Date: November 22, 2002

To: NEPAG PEMs Evaluation Team

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Subject: Recommendation Regarding Package Related Tests

Cc: Phil Zuluetta, JPL
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The NEPAG PEMs Evaluation Team asked the NEPP EPAC representatives, Dave Gerke of JPL and Jeannette Plante (DRC for GSFC) for inputs regarding the tests that should be applied to evaluate the packaging related aspects of PEMs reliability and assurance. They were also asked to research how the manufacturers of the test candidates calculate FIT rate, specifically what confidence level is used for determining sample size, and the value of the following variables, used in the Arrehnius equation, for calculating acceleration factor: base plate (or "use") temperature and activation energy. Section 1. below addresses the test flow and Section 2. addresses the questions about the calculations.

1. Packaging Test Flow

The current flow "NEPAG COTS EVALUATION FLOW Nov 12,02.xls" shows the package related tests in a section called Group D. It consists of five sub-groups of tests for samples selected from screened material. The subgroup tests are arranged in parallel paths rather than serial ones so each individual part only sees one leg of the test flow, not all five legs. The tests include surface mount preconditioning, electricals, CSAM, Temperature Cycling, HAST, vibration and cold start-up. Standard JEDEC test methods are referenced.

Two philosophies can be applied when generating the packaging test flow. One philosophy dictates that stress conditions be separated within the flow to simplify separation of variables during data reduction. This philosophy was used to generate the existing test flow. The second philosophy dictates that standard test methods be used in a way that both parallels how the manufacturers would apply the tests and simulate the stresses that the parts would see in system production prior to exposure to long-term qualification tests. This second philosophy is recommended and discussed below. A meeting was held on November 18, 2002 with the authors of the existing test flow and it was decided that due to cost factors and a significant difference of opinion, that both philosophies would be explored if possible within the current budget. The discussion and recommendations below reflect this agreement.

1.1 Moisture Sensitivity and Preconditioning:

1.1.1 There is a need to verify the moisture rating of the parts using test method J-STD-020B, *Moisture/Reflow Sensitivity Classification for Non-Hermetic Solid State Surface Mount Devices.*

This test is not currently part of the test flow. The moisture level ratings reported by the manufacturers are as follows:

1. ADC1175 - Moisture Level 1
2. MAX306 - Moisture Level 1
3. LT1468 - Moisture Level 1
4. AD780 - Moisture Level 1
5. INA117 - Moisture Level 3

These ratings dictate the moisture soak condition to use for the Preconditioning Screening step (see below) [Preconditioning of Nonhermetic Surface Mount Devices Prior to Reliability Testing, JESD22-A113-B]. (The sources of these rating numbers were included in a prior memo: 11/20/02, To: D. Gerke, M. Sandor, D. Peters, From: J. Plante, Subject: Correspondence and Research Record for Investigation of Moisture Sensitivity Level for the Five Test Candidates for the NEPAG-PEMS Evaluation)

A sample set of 5 pieces is recommended for the Moisture Sensitivity Rating test. The test flow for moisture sensitivity rating consists of Visual, CSAM, Bake (24 hr, 125°C), Moisture Soak, Reflow (convection is the preferred method and it is to be performed no sooner than 15 min out of the moisture soak and no longer than 4 hours following the moisture soak), Visual, Electricals, CSAM, 25°C electrical dc and functional testing. The moisture precondition exposure level for a JEDEC Level 1 package is 85°C/85% RH for 168 hrs, the moisture precondition exposure level for a Level 3 Package is 30°C/60% RH for 192 hours (or 60°C/60% RH for 40 hours).There is concern regarding adding extra cost to the finalized contracts in place at the test houses. This moisture sensitivity can be performed at JPL or GSFC for the cost of the CSAM inspection labor. The five-piece sample can be taken from the 50 piece sample set aside for the moisture preconditioning test. The electrical measurements can be performed at the test houses as it normally would have been done following the moisture preconditioning test. This approach adds very little to no cost to the program.

1.1.2 Moisture Preconditioning.

This standard test sequence simulates real handling and board assembly conditions that all parts would experience in every application. The steps of the test method simulate these through thermal cycling (to simulate shipping conditions), temperature bake (to dry the packages), moisture soak (to simulate exposure to factory floor conditions), exposure to reflow temperature profiles, cleaning steps and electrical verification.

The NEPAG test flow omits some steps of this standard test method. Some reductions are acceptable because the parts have a screening history. They will all have been thermal cycled ten times from -60°C to 150°C (this satisfies the JEDEC simulated shipping criteria), XRay-ed, inspected with CSAM and burned-in (the 168 hours of static and dynamic burn-in satisfies the JEDEC bake out criteria for 24 hours minimum at 125°C) prior to the preconditioning flow. This screening establishes that All of the samples meet a minimum level of assurance and that we will not be doing qualification testing on infant mortals. The moisture preconditioning test does the

same thing from a packaging/board assembly perspective. That is why All parts used in Group D of the NEPAG test flow should go through the moisture preconditioning test prior to the environmental tests of temperature cycle and HAST. The plan to separate temperature and moisture stresses in the test flow will not accomplish the necessary combination of assembly process steps to represent a realistic evaluation of the packages.

It is important to perform the Moisture Preconditioning test as written because this test method is designed to assess the affect of moisture exposure prior to experiencing reflow temperatures. By omitting the moisture soak condition, the resulting data will not be comparable to industry data associated with the JEDEC standard. The reflow profile should follow the convection conditions rather than the vapor phase conditions. Convection reflow is the preferred method called out in the JEDEC specification and convection and IR reflow furnaces are the norm at NASA and many of NASA's contractors rather than vapor phase. The flux and cleaning step (with de-ionized water), are also critical because they provide a possible failure mechanism that is enhanced by the assembly process by which mold compound adhesion to the lead frame is weakened as a result of the moisture and thermal exposures. After the cleaning step, the JEDEC test method and the NASA plan converge with the performance of electrical tests. Testing costs for a separate qualification flow which attends to the standard Moisture Preconditioning test can leverage off of the fixturing and test programs that are in place and in use at the contract test houses.

The 22-piece sample Resistance to Soldering Heat test is acceptable though the test method should resemble the Preconditioning test where the solder dip replaces the reflow temperature profile exposure. In this way, all of the samples will see the Preconditioning screen with all of the temperature, moisture and cleaning steps.

Engineering preference has dictated that the Moisture Preconditioning will not be done prior to the package qualification stresses as shown in the current flow and will not be done on "screened" parts. Therefore it is recommended that the entire Moisture Preconditioning test be performed to simulate the condition of these 5 part types going through a simulated board assembly reflow and hand soldering. The end users will undoubtedly assemble PEMs to the PWBs in order to use them in a system; therefore, these devices should see those conditions through use of the standard Moisture Preconditioning test. The test method requires use of an 11 piece sample.

2.0 Failure In Time (FIT) Calculations

Table 1 shows the results of the research into FIT and Arrehnius calculations used by the manufacturers in the study. The baseplate temperature, activation energy and confidence level numbers were found for all five vendors. A full explanation of how each vendor calculates FIT rate for their processes requires a longer research effort. This is not typically a "packaging" data point so guidance is being sought from the EPAC project manager to get allowance to provide this type of information as a deliverable against the EPAC support task.

3.0 Summary

3.1 Moisture Testing.

3.1.1 Moisture Rating. The addition of a test to validate the Moisture Rating of the five part types is recommended. This test can be done outside of the existing flow with five each, of unscreened samples. The cost impact would be minimal. The data is needed to establish the proper test conditions for the Moisture Preconditioning test.

3.1.2 Moisture Preconditioning. It is recommended that:
This test be performed in accordance with the standard test method on 22 unscreened units for each part type. All parts will go through the same test flow Except that during the temperature exposure step, 11 pieces will be exposed to the conditions outlined for convection reflow and the other 11 will be exposed to solder dip.

Table 1. Values Used by Manufacturers to Calculate FIT Numbers

PEMs Manufacturer	FIT Calculation methodology	Sample size	Activation Energy	Base-plate Temp.	Confidence Level
Analog Devices (AD780BR)	**Fr = Nf/Ndt** Number of device hours at Temp = Number of failures/devices hours at a certain temp **Ndt = Nd x Nh x AF** # device hrs = # devices tested x hours of testing x Accel factor FIT = Fr(E9) MTTF = 1/Fr *(interval between failures)*	45, 77	Ea = 0.7 eV **Failure Mechanism** / **Ea (eV)** Oxide / 0.8 Contamination / 1.4 Silicon Junction Defects / 0.8 Voltage acceleration rarely used. Arrehnius equation: When establishing the Ea, a test temp of 180°C to 225°C	70°C	Numbers reported are for 60% and 90% confidence levels using chi squared tables
National (ADC1175CIJM)	Arrehnius for FIT FIT numbers by year are given for ALL National product combined in one place and for a list of specific technologies in another.	Sample size is 125 pieces per lot. Another place says: Samples sizes vary between 1704 to 26,700	0.7 eV activation energy is used	55C is use temp	60% confidence interval used with a Chi-squared distribution for PPM.
Linear Technologies (LT1468CS8)	FIT data given for all products combined in two groups: hermetic and plastic. Overall plastic is better	Sample size is 193 to 36,446	1.0 eV	55°C	60% confidence interval
Maxim (MAX306CWI)	In addition to routine production Burn-In, Maxim pulls a sample from every fabrication process three times per week and subjects it to an extended Burn-In prior to shipment to ensure its reliability. The reliability control level for each lot to be shipped as standard product is 59 F.I.T. at a 60% confidence level, which equates to 3 failures in an 80 piece sample.	Sample size is 80	0.8eV	25°C	60% confidence interval
TI(INA117)	Arrehnius Eq is used. Still researching FITcalculation. Can't find how often and on what products reliability testing is done.	Sample size is 232	0.7eV	MTTF & FIT is provided for variety of use temp.	90% confidence interval