



# JG-PP Email

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Joint Group on Pollution  
Prevention

**From:** Brian Greene, Project Integrator  
**Date:** 7/30/02  
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## *JG-PP Lead-Free Solder Project Technical Meeting Minutes July 17, 2002*

*Govt. Project Manager: Warren Assink, WPAFB*

**Comments:**

Attached please find the minutes from the July 17, 2002, 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 29, 2002**

**Subject: Meeting Summary and Minutes – July 17, 2002**

**Material(s) Identified:** Lead

**Process Identified:** Electronics soldering

**Methodology Phase:** I-Identification, II - Technical

**Summary:**

On July 17, 2002, technical representatives from American Competitiveness Institute, Amkor, Astrium Space UK, the Boeing Company, Hill AFB, ITB, Inc., Lockheed Martin, Mitsui Comtek/Senju Metals Co., NASA-Marshall Space Flight Center, NAVAIR, Northrop Grumman, Raytheon, Redstone Army Arsenal, Robins Air Force Base, Texas Instruments, Rockwell Collins, Sandia Labs, TRW/ICBM, U.S. Army TACOM 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 and test board design.

**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:** TBD

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



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### Minutes

1. Mr. Brian Greene, NASA Acquisition Pollution Prevention Office/ITB, opened the meeting by discussing the upcoming face-to-face meeting August 13 and 14 in Dallas Texas. Next, he summarized the most recent (June 6, 2002) project teleconference. Topics discussed included the Joint Test Protocol (JTP) schedule, Pb-free solder alloys for testing, Manufacturing and Repair JTPs, and test board design.
2. JTP Schedule. JTP comments are desired by August 1, 2002 so a revision of the JTPs can be distributed prior to the August 13 and 14 face-to-face meeting in Dallas, Texas.
3. Solder Alloys. Mr. Greene asked the question, do we need to repair wave soldered Sn/0.7Cu boards using Sn/0.7Cu solder alloy? This would be in addition to the two solder alloys (Sn/Ag/Cu & Sn/Ag/Cu/Bi) that the group has already selected for repair work as well as the baseline Sn/Pb. Mr. Jeff Bradford, Raytheon, made two points. First, adding another solder alloy to the test plan would significantly increase the number of test boards needed in the study, and thus the testing cost. Second, his understanding was that the intent of the repair JTP is to study the effects of Pb contamination when using lead-free solders. If that is the case, it makes sense that the Sn/Cu boards would be repaired using Sn/Pb solder alloy. Mr. Greene stated that unless anyone objected, the matrix of solder alloys will stand as it is currently written, i.e., Sn/0.7Cu solder alloy will only be included as a wave solder alloy but not as a reflow or manual solder.
4. Repair and Manufacturing JTPs
  - a. Mr. Greene asked the group for comments concerning the test flow diagrams from the JTPs, figures 1a and 1b, as well as comments on the test flow diagram that AMCOM had distributed to the group.
    - i. Mr. Tom Woodrow, Boeing, stated that he liked the fact that AMCOM has suggested long term temperature cycling testing in which a state of failure is reached, but reminded the group that this will add time and expense to the test program. Mr. Woodrow also stated that he would suggest performing only two temperature cycles and not three, which AMCOM suggests. Mr. Woodrow had concerns on the ability to generate Coffin-Manson equations from the thermal cycling test results.
    - ii. Mr. Bill Marsh, NASA Ames Research Center, and Mr. Dave Hillman, Rockwell Collins, both concurred with Mr. Woodrow's assessment of the thermal cycle testing and the potentially long testing time. Mr. Marsh further stated that the minimum and maximum temperatures required by AMCOM would encompass the temperature range suitable for NASA's needs.
    - iii. Mr. Greene stated that it would be beneficial to discuss off-line with AMCOM the exact parameters that AMCOM needs for testing, and said he would try to arrange a small-group telecon with AMCOM. The main issues in



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- question are the determination of temperature ranges to be used during the temperature cycle testing.
- b. Mr. Greene inquired how AMCOM's proposal to test only three circuit boards for temperature cycling  $-20^{\circ}/+80^{\circ}\text{C}$  and only test two circuit boards for temperature shock  $-55^{\circ}/+125^{\circ}\text{C}$  will effect statistical evaluation and calculations? Mr. Woodrow suggested that Mr. Dave Locker, AMCOM, provide a written explanation of test flow diagram and how the resulting test data will be used in the Coffin-Manson equations.
  - c. Mr. Greene raised the question of how many components/solder joints must fail in order to consider the test complete. Mr. Hillman stated that typically industry sets the statistical (Weibull) test completion at a failure level of "N63", meaning the point at which 63% of the components have failed (electrically). Mr. Hillman stated the group should decide the desired percent failure number for the lead free solder testing program. Once that statistical number of components has failed, that test PWB is complete. The higher the number that is used to set the failure criteria, the more substantiated the conclusion will be, but the longer the testing will be. Mr. Woodrow stated that as per IPC-SM-785, 32 samples are needed in order to have reliable statistical data to develop Weibull plots. Mr. Woodrow agreed to summarize for everyone those references for statistically significant sample sizes and other pertinent testing "rules of thumb". (Action Item **LFS.02.07.01**).
  - d. Mr. Greene asked the group to define the pass/fail criteria, if any, for the Highly Accelerated Life Test (HALT) test. Several individuals (Mr. Marsh, Mr. Hillman, Mr. Alva Maynard) noted that the HALT test is intended to purposely stress a test sample beyond normal operating parameters until the sample breaks, than you can examine the modes and mechanisms of failure. However, the issue of actual pass/fail criteria was not resolved.
  - e. Mr. Greene asked the group if HALT should be run before the other environmental tests, as a kind of "prescreen." Mr. Hillman stated that data from HALT testing could be used as a steering mechanism or prescreen for future specification tests. No final decision was made as to the placement of the HALT test. Mr. Greene will contact Joe Felty, Raytheon, for his comment on HALT placement in the test program.
  - f. Mr. Greene asked if vibration testing should be performed before or after temperature shock test.
    - i. Mr. Bradford, Mr. Woodrow, Mr. Marsh and Mr. Strickland (NASA Marshall Space Flight Center) concurred that temperature shock testing should be completed before vibration testing. Vibration testing only magnifies existing cracks, but does not create cracks.
    - ii. Mr. Bradford stated that thermal shock testing and vibration testing are a part of HALT, and raised the possibility of duplication of effort. Mr. Marsh stated that he would to see separate thermal shock and vibration testing for both for HALT and specification testing. Mr. Marsh stated that HALT testing is uncontrolled, while specification testing is done inside strict boundaries and under very tight standards.



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### 5. Test Board Design

- a. Mr. Hillman stated that he is still developing the bill of materials, and should have it completed in the next couple of weeks. One concern is the solder finishes on the ball grid array (BGA) and chip scale package (CSP) components. The group had previously decided on three solder finishes for components: tin/lead (Sn/Pb) (standard), Sn and gold/palladium/nickel (Au/Pd/Ni). For area array components, such as BGA and CSP, Mr. Hillman has been unable to find a Au/Pd/Ni finish; industry standard for these components seems to be a Sn/Ag/Cu finish. Therefore, Mr. Hillman proposed to the group that BGA and CSP only have two solder finishes: Sn/Pb (baseline) and Sn/Ag/Cu. Therefore, Mr. Hillman proposed to the group that BGA and CSP only have two solder finishes: Sn/Pb (standard) and Sn/Ag/Cu. Initially, none of the teleconference participants had a problem with Mr. Hillman's proposal. However, Mr. Doug Romm, Texas Instruments, countered that it would be technically desirable to test more than one Pb-free finish for BGAs and CSPs, and that one option is to choose two different formulations of the Sn/Ag/Cu—one high-silver content (e.g., ~3.4-3.5% Ag) and another low-silver content (<3.0% Ag). The question is, will a slight variation of the Ag content have offer any significant difference in performance? Mr. Hillman stated that he would further discuss this issue offline with Mr. Romm, Mr. Mark Kwoka (Intersil) and Mr. Bradford, and provide a recommendation back to everyone.
- b. Mr. Hillman stated that a hybrid component would be placed on the test board. Hybrid components and chip capacitors will be finished with only two types of finishes, Sn/Pb and Sn.
- c. On chip capacitor, Mr. Hillman also proposed only two finishes—Sn/Pb (baseline) and Sn—based on industry trends. Mr. Lee Whiteman agreed with the proposal. Mr. Hillman reminded everyone that the intention is to still additionally use Au/Pd/Ni on components where that finish can be readily found. In summary, the test vehicle includes.
- d. Mr. Hillman stated that he is currently working to complete a component matrix with component type, lead finishes, board finishes, solder types and cost data.
- e. Mr. Woodrow stated that he would like to get the total number boards and the total number of channels or number of channels per board so that cost estimates can be developed for those facilities interested in performing testing. Mr. Hillman stated that there are 25 boards per test (depending on how many thermal cycles are performed), and one component per channel on the board. All components on the board have dye in them and are daisy chained. Components will act and move as a live parts but will not function. The board will be set up so that board testing can be in accordance with IPC-SM-785 or the new IPC-9701 specification. Mr. Hillman envisioned the components being arranged in segments of ten, which could be pulled from the board every 250 cycles for testing



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6. Laboratory Survey Form. Mr. Greene had earlier emailed to everyone a survey form to be completed and returned by those facilities capable and interested in performing the JTP testing (Action Item **LFS.02.07.02**). Responses are due August 9, so that the results can be summarized and presented at the August face-to-face meeting.
7. Next Meeting. On 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. Both technical and business matters will be discussed.
8. The teleconference was adjourned at approximately 12:30 p.m.

*SIGNED (Approved by W. Assink 07/29/02)*

Warren Assink  
Govt. Project Manager, WPAFB

Attachments:

1. Action Items

**Summary of Lead-Free Solder Action Items**  
**As of 7/22/02**

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**New Action Items**

**LFS.02.07.01**

**Date Due:** 08/05/02  
**Responsibility:** Boeing (Tom Woodrow)  
**Required Action:** Provide references for statistically significant sample sizes and other pertinent testing "rules of thumb".  
**Comments:** 07/22/02 – Boeing's comments emailed to everyone. When interpreting thermal cycling data, one piece of important information is the number of cycles required to reach 63.2% failures (called alpha or the characteristic life). Weibull plots for different component types can be compared to determine which type of solder joints last the longest. To generate useful Weibull plots, you must fail a large percentage of the components, which requires many thermal cycles. IPC-SM-785 has equations for calculating the minimum sample size required for valid Weibull plots. The rule of thumb from this document is "For tests for which the test duration is long enough to allow at least half of the samples to have failed, a minimum sample size of 32 is recommended." Shorter test times can be achieved by increasing the sample size and vice versa.

**LFS.02.07.02**

**Date Due:** 08/09/02  
**Responsibility:** Potential testing facilities  
**Required Action:** Complete Lab Survey form  
**Comments:**

**Open 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:** Comments continue to be received. Look for revised JTPs to be distributed 1st week of August.

**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

**Summary of Lead-Free Solder Action Items**  
**As of 7/22/02**

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**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