NASA Testing & Derating Document Update

Chris Green, NASA Goddard Space Flight Center,

Christopher.m.green-1@nasa.gov

Noman Siddiqi, Jacobs Engineering Group Inc., work performed for NASA Goddard Space Flight Center

noman.a.siddiqi@nasa.gov

Electrical Engineering Division, Code 560

Acronyms

AEC	Automotive Electronics Council	MIL	Military
ARC	Ames Research Center	MSFC	Marshall Space Flight Center
BME	Base Metal Electrode	MSL	Moisture Sensitivity Level
COTS	Commercial Off The Shelf	NASA	National Aeronautics & Space Administration
DPA	Destructive Physical Analysis	NESC	NASA Engineering & Safety Center
EEE	Electrical, Electronic, and Electromechanical	NPD	NASA Policy Directive
EEEE	Electrical, Electronic, Electromechanical, and Electro-Optical	NPR	NASA Procedural Requirement
GPR	Goddard Procedural Requirement	PCB	Parts Control Board
GRC	Glenn Research Center	PDA	Percent Defect Allowable
GSFC	Goddard Space Flight Center	PEM	Plastic Encapsulated Microcircuit
HAST	Highly Accelerated Temperature and Humidity Stress Test	PIND	Particle Impact Noise Detection
HTOL	High Temperature Operating Life	PRT	Platinum Resistance Thermometer
ISO	International Organization for Standardization	QML	Qualified Manufacturers List
JEDEC	Joint Electron Device Engineering Council	RF	Radio Frequency
JPL	Jet Propulsion Laboratory	RTD	Resistance Temperature Detector
JSC	Johnson Space Center	SCD	Source Control Drawing
KSC	Kennedy Space Center	SMA	Safety and Mission Assurance
LARC	Langley Research Center	SPEC	Specification
LAT	Lot Acceptance Testing	STD	Standard
MAR	Mission Assurance Requirements	VICD	Vendor Item Control Drawing

Applicable Documents

- **NPD 8730.2:** NASA Parts Policy
- **NPR 7120.5**: NASA Space Flight Program and Project Management Requirements
  - Covers Class A, B, C, and D missions
- **NPR 7120.8**: NASA Research and Technology Program and Project Management Requirements
  - Tech Demo, Do no harm, etc.
- **NASA-STD-8739.10**: Electrical, Electronic, and Electromechanical (EEE) Parts Assurance Standard
- **NPR 8705.4A**: Risk Classification for NASA Payloads
  - https://nodis3.gsfc.nasa.gov/displayDir.cfm?Internal_ID=N_PR_8705_004A_&page_name=main
  - Rev A, Effective Date April 29, 2021
  - https://sma.nasa.gov/news/articles/newsitem/2021/05/06/osma-releases-significant-npr-8705-4a-updates
- **GPR 8705.4**: Risk Classification Guidelines and Risk-Based SMA Practices for GSFC Payloads and Systems
- **EEE-INST-002**: Instructions for EEE Parts Selection, Screening, Qualification, and Derating
  - Defines 3 “Levels”
- **NASA-STD-8739.11:** Electrical, Electronic, Electromechanical, and Electro-Optical (EEEE) Parts Selection, Testing, and Derating Standard
  - To supersede EEE-INST-002
  - Defines 4 “Assurance Levels”, 1-4
  - Quad ”EEEE” to include guidance on electro-optic parts

NPR 8705.4A: Mission Classification to Parts Level

SMA Area	Class A	Class B	Class C	Class D
Electronics, Electrical, and Electromechanical (EEE) Parts	Select EEE parts at an appropriate level for functions tied directly to mission success commensurate with safety, performance and environmental requirements. Perform additional screening and qualification tests, as necessary, to reduce mission risk. For secondary functions not tied directly to mission success, lower level parts are acceptable in accordance with project-level documentation Accepted Standard: NASA-STD-8739.10, Electrical, Electronic, and Electromechanical (EEE) Parts Assurance Standard.			
	Level 1 parts, equivalent Source Control Drawings (SCD) or requirements per Center Parts Management Plan.	Class A criteria or Level 2 parts, equivalent SCD or requirements per Center Parts Management Plan.	Class B criteria or Level 3 parts, equivalent SCD or requirements per Center Parts Management Plan.	Class C criteria or Level 4 parts, equivalent SCD or requirements per Center Parts Management Plan.

Introducing NASA-STD-8739.11

- NASA-STD-8739.11: Electrical, Electronic, Electromechanical, and Electro-Optical (EEEE) Parts Selection, Testing, and Derating Standard
  - Follows from top level guidance provided in NASA-STD-8739.10
  - Provide testing requirements and guidance for specific part commodity types
  - To supersede, and update requirements of EEE-INST-002
  - Quad ”EEEE” to include guidance on electro-optic parts
  - Defines “Assurance Levels”, 1-4

NASA-STD-8739.11 Assurance Level Philosophies

- Level 1: Level 1 represents the most stringent set of testing requirements and typically favors the highest classes of MIL-SPEC parts. Requirements include Screening, Lot Acceptance Testing, Destructive Physical Analysis (DPA), and use of Source Control Drawings (SCD) for custom testing flows.
- Level 2: Level 2 is a substantial set of testing requirements and typically favors the second highest classes of MIL-SPEC parts. Requirements include Screening, Lot Acceptance Testing, and DPA, but with some reduced tests, sample sizes, and durations from Level 1. Use of Source Control Drawings is encouraged, but not always required.
- Level 3: Level 3 generally allows both MIL-SPEC based designs, as well as infusion of commercial parts based designs with minimally burdensome piece part testing requirements. Level 3 generally includes some Screening, but does not impose Lot Acceptance Testing. Level 3 criteria rely heavily on Destructive Physical Analysis as an inexpensive test to obtain objective insight into manufacturer workmanship and quality.
- Level 4: Use of commercial parts with no additional screening or qualification. At level 4, in applications that have low tolerance for risk and sufficient resources, it is essential to have detailed information about the manufacturer and part prior histories.
- ***Derating is a primary driver for reliable application, and is independent from the assurance levels.***

NASA-STD-8739.11 Flexibility: Alternate Assurance Approaches

- NASA recognizes the need to infuse commercial parts and technologies, and that the traditional screening practices are not always the best approach. NASA-STD-8739.11 intends to allow certain flexibilities in order to infuse the new technologies that NASA missions require.
  - Piece part testing is a brute force method for establishing an assurance level or confidence in the reliability of a part.
    - Historically has worked, but expensive on a production basis.
    - MIL spec approaches and manufacturing processes have generally followed this approach.
    - Modern technology components are often incompatible with MIL spec testing requirements.
  - Commercial industry has evolved different methods for ensuring production of reliable parts.
    - Favors reliability through high volume production, high levels of automation, statistical process controls, and process parameter trending.
    - Many commercial parts are achieving comparably high reliability, and would be suitable for NASA missions- but how do we tell them apart ***without*** the expensive testing?
    - Out of scope for 8739.11- but there are parallel efforts working towards that goal. 8739.11 hopes to be compatible with these approaches- particularly in level 3 applications, and in place of "recommended" tests.
  - *NESC-RP-19-01490: Phase I - Recommendations on Use of Commercial-Off-The-Shelf (COTS) Electrical, Electronic, and Electromechanical (EEE) Parts for NASA Missions*
    - Available on https://ntrs.nasa.gov/citations/20205011579
    - Phase II nearing completion

NASA-STD-8739.11 Flexibility: Recommended vs Required Tests

- NASA missions require additional flexibility to successfully infuse new technologies and commercial parts for flight applications.
- Hardware developers are expected to provide data to justify proposed candidate parts.
  - This may include successful previous flight missions, a known or expected radiation performance, significant part experience through prototype designs or engineering model testing, and familiarity with and knowledge of the part manufacturer, product line, process controls, and quality. Information regarding design fault tolerance, benign stress conditions, low criticality applications, and planned board and box level testing campaigns will also help to support this justification.
  - In situations where this data is available and can be presented, it is expected that the Parts Control Board (PCB) will not impose the “recommended” piece part tests.
- When a candidate part represents a relatively new technology, lesser known manufacturer data, challenging construction techniques, manufacturing processes, or stressful or unique application conditions, the PCB may impose the “recommended” piece part tests to achieve the desired assurance.
  - These tests should be imposed sparingly, but ultimately the PCB is responsible to determine if the justification is sufficient, or the additional tests are needed to establish parts assurance.

EEEE Part Assurance Levels

- EEE-INST-002 / NASA-STD-8739.11 Primarily defining different screening and lot acceptance test requirements.
- You can't test in quality. Testing doesn't enhance the quality or grade of part, although may improve confidence.
- The levels of NASA-STD-8739.11 really define how much assurance testing is required.
- Some "grades" of parts may meet a desired "assurance level" as-is. (MIL Class V microcircuit meets assurance level 1, for example).
- For purposes of 8739.11 "assurance level" is the most accurate terminology.

NASA-STD-8739.11 Section Updates

Part Category	Document Section
General Instructions for All Part Categories	1
Capacitors (including BME*)	C1
Connectors and Contacts	C2
Crystals	C3
Crystal Oscillators	C4
Detectors*	D1
Fiber Optics and Passive Components* (Fiber, Cables, Connectors, and Assemblies)	F1
Filters	F2
Fuses	F3
Heaters	H1
Magnetics	M1
Microcircuits, Hybrid Hermetic	M2
Microcircuits, Monolithic	M3

Part Category	Document Section
Microcircuits, Monolithic Plastic Encapsulated	M5
Microwave and RF Devices*	M6
Microcircuits, Hybrid Non-Hermetic*	M7
Optoelectronic Devices*	O1
Laser Devices*	L1
~~Printed Circuit Boards*~~	~~P1~~
Relays, Electromagnetic	R1
Resistors	R2
Semiconductor Devices, Discrete	S1
Semiconductor Devices, Plastic Encapsulated*	S2
Switches	S3
~~Thermistors~~ Thermal Sensors	T1
Wire and Cable	W1

- 26 individual sections were originally authored
  - *Included 9 new sections
- 7 sections updated this year
- 1 section omitted from final cut

NASA-STD-8739.11 Section Format

- Each Commodity Section is Formatted as:

  Introduction:
  - Brief description of the commodity.
  - General guidelines and important usage factors for the commodity.

  Tables
  - Table 1 - Overall requirements for each level
  - Table 2 - Screening (100%)
  - Table 3 - Lot Acceptance Testing (LAT), (sample)
  - Table 4 - Derating Criteria

Notable Changes: Connectors and Contacts

- Removal of the “prohibition” of press-fit and compliant pin connectors
  - Warning: ALL OF THE CONCERNS associated with press fit connector applications still exist and are valid
  - However, NASA has increasing needs for high-speed, high-density connectors, and a path for infusion of compliant pin connector solutions
  - Recommendation: Develop workmanship plans, manufacturing processes, and verifications of those processes for specific compliant pin applications
    - NASA-STD-8739.11 will provide minimal guidance- puts burden on hardware developers to justify their process and verification.

Notable Changes: Printed Circuit Boards

- Printed Circuit Boards omitted from the final cut
  - Existing Printed Circuit Board requirements and guidance did not fit well within the format and context of NASA-STD-8739.11
  - Recommendation: Look to existing documents for requirements and guidance on specifying and accepting printed circuit boards
    - Example: GSFC-STD-8001: Standard Quality Assurance Requirements for Printed Circuit Boards

Notable Changes: Thermal Sensors

- Updated to include guidance for Thermistors and Resistance Temperature Detectors (RTDs) including Platinum Resistance Thermometers (PRTs)
- Added notes to clarify derating criteria and applicability
- Retitled section to match expanded commodity coverage

Other Updates

- Added QML Class “P” classification to PEM Section
- Updated Magnetics Section

- Derating:
  - Capacitor Section: Added note for tantalum capacitor surge current derating.
  - Wire and Cable Section: Derating criteria updated

M5, Plastic Encapsulated Microcircuit, Table 1: Requirements

Table 1. PLASTIC ENCAPSULATED MICROCIRCUIT REQUIREMENTS 1/

Assurance Level	Monolithic Microcircuit Type	Specification	Use as Is	Screening	LAT	DPA
Level 1	QML Class P	MIL-PRF-38535				X
	SCD **2/**	SCD		X	X	X
Level 2	QML Class P or N	MIL-PRF-38535				X
	Automotive, Commercial, SCD **2/**	AEC-Q100, VICD, SCD		X	X	X
Level 3	QML Class P or N	MIL-PRF-38535				X
	Automotive, Commercial, SCD **2/**	AEC-Q100, VICD, SCD		X		X
Level 4	QML Class P or N	MIL-PRF-38535	X			
	Automotive, Commercial, SCD **2/**	AEC-Q100, VICD, SCD	X			

Notes:

1/ The character "X" designates a requirement. The character "R" designates a recommendation.

2/ SCD shall be generated to the program-specific Parts Procurement Plan that specifies screening and qualification testing.

Status and Plans for Release

- Individual sections have been compiled into one composite document
- Document and sections have been formatted to meet NASA standard document requirements
- Final draft is undergoing review by NESC Technical Editors
- Intend to publish the draft on NASA Technical Reports Server - Target August 2022
- NASA standard document review and acceptance process to publish final draft and official release – Target January 2023
- Phasing of EEE-INST-002 to NASA-STD-8739.11
  - Expect NASA-STD-8739.11 to be mostly compatible with existing EEE-INST-002 requirements (alleviates requirements)
  - NASA-STD-8739.11 phased in as new projects develop their requirements and contracts

NASA Centers Review Team

- 8739.11 Section drafts established with help from EEEE Parts experts from across NASA Centers and external reviewers.
- Thank you to all contributors!
- Thank you to the NASA Electronic Parts and Packaging Program!

NASA Centers	
ARC	Ames Research Center
GRC	Glenn Research Center
GSFC	Goddard Space Flight Center
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
KSC	Kennedy Space Center
LARC	Langley Research Center
MSFC	Marshall Space Flight Center