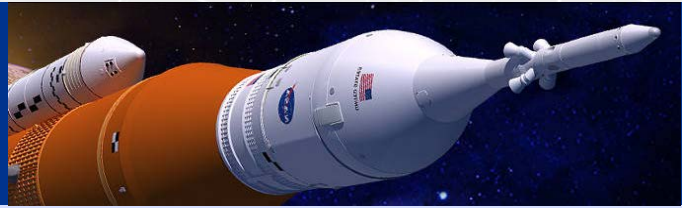
MIL-PRF-19500 Appendix J:

Inclusion of Plastic Encapsulated Discrete Semiconductor Devices for Military Applications Task Group Status Update for NEPP ETW



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Date 06-15-2020

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Acronyms

- AC – Autoclave
- CA – Constant Acceleration
- CA – Construction Analysis
- DLA – Defense Logistics Agency
- DPA – Destructive Physical Analysis
- EP – Engineering Practice
- ESD – Electrostatic Discharge
- HAST – Highly Accelerated Stress Testing
- HTRB – High Temperature Reverse Bias
- IOL – Intermittent Operating Life
- JAN – Joint Army Navy
- JANTX – Joint Army Navy eXtra Testing
- JANTXV – Joint Army Navy eXtra Testing with Visual
- JEDEC – Joint Electronic Devices Council
- NASA – National Aeronautics and Space Administration
- PEDS – Plastic Encapsulated Discrete Semiconductors
- SAE – Society of Automotive Engineers
- Tg – Glassivation Temperature
- Tj – Junction Temperature
- TS – Terminal Strength
- UHAST – Unbiased Highly Accelerated Stress Test

Agenda

1. Marshall Space Flight Center
2. MIL-PRF-19500 Task Appendix J Group
3. Appendix J comparison to SAE 6294/3 and /4 document
4. Appendix J differences in screening and qualification flows
5. Appendix J Task Group Status Summary
6. Appendix J Task Group Future Plans
7. Backup data

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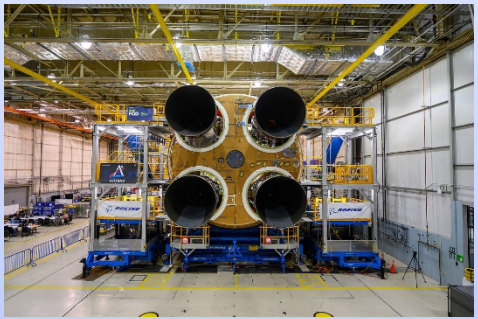
Marshall Space Flight Center (MSFC)

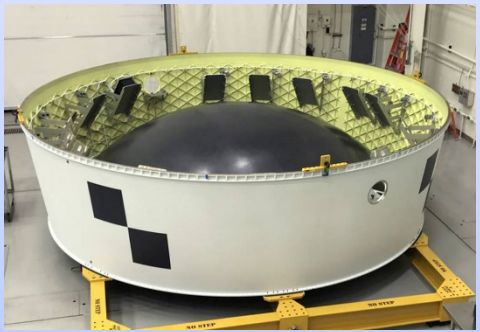
SLS Main Engines
Photo courtesy of NASA

Charter: Space Launch, Propulsion, Exploration Systems, Materials and Manufacturing, Scientific Research Photo courtesy of NASA

Life Sciences Glove Box for ISS
Photo courtesy of NASA



4 RS-25 Main Engines attached to the SLS Core Stage
Photo courtesy of NASA



Orion stage adapter flight hardware Photo courtesy of NASA

Environmental Controlled Life Support System (ECLSS) used on ISS Photo courtesy of NASA

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Liquid Hydrogen Tank in Test Stand
Photo courtesy of NASA

2019 NASA Great Moon Buggy race, 25th anniversary Photo courtesy of NASA

Payload Operations Center for ISS Experiments
Photo courtesy of NASA

ES43 Printed Circuit Board Assembly for experiments and flight hardware
Photo courtesy of NASA

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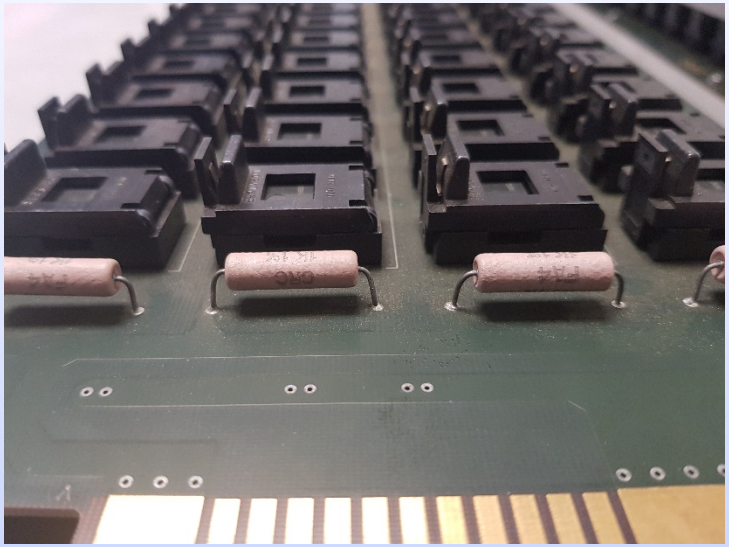
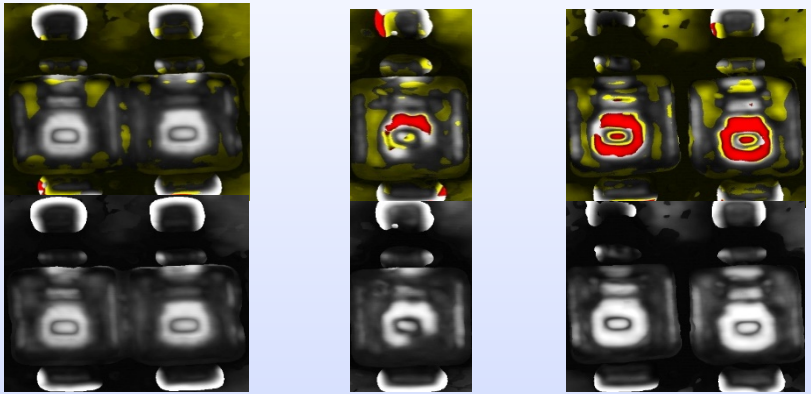
Microchip Technologies



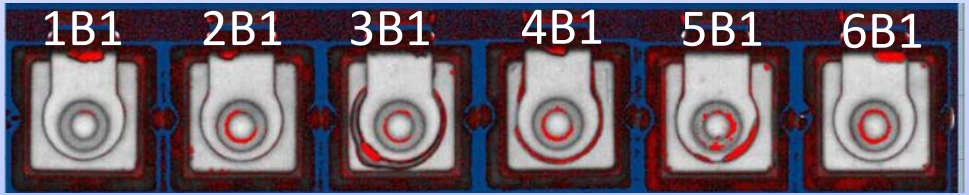
Burn-in board for plastic encapsulated discrete semiconductors

Photo courtesy of Microchip Technologies



Acoustic microscopy images of plastic encapsulated discrete semiconductors

Photos courtesy of Microchip Technologies



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19500 Appendix J Task Group

- The Appendix J Task group was started to address the need for military grade PEDs in Department of Defense programs. Some department of defense programs use plastic encapsulated versions of military discrete semiconductors and have to screen each lot of procured devices prior to usage in their programs. The goal of this effort is to enable the user community to have access to a military qualified plastic encapsulated discrete semiconductor available and eventually have a space qualified plastic encapsulated device.
- There are several concerns with commercial off the shelf PEDs
  - No control over device changes – the military and space user community have no control or oversight into device design changes made by the device manufacturer.
  - Parts Obsolescence – Life cycle for commercial off the shelf PEDs is technology dependent and varies from manufacturer to manufacturer; whereas many military grade devices have been manufactured for decades and continue to be manufactured

19500 Appendix J Task Group Continued

- Lower operating temperature range – commercial off the shelf devices typically have a lower operating temperature range than comparable military grade. For example a military grade 2N2222 transistor operating temperature range is -65C to +200C, while the commercial version operating temperature range is -55C to +150C or less
- Costly screening and qualification testing required for each lot of commercial off the shelf PEDs utilized because there is no guarantee that the device design won't change between procurements of the same part number.

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19500 Appendix J Comparison to SAE 6294/3, /4

- SAE AS6294/3 and AS6294/4 PEDS documents were developed to provide the user community with standard screening and qualification guidelines for commercial off the shelf discrete semiconductors utilized in space and military applications.

- MIL-PRF-19500 Appendix J document development focus has been to provide government and military users with the following: DLA Land and Maritime audited and certified manufacturers, DLA qualified military product, standard screening flows, non-hermetic part number prefix scheme, and standard products.
  - DLA Land and Maritime initial manufacturer audits required to certify and qualify manufacturing lines to supply military qualified non-hermetic MIL-PRF-19500 product
  - Periodic DLA manufacturer re-certification audits identical to the hermetic audits with exceptions due to packaging are required.
  - Standard military screening and qualification flows based on MIL-PRF-19500 hermetic screening and qualification flows with packaging exceptions.
  - Initial DLA Land and Maritime device qualification will be for JANTXV-like and JANTX-like levels only. Initial part numbering scheme prefix is planned to be JANP, JANPX, and JANPXV.
  - Major change table added to appendix J to provide requalification requirements for plastic military qualified devices.

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19500 Appendix J Screening Differences

- Non-hermetic screening flow follows the hermetic screening with differences listed below and as shown in the following slides:
  - Temperature cycling is performed at a lower temperature range than hermetic devices.
  - High Temperature Reverse Bias performed at 125°C ambient temperature or 80 percent of maximum operating temperature if maximum operating temperature is less than 150°C.
  - Burn-in performed at 125°C junction temperature or 80 percent of maximum operating temperature if maximum operating temperature is less than 150°C.

19500 Appendix J Screening Differences Cont.'d

- Non-hermetic screening flow follows the hermetic screening with differences listed below and as shown in the following slides:
  - Radiography 'as specified'.
  - 100 percent Acoustic Microscopy screening 'as specified'.
  - non hermetic JANPXV and JANPX no hermeticity testing required

19500 Appendix J Screening Flow

Screen	JANTXV/JANTX Hermetic	JANTXV-like/JANTX-like Non-hermetic
• Internal Visual	Yes	Yes
• High Temperature Non-operating life	Optional	Optional
• Temperature Cycling	Condition C*	Condition G**

* Method 1051 condition C temperature range is -55°C to +175°C

** Method 1051 condition G temperature range is -55°C to +150°C or maximum storage temperature.

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19500 Appendix J Screening Flow Cont.'d

Screen	JANTXV/JANTX Hermetic	JANTXV-like/JANTX-like Non-hermetic
• Surge	Yes	Yes
• Thermal Impedance	Yes	Yes
• PIND	Optional	Not applicable

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19500 Appendix J Screening Flow Cont.'d

Screen	JANTXV/JANTX Hermetic	JANTXV-like/JANTX-like Non-hermetic
• Interim Electrical Parameters	Yes	Yes
• High Temperature Reverse Bias	Yes	Yes*
• Interim Electrical Parameters	Yes	Yes

*Minimum Tj of 125°C or 80% of maximum operating temperature if less than 150°C

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19500 Appendix J Screening Flow Cont.'d

Screen	JANTXV/JANTX Hermetic	JANTXV-like/JANTX-like Non-hermetic
• Burn in	Yes (Tj = 135°C typical)	Yes*
• Final Electrical Parameters	Yes	Yes

* Minimum Tj of 125°C or 80% of maximum operating temperature if less than 150°C.

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19500 Appendix J Screening Flow Cont.'d

Screen	JANTXV/JANTX Hermetic	JANTXV-like/JANTX-like Non-hermetic
• Final Electrical Parameters	Yes	Yes
• Radiography	As specified	As specified
• Hermeticity	Yes	Not applicable
• Acoustic Microscopy	Not applicable	As specified

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19500 Appendix J Screening Flow Cont.'d

Screen	JANTXV/JANTX Hermetic	JANTXV-like/JANTX-like Non-hermetic
• External Visual	No	Yes
• Case Isolation	As specified	Not applicable

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19500 Appendix J Group A Qualification Differences

- Non-hermetic qualification flow = hermetic (except as noted)
  - Temperature cycling is performed at a lower temperature range than hermetic devices.
  - Added Autoclave or unbiased HAST (sequential test flow) option testing for small die flow which is Group B testing for the small die flow devices.
  - Acoustic Microscopy screening will be ‘As specified’ on a slash sheet by slash sheet basis for non hermetic JANTXV-like and JANTX-like devices

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19500 Appendix J Group A Qualification Differences

- Group A subgroup 1, small die flow
  - Highly Accelerated Stress Testing
    - 130C/85% RH t = 96 hours, or
    - 110C/85% RH t = 264 hours, or
    - Autoclave – 121C/100% RH t = 96 hours
  - Temperature cycling test condition G instead of condition C

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19500 Appendix J Group B Qualification Differences

- Non-hermetic qualification flow = hermetic (except as noted)
  - Temperature cycling is performed at a lower temperature range than hermetic devices.
  - Life testing (340 hours) performed at lower temperature (+125°C)or 80 percent of maximum operating temperature
  - Acoustic Microscopy screening is required as part of the decapsulation design verification process.
  - Added Autoclave or unbiased HAST sequential testing for non small die flow products.
  - Added glass transition (Tg) temperature test.

19500 Appendix J Group B Qualification Differences

- Group B subgroup 2
  - Preconditioning per J-STD-020
  - Temperature cycling 90 cycles

- Group B subgroup 4
  - Acoustic Microscopy
  - Design verification using MIL-STD-750 test method 2075 and MIL-STD-1580 requirement 16 for plastic criteria

- Group B subgroup 7
  - Glass transition temperature Tg

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19500 Appendix J Group C Qualification Differences

- Non-hermetic qualification flow = hermetic (except as noted)
  - Group C subgroup 2
    - Preconditioning per J-STD-020
    - Temperature cycling 500 cycles
  - Group C subgroup 3
    - Moisture sensitivity level
    - Highly Accelerated Stress Testing
    - Temperature cycling test condition G instead of condition C
    - 1000 hour temperature humidity test – 85C/85% RH

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19500 Appendix J Group D Qualification Differences

- Non-hermetic qualification flow = hermetic (except as noted)
  - Group D subgroup 2 – steady state total dose radiation testing
    - Device burn in completion will be required prior to beginning total dose radiation testing. Sample size of 10 – 15 devices required for radiation testing is specified in the draft document.

19500 Appendix J Group E Qualification Differences

- Non-hermetic qualification flow = hermetic (except as noted)
  - Group E subgroup 1
    - Preconditioning per J-STD-020
    - HAST or Temperature Humidity Bias (THB)
    - Temperature cycling 200 cycles versus 500 for hermetic devices
  - Group E subgroup 1a
    - Preconditioning per J-STD-020
    - Temperature cycling 500 cycles
  - Group E subgroup 9
    - Acoustic Microscopy
    - Moisture sensitivity level
    - Acoustic microscopy

19500 Appendix J Group E Qualification Differences

- Non-hermetic qualification flow = hermetic (except as noted)
  - Group E subgroup 10
    - Glassivation temperature - Tg
    - Plastic evaluation per MIL-STD-883 method 5011
    - Construction analysis per SAE AS6294/3
    - Outgassing and flammability per NASA-STD-6001

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19500 Appendix J Group E Qualification Differences

- Non-hermetic qualification flow = hermetic (except as noted)
  - Group E subgroup 11

    - Single Event Effect Testing – Characterization curves will be required for MOSFETs. Characterization data will be required for Schottky diodes with a forward current rating greater than or equal to 1 Amp.

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19500 Appendix J Task Group Status Summary

- The Task Group reviewed the final draft of 19500 Appendix J dated May 19, 2020 during the May 26, 2020 teleconference to resolve reference to quality system requirements in MIL-PRF-19500 appendix D and ESD marking requirements in appendix E. Verbiage was added to the new Appendix J draft to reference MIL-PRF-19500 Appendix D and Appendix E for ESD marking requirements.
- The 19500 Appendix J draft dated May 19, 2020 was submitted on May 26, 2020 to DLA Land and Maritime for inclusion into the next initial draft of MIL-PRF-19500 which is scheduled to be revision P, amendment 5. Draft revision MIL-PRF-19500 Revision P, Amendment 5 is tentatively scheduled to be released as an initial draft to the government and user communities for review and comment in the June/July 2020 timeframe.

19500 Appendix J Task Group Future Plans

Current plan:

- Develop a list of test methods for inclusion in MIL-STD-750
- Review comments to the initial draft of MIL-PRF-19500 revision P amendment 5

Future work:

- Plans to add JANS flow to Appendix J will depend on user acceptance of the new Appendix J non hermetic military products

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Thank You!!

We would like to express our gratitude to the NASA NEPAG and SLS programs, Government Working Group, and Microchip Technologies for their continued support of this effort.

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19500 Appendix J

Back up Slides

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19500 Appendix J Group A Qualification Differences

- Group A subgroup 1 small die flow

Subgroup 1 (for small die flow only 2/ 3/)		
Visual and mechanical examination 4 /	2071	116 devices, c = 0 (JANTXV) 45 devices, c = 0 (JAN, JANTX)
Acoustic microscopy	J-STD-035	Test condition per JEDEC J-STD-020 Condition as specified and documented by supplier. Option-temp cycle. No rejects allowed
Solderability 4/	2026	15 leads, c = 0
Resistance to solvents 4/	1022	15 devices, c = 0
Preconditioning	JEDEC JESD22-A113	
Acoustic microscopy	J-STD-035	Test condition per JEDEC J-STD-020 Condition as specified and documented by supplier. Option-temp cycle. No rejects allowed
	JESD22-A102	121C/100%RH t = 96 hrs, or
Autoclave or,	JESD22-A118	130C/85% RH t = 96 hrs, or
UHAST or,		110C/85%RH t =264 hrs
UHAST		

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19500 Appendix J Group A Qualification Differences

- Group A subgroup 1 small die flow

Temperature cycling (air to air) 4/	1051	Test condition G, or maximum storage temperature, whichever is less, 25 cycles. 22 devices, c = 0
		121C/100%RH t = 96 hrs, or 130C/85% RH t = 96 hrs, or 110C/85%RH t =264 hrs
Autoclave or,	JESD22-A102	121C/100%RH t = 96 hrs, or
UHAST or,	JESD22-A118	130C/85% RH t = 96 hrs, or
UHAST		110C/85%RH t =264 hrs
Temperature cycling (air to air) 4/	1051	Test condition G, or maximum storage temperature, whichever is less, 25 cycles. 22 devices, c = 0
Acoustic microscopy	J-STD-035	Test condition per JEDEC J-STD-020 Condition as specified and documented by supplier.
Electrical measurements (group A, subgroup 2)		
Bond strength 4/	2037	Precondition T_A = +250°C at t = 24 hrs or T_A = +300°C at t = 2 hrs 11 wires, c = 0
Decap internal visual (design verification)	2075	4 devices, c = 0

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19500 Appendix J Group B Qualification Differences

- Group B subgroup 2

Sequential testing

Subgroup 2		Start of sequential testing
Acoustic Microscopy	J-STD-035	Test condition per JEDEC J-STD-020 Condition as specified and documented by supplier. Option-temp cycle. No rejects allowed
Preconditioning	JESD22-A113	
Acoustic Microscopy	J-STD-035	Test condition per JEDEC J-STD-020 Condition as specified and documented by supplier. Option-temp cycle. No rejects allowed
Autoclave , or	JESD22-A102	121C/100% RH, 96 hours or
UHAST, or	JESD22-A118	130C/ 100% RH, 96 hours, or
UHAST		110C/85%RH, 264 hours
Electrical measurements 4/		

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19500 Appendix J Group B Qualification Differences

- Group B subgroup 2

Sequential testing

Temperature cycling (air-to-air)	1051	Test condition G or maximum storage temperature, whichever is less. (45 cycles including screening)
Autoclave	JESD22 -A102	121C/100%RH t = 96 hrs, or
UHAST, or	JESD22 -A118	130C/100% RH, 96 hours or
UHAST		110C/85% RH, 264 hours
Electrical measurements 4/	1051	Test condition G or maximum storage temperature, hichever is less. (45 cycles including screening)
Temperature cycling (air to air)		
Electrical measurements 4/		
Acoustic Microscopy	J-STD-035	Test condition per JEDEC J-STD-020 Condition as specified and documented by supplier. Option-temp cycle. No rejects allowed
Surge	4066	As specified.

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19500 Appendix J Group B Qualification Differences

– Group B subgroup 4

<u>Subgroup 4</u> Acoustic microscopy Decap internal visual (design verification)	 J-STD-035 2075	 Visual criteria in accordance with qualified design. Plastic concerns for 2075. Refer to MIL-STD-1580 Requirement 16 for plastic microcircuits,

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19500 Appendix J Group B Qualification Differences

– Group B subgroup 7

Subgroup 7 Glass transition temperature	ASTM 1640	

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19500 Appendix J Group C Qualification Differences

– Group C subgroup 2

Subgroup 2		
Acoustic Microscopy	J-STD-035	Test condition per JEDEC J-STD-020 Condition as specified and documented by supplier
Preconditioning	JEDEC JESD22 -A113	
Acoustic Microscopy	J-STD-035	Test condition per JEDEC J-STD-020 Condition as specified and documented by supplier.
Temperature cycling (air-to-air)	1051	Test condition G, or maximum storage temperature, whichever is less. (500 cycles).
Acoustic Microscopy		Test condition per JEDEC J-STD-020 Condition as specified and documented by supplier. Option-temp cycle. No rejects allowed
Electrical measurements		Group A, subgroup 2.

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19500 Appendix J Group C Qualification Differences

– Group C subgroup 3

Subgroup 3		
Acoustic Microscopy	J-std-035	Test condition per JEDEC J-STD-020 Condition as specified and documented by supplier.
Preconditioning	JEDEC JESD22 -A113	
~~Temperature cycling (Air to air)~~	~~1051~~	~~Test condition G (-55C/+150C), or maximum storage temperature, whichever is less. (100 cycles).~~
Highly Accelerated Stress Test (HAST, Biased)	JEDEC JESD22 -A110	130C/85%RH, biased , 96 hours, or 110C/85%RH, biased, 264 hours
Temperature cycling (air to air)	1051	Test condition G (-55C/+150C), or maximum storage temperature, whichever is less. (100 cycles).
Temp Humidity Bias		85C/85%RH, biased, 1000 hours
Acoustic microscopy	J-STD-035	
Electrical measurements		Group A, subgroup 2.

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19500 Appendix J Group E Qualification Differences

- Group E subgroup 9

Subgroup 9			
Acoustic Microscopy	JEDEC J-STD-035	Delamination >10%	10 devices from MSL sample. C = 0
Moisture Sensitivity Level Classification	JEDEC J-STD-020	Test is performed to determine moisture sensitivity level per JEDEC J-STD-020. Conditions will be used based on supplier data available. Moisture level will be the lowest numerical level (1-6) that has no failures based on pass/fail criteria in J-STD-020.	45 devices, c = 0
Acoustic Microscopy 3/	JEDEC J-STD-035	Delamination >10%, no additional delamination from pre-stress.	10 devices from previous Acoustic Microscopy C = 0
Electrical Measurements		Group A, subgroup 2.	45 devices, c = 0

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19500 Appendix J Group E Qualification Differences

- Group E subgroup 10

Subgroup 10		
Glassivation Temperature (Tg)	ASTM E1640	
Plastic evaluation	883/5011	Type I electrically conductive or Type II electrically insulative
Construction analysis	SAE6294/3	A construction analysis as per SAE6294/3 is recommended
Outgassing	ASTM E595	

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