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Joint Group on Pollution Prevention

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JG-PP Lead-Free Solder Project
Technical Meeting Minutes
June 6, 2002

Govt. Project Manager: Warren Assink, WPAFB

Comments:

Attached please find the minutes from the June 6, 2002, Lead-Free Solder Technical Teleconference. If you have questions about the minutes, please contact Warren Assink or Brian Greene. Please further distribute as necessary.

MEMORANDUM FOR RECORD **July 16, 2002**

Subject: Meeting Summary and Minutes – June 6, 2002

Material(s) Identified: Lead

Process Identified: Electronics soldering

Methodology Phase: I-Identification, II - Technical

Summary:

On June 6, 2002, technical representatives from American Competitiveness Institute, Amkor, the Boeing Company, British Aerospace Systems (United Kingdom), Coining Corp., Intersil, Lockheed Martin, Mitsui Comtek/Senju Metals Co., NASA-Goddard Space Flight Center, NASA-Kennedy Space Center, NASA-Marshall Space Flight Center, Nihon Superior, Raytheon, Northrop Grumman, Redstone Army Arsenal, Robins Air Force Base, Texas Instruments, Rockwell Collins, Sandia Labs, TRW/ICBM, U.S. Army Communications Electronic Command, U.S. Marine Corps, and Wright Patterson Air Force Base participated in a teleconference with representatives from the Joint Group on Pollution Prevention Working Group. The objective of the teleconference was to further develop the Joint Test Protocols for Manufacturing and Repair, and discuss the short list of lead-free solder alloys, test board design, and cost benefit analysis.

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)

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- 11/1/01 – A second JTP will be developed for qualifying lead-free solder alloy used in the repair of lead-containing PWAs.
- 3/7/02 – By consensus, the solder alloys currently recommended for testing are:

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

Next Teleconference: July 17, 2002, 11:00 AM Eastern

Next Meeting: August 13-14, 2002, Dallas, Texas

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Minutes

1. Mr. Brian Greene, NASA/ITB, opened the meeting by reviewing the action items taken at the last teleconference, April 26, 2002. These action items included: incorporating stakeholder comments into the manufacturing and repair JTPs, distributing Mr. Dave Hillman's synopsis of the APEX Conference papers, surveying solder alloy suppliers for product availability and updating the test board design.

2. JTP Schedule
   a. Mr. Clive Simmonds, BAE Systems, asked by what date the JTPs will be completed and when comments are needed. Mr. Greene stated that final inputs and revisions where due over the next two months with the finished JTP documents to be completed in July. Following the completion of the JTPs a face-to-face meeting will be held August 13-14, in order for the group to go through the JTPs and get everyone's approval. In addition, Mr. Greene will likely bring up funding and other business issues at the August meeting.
   b. Mr. Greene stated that a teleconference should be held in July for those who cannot attend the August face-to-face meeting. The July teleconference would give those unable to attend the August 13-14 face-to-face meeting a chance to review the completed JTPs and give their opinions and comments. A meeting date of July 17, 2002 was set for the teleconference.
   c. Mr. Simmonds stated that JTP comments should be turned in 1 to 2 weeks prior to the July 17 teleconference. Mr. Greene agreed and set the week of July 1 as the final week for the group to send comments and revisions. This time frame will give Mr. Greene a chance to make final revisions to the JTPs prior to the July 17 teleconference.

3. Solder Alloys
   a. Mr. Dave Hillman, Rockwell Collins, referred to the compilation he did of the papers from the APEX and JEDEC IPC conferences on lead and non-lead solder interactions and the intermetallic contamination that may exist. Mr. Hillman stated that there is not a lot of information available on the subject. Personnel from DOE Ames Labs have studied the issue from a kinetics/thermodynamics aspect, which Mr. Hillman stated as being a good practice in theory but not in application. Mr. Hillman feels that Boeing has done some of the best work in studying the impact of lead contamination in repair applications. From what Mr. Hillman has seen some data that for certain material tests and substrate-finish combinations, a Pb-contaminated joint performs better than the current standard all-SnPb joint, but not as good as an all Pb-free joint. The group should take a look at the data Mr. Hillman pulled together to better understand how it impacts lead contamination during repair.
   b. Mr. Hillman suggested to the group that specific parts of the JTP be executed in a manner that allows the group to understand how much contamination and what specifically the contamination that is formed allowing the group to finalize this particular area of discussion.
   c. Mr. Hillman did inform the group that Celestica is conducting a very extensive study including rework and contamination/non-contamination issues. Celestica just got its test

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boards completed so test data will not be available until the APEX and IPC conference in January/February 2003. Mr. Hillman will contact Celestica for more data on the lead contamination study. Mr. Hillman will compare the rework procedure from the group with Celestica.

d. Mr. Simmonds informed the group that the UK Solvent Science and Technology Club (run by National Physical Laboratory, UK) published on its Web site, approximately ten papers from the on the subject of lead contamination. The papers focus on mixing lead-free and tin-lead solders. The study looked at different percentages of the solders being mixed, such as 25%, 50% and 75% lead-free and tin-lead. But no one has really looked at the situation of trace materials being left over from rework. Mr. Simmonds stated that NPL's basic conclusions were that the contaminated specimens performed no worse than Sn/Pb. A conclusion made was that there are substantial problems with the flux technology caused by higher temperatures and longer dwell times. The papers will be published on a Web site; Mr. Simmonds will email Mr. Greene when the papers are available.

e. Mr. Greene reported that he found out that more than vendor can supply the desired Pb-free solders in bar and paste form. Mr. Simmonds noted that it would be highly desirable to obtain a particular solder alloy from only one vendor, rather than multiple suppliers, to reduce variability in the composition. This would be done for test purposes only, because this cannot be accomplished in the current government procurement system.

f. Ms. Heather Moyer, CTC, asked which solder would be used to repair the wave soldered Sn/0.7Cu. Should Sn/0.7Cu be used to repair? It was noted that it is common commercial practice to repair wave soldered Sn/Cu boards with the same Sn/Cu alloy. Ms. Martha Schuster, AMCOM, stated that different repair solders would be used ~~is~~ because that is more representative of what would occur in the field and at repair facilities.

g. Mr. Jeff Gaul, Mitsui, indicated that Mitsui will offer to provide the desired solders. He asked when the solders would be needed, which Mr. Greene stated would be in early 2003.

4. <u>Repair JTP</u>

a. Mr. Greene discussed the topic of needing more details when establishing the exact process by which the test boards will be repaired. The group agrees that the JTP will need to be written in such a way that an understanding of lead contamination can be gleaned from the test.

b. Mr. Greene questioned what pass/fail criteria was needed to evaluate the repair work, e.g., measure weight of original solder removed and repair solder applied?

c. Mr. Hillman mentioned that most lead-solder studies found have not performed a detailed assessment of post-characterization failure and measurement. Sandia Labs is one exception, having performed a detailed study of how much lead was used in the solder joint.

d. Mr. Joe Felty, Raytheon, stated that the JTP should contain the rework procedure. Team members should also understand that there will be some loss of solder, leaded solder, under normal circumstances during repair component removal. Mr. Felty felt that there must be solid engineering documentation of the rework procedures. Mr. Simmonds agreed, stating that variations in repair processes and equipment could lead to differing soldering material characteristics and results.

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e. The issue was then raised that one site should manufacture all the boards while one site should do all the repair work. The single site processing will help control variability in end test products. Single site processing will also help the group track process characteristics.

f. Mr. Lee Whiteman asked the question how many facilities within the JG-PP team have the capability to repair and rebuild hardware? Mr. Hillman stated that numerous group members can do so. Mr. Whiteman stated that we need to ensure that processes are well documented and characterized to ensure the process is sound. The group agreed-there needs to be step-by-step testing process characterization.

5. Repair and Manufacturing JTPs

a. Mr. Felty asked about the need for 3 temperatures cycles used during testing. Mr. Greene stated that the information came from AMCOM personnel. AMCOM plans to send out a clarification on the issues. Mr. Dave Locker stated that at least two ranges were needed for Compton-Manson.

b. Mr. Hillman questioned the need for the temperature ranges based on the number of circuit card assemblies in the temperature shock test.

c. AMCOM stated that the temperature range -20 to 180 and –55 to 125 for temperature shock testing. The more ranges that are in the testing the better the numbers will be.

d. Mr. Tom Woodrow, Boeing, mentioned that 1,000 cycles for temperature testing may not be enough cycles. If the test must be run till failure this could take as many as 10,000 cycles. A comment was made that this is a solder joint test not a component evaluation. Mr. Hillman stated that the components would be dummy—not functional—parts, thus ensuring that physical parts evaluation is not part of the testing but merely electrical performance. Mr. Hillman also stated that 2,000 cycles takes 6 months so the length of the program could dictate the number of cycles. Mr. Greene will update the JTPs to note that a certain minimum number of temperature cycles will be run (e.g., 2,000 cycles), then an evaluation will be made as to whether to extend the testing beyond 2,000 cycles, per the above discussion. Anyone who has suggestions on how this should be worded should notify Mr. Greene.

6. Test Board Design

a. Mr. Hillman stated that the test board components and component finishes have been pretty well defined:

- Approx. 8 x 8 inches, .062 inches thick (common industry standard)
- 10 layers, with internals as dummy layers, to simulate real-board thermal mass.
- Quoted cost of the circuit board (in high-temperature FR-4) is estimated at $25 to $50 per board. The cost is dependent on the number of boards ordered; the more boards the lower the cost. Intersil may be able to donate some parts.

b. Mr. Hillman is working two issues:

- He is working with TI and Amkor on the fine pitch on top. There could be difficulty in obtaining the parts in all the three finishes that group desires requirements
- He needs to contact Mark Stibitz, Robins AFB/F-15, about the pad layouts for multi chip components.

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c. Ms. Martha Schuster raised the question of where will the boards be built at? Mr. Simmonds stated that once the processes are established they need to be characterized and defined so that the processes can be transferred to many locations, the group agrees. Mr. Woodrow stated that he agrees that one company should build and assembly all boards, the group agrees. The statement is then made that one company should do all the work or that three individual companies should perform one of each of the three processes; build, repair, and rework.

d. Mr. Greene asked the group to provide information on what facilities can perform the specific rework and repair requirements in addition to manufacturing. Mr. Hillman states that in addition to asking which facilities can prepare the test vehicles but also find out which facilities can do what specific tests. The question was then raised as to the total number of assembled boards that will be needed. Mr. Felty stated that Mr. Jeff Bradford has already determined the total number of boards and that number was sent to Mr. Greene. Mr. Hillman stated that Rockwell has equipment to allow testing of 3,000 open channels.

7. Cost Benefit Analysis

a. Ms. Heather Moyer from CTC gave a summary of the CBA. For manual soldering, it was not anticipated that there would be any EH&S savings, so material costs drove the comparison, leading to a small increase in cost because of the higher purchase price of lead-free solders. On the wave and reflow soldering, at least one OEM anticipated significant EH&S cost avoidances and resulting overall cost savings from lead-free solder implementation, though this won't be the case for every potential OEM.

b. Ms. Moyer would like baseline data from those survey responders who left that section of the CBA survey form blank. Data from Rockwell Collins was received after publication of the CBA; a revised version of the CBA will be prepared with Rockwell's data and analysis.

8. Next Meeting

a. Teleconference July 17, 2002. A preparatory teleconference will be held on July 17 (Wednesday) 11:00 a.m. in order to obtain comments and reviews on the proposed final JTPs from group members that will not be able to attend the face-to-face meeting held in Dallas, Texas on August 13 and 14.

b. Face-to-face August 13 and 14, 2002. A face-to-face meeting will be held in Dallas, Texas at the Texas Instruments/Raytheon Expressway Facility, at the Texas Instruments Semiconductor Facility.

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9. The teleconference was adjourned at approximately 12:30 p.m.

SIGNED (Approved by W. Assink 07/16/02)

Warren Assink
Govt. Project Manager, WPAFB

Attachments:

1. Action Items

New Action Items

LFS.02.06.01

Date Due:	**07/10/02**
Responsibility:	NASA/ITB (Greene)
Required Action:	Make correction to the JTPs and redistribute the JTPs to the group.
Comments:	7/10/02 – No significant new comments received

LFS.02.06.02

Date Due:	**07/10/02**
Responsibility:	Rockwell-Collins (Dave Hillman), NASA/ITB (Greene)
Required Action:	Prepare a bill of materials for the test board and distribute to the group.
Comments:	In progress

LFS.02.06.03

Date Due:	**07/10/02**
Responsibility:	NASA/ITB (Greene)
Required Action:	Survey facilities that can perform the desired testing.
Comments:	7/10/02 – Form is almost ready to distribute

Open Action Items

LFS.02.04.01

Date Due:	**05/14/02**
Responsibility:	Air Force, Navy, Army and NASA technical representatives
Required Action:	JTP: Provide Brian Greene any new/additional comments on the Manufacturing JTP and Repair JTP in two weeks. Brian Greene will then prepare and redistribute the revised JTPs.
Comments:	6/5/02 – Completed with email distribution of both updated JTPs

LFS.02.04.02

Date Due:	**05/14/02**
Responsibility:	Rockwell Collins (Dave Hillman); Technical representatives
Required Action:	Solder Alloys: Recompile the pertinent papers published in the APEX 2002 Proceedings that discuss complications with lead vs. lead-free repair. Technical representatives should review this information to determine whether any changes should be made to the short list of alternative alloys.
Comments:	Completed. Dave Hillman's information distributed

LFS.02.04.03

Date Due: **05/14/02**

Responsibility: NASA/ITB (Brian Greene)

Required Action: Solder Alloys: Send the list of candidate solder alloys to the solder suppliers to ask which alloys they can supply in bar and paste.

Comments: 07/03/02 – Completed. Summary of responses received to date:

AIM: **Yes**
EFD: No (only in paste)
Indium: Can only supply Sn 3.8Ag .7Cu (in bar & paste)
Kester: **Yes** for Sn/0.7Cu & Sn/3.4Ag/0.1Cu/3.3Bi. For Sn/3.9Ag/0.6Cu, closet alloy available is 96.5Sn/3.0Ag/0.5Cu
Mitsui Comptek: **Yes**
Qualitek: **Yes**
(Contacted, but no response, from Alpha Metals/Cookson, Amtech, Heraeus, OMG, P. Kav Metal.)

Most suppliers need to know the amount of solder, the type of a flux vehicle, and the mesh size to provide a quote.

LFS.02.04.05

Date Due: **05/14/02**

Responsibility: RockwellCollins (Dave Hillman), F-15 (Mark Stibitz), NASA/ITB (Brian Greene)

Required Action: Test Vehicle: Resolve the issue of adding hybrids, or a daisy-chained facsimile thereof, to the test board, and report to the team for decision.

Comments: 6/13/02 – Resolved via conference call with D. Hillman and M. Stibitz. Dead and live hybrids will be added. M. Stibitz will forward specs on the parts to D. Hillman for incorporation on the test board design.

LFS.02.03.01

Date Due: **05/10/02**

Responsibility: Rockwell-Collins (Dave Hillman), F-15 (Mark Stibitz), NASA/ITB (Brian Greene)

Required Action: Dave Hillman work with component suppliers and possibly leverage off the EMMA program work on SnPb (POC: Lee Whiteman) to prepare a component list, with pin counts for each component type listed. Once this is completed, Mr. Hillman should work with Mark Stibitz to determine if hybrids can be added.

Comments: Being updated by Dave Hillman

LFS.02.03.02

Date Due: **05/17/02**

Responsibility: Air Force, Navy, Army and NASA technical representatives

Required Action: Determine if adding hybrid devices to the test vehicle is a requirement of any of their programs.

Comments: 6/13/02 – Recommend closure. Hybrids are being added at the request of F-15. No other systems have responded to this action item.