



JG-PP Email

1

Joint Group on Pollution
Prevention

From: Brian Greene, Project Integrator
Date: 11/26/02
No. of 10
Pages:

Phone: 321-867-8481
Fax: 321-867-8479
Email: GreenBE@kscems.ksc.nasa.gov

***JG-PP Lead-Free Solder Project
Technical and Business Meeting Minutes
November 12, 2002***

Govt. Project Manager: Warren Assink, WPAFB

MEMORANDUM FOR RECORD

Subject: Meeting Summary and Minutes – November 12, 2002

Material(s) Identified: Lead

Process Identified: Electronics soldering

Methodology Phase: II - Technical, III - Business

Summary:

On November 12, 2002, technical representatives from Boeing, Concurrent Technologies Corporation, Headquarters Air Force Materiel Command, Lockheed Martin, NASA Marshall Space Flight Center, Raytheon, Texas Instruments, U.S. Army Missile Command (AMCOM), and U.S. Air Force F-15 Engineering participated in a meeting with representatives from the Joint Group on Pollution Prevention Working Group and their contractors. The objective of the meeting was to further develop the Joint Test Protocol for Manufacturing and Repair, review the latest test board design, and discuss business issues. All the meeting's objectives were met, although some changes must be made to the JTP, test vehicle design, and cost estimate. Action items were taken to update the test board layout and for participating defense contractors to identify and quantify their intended in-kind contributions for 2003 and 2004.

Prior Decisions:

- 5/9/01 – Lead as used is tin-lead (Sn/Pb) solder was chosen as the target HazMat.
- 6/20/01 – A Joint Test Protocol (JTP) will be developed for qualifying lead-free solder alloy used in the manufacture of lead-free printed wiring assemblies (PWAs)
- 11/1/01 – A second JTP will be developed for qualifying lead-free solder alloy used in the rework of lead-containing PWAs.
- 3/7/02 – By consensus, the solder alloys currently recommended for testing are:



JG-PP Email

Joint Group on Pollution Prevention

Wave Solder:	Sn/0.7Cu Sn/3.9Ag/0.6Cu Sn/3.4Ag/1.0Cu/3.3Bi
Reflow/Manual Solder:	Sn/3.9Ag/0.6Cu Sn/3.4Ag/1.0Cu/3.3Bi
Baseline:	Sn/37Pb

- 10/1/02 – Because of numerous similarities in the testing procedures, all the PWA manufacturing and rework requirements will be folded into just one JTP.

Next Teleconference: December 8, 2002 (Postponed); and December 12, 2002, 11:00 AM

Next Meeting: TBD



JG-PP Email

Joint Group on Pollution Prevention

Minutes

1. The meeting began at 9:00 AM in the North Building at Raytheon's expressway site, Dallas, TX. Mr. Joe Felty, Raytheon, welcomed everyone and reviewed the building safety procedures. Mr. Brian Greene, NASA Acquisition Pollution Prevention Office/ITB, reviewed the agenda. Everyone in attendance then introduced themselves.

2. **Test Board Design**

Mr. Dave Hillman, Rockwell Collins, presented a pictorial of the latest design for the test vehicle.

- a. A discussion ensued largely between Mr. Hillman and Mr. Tom Woodrow, Boeing, concerning whether vias (small drilled holes that go through the board) should be used on the board. The concern is, if components start failing during testing, can we easily discern whether it is caused by the solder joint or by a via. Removing all vias and instead tracing the affected parts would alleviate the concern, but Mr. Hillman did not think it was physically possible to have all the desired component types fully traced on the test PWA if there were no vias. After further discussion of the issue, everyone agreed that having the vias could make failure analysis more difficult (e.g., all failed boards might have to be cross-sectioned after testing), which was undesirable. The potential disadvantages of removing the vias is that the board area, and possibly the board cost, will increase somewhat. Therefore, the team consensus was to include no vias on either the manufacturing or rework boards and instead just trace the affected components as much as possible.
- b. The team agreed that, with regard to the resistors, they should all have individual channels and reside on the breakout coupon on the test PWA.
- c. The participants agreed with Mr. Hillman's proposal to remove individual rows of capacitors periodically through thermal cycling testing.
- d. Mr. Hillman noted that the test PWA will be one-sided. He felt that a one-sided board would be simpler to process and be less problematic overall.
- e. At the suggestion of Mr. Woodrow, all agreed that the test board will now include two more rows of 5 resistors each, for a total of ten additional resistors. This would allow for the option to stake some of the resistors—a previously noted desire of Boeing.
- f. A team member noted that the spacing between some of the components, such as the BGAs, seemed tight. This could make rework difficult. Mr. Hillman said he would look into this concern.
- g. Mr. Hillman took an action item (**AI LFS.02.11.03**) to modify the test board design to incorporate (a) tracing of certain components in lieu of vias, (b) 10 additional resistors, and (c) the possible need for more clearance between components.



JG-PP Email

4

Joint Group on Pollution Prevention

3. The team members reviewed the bill of materials for the test PWA components. The one missing cost item is the cost of tinning. (Mr. Woodrow is working this.) Mr. Mike Cottrell, Texas Instruments, confirmed TI would be donating for free 1,000 tin-lead CLCCs and 3,000 lead-free (silver coating) CLCCs.

4. **Joint Test Protocol for Manufacturing and Rework**

Mr. Greene led the participants through a review of the JTP for manufacturing and rework of PWAs. Most of the changes were made to the electronic copy of the JTP during the meeting; this JTP is attached to these minutes and the changes highlighted by revision marks. Following are some notable changes.

- a. General Comments

- 2) Acceptance Criteria. Mr. Robert Vanderwiel, Lockheed Martin, asked what the criteria should be to implement lead-free solders. Mr. Greene noted that, in general, most of the JTP's criteria call for performance equal to or better than eutectic tin-lead solder. Mr. Hillman further added that it will be the responsibility of each DoD customer to define the acceptance criteria for their program. For example, it is conceivable that AMCOM's missile requirements may be more stringent than for Navy carrier-based aircraft, which may be more stringent than for Air Force F-15 aircraft.
- 3) Rework vs. Repair. Search for all references to PWA "repair" and change the word to "rework", as appropriate.

- b. Sec. 2.1.1.2, Baseline Assembly and Sec. 2.1.2.2, Tin/Lead Rework of Tin/Lead Assemblies.

- 2) Delete Figures 1 and 2, since they don't really add anything to the description of the test board preparation.
- 3) Change the "High Tg" laminate in Table 2 (Test Vehicle Matrix for Manufactured PWAs) to read "High Tg, GF". Change the "FR4" laminate in Table 3 (Test Vehicle Matrix for Reworked PWAs) to read "Low Tg, GF". In addition, clarify in a footnote to these tables that a separate set of boards will be prepared for each line in the table (i.e., each row in the right-hand portion of the table comprises one-third of the prepared PWAs).

- c. Sec. 2.1.2.1, Lead-Free Rework of Tin/Lead Assemblies. The following four components and finish types are proposed for rework:

- BGA - SnAgCu
- TQFP - Au/Pd/Ni
- TSOP - Sn/Cu
- PDIP - Au/Pd/Ni

- d. Sec. 3.1.1, Electrical Continuity Testing. Change the criterion for electrical interruption from "greater than 300 ohms" [for all tests] for "1 microsecond" to "greater than 300 ohms resistance for Thermal Shock and Thermal Cycling and



JG-PP Email

5

Joint Group on Pollution Prevention

greater than 1,000 ohms resistance for Vibration and Mechanical Shock” for “0.2 microseconds”, in accordance with IPC-SM-785.

- e. Sec. 3.2.4, Thermal Cycling.
 - 2) The referenced standard should stay listed as IPC-SM-785, and not IPC-9701. As a point of reference, Bob Ogden, Raytheon, clarified that IPC-SM-785 (*Guidelines for Accelerated Reliability Testing of Surface Mount Solder Attachments*) is a guideline only, while IPC-9701 (*Performance Test Methods and Qualification Requirements for Surface Mount Solder Attachments*) is an industry standard. Therefore, relatively speaking, IPC-9701 carried more weight. However, IPC-9701 requires 33 of each component type on the test vehicle, while we will have fewer components than this.
 - 3) Change the ramp rate from “10 deg. C per minute” to “5-10 deg. C per minute.”
- f. Sec. 3.3.1, Salt Fog and Sec. 3.3.2, Humidity. Change “surface insulation resistance” everywhere to “net resistance.”
- g. Sec. 3.3.3, Surface Insulation Resistance and Sec. 3.3.4, Electrochemical Migration Resistance Test.
 - 2) Note that these tests will be performed as part of the PWA manufacturing requirements (not rework).
 - 3) Change “40 customer-prepared...” to “35 processed...” The correct number, 35, is determined from 10 boards for each of the two lead-free assemblies listed in Table 2 plus 10 tin-lead (baseline) boards plus 5 controls.
- h. Sec. 3.3.3, Surface Insulation Resistance. The SIR acceptance criteria will be 10^8 ohms per minute.
- i. Sec. 3.3.4, Electrochemical Migration Resistance Test.
 - 1) List in the JTP all three temperature ranges for electrochemical migration resistance testing. However, note that the temperature range(s) used will depend upon the flux being used.
 - 2) Per a handout distributed at the meeting by one of the OEMs, include in the acceptance criteria the following:
 - (1) $IR_{\text{final}} \geq (IR_{\text{initial}})/10$, that is the average insulation resistance shall not degrade by more than one decade as a result of the applied bias;
 - (2) No evidence of electrochemical migration (filament growth) that reduces the conductor spacing by more than 20%; and
 - (3) No corrosion of the conductors; minor discoloration of one polarity of the comb pattern conductors is normal. (IR= insulation resistance.)

5. Testing Cost Estimate

Mr. Greene reviewed the year-by-year and total estimated cost for the Lead-Free Solder project under two different scenarios: full requirements, and tailored NASA & OEM-only



JG-PP Email

6

Joint Group on Pollution Prevention

requirements. Both estimates assume testing three lead-free solder alloys plus the baseline and generally 5 components per component type. The tailored estimate assumes a scaling back in the number of tests performed and does not include the hybrid component. Estimates were provided for a 4-year project: the first two years would predominantly address the JTP reliability testing, whereas FY05 and 06 would address life cycle analysis and implementation issues. The cost estimates are provided in the attached 'Business Issues' slide presentation.

6. **Cost Share and Funding Commitments**

Mr. Greene briefed that funding of this JTP is still an issue. Currently NASA has committed funding for FY03 and tentatively for FY04; additional DOD component funding commitments are still being worked. Original Equipment Manufacturers (OEMs) funding commitments still need to be finalized.

NASA's FY 03 funding will kick-start the testing, however, will not be enough to come close to fully funding the requirements. The currently estimated testing delta between known contributions to-date and the estimated testing cost ranges from a stripped-down JTP \$788K to fully currently documented JTP at \$1.174M. For example, currently the AF and the F-15 require expensive hybrid components on the test boards which will not assured without additional funding.

An action item was assigned to all the participants to report to Mr. Greene and Mr. Assink the nature and extent of the intended contributions, either direct cash or in-kind, to the testing effort for 2003-04 (**LFS.02.11.04**).

7. **Recommended Testing Facilities**

Mr. Greene presented a table summarizing the responses received to the laboratory survey. The table notes (via checkmarks) those facilities most interested and capable of performing specific JTP tests at this time. (See attached 'Business Issues' slide presentation.) The technical representatives were asked to review this table and respond to Mr. Greene and Mr. Assink whether they agree or disagree with any of the proposed testing assignments shown in the table, the reasons for disagreement, and whether they would propose another facility for conducting a particular test (**LFS.02.11.05**).

8. Mr. Tom Woodrow agreed to host the next two teleconference: on November 20 to discuss Mechanical Shock test procedure (assuming that the write-up was complete before then), and December 12 to discuss business issues.



JG-PP Email

Joint Group on Pollution
Prevention

9. Mr. Greene thanked Raytheon for hosting the meeting. The meeting was adjourned at approximately 3:30 PM.

SIGNED (Approved by W. Assink 11/25/02)

Warren Assink
Govt. Project Manager, WPAFB

Attachments:

1. Action Items
2. Business Issues slides, B. Greene

**Summary of Lead-Free Solder Action Items
As of 11/12/02**

8

New Action Items

LFS.02.11.03

Date Due: 12/02/02

Responsibility: Rockwell Collins (Dave Hillman)

Required Action: Modify the test board design to incorporate (a) tracing of certain components in lieu of vias, (b) 10 additional resistors, and (c) the possible need for more clearance between components.

Comments:

LFS.02.11.04

Date Due: 12/02/02

Responsibility: OEM Business Representatives

Required Action: Report to B. Greene and W. Assink the nature and extent of the intended contributions, either direct cash or in-kind, to the lead-free solder testing effort over 2003-04

Comments:

LFS.02.11.05

Date Due: 12/02/02

Responsibility: All Technical Representatives

Required Action: Review the 'Proposed Testing Facilities' table in B. Greene's 11/12/02 slide presentation and respond to B. Greene and W. Assink whether you agree or disagree with any of the proposed testing assignments shown in the table, the reasons for disagreement, and whether you would propose another facility for conducting a particular test.

Comments:

Open Action Items

LFS.02.11.02

Date Due: 11/13/02

Responsibility: ARDEC (Dave Locker)

Required Action: Will write the testing procedure, JTP Section 3.2.2 Mechanical Shock, for the JTP taking into account all stakeholders concerns.

Comments: To discuss at 12 Dec telecon

LFS.02.10.03

Date Due: 11/01/02

Responsibility: All technical representatives

Required Action: Identify to Brian Greene and Warren Assink their organizational business point of contact, if other than themselves

Comments: In progress

**Summary of Lead-Free Solder Action Items
As of 11/12/02**

9

LFS.02.10.04

Date Due: 11/01/02
Responsibility: OEMs
Required Action: Identify the frequency of their use of hybrids
Comments: Raytheon uses 13% hybrids

LFS.02.08.09

Date Due: 10/26/02
Responsibility: OEMs
Required Action: OEMs submit concept paper
Comments:

LFS.02.08.10

Date Due: 09/16/02
Responsibility: ITB, Inc. (Brian Greene)
Required Action: Distribute guideline and examples of DCMA concept paper
Comments: In progress by JG-PP

LFS.02.08.12

Date Due: 09/16/02
Responsibility: OEMs
Required Action: OEMs identify their past and forecasted in-kind contributions, including labor and other expenses for meetings, JTP development, etc.
Comments: Past contributions: Tom Woodrow of Boeing has provided information on past in-kind contributions
Future contributions: At least the following OEMS have indicated that they will provide testing as an in-kind contribution, Boeing, Raytheon and Rockwell Collins.
As of 10/11/2002 the following has provided past LFS contributions; hours per month, travel costs, and materials cost; LM Aero Fort Worth, Boeing Seattle, Rockwell Collins, Naval Air Warfare Center, Weapons Division, Boeing Texas, Raytheon-Dallas, and CTC

LFS.02.08.13

Date Due: 09/30/02
Responsibility: ITB, Inc. (Brian Greene)
Required Action: Distribute expected contributions from stakeholders once cost estimate is better defined
Comments: In progress.
11/12/02 - B. Greene presented a summary of the estimated cost of testing and the current amount that that Government indicated they would fund. The shortfall would need to be made up by the OEMs and/or the scope of the testing reduced. A new action items was taken for OEMs to assess the nature and extent of their contributions.

**Summary of Lead-Free Solder Action Items
As of 11/12/02**

10

LFS.02.07.02

Date Due: **08/09/02**
Responsibility: Potential testing facilities
Required Action: Complete Lab Survey form
Comments: In progress, as of 11/08/2002 survey forms have been received from; ACI, Raytheon, Sandia, Boeing Rockwell Collins and NAVAIR

Action Items Closed at this (11/12/02) Meeting

LFS.02.11.01

Date Due: **11/13/02**
Responsibility: Mr. Dave Hillman (Rockwell Collins)
Required Action: Develop a paragraph for section 3.1.1 taking into consideration the IPC specifications that spell out the composite versus uniform CTE measurement. Performing the CTE will increase both cost and time.

Comments: 11/12/02 - Closed. D. Hillman provided CTE text which was incorporated into the JTP.

LFS.02.09.02

Date Due: **08/09/02**
Responsibility: Rockwell Collins (Dave Hillman) and Raytheon (Jeff Bradford)
Required Action: Determine what effects reducing part count will have on statistical analysis and failure criteria, provide findings to Brian Greene

Comments: 11/12/02 - Closed. Minimum part count must be 5 of each type to have statistically valid results.