National Aeronautics and Space Administration

One NASA PEM Qualification Standard

Comparison of JPL and GSFC Standards

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1 BACKGROUND

Although use of plastic encapsulated microelectronics (PEMs) in space applications is discouraged, their use is mandatory for selected applications involving the need for advanced technology and small packages. Various space systems designers and manufacturers have developed methods to qualify and screen PEMs. In general, each procedure is different. The purpose of this fiscal year's investigation is to initiate a process to coordinate the efforts at various NASA centers to eventually develop a One NASA method. Part of this activity includes sharing of test data and PEM qualification methodologies.

2 SUMMARY OF FISCAL YEAR 09 ACTIVITY

Various experts in the NASA community were identified and contacted to support this effort. We were successful in finding such experts at GSFC, APL, and the Constellation office (Orion and Ares). These experts provided typical qualification program plans. In the case of Constellation, it was found that their plans were similar to the IEEE-INST-002 in a previous version. Therefore, since funding was severely restricted, it was decided to concentrate on coordination activity with GSFC.

GSFC plans for development of a new version of the IEEE-INST-002 section applying to PEMs is planned. The GSFC expert (Dr. Alexander Teverovsky) provided a detailed assessment of the differences between the planned new version of IEEE-INST-002 and the JPL guideline (JPL D-19426) as well as a summary rationale for the decisions within the IEEE-INST-002. It should be noted that GSFC's assessment of IEEE-INST-002 in the area of PEMs is not finalized. JPL is also considering changes in PEM qualification methodologies based on test data from recent qualification testing for their newer projects (MSL, Grail, and Juno).

3 COMPARISON OF STANDARDS

The current JPL and GSFC standards are summarized and compared in Table 3-1, Technical Requirements Comparison of IEEE-INST-002 and JPL D-19426.

Table 3-1. Technical Requirements Comparison of IEEE-INST-002 and JPL D-19426

	IEEE-INST-002 Planned Requirement	JPL-D-19426 Requirement	Comments
Screening			
1	DPA per MIL-STD-1580, including X-radiograph and CSAM on sample only	DPA per MIL-STD-1580 (excluding X-radiograph and CSAM) on sample only	GSFC keeps radiographic and CSAM tests for consistency with MIL-STD-1580. JPL has seen no failures in radiographic tests, and CSAM results do not correlate to electrical failures in screening or qualification tests.
2	100% external visual and serialization	100% serialization; sample external visual	Equivalent
3	Temperature cycling per MIL-STD-883, Method 1010, Condition B or to manufacturer's storage temperature range; 20 cycles except 10 cycles for Level 3	Not done	GSFC believes that temperature cycling is an important (and inexpensive) test to verify PEM construction quality and plans to keep in INST. JPL temperature cycling is a wearout issue (increasing failure rate with cycles) and cannot be screened out.
4	100% radiographic (for wire sweep)	Not done	JPL has seen no failures in this test.
5	Pre-burn-in electrical test (3 temperatures per datasheet unless application is unusual)	Pre-burn-in electrical test (3 temperatures per datasheet unless application is unusual)	
6	PDA dependent on level of application	JPL does engineering assessment of electrical test data	Similar requirement
7	Burn-in per MIL-STD-883, Method 1015, Condition C or D	Burn-in per MIL-STD-883, Method 1015, Condition C or D	
8	Burn-in ambient temperature specified to +125 degrees Celsius	Burn-in oven temperature adjusted to meet junction temperature calculated to +125 degrees Celsius	Self heating significant in JPL view.
9	PDA dependent on level of application (2% for Level 1; 5% for Level 2; may be eliminated for Level 3)	Acceptability of the burn-in failure rate per the judgment of the JPL PEM expert. A statistical analysis of the post-burn-in versus pre-burn-in data is done.	
10	External visual and serialization	100% serialization; sample external visual	Equivalent

Color Legend:

= Same or equivalent tests

= JPL has more tests or more extensive tests

= GSFC has more tests or more extensive tests

Table 3-2. Qualification

	IEEE-INST-002 Planned Requirement	JPL-D-19426 Requirement	Comments
1	External visual and serialization	Qualification done on parts passing screening	
2	Radiography	Not done	
3	Baseline C-SAM	Not done	
4	Initial electrical measurements (3 temperatures) per vendor datasheet	Initial Electrical measurements (3 temperatures) per vendor datasheet	
5	Pre-conditioning (JESD32-A113)	Pre-conditioning (JESD32-A113)	GSFC treats all devices as Level 0, since MSL data is not always available or consistent. JESD test method is independent of MSL level.
6	Post pre-conditioning C-SAM	Not done	JPL has seen no correlation of CSAM results with electrical failures in other tests.
7	Electrical measurements (3 temperatures)	Previously done as part of screening	
8	Life testing per MIL-STD-883, Method 1005, Condition D on 45 pieces for 2000 hours; 30 pieces for 1000 hours; or 22 pieces for 500 hours for Levels 1, 2, and 3	Life testing per MIL-STD-883, Method 1005, Cond D on 45 pieces for 1000 hours	Equivalent.
9	Post life test electricals at 160 hours and 1000 hours	Post life test electricals at 1000 hours and intermediate points as determined by JPL PEM specialist. A statistical analysis of post life test electricals is done	
10	Temperature cycling per MIL-STD-883, Method 1010, Condition B, for 500, 200, and 100 cycles for Levels 1, 2, and 3 on 20 devices	Temperature cycling per MIL-STD-883, Method 101, Condition B for 100 cycles (shorter duration mission) or 300 cycles (long duration mission) depending on JPL PEM specialist on 22 devices	JPL has not seen failures in this test.
11	Post temperature cycling electrical measurements (3 temperatures)	Post temperature cycling electrical measurements (3 temperatures)	JPL has not seen failures in this test.
12	DPA and failure analysis may be done on failures or out of family devices from steps 9 and 11 using engineering judgment	DPA and failure analysis must be done on failures or out of family devices from steps 9 and 11	
13	C-SAM	Not done	
14	Unbiased HAST per JESD22-A118, Condition A (96 hours, +130°C, 85% RH) on 20, 20, and 10 devices for Levels 1, 2, and 3	Not done	
15	Electrical measurements (room temperature only)	Not done	

	IEEE-INST-002 Planned Requirement	JPL-D-19426 Requirement	Comments
16	Burn-in per MIL-STD-883, Method 1005, Condition D for 168 hours at room temperature	Not done	
17	Electrical measurements (room temperature only)	Not done	

Color Legend:

= Same or equivalent tests

= JPL has more or more extensive tests

= GSFC has more or more extensive tests

4 COMMENTS AND FUTURE WORK REQUIRED

The major differences between the JPL approach and the GSFC approach are in the methods of indicating different risk postures and in the highly accelerated stress test (HAST) portion of the qualification. GSFC uses their method of Level 1, 2, or 3. JPL indicates a typical 1-year and 10-year mission. The risk posture for short or longer duration space missions is indicated differently between the JPL and GSFC documents; however, the intent is similar.

The GSFC HAST testing involves steps 14–17 of qualification and is a new development on GSFC's part. It is important that this expensive testing be investigated to determine its appropriateness to various levels of risk depending on hardware build and handling. JPL currently considers this testing as unnecessary since flight hardware is handled in severely climate-controlled environments. During discussions with GSFC, GSFC stated that their hardware was frequently subjected to a much less controlled storage environment prior to launch. Sharing of analyses and test data is important to elucidate the technical risk in this area.

Other areas meriting coordination and data sharing are items 8 and 9 of screening and 8, 9, and 12 of qualification.