



JG-PP Email

Joint Group on Pollution Prevention

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Pages:

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JG-PP Lead-Free Solder Project Technical Meeting Minutes March 19, 2002

Govt. Project Manager: Warren Assink, WPAFB

MEMORANDUM FOR RECORD

April 25, 2002

Subject: Meeting Summary and Minutes – March 19, 2002

Material(s) Identified: Lead

Process Identified: Electronics soldering

Methodology Phase: I-Identification, II - Technical

Summary:

On March 19, 2002, technical representatives from defense contractors, AMCOM, and other organizations involved in the JG-PP Lead-Free Solder project participated in a teleconference with representatives from the Joint Group on Pollution Prevention Working Group. The objective of the teleconference was to review the content of the Joint Test Protocol, using comments received from AMCOM as a basis for initial discussion and the agenda for the telecon. The aim of the telecon was to bring to closure the outstanding issue on Solder Joint Reliability Test Requirements. The group agreed to a temperature ramp rate and the number of temperature excursions. A block diagram describing the test flow will be created, along with revisions to the design of the test board.

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 repair of lead-containing PWAs.

Next Teleconference: April 26, 2002, 11:00 AM

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Next Meeting: TBD

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Minutes

1. A teleconference was held on Tuesday, March 19, 2002 for the JG-PP Lead-Free Solder project. The objective of the teleconference was to review the content of the Joint Test Protocol (JTP), using comments received from the U.S. Army Aviation and Missile Command (AMCOM) as a basis for initial discussion and the agenda for the telecon. The aim of the telecon was to bring to closure the outstanding issue on solder joint reliability test requirements.
2. Following the roll call, Mr. Joe Felty, Raytheon, opened the conference by reminding the participants to have before them Brian Greene's March 15, 2002 e-mail with the agenda; Dave Locker's message of March 15, 2002 which describes his proposed "Solder Joint Reliability Test Requirements" and Figure 1 which depicts the "Recommended Test Approach"; and Brian Greene's message of March 7, 2002 which contains Dave Hillman's strawman of the JG-PP test printed wiring board.
3. Mr. Denny Jarvi, ITB, said the purpose of the JG-PP project was to compare the alternative lead free solders to tin-lead solders with all of the services test requirements contained within the JG-PP JTP which will then allow the services to initiate implementing the changes needed to use the alternative solders that pass the tests in the JTP.
4. Mr. John Myer, CECOM, asked if there were two JTPs, one for manufacturing and one for repair. Denny Jarvi said yes, they are on the JG-PP web page and the most current ones are dated December 7, 2001. He went on to say the recommended changes to those JTPs are contained in the minutes of the meetings and teleconference calls since that date. The purpose of this teleconference call was to settle outstanding issues with the JTP, which can then be updated on the web.
5. Mr. Dave Hillman, RockwellCollins, opened the technical discussion of the proposed "Solder Joint Reliability Test Requirements". The initial discussion was on ramp rates and dwell times. He said based on lessons learned at RockwellCollins, in order to capture the behavior of the alternative lead free solders the tests will need to be designed to permit an 'apples-to-apples' comparison of the alternative to SnPb solders. He said ramp rates of 5-8°C/minute with 15-minute dwell times will allow the joint to settle. He said we could modify the ramp rates with the dwell times but what is needed is to understand the full effect without allowing creep. He suggested thermal shock could be studied separately. He said this is dependent on several design features including board thickness, board type. He recommended against ramp rates faster than 20°C/minute. Mr. Felty said Raytheon tests with faster cycle times but these tests will lead to obtaining the information needed. Mr. Mark Strickland, MSFC, said NASA uses 5°C/minute as a ramp rate but could live with a range of 5-8°C/minute, but not faster than that. He said NASA guards against adding shock and uses 5°C/minute with a 15-minute dwell time. The group agreed to use 5-8°C/minute with 15-minute dwell times, which is a lower ramp rate than the 20°C/minute contained in Dave Locker's proposal.

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6. The next test parameter discussed was the number of cycles and whether there would be two test temperatures or just one. Mr. Tom Woodrow, Boeing, said the JTP is written so the entire project is an environmental screening and not a long-term reliability test. Mr. Hillman said the total number of cycles needs to be identified. Mr. Hillman said that RockwellCollins uses 2,000 cycles in tests for all of the Boeing equipment. A participant noted that 2,000 cycles was too small, that they test to 10,000 cycles or to failure. Mr. Woodrow suggested that long-term testing be accomplished in order to get enough data and to break the parts so the data tables could be built. It was suggested that a separate JTP could be built for this one test. Mr. Hillman suggested the intent of the current test could be met without having to do all of the cycles. Mr. Dave Locker, AMCOM, said he thought two different temperature excursion tests are needed. He said there is no other second temp range available to help refine the model for predictive issues. Mr. Hillman disagreed, saying it is possible to combining the temperature cycle and vibration tests in a combined HALT test, thus eliminating the need to execute two temperature tests. Mr. Locker said there are no data available from long-term reliability tests. Many companies in many countries are accomplishing these tests now in an attempt to understand long tem reliability of the lead free solders. He went on to say that the Army will need to run additional tests requested by each of the individual program offices before the Army could change the solders in those programs. He is hoping these tests will provide the basis for the Army to move forward.
7. Mr. Felty said the intent of the JG-PP JTP is to conduct those tests that are necessary to qualify lead-free solders. He said that Raytheon was able to use low-VOC coatings and later powder paints following the JG-PP JTP for low/no VOC coatings. He said the same intent is for this project.
8. EIA SSB-1 has a set of formulas that help determine long-term reliability. Mr. Locker said those formulas are for microcircuits. Mr. Hillman said RockwellCollins has been using the EIA SSB-1 formulas for years in conjunction with Miner's Rule to obtain predictive information. Mr. Hillman suggested he and Mr. Locker carry on the conversation off line.
9. Mr. Jeff Bradford, Raytheon, began a discussion on the number of test vehicles. He said if 5 test vehicles were used per test, if combined would yield 25 test per solder alloy times the number of tests yields a total of 275 total test vehicles. The question was asked if there were two temperature excursion tests instead of one, the total test vehicles would be 330. Following a discussion of several options, Mr. Felty said what is needed is to establish a test flow and compare that with what is desired. For the repair JTP, it was thought both temperature excursion tests would be needed for each of the alternatives to compare against the SnPb solders to understand the effect of rework. Dave Locker said data was needed from a common pedigree up to thermal cycle temperature differences, but it was not necessary to run through all of the potential combinations. Mr. Hillman raised the potential of using the HALT tests. Mr. Locker said the HALT tests do not provide the underlying understanding of the long-term reliability needed to predict what will happen. Mr. Lee

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Whiteman, ACI, said that he is concerned with relying on the HALT tests is the group is looking at the performance of microcircuits and what is happening inside the packages.

10. Mr. Felty reminded the group the JTP is focused on solder joint solderability. He said the group needed to pick the HALT test, run the test, sacrifice boards, drive to failure to find the boundaries. Mr. Felty went on to say Raytheon has prepared an 8-page report that discusses the HALT tests and how to use them in long-term reliability tests. He also said Jeff Bradford has prepared a test matrix which defines the tests needed to meet the goals of the JTP.
11. Mr. Woodrow asked if there was a block diagram of the test flow up through the environmental tests. He wondered if it was necessary to do the salt fog tests currently in the JTP. He went on to say there are currently no sequential tests, that all are written as unique block test. Combinations of tests and multiple uses of the test boards could be accomplished saving the number of test boards needed. Mr. Felty concurred, but some of the tests need to be conducted singly to understand the behavior of the alternative lead free solder. Mr. Felty said that some combined tests were a good idea but that these would have to be thought out to ensure the objective of the tests were met as well as being efficient in running the tests.
12. Mr. Locker said he sent out a March 15, 2002 e-mail with a notional component life cycle from the point of view of what the hardware sees during its lifetime. He said it was necessary to understand what the actual environment the electronic system is exposed to during its life. This diagram depicts the conditions the components face from fabrication through assembly, shipment, storage and use. Accelerated life tests are used to simulate this real world environment. He said understanding each of the real life environments are needed to properly test the electronics. He said MIL STD 810 uses this basic concept but the older versions of MIL STD 810 contain a much better description of the tests that are needed. Mr. Felty asked if a temperature excursion from -55°C to +125°C and driving the tests until you reached an 80% failure would accomplish what is needed. Mr. Locker said it depends upon what is happening on strain and the material structure in the joint. Mr. Felty said that in Raytheon the metals are evaluated by the metallurgists who provide Raytheon with their analysis of the results of the tests he just described and uses the 80% failure level to define the boundaries of the alternative. Mr. Hillman said these tests will provide a common basis of understanding for use but each individual product will have to undergo its own qualification tests. Mr. Locker once again said the data are not there yet to provide predictive information. He went on to say the Army stores systems for 30 years and then uses them. He needs to ensure the equipment will operate when it's drawn into action. Mr. Felty said the JTP was never intended to peel that deep into the onion where each potential use of the electronics would be tested. He went on to say there are several layers beneath the level of tests described in the two JTPs that each of the end item designs will have to test.

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13. John Myer said the vibration cycles will provide a general spectrum, but finding all of the answers is an impossibly expensive task. He thought each program will have to demonstrate re-qualification of their equipment with the new solders. He said a Weibull approach driving to failures will be helpful. He thought this approach will help define the test costs and have good predictive test results. Mr. Felty said that was why NCMS drove to failure, so that comparisons between the solders could be made. Mr. Felty said the group ought to take a small population of boards and test them to see if they fail and then review the test results to see if they make sense in the real world.
14. Mr. Felty proposed that he forward the test matrix and the HALT tests described in the 8 page report he prepared to Dave Locker, Dave Hillman, John Myer, and Mark Stibitz for their comments. Once they concurred on the overall approach that will satisfy them, a block diagram describing the test flow could be created and revisions to the design of the test boards could be accomplished. These would be forwarded to the technical group on this telecon for comment. **(AI: LFS. 02.03.03)**
15. Mr. Warren Assink, HQ AFMC, asked Dave Locker if he has asked for Army money to pay for their share of the project. Dave Locker said that he cannot go to the programs to ask for funds unless he feels assured the programs will benefit from the data obtained for monies expended. Mr. Jarvi told the group the specific purpose of the JG-PP, the creation of the JTP, and all that follows is to satisfy the test needs each of the programs need that will permit their acceptance of the test results and implement the solders that pass the tests in the JTP. It is the group's responsibility to find out what tests are required and to get them into the appropriate JTP (original manufacture or rework or both). Mr. Locker said that if the JTPs included the tests to get the data he thought needed that he would not have a problem going to the programs for funding support.
16. The discussion shifted back to the temperature ranges. Mr. Whiteman and Mr. Strickland remarked that NASA looks at one temperature range, from -55°C to +125°C and ran the test for at least 1,000 cycles. This test satisfies NASA test requirements. AMCOM said the boundary limits of the box in the life cycle are of interest. From a materials property perspective, we need to get to the worse case and then get the metallurgists involved to look at the joints. Hopefully we will have failures. Mr. Myer said he has seen several objectives being talked about but the group needs to get back to the stated objectives of the two JTPs, to find and qualify lead free solders and then let the individual programs do what they need to do.
17. An Army representative said the Army had a lot of G-forces involved in some of their circuits on tanks and artillery pieces. He said most of these circuits are not remanufactured, that they are located in difficult places to reach and are just replaced when they fail.
18. Mr. Felty asked if temperature shock could be dropped from the test matrix. Mr. Locker suggested thermal shock could be introduced in a test sequence to develop an assurance the joints will survive but not necessarily drive to failure. He recommended 3 to 5 temperature excursions. Mr. Stibitz

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said WR-ALC will want to see the effect of temperature shock. Mr. Bradford asked if 3 to 5 temperature excursions were satisfactory and the group concurred. He asked the group if it would be OK to sequence these tests in with the others. Mr. Stibitz and Mr. Locker concurred.

19. Mr. Felty said these remarks will be reflected in the test matrix that he will send out.
20. A question was raised on what finishes will be included. Mr. Felty said SnPb, NiPdAu, and Sn as the component finishes was agreed upon.
21. Mr. Hillman agreed to re-draft the strawman test board. The group thought 5 of each device would be enough. He said Weibull plots need 30 components with 5 to 10 failures to effectively test the joints.
22. The group agreed to read MIL STD 202 Method 106F to understand the differences between this military standard and MIL STD 810.
23. The group was reminded that a potential source of funds is the Environmental Security Technology Certification Program (ESTCP). They meet on April 11, 2002 so the time is short in putting together a proposal for funds. Mr. Jarvi told the group the Joint Logistics Commanders is meeting with the JG-PP and funding for the lead free project is on the table. Once the JG-PP understands what funding may be sponsored by the JG-PP, the need to go to ESTCP will be evaluated.
24. Mr. Hillman reminded the group that Texas Instruments and Amkor have volunteered parts free or at very reasonable costs. Mr. Hillman said he is working with TI on the layout of the strawman test board and has assumed using TI parts for the tests. He was asked to re-draft the strawman test board following the discussions on the test matrix and test flow block diagrams (**AI: LFS. 02.03.04**)

SIGNED (Approved by W. Assink 05/01/02)

Warren Assink
Govt. Project Manager, WPAFB

Attachments:

1. Action Items

New Action Items

LFS.02.03.03

Date Due: 04/09/02

Responsibility: Raytheon (Joe Felty)

Required Action: Provide the test matrix and HALT tests to the Dave Hillman, John Myer, Dave Locker, and Mark Stibitz. Gather concurrence on the tests needed and sequences. Prepare block flow diagram and provide to Dave Hillman

Comments: 3/22/02 – Completed with email of updated flow chart from Jeff Bradford to Brian Greene. Jeff also submitted pdf files of MIL-STD-202 and MIL-STD-810 so the documents could be sent to members for comparison of humidity test requirements.

LFS.02.03.04

Date Due: 04/09/02

Responsibility: RockwellCollins (Dave Hillman)

Required Action: Based on the discussions held for Action item LFS.02.03.03, and the block flow diagram, re-draft the strawman test board and provide to Brian Greene for distribution.

Comments:

Open Action Items

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:

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:

LFS.01.12.01**Date Due:** 01/07/02**Responsibility:** Rockwell-Collins (Dave Hillman)**Required Action:** Solders. Prepare a synopsis of published data on lead-free solder fatigue life testing.**Comments:** 1/21/01 – In progress**LFS.01.12.02****Date Due:** **One week after completion of LFS.01.12.01****Responsibility:** All technical representatives**Required Action:** Solders. Review Mr. Hillman's synopsis and suggest any modifications to the short list of lead-free solder alloys for both manufacturing and repair testing.**Comments:****LFS.01.12.05****Date Due:** 01/07/02**Responsibility:** Raytheon (Joe Felty)**Required Action:** Solders. Provide information about toxic metals in solder alloys from the original NCMS lead free solder study to Brian Greene for distribution.**Comments:****LFS.01.12.06****Date Due:** 01/07/02**Responsibility:** All technical representatives**Required Action:** JTPs. Review the Manufacturing and Repair JTPs and provide comment to Brian Greene**Comments:** 2/13/02 – Received comments from AMCOM**LFS.01.11.04****Date Due:** 12/11/01**Responsibility:** Raytheon (Joe Felty)**Required Action:** JTPs. Ask a statistician whether five PWAs was a statistically sufficient number of samples.**Comments:** Agreed that 5 test vehicles per condition should be acceptable as long as a sufficient total quantity of each component types was included in the 5 vehicles. In the 3/19/02 telecon, 30 components per test condition were agreed as the number of components needed to provide statistically meaningful results.

LFS.01.11.05**Date Due:** 12/11/01**Responsibility:** Raytheon (Joe Felty)**Required Action:** JTPs. Ask a statistician what should be the general criteria for test failure (e.g., 2 out of 5; 3 out of 5)**Comments:** Raytheon proposed defining as electrical test failure as: 15 events above 300 ohms for any component interconnect/circuit (EMMA consortia criteria)**LFS.01.11.06****Date Due:** 12/11/01**Responsibility:** Army (Keith DeGroot), Raytheon (Joe Felty)**Required Action:** Manufacturing JTP. Contact their respective organizations to obtain worst-case vibration spectra for inclusion in the Manufacturing JTP Vibration Test.**Comments:** Raytheon submitted a modified version of the NAWC proposed vibration profile to Brian Greene.**LFS.01.11.08****Date Due:** 12/11/01**Responsibility:** All technical representatives**Required Action:** Manufacturing JTP. Check with respective organizations to make sure that 200 cycles is a sufficient maximum number of cycles to run Thermal Shock for the Manufacturing JTP Thermal Shock Test.**Comments:** 2/13/02 – AMCOM response: The 200 cycles for the thermal shock test in the JTP provides acceptable performance metric based on past experience qualifying and fielding Army equipment. For instance, the commonly used requirement for electronics equipment (MIL-STD-202F, Thermal Shock, method 107G) allows for a maximum 100 cycles. For general reliability characterization, thermal cycle testing over various temperature ranges and at different average temperatures will provide the primary basis for extrapolating performance to particular use conditions. Thermal shock performance depends on more thermal properties of equipment design rather than the temperature cycling characteristics.

12/17/01 –M. Stibitz responded that 200 thermal shock cycles are sufficient for WR-ALC as long as the level of shock being used is per the MIL-STD-883 requirements.

LFS.01.11.12**Date Due:** 12/11/01**Responsibility:** Boeing (Tom Woodrow)**Required Action:** Test Board Design. Provide data from Lucent on the performance of immersion silver surface finish.**Comments:****LFS.01.08.01****Date Due:** 11/1/01 (originally 08/22/01)**Responsibility:** All Services and NASA [e.g., AFRL (Dave Johnson), TACOM (Carl Handsy), NAWCWD (John Nelson), USMC (Don Bowie), NASA (Bob Hill)]**Required Action:** Itemize and describe any technical concerns your Service/organization has with use of lead-free solders. Distinguish concerns by new systems (manufacturing) versus old systems (depot repair).**Comments:** Technical concerns noted to date include:

- o Predictive modeling of the solders' long-term reliability (repair)
- o Tin whiskering (repair)
- o Developing soldering process guidelines to minimize the likelihood of creating low-temperature intermetallics when using bismuth-containing solder alloys with a SnPb component (repair)
- o How will lead-free vs. lead containing parts be identified/tracked in the field (repair)

LFS.01.08.02**Date Due:** 11/1/01 (originally 08/22/01)**Responsibility:** All Services and NASA [e.g., AFRL (Dave Johnson), TACOM (Carl Handsy), NAWCWD (John Nelson), USMC (Don Bowie), NASA (Bob Hill)]**Required Action:** Identify the range of currently used lead-containing solder formulations and applications that the Services and NASA would be trying to replace (e.g., are they all eutectic [63% Sn/ 37% Pb]?).**Comments:** 09/18/01 – WR-ALC indicates that 95% of their solders are 63Sn/37Pb. Awaiting more service input.**LFS.01.08.03****Date Due:** 11/1/01 (originally 08/22/01)**Responsibility:** All project technical representatives**Required Action:** Review and comment on the suitability of the candidate lead-free solders that were emailed to the technical representatives on Tuesday, August 7. The information is contained in the four attached files. Brian Greene will consolidate all responses and provide them to all via e-mail within 2 weeks of final receipt (no later than 09/05/01).**Comments:** 11/15/01 – Progress was made at the Nov 14-15 meeting. Awaiting input from more of the stakeholders.

LFS.01.06.06***Date Due:*** 10/11/01 (originally 07/30/01)*Responsibility:* All Technical Representatives*Required Action:* Identify their top lead-free solder candidates to Joe Felty, Raytheon
Comments: 09/19/01 – Raytheon provided their recommendations; posted to the JG-PP Web site

11/15/01 – Progress was made at the Nov 14-15 meeting. Awaiting input from more of the stakeholders.

LFS.01.06.07***Date Due:*** 11/1/01 (originally 08/03/01)*Responsibility:* All Technical Representatives*Required Action:* Consolidate the candidate lead-free solders and provide them to CTC for inclusion in a draft JG-PP Potential Alternatives Report (PAR)*Comments:* 11/15/01 – Progress was made at the Nov 14-15 meeting. At that meeting, a more refined list of alternatives was identified. Awaiting input from more of the stakeholders.**LFS.01.06.06*****Date Due:*** 10/11/01 (originally 07/30/01)*Responsibility:* All Technical Representatives*Required Action:* Identify their top lead-free solder candidates to Joe Felty, Raytheon
Comments: 09/19/01 – Raytheon provided their recommendations; posted to the JG-PP Web site

11/15/01 – Progress was made at the Nov 14-15 meeting. Awaiting input from more of the stakeholders.

LFS.01.06.07***Date Due:*** 11/1/01 (originally 08/03/01)*Responsibility:* All Technical Representatives*Required Action:* Consolidate the candidate lead-free solders and provide them to CTC for inclusion in a draft JG-PP Potential Alternatives Report (PAR)*Comments:* 11/15/01 – Progress was made at the Nov 14-15 meeting. At that meeting, a more refined list of alternatives was identified. Awaiting input from more of the stakeholders.