are some complex Electrical, Electronic, and Electromechanical (EEE) products that may only exist in plastic packages and have been risk mitigated for the intended applications. However, the industry needs different ways of screening and qualifying PEDS. This document was created by a subcommittee of SAE CE-12 to standardize a PEDS flow and address possible future extension of the QML system to include PEDS for space. The committee has utilized existing AS6294/1 as baseline and cross references NASA Goddard PEM-INST-001, NASA EEE-INST-002, NASA Marshall Space Flight Center MSFC-STD-3012, and SAE SSB-1, as well as reviews of multiple industry practices.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E595	Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment
ASTM E1640	Standard Test Method for Assignment of the Glass Transition Temperature By Dynamic Mechanical Analysis
ASTM F1192	Standard Guide for the Measurement of Single Event Phenomena (SEP) Induced by Heavy Ion Irradiation of Semiconductor Devices
ASTM F1892	Standard Guide for Ionizing Radiation (Total Dose) Effects Testing of Semiconductor Devices

2.1.2 Military Publications

ESCC Basic Specification No. 22900	Total Dose Steady-State Irradiation Test Method
ESCC Basic Specification No. 25100	Single Event Effects Test Method and Guidelines
MIL-HDBK-814 1994	Ionizing Dose and Neutron Hardness Assurance Guidelines for Microcircuit and Semiconductor Devices
MIL-PRF-19500	Performance Specification, General Specification for Semiconductor Devices

MIL-STD-1580	Destructive Physical Analysis for Electronic, Electromagnetic, and Electromechanical Parts
MIL-STD-750	Test Method Standard for Semiconductor Devices
MIL-STD-883	Test Method Standard for Microcircuits, Method 5011, Method 1019 (ELDRS)
QPDSIS-19500	Qualified Products Database, Supplemental Information Sheet for Electronics QML-19500

2.1.3 NASA Publications

Available from NASA Technical Services, NASA STI Program STI Support Services, Mail Stop 148, NASA Langley Research Center, Hampton, VA 23681-2199, 757-864-9658, Fax: 757-864-6500, <http://ntrs.nasa.gov>.

EEE-INST-002	Instructions for EEE Parts Selection, Screening, Qualification, and Derating
MSFC-STD-3012	Electrical, Electronic, and Electromechanical (EEE) Parts Management and Control Requirements for MSFC Space Flight Hardware
NASA-STD-6001	Flammability, Out-Gassing, and Compatibility Requirements and Test Procedures
PEM-INST-001	Instructions for Plastic Encapsulated Microcircuits (PEMs) Selection, Screening, and Qualification

2.1.4 Other Publications

AEC Q006	Qualification Requirements for Components Using Copper (Cu) Wire Interconnections
JESD22-A101	Steady State Temperature Humidity Bias Life Test
JESD22-A102	Accelerated Moisture Resistance - Unbiased Autoclave
JESD22-A110	Highly Accelerated Temperature and Humidity Stress Test (HAST)
JESD22-A113	Preconditioning of Nonhermetic Surface Mount Devices Prior to Reliability Testing
JESD22-A118	Accelerated Moisture Resistance - Unbiased HAST
JESD22-B106	Resistance to Solder Shock for Through-Hole Mounted Devices
JESD57	Test Procedures for the Measurement of Single-Event Effects in Semiconductor Devices from Heavy Ion Irradiation
JESD234	Test Standard for the Measurement of Proton Radiation Single Event Effects in Electronic Devices
J-STD-020	Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices
J-STD-033	Handling, Packing, Shipping and use of Moisture/Reflow Sensitive Surface Mount Devices
J-STD-035	Acoustic Microscopy for Non-hermetic Encapsulated Electronic Components
TOR-2006(8583)-5236	Technical Requirements for Electronic Part, Material, and Processes used in Space Vehicle

2.2 ACRONYMS

AOQ	Average Outgoing Quality
BGA	Ball Grid Array
BI	Burn-In
BJT	Bipolar Junction Transistor
CA	Construction Analysis
CDM	Charge Device Model
COTS	Commercial-off-the-Shelf
Cpk	Process Capability Index
CTE	Coefficient of Thermal Expansion
DDD	Displacement Damage Degradation
EEE	Electrical, Electronic and Electromechanical
LDRS	Low Dose Rate Sensitivity
EOS	Electrical Overstressed
ESD	Electrostatic Discharge
FA	Failure Analysis
HAST	Highly Accelerated Stress Test
HBM	Human Body Model
HSL	Higher Specification Limit
HTOL	High Temperature Operational Life Test
K _{TL}	One Sided Tolerance Limit Constant
LAT	Lot Acceptance Testing
LSL	Lower Specification Limit
MSL	Moisture Sensitivity Level
PEMs	Plastic Encapsulated Microcircuits
PEDS	Plastic Encapsulated Discrete Semiconductors
PETS	Pre-Irradiation Elevated Thermal Stress
PMPCB	Parts, Material, and Process Control Board
QML	Qualified Manufacturer's List
QCI	Quality Conformance Inspection

RLAT	Radiation Lot Acceptance Testing
RMS	Root Mean Square
SEE	Single-Event Effects
SEM	Scanning Electron Microscopy
SMT	Surface Mount Technology
SPC	Statistical Process Control
Tg	Glass Transition Temperature
TID	Total Ionization Dose

3. GENERAL REQUIREMENTS

- 3.1 PEDS intended for spaceflight applications should meet all of the requirements within this document, including but not limited to the following screening and lot acceptance requirements.
- 3.2 Qualification: Devices for qualification shall be subjected to characterization testing and evaluations of failure mechanisms of Section 5 or have data to show the technology meets or exceeds these requirements. The qualification shall comply with the requirements of Section 6 for screening and Section 8 for lot acceptance requirements.
- 3.3 The lot acceptance testing in Table 8 is limited to the specific lot that is being subjected to screening. It is expected that the manufacturer of the component (OCM) has performed product qualification using industry acceptable standards such as JESD47 (Stress-Test-Driven Qualification of Integrated Circuits) or AEC-Q101 (Automotive Electronic Council) documents. The product qualification is intended to qualify the product and process of the device being considered for screening and lot acceptance. The user of the lot being subjected to screening and lot acceptance may consider additional testing to be added to lot acceptance tests based upon available data from OCM or as required by application for which the lot is being used.

4. DEVICE CLASSIFICATION DETERMINATION

4.1 Purpose of Determining Device Classification

- a. Product that may require further validation or if a product can be committed to proceed to the normal screening and lot acceptance requirements shall be determined by following the process as shown in Figure 1.
- 4.2 Commercial-off-the-shelf (COTS) part is a part designed primarily for commercial applications for which the item manufacturer solely establishes and controls the specifications for performance, configuration and reliability, including design, materials, processes, testing, and physical/failure analysis without communicating additional or custom requirements imposed by users. For example, this would include any type of part from a catalog without any additional parts level testing.
- 4.3 Qualified manufacturer's list (QML) refers to parts qualified by QML suppliers as defined by MIL-PRF-19500. Such parts may not need to go through the device characterization flow, because they have previously been through such a characterization as part of their initial space qualification. It is however recognized that PEDS do not currently meet all requirements of MIL-PRF-19500 for space applications.

Applicable only for current or active products

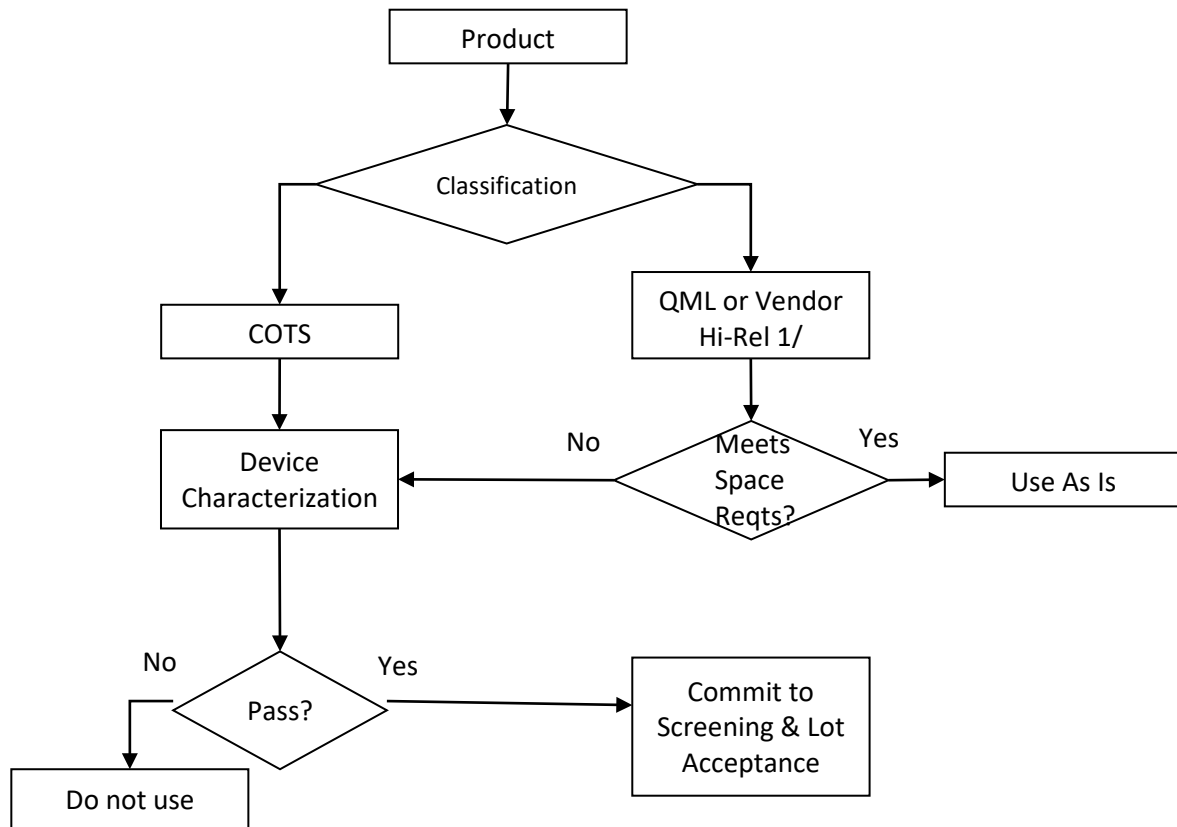


Figure 1 - Device classification determination

1/ Vendor Hi-Rel is non-space; the QML at the present time does not have PEDS.

5. DEVICE CHARACTERIZATION

5.1 Purpose of Device Characterization

- The device characterization covers the initial investigations needed to understand the details of the technology used in a PEDS product. The device characterization process is meant to provide the necessary information to determine what environmental boundary conditions need to be set during the screening and lot acceptance testing/qualification.
- Where performance and reliability of a PEDS in a space environment has not been evaluated by the manufacturer, it is important to perform a suitably detailed technology evaluation program (device characterization) before committing to device screening and lot acceptance testing.
- The depth of this evaluation may vary with the amount of information available from the manufacturer and will require the user to perform the necessary analyses and tests that are required for a space level PEDS. Figure 2 provides a high level view of a typical device characterization program.

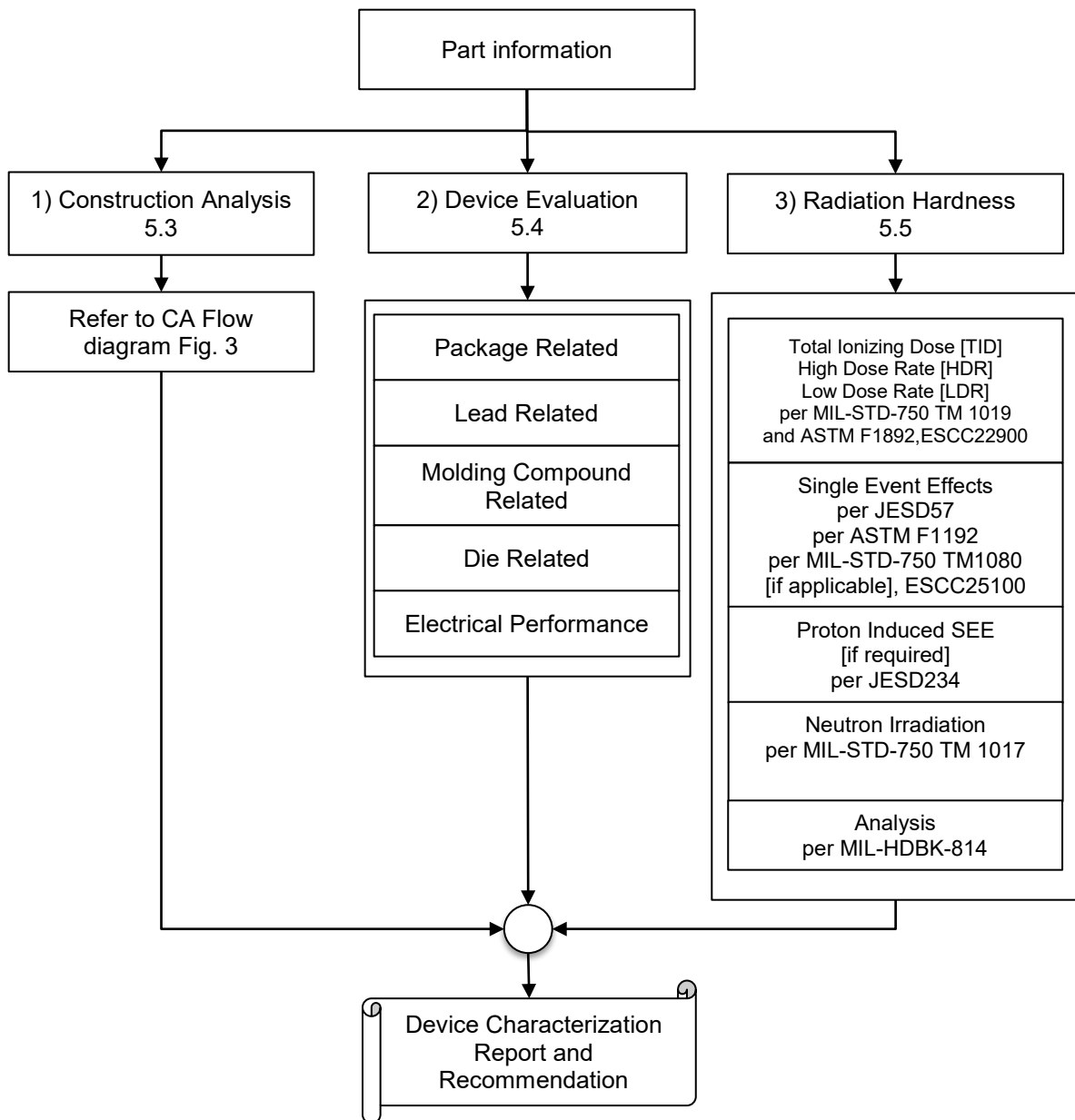


Figure 2 - Typical device characterization flow for PEDS



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