

ENGINEERING PRACTICES STUDY

TITLE: ENGINEERING PRACTICE STUDY TO REVIEW PROPOSAL TO ADD A
NON-HERMETIC APPENDIX TO MIL-PRF-19500

12 February 2020

STUDY PROJECT (SEE ATTACHMENT 1)

FINAL REPORT

Study Conducted by DLA LAND AND MARITIME

Project Number: 5961-2019-074

Prepared by:

Jason Hochstetler

I. OBJECTIVES: An engineering practice study was conducted to review a proposal of a new appendix that covers non-hermetic devices for MIL-PRF-19500. The purpose of this study was to obtain input from the military services, device manufacturers, and user community concerning the proposed appendix that will be used to prepare an initial draft.

II. BACKGROUND: Military services have requested that DLA add performance requirements and verification testing for non-hermetic devices to MIL-PRF-19500. DLA has received comments that indicate non-hermetic plastic encapsulated devices are desired for some applications or circumstances. Many programs are currently using non-hermetic commercial off the shelf (COTS) or automotive components but require additional testing before use.

The addition of a non-hermetic appendix to MIL-PRF-19500 would allow for standardization of this additional testing, and would also include conformance inspection testing, which is not typically included in existing non-hermetic semiconductor specifications. In addition to those benefits, Manufacturers who wish to supply devices to the new appendix must be certified and qualified to MIL-PRF-19500.

At the time of this final report, the proposed non-hermetic appendix covers non-space level devices.

III. RESULTS: In addition to the study, a biweekly meeting was initiated to review the drafts and inputs from the study to provide additional suggestions and content to be used for the creation of the new appendix to be included in an initial draft. The comments received by DLA Land and Maritime in ATTACHMENT 1 have also been reviewed and discussed at the JEDEC "MIL-PRF-19500 Appendix J, Non-hermetic parts for ground applications" subcommittee meeting. The subcommittee requested that the Appendix J proposal also be circulated on the JEDEC website through a ballot process to obtain additional feedback.

IV. CONCLUSIONS: Based on feedback received from the initial comments, DLA Land and Maritime will propose adding the non hermetic appendix proposal to the upcoming draft of MIL-PRF-19500. DLA Land and Maritime will continue to coordinate remaining concerns listed in ATTACHMENT 1 regarding the testing and conditions of this proposed appendix through biweekly teleconference meetings. DLA Land and Maritime will propose the results of the final coordination as a new Appendix J for Non Hermetic devices in the next coordination of MIL-PRF-19500.

V. RECOMMENDATIONS: DLA Land and Maritime recommends that the proposed new appendix for non hermetic devices be incorporated as Appendix J of MIL-PRF-19500, and included in the initial draft of MIL-PRF-19500 revision R. In addition, it is recommended that all manufacturers, military, and industry representatives review the upcoming draft and provide comments.

Attachment 1		
Paragraph no.	Comment	Resolution
J.1.1	1st paragraph: There is a reference to 3.2.1.1, but no 3.2.1.1 in main document.	3.2.1.1, along with other paragraphs proposed be added to MIL-PRF-19500, is located at the end of the word file of the appendix J draft.
	2nd paragraph: Should we consider the word "shall" in lieu of "should"	Shall is not permitted to be used in section 1
J.2.1.1	Add MIL-STD-883/1015.x	Remove method 1015 and leave MIL-STD-883
	J.2.1.1 and J.2.2: Appear to be many reference documents called out in these sections that do not appear in the body of the document. For example, NASA-STD-6001, 2 ESCC documents, JESD22-A101, JESD22-B106, JESD47, JESD94, J-STD-046, JESD625	These might have been used in earlier drafts of this Appendix J. These will be noted and the documents not used will be removed in the final version.
J.2.2	Check ESCC spec access	Currently only listed as reference and not used in the draft. Will be removed for draft.
	Check JEDEC access to specs	JEDEC specifications referenced are available on the JEDEC website, If concerns still exist over availability users may work with DLA to create test methods in MIL-STD-750.
	Since this is a US military specification, the use of foreign specifications for which we have no editorial control nor inputs is not recommended, at this time.	Currently only listed as reference and not used in the draft. Will be removed for draft.
J.3.1	Appears that the following reference documents, for example, are not referenced in sections J.4 and E.2 as indicated; JEDEC JESD22-A113, JEDEC JESD22-A118, ASTM 1640, ASTM E595	J.3.1 will be corrected/clarified to identify the correct usage of the listed documents. Reference E.3.4
J.3.3	Both JESD22-B101 and JEDEC J-STD-033 documents do not seem to be referenced elsewhere in the document in terms of application of these tests.	These might have been used in earlier drafts of this Appendix J. These will be noted and the documents not used will be removed in the final version.
J.4.1		
Table I	Subcons qualified to MIL specs	Needs clarification or more specifics
	Internal visual	Precap performed prior to mold, test method update for plastic
	High temper non operating life - add 340 hr min?	Slash sheet should specify minimum time and temperature
	High temper non operating life - optional	Agree, slash sheet specific
	Should default high temp nonoperating life be specified	Yes, this will be specified in the slash sheet
	The first test is 1b. What happened to 1a?	This table is based off of the existing screening table in 19500, and 1a is die visual for glass diodes and it is not needed in this appendix.
	We may want to leave glass transition temp test here so that we know what it is and avoid exposing all the parts to temps that are too high in subsequent SGs.	Tg testing will not be part of screening. glass transition testing shall be part of the incoming inspection by the manufacturer and data reviewable by DLA in addition

		to the 5011 testing. Add as paragraph in appendix J
Table I, screen 3.a	Test condition G or maximum storage temperature	Agree to same format as hermetic for this screen
Screen 3b	Why hermeticity N/A? Should this note on screen 3B and screen 3C read closer to existing screening table? "Shall be performed any time before completion of screen 13. Surge shall precede thermal impedance. Surge and thermal impedance are applicable only when specified in the screening table of the specification sheet."	Needs clarification
	Screening table notes	Need to review and make sure that all applicable notes are included. Delete nonapplicable notes
Screen 10	Time should be increased as a function of the devices minimum Ea, using the Arrhenius Equation.	Agree, add applicable time/temp options, and provide reference to test method or refer to slash sheet.
Screen 10c	Is 125 C for TVS, would transistor be higher rated temperature? What if device rated to 175 C? Max operating, is this Tstg or Tj? Why 80% or rated temperature? "Whichever is less is" to be added?	Should specify 125 C in screening table unless other specified in slash sheet
	Deleted storage	Agree
Screen 10a	Would default to 150 if read this TM alone? Same for 1038?	Need to modify the HTRB temperature for transistors to be 125 or 80% of max operating temperature
	In screens 10, the temperature specified should be based on junction temperature Tj not ambient temperature Ta.	Agree
Screen 12	What about Tj for transistors? Done at ambient temperature	Agree. Burn in is Tj so add Tj for burn in temp.
	What percentage of MIL-STD-883/1015 table class level B	Discussed this note and don't believe that 883 reference is applicable.
	Should this be Tstg or Tg (glass transition temperature?) or both?	Could apply to both. Need further review. Tj of 125C is used not Tg or Tstg.
	No note 10, MIL-PRF-19500 has "Optional accelerated HTRB for power FETs in accordance with test method 1042 of MIL-STD-750, condition A, shall be 48 hours minimum at TA = +175°C minimum. Initial use of this option is contingent upon subsequent completion of a one time 1,000 hour qualification in accordance with test method 1042 condition A, at TA = +175°C minimum, and as specified on group E of the individual specification sheet; to be submitted with the initial qualification report. Alternate flow options shall not be used to qualify this accelerated HTRB option"	MOSFET manufacturers are not performing the accelerated HTRB for MOSFETs. Decision is to leave historical option in as written.
	Agree with NASA that the temp should be increased but would not use MIL-STD-883/1015 table since it is under review. Recommend using the actual device Ea and the Arrhenius Equation.	Remove reference to MIL-STD-883 in this instance.
	In screen 12, the temperature specified should be based on junction temperature Tj not ambient temperature Ta.	Agree

Screen 15b	Acoustic microscopy Delta pre and post MSL? Problem on curved surfaces versus flat surfaces.	Need further review - currently on an as specified basis in Appendix J. 100% CSAM required when an issue found in qualification process. Need to specify what the failure criteria should be.
Screen 16	External visual - Why 100%? TM re-write or new spec?	Need clarification from commenter - Currently under review.
J.5	J.5 CONFORMANCE INSPECTION FOR NON-HERMETIC MOLDED DEVICES - What action is required by 19500 when a QCI fails?	QCI failure is currently covered by the existing nonconformance E.6.1.1, and Resubmitted lots paragraph E.3.6.1 of MIL-PRF-19500.
J.5.5	J.5.5 <u>Group D inspection</u> . Radiation hardness qualification for plastic encapsulated discrete semiconductor devices shall be performed in accordance with the verification requirements of appendix E, see E.4 with the following exceptions due to the packaging. Radiation qualification for plastic encapsulated discrete semiconductor devices shall require radiation testing of post burn-in devices with a minimum sample size of 10 – 15 devices. The current industry recommended practice for radiation testing of plastic encapsulated devices is that the parts to be radiation tested must have completed burn-in.	Currently under review - Group D inspection, paragraph E.6.5 requires that devices must have completed Group A, subgroup 2 prior to irradiation as a minimum. Paragraph also references paragraph E.4.1 for Group D qualification inspection requirements. TID and low dose rate testing would be performed in the package. SEE testing would be performed on a decapsulated or exposed die. In addition, the last sentence should be restructured.
J.5.6	J.5.6 <u>Group E inspection</u> . Group E is a workmanship, ruggedness, and critical interface verification inspection. Group E testing, when specified on the specification sheet is required for initial qualification, re-qualification, and when group E requirements are changed. Whenever group E is re-performed due to changes in requirements (including sample size and bias condition modifications), only the affected subgroups need to be performed. The results of group E testing shall be submitted to the qualifying activity (by all manufacturers prior to shipment of product, as applicable). Product redesigns may be subjected to group E testing as required by the qualifying activity.	Add a change table similar to Table E-III or AEC Q101 change table for this appendix?
J.5.6.1	J.5.6.1 <u>Group E testing requirements</u> . Group E shall be performed in accordance with table J-V and the specification sheet. All tests within a subgroup shall be performed in the order specified. An evaluation shall be performed on all failures to determine if the failure mode is the result of a latent (time dependent) defect, workmanship, or design weakness. Appropriate corrective action shall be performed and approved by the qualifying activity .	Agree that construction analysis is suitable for group E similar to PEDs
Table I, Group A Subgroup1 Small die flow	Preconditioning	Agree sample size for preconditioning should be 22. preconditioning only required for surface mount. Agree should call out when to use
Table I, Group A Subgroup1 Small die flow	Bond strength - Have as a process monitor prior to precap?	Leave as is at current time. Not applicable to packages where no wire bonding is involved.

Table II, Group A Subgroup 1, Small die flow	Recommend adding CSAM just before electrical measurements.	Currently under review.
Table I, Group A Subgroup 3	DC static tests at minimum/maximum temperatures	Agree that small lot sample = 45 pieces
Table J-III Group B, subgroup B2	Preconditioning	Agree small sample size should be added
Table J-III Group B, subgroup B2	UHAST	Add autoclave option after temperature cycling
Table J-III Group B, subgroup B2	Acoustic Microscopy	Need to add a pre acoustic microscopy before preconditioning. Either Serialization or keep parts in sequence between tests is required. Need to add spec for delta requirements ofr acoustic microscopy J-STD-035? (check spec).
Table J-III Group B, subgroup B3	Bond strength	Not applicable to packages where no wire bonding is involved
Table J-III Group B, subgroup B4	Acoustic Microscopy	Currently included, under review if it is needed.
Table J-III Group B, subgroup B4	Recommend we move CSAM to SG3 & SG6 just before Electrical measurements.	Agree
Table J-III, subgroup 7	Recommend eliminating SG7 and performing glass transition temp test in screening. We should determine what the transition temp is so we don't expose the samples to too high a temp in subsequent high temp tests	Disagree. We know what the glass transition temperature Tg is. This is a verification.
Table J-III Group B, note 5	If a given inspection lot undergoing group B inspection has been selected to satisfy group C inspection requirements, the 340 hour or 2,000 cycle life tests may be continued on test to 1,000 hours or 6,000 cycles, as applicable, in order to satisfy the group C life test requirements; and bond pull may be performed after group C life test. End point measurements shall be performed or either group B, subgroup 3 (340 hours or 2,000 cycles, as applicable) to satisfy group B lot acceptance or group C, subgroup 6 (1,000 hours or 6,000 cycles, as applicable) to satisfy group B and C lot acceptance.	Agree
	"...shall be performed or either group B..." - Shouldn't "or" be "on".	Should be changed to "at" to match existing MIL-PRF-19500.
Table J-IIIA small die flow step 1	Steady state life test	Tj is called out in slash sheet.

	Recommend adding a CSAM before Electrical measurements for both steady state and intermittent life, and non-op HTL.	Currently under review.
Table J-III A small die flow step 2	HTRB	Default will be at rated junction temperature.
Table J-III A small die flow step 3	High temperature non operating life TA = +200C	Default to maximum junction temperature.
	Conditions, TA = 200C - That is probably too high a temp for plastic parts to maintain their initial glass transition temp.	Agreed
Table J-III A small die flow step 3	Glass transition temperature	Currently included
Table J-IV Subgroup 1	(not required for JANS)	JANS verbiage will be removed for the initial release.
Table J-IV Subgroup 2	Temperature cycling	Currently included, 1051
Table J-IV Subgroup 2	Electrical measurements, Recommend adding CSAM just before electrical measurements.	Currently under review.
Table J-IV Subgroup 3	HAST testing	Currently included
Table J-IV Subgroup 3	Electrical measurements, Recommend adding CSAM just before electrical measurements.	Currently under review.
Table J-IV subgroup 6	Electrical measurements, Recommend adding CSAM just before electrical measurements for SSOL, IOL, and BL.	Currently under review.
Table J-IV note 5	If a given inspection lot undergoing group B inspection has been selected to satisfy group C inspection requirements, the 328 hour or 2,000 cycle life tests may be continued on test to 1,000 hours or 6,000 cycles, as applicable, in order to satisfy the group C life test requirements; and bond pull may be performed after group C life test. End point measurements shall be performed on either group B, subgroup 3 (328 hours or 2,000 cycles, as applicable) to satisfy group B lot acceptance or group C, subgroup 6 (1,000 hours or 6,000 cycles, as applicable) to satisfy group B and C lot acceptance.	Agree
Table J-IV note 7	T _J = 150°C (min) or rated T _J whichever is less (except Schottky and power MOSFETs) for operation life	Currently included
Table J-V, Subgroup 1	Preconditioning	Currently included
Table J-V, Subgroup 1	HTSL	Currently included
Table J-V, Subgroup 1	Hast or thb, Temperature cycling	Currently included
	HTSL	Currently included
	Hast or thb	Currently included

Table J-V, Subgroup 1	Temperature cycling	Currently included
Table J-V, Subgroup 1	Electrical measurements, Recommend adding CSAM just before electrical measurements, in SGs 1, & 2.	Currently under review.
Table J-V, Subgroup 2	Electrical measurements or steady-state operating life	Currently included
Table J-V, Subgroup 7	Resistance to soldering heat	Currently included
Table J-V, Subgroup 9	Acoustic Microscopy Delamination > 10%	Currently included
	Group B:	
Table J-III	Subgroup 2 seems overly harsh, can it be reduced from: Pre-Conditioning -> Autoclave/UHAST -> Temperature Cycling -> Autoclave/UHAST -> Temperature Cycling -> Acoustic Microscopy -> Surge -> Electrical to Pre-Conditioning -> Autoclave/UHAST -> Temperature Cycling -> Acoustic Microscopy -> Surge -> Electrical	Requested Army to share data their experiences with discrete plastic parts. Is this primarily an IC problem? Multiple lots of same part number/manufacture data available to share? Consider moving the sequential testing from Group B (every lot), to Group C on an annual basis.
	Can Bond Strength be removed from Group B given difficulties of performing test without affecting encapsulant?	Will review - may move to Group C.
	Can Glass Transition temperature Test be removed from Group B?	Recommend move to Group C annual test. Some discussion about whether burn in/life test of parts above the glass transition temperature could be damaging to the parts or benign?
	Group C:	
Table J-IV	Subgroup 3 again seems overly harsh, can it be reduced from: Pre-Conditioning -> Temperature Cycling (x100) -> HAST (130°C/85%, biased 96 Hrs) -> Temperature Cycling -> Temp Humidity Bias (85°C/85%, biased 1000 Hours) -> Electrical to Pre-Conditioning -> -> Temperature Cycling -> Temp Humidity Bias/HAST -> Electrical	Currently under review.
	Group E:	
Table J-V	Subgroup 1 will kill all remaining devices. Can it be reduced from: Preconditioning -> HAST (96 Hours)/THB (500 Hours) -> Temperature Cycles (350 Minimum) -> HAST (96 Hours)/THB (500 Hours) -> Temperature Cycles (350 Minimum) -> Electrical to Preconditioning -> HAST (96 Hours)/THB (500 Hours) -> Temperature Cycles (350 Minimum) -> Electrical	Currently under review.

Table J-V	Can the wording also be changed to read that there is no delamination growth in the active area so that it is in line with the JEDEC standards?	Currently under review.
General comments	It was stated that this appendix does not address space requirements at this time. However, is there a possibility that there could be some mutual benefit in terms of "lessons learned" if vendors were able to or wanted to voluntarily subject there products to space type requirements? I was just speculating that this be could possibly be an opportunity for the vendor to voluntarily test space requirements with some reasonable delta cost for information purposes.	JANS was purposely left out of the appendix J flow. This was done in order to develop a military qualified flow and gauge whether there is sufficient demand for plastic military qualified devices before proceeding to implement a JANS flow for plastic encapsulated devices.