JG-PP Email

Joint Group on Pollution Prevention

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JG-PP Lead-Free Solder Project Technical Teleconference Minutes October 1, 2002

Govt. Project Manager: Warren Assink, WPAFB

Comments:

Attached please find the minutes from the October 1, 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.

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MEMORANDUM FOR RECORD **October 29, 2002**

Subject: Meeting Summary and Minutes – October 1, 2002

Material(s) Identified: Lead

Process Identified: Electronics soldering

Methodology Phase: II - Technical, III - Business

Summary:
On October 1, 2002, technical representatives from the Boeing Company, Air Force Research Laboratory, BAE Systems (U. K.), Harris Corp., Hill Air Force Base, HQ Air Force Materiel Command, Intersil, Lockheed Martin, NASA- Marshall Space Flight Center, Naval Air Systems Command, Naval Surface Warfare Center- Crane Div., NAVSEA, Picatinny Army Arsenal, Raytheon, Redstone Army Arsenal, Rockwell-Collins, Sandia Laboratory, Texas Instruments, U.S. Army Communications Command, and U.S. Marine Corps participated in a meeting with representatives from the Joint Group on Pollution Prevention Working Group. The objective of the meeting 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 potential testing cost. For convenience, ITB has folded both the repair and manufacturing requirements into one JTP.

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.
- 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: November 8, 2002, 11:00 AM Eastern

Next Meeting: November 12, 2002, Raytheon, Dallas, TX, 9:00 AM Central

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Minutes

1. Mr. Brian Greene, NASA Acquisition Pollution Prevention Office/ITB, opened the teleconference by reviewing the teleconference agenda. A roll call was taken. All military services and NASA were represented.

2. **Solder Alloys**. Mr. Warren Assink, HQ Air Force Materiel Command and JG-PP Government Project Manager, reminded everyone that our goal was to include as many end-user requirements as possible. He referred everyone to the email he distributed several weeks ago containing the Air Force Research Laboratory's comments to the solder alloys and Joint Test Protocol. Next, Mr. Larry Perkins, AFRL, Materials Directorate, provided his recommendations to the project, with an emphasis on the solder alloys currently selected for testing.

    a. Mr. Perkins made several key points concerning the Pb-free solder alloys, to which various long-term participants of the Lead-Free Solder project attempted to address. Mr. Perkins main point was: Why are few, if any, of the approximately 20 Pb-free solder alloys listed in the J-STD-006 standard not on the current JG-PP Lead-Free Solder short-list of alloys to be tested? Specifically, shouldn't the following Pb-free solder alloys be considered as the JG-PP testing baseline?
        - Sn95Ag5
        - In52Sn48
        - Sn42Bi58
        - Sn99Cu0.7

    b. A summary of this dialogue is contained in the table below. At the end of the discussion, Mr. Assink summarized that the AFRL recommendation was to add one or two of the J-STD-006 Pb-free solder alloys to the Potential Alternatives Report (PAR). Mr. Perkins did not recommend one or two specific alloys for general solder applications at this time, saying that the decision depends more upon the specific application requirements e.g., elevated temperature step soldering (in which case he might recommend the Sn95Ag5 and Sn99Cu0.7); or space applications where control of expansion coefficients may be important (in which case the Sn42Bi58 might be recommended). Mr. Joe Felty, Raytheon, stated that if AFRL recommended these alloys, they should be considered for testing by the group. An action item was taken by Mr. Warren Assink to collect AFRL's recommended solder alloys for testing, and forward the recommendations to Mr. Greene and Ms. Heather Moyer, CTC, for inclusion in the PAR (Action Item **LFS.02.10.01**).

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AFRL Comment on Solder Alloys	Group Member Response
A whole industry exists in the U.S. to provide the J-STD-006 Pb-free solder alloys to the quality and specifications required.	Multiple U.S. (and overseas) sources exist to provide the proposed JG-PP solder alloys to the quality and specifications required and in the volumes required to meet future military needs (T. Woodrow, C. Simmonds). The proposed Pb-free reflow solder alloys were selected largely based on information that suggests that SnAgCu will become the U.S. industry standard general application Pb-free alloy. In addition, there is likely a greater risk of industry not supporting some J-STD-006 alloys in the future because of the scarce resources. For example, many people think that natural supplies of Indium are too low to support use of an alloy (In52Sn48) containing high amounts of Indium. (T. Woodrow)
Air Force processes and procedures exist for ensuring J-STD-006 solder alloys are used correctly. The Air Force has real-world reliability data for these alloys, and shows that they work fine for military applications. Furthermore, we don't know what hidden problems these new Pb-free solder alloys may present--problems that laboratory testing alone won't predict. Examples include corrosion problems, fixturing problems, etc. Does such data exist for how these materials actually perform in the field? If not, then this actually presents a higher risk than using current J-STD-006 Pb-free solder alloys.	Because the proposed JG-PP Pb-free solders are already in production (Multicore, Alpha, Kester, Heraeus, etc.) and being used on the commercial side, most if not all processibility issues have been resolved. For example, the Pb-free reflow solders have melt temps around 217°C, which even at peak reflow temp will not damage sensitive components. The only remaining issue is whether the alloys meet military performance requirements (C. Simmonds).

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AFRL Comment on Solder Alloys	Group Member Response
To be qualified, the entire Pb-free soldering process will need to be closely examined and understood, e.g., wettability, cleaning procedure. For example, any Pb-free solder alloy will have to be compatible with the SnPb solder previously on the board. Are the proposed JG-PP Pb-free solder alloys compatible with Au, AuPd, and Sn finishes like the J-STD-006 alloys? Are they compatible with common fluxing systems?	Part of the JG-PP Lead-Free Solder test program is to evaluate the repair of SnPb PWBs with Pb-free solders, and the effects of different component and surface finishes deemed most common (C. Simmonds). The particular fluxing system that will be used will be that recommended by the solder supplier (T. Woodrow).
Shouldn't the J-STD-006 Pb-free solder alloys be included as part of the "baseline" solder alloys (along with the SnPb eutectic), since the J-STD-006 alloys are the next best thing currently available? For example, if JG-PP testing shows the J-STD-006 Pb-free alloys perform significantly worse than the new Pb-free solder alloys, one would wonder why that observation disagrees with the satisfactory performance the Air Force is seeing in the field with the J-STD-006 alloys.	First, the AFRL-proposed J-STD-006 alloys are not well suited to the kind of common, broad-based soldering applications currently defined by the stakeholders as the scope of the JG-PP project. These J-STD-006 alloys present problems of their own of which AFRL may be unaware: - Sn95Ag5: Was not one of the better performers (thermal cycle) in the latest NCMS study (T. Woodrow), and it melts too hot (235°C) (J. Felty). - In52Sn48: Many people think that natural supplies of Indium are too low to support use of an alloy containing high amounts (52%) of Indium. (T. Woodrow). Because its low melting point (118°C) is below that of 125°C storage temperature requirements, use of such an alloy would be limited. (J. Felty) - Sn42Bi58: Melts at 138°C, which is close to 125°C storage temps. The slightest amount of Pb contamination (e.g., from repair) causes these joints to fall apart (T. Woodrow). - Sn99Cu0.7: JG-PP is looking at this J-STD-006 alloy for wave solder. This alloy's melt temp (230°C) is too high to be considered for reflow soldering (plastic parts would melt). (T. Woodrow)

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AFRL Comment on Solder Alloys	Group Member Response
	Second, enough testing already exists by which to judge the relatively poor performance of the J-STD-006 alloys compared to the JG-PP-proposed Pb-free solder alloys. For example, the purpose of the two NCMS studies was to compare the performance of many "old" and "new" Pb-free solders under long-term thermal cycling (-55/+125°C and 0/100°C). The JG-PP effort used this NCMS data in down selecting the solders for JG-PP testing. Why use resources to confirm what is already known? (T. Woodrow) Third, if JG-PP testing shows the J-STD-006 Pb-free alloys perform significantly worse than the new Pb-free solder alloys, this does not provide any useful information that can aid in implementing the JG-PP Pb-free solders? Specifically, if OEMs are pressured to begin using Pb-free solders, it will be to replace SnPb eutectic solder alloy. Therefore, from an implementation standpoint, there is only value in comparing the performance of Pb-free solder alloys to SnPb, not to some other Pb-free alloy like Sn95Ag5. As such, an important step in the JG-PP Lead-Free Solder study is to identify those small number of general Pb-free solder alloys that offer the best potential to meet or exceed the performance of SnPb eutectic solder for wave and reflow manufacturing as well as circuit card repair (J. Felty).

c. Mr. Tom Woodrow, Boeing Phantom Works, and Vuong Trinh, Lockheed Martin, Sunnyvale, both noted that the Pb-free reflow solder alloys currently proposed for testing were selected largely based on information that suggests that SnAgCu will become the U.S. industry standard Pb-free alloy, and the SnAgCuBi was the best performer (highest reliability) in the most recent NCMS study.

3. **Joint Test Protocol (Manufacturing & Repair)**. A summary of this dialogue between Mr. Perkins and other group members concerning the scope of the testing is contained in the table below. At the end of the discussion, an action item was taken by Mr. Warren Assink to collect AFRL's performance requirements and acceptance criteria for the Joint Test Protocol (JTP) and provide them to Mr. Greene (Action Item **LFS.02.10.02**).

a. Mr. Perkins summarized a few of the technical concerns that AFRL has experienced with other solders--concerns for which he feels the JG-PP test program should consider addressing: How does the number of touch-ups affect ability to withstand thermal cycling? What will be the visual inspection criteria? What are the effects of different protective component finishes?

b. Mr. Perkins closed by stating that he was providing recommendations only for the group to hash out. Anyone with further questions can contact Mr. Perkins through Mr. Assink. Both Mr. Felty and Mr. Assink felt that Mr. Perkins experience would be valuable to the JG-PP project and asked Mr. Perkins' if he or anyone from his office could be an active participant in the project and any future meetings. Mr. Perkins declined to commit to be a regular participant because of his workload, but said he would be very interested to see the final test results. In the meantime, Mr. Perkins said he would look into the possibility of someone else from his office being a regular participant. He also agreed to entertain any specific questions directed through Mr. Assink.

c. Mr. Greene reviewed some of the recent changes and outstanding issues with the JTP:

1) Mr. Jim Blanche, NASA Marshall Space Flight Center, worked with several stakeholders in the weeks prior to the teleconference to develop a step-stress vibration spectrum. This spectrum is recommended for the Vibration testing of manufactured and repaired boards. The test would start with an approximate grms of about 9.9 and continue with an increase of grms in a stepwise fashion until failure criteria are met. The test will run at 1 hour per axis. Technical representatives were asked to closely examine this test to make sure it meets their program's requirements, as well as report what the upper (cut-off) grms value should be.

2) More information is needed from the technical representatives requesting humidity and salt fog testing. Key issues remain unresolved such as SIR circuit patterns and the presence of a comb pattern or a pickle-fork pattern. Specifically, the NAVAIR has asked for SIR evaluation, but there is no SIR pattern in the proposed test board. Adding such a pattern would increase the size (and cost) of the board.

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AFRL Comment on JTP	Group Member Response
Disagrees with perceived JG-PP approach to qualify a Pb-free solder for a wide variety of weapons systems with limited testing on single test boards, rather than qualifying weapon system by weapon system.	This project will provide the baseline data for military customers to compare the performance of Pb-free solder alloys against SnPb under fairly extensive (not limited) testing. It is understood that certain customers will always require system-level testing of the Pb-free alloys to validate the conclusions of the environmental screening testing, but no military customers have stepped forward at this time to offer details or funding for such system-level testing (J. Felty).
Why doesn't the JG-PP test program seem to address some of the Air Force's severe performance requirements and soldering applications, e.g., step-soldering (at elevated soldering temperatures)?	The current AFRL Pb-free solder applications seem to represent niche applications that are not in line with the scope of the JG-PP JTP. The focus of the JG-PP Lead-Free Solder JTP is to evaluate some general Pb-free solder alloys for use in a fairly broad range of soldering processes that are COMMON to all stakeholders. Step soldering applications (and possibly some unique space and aircraft applications) do not fit the definition of "common" solder application. (J. Felty, C. Simmonds)
Why doesn't the JG-PP test program seem to address the processibility of the new Pb-free solder alloys? Will this test program provide the data on the new Pb-free solder alloys specific to Air Force systems to show that the quality control is in place to produce the assemblies on a daily basis like the SnPb assemblies?	The JTP, as currently defined, is to evaluate the performance of the solders under simulated real-life environmental conditions (e.g., in flight, or on communications equipment, etc.). Tests such as thermal cycling (and others) are the industry standard for determining the reliability of solder joints to simulate these environments (T. Woodrow). Processibility issues ARE being considered in the downselection of alternatives, but are not factored into the JTP.
How is PWB touch-up factored in to the JTP?	AFRL was requested to provide comprehensive testing requirements to the group via Mr. Assink.

3) For convenience and to reduce errors, all the manufacturing and repair requirements have been rolled into one JTP. The basic test requirements for the manufacturing and repair elements are very similar, except for one additional thermal cycle test for manufacturing boards and the need to

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fabricate, assemble and prepare the repair boards differently than the manufactured boards. The repair requirements can always be separated into their own JTP at a later time, if warranted. When prompted, none of the stakeholders noted concern about this change.

4) Pre- and post-testing inspection procedures are still required for the JTP.

4. **Test Board Design**. Mr. Greene reported that Dave Hillman, RockwellCollins, was working on another revision of the test board design. Once this is completed, it will be shared with the group at large. Some recent recommendations on the test vehicle design that technical representatives should review and comment on, as necessary:

   a. It is desirable to reduce the test board's I/O count, and thus the number of cables existing the test chamber. Some participating facilities have a limited capacity to measure I/O much above 1,000. It is proposed that the number of parts be reduced from six to five for all parts except capacitors, resistors, and hybrids.

   b. The components recommended for repair are BGA, TSOP, TQFP and PDIP.

   c. It is recommended that the 0402 resistors be dropped from the test board and replaced with a set of 1206 resistors that will be staked. Staking the chip resistors would increase their reliability when being attached with lead-free solders. Tom Woodrow would send out a proposal for staking the chip resistors.

5. **Business Issues**. Mr. Greene stated that the estimate of testing cost was still being refined. The total cost will depend on, among other things, the number of lead-free solder alloys that are recommended for testing.

6. Two additional action items were taken: Each program should identify to Mr. Greene and Mr. Assink their organizational business point of contact (Action Item **LFS.02.10.03**); and OEMs identify the frequency of their use of hybrids (Action Item **LFS.02.10.04**).

7. The teleconference was adjourned at approximately 1:00 p.m.

SIGNED (Approved by W. Assink 10/29/02)

Warren Assink
Govt. Project Manager, WPAFB

Attachments:

1. Action Items

Summary of Lead-Free Solder Action Items
As of 10/01/02

New Action Items

LFS.02.10.01

Date Due: **11/05/02**
Responsibility: HQ AFMC (Warren Assink)
Required Action: Collect AFRL's recommended solder alloys for testing, and forward the recommendations to Brian Greene and Heather Moyer, CTC, for inclusion in the PAR
Comments:

LFS.02.10.02

Date Due: **11/05/02**
Responsibility: HQ AFMC (Warren Assink)
Required Action: Collect AFRL's performance requirements and acceptance criteria for the Joint Test Protocol (JTP) and provide them to Brian Greene
Comments:

LFS.02.10.03

Date Due: **11/05/02**
Responsibility: All technical representatives
Required Action: Identify to Brian Greene and Warren Assink their organizational business point of contact, if other than themselves
Comments:

LFS.02.10.04

Date Due: **11/05/02**
Responsibility: OEMs
Required Action: Identify the frequency of their use of hybrids
Comments:

Open Action Items

LFS.02.10.01

Date Due: **10/10/02**
Responsibility: HQ AFMC (Warren Assink)
Required Action: Collect AFRLs recommendations on lead-free solder alloys for testing and send to Brian Greene for distribution
Comments:

LFS.02.10.02

Date Due: **10/10/02**
Responsibility: HQ AFMC (Warren Assink)
Required Action: Collect AFRLs recommendations on additional Air Force requirements
Comments:

LFS.02.08.07

Date Due: **09/16/02**
Responsibility: Army (Dave Locker)
Required Action: Provide reasonable number for mechanical shock. Mr. Greene will also try to identify original diagrams
Comments: In progress, Brian Greene identified that the original diagram came from NAVAL AIR WARFARE CENTER WEAPONS DIVISION
Reminder sent by Kurt Kessel on 9/16/2002

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-king 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

LFS.02.07.02

Date Due: **08/09/02**
Responsibility: Potential testing facilities
Required Action: Complete Lab Survey form
Comments: In progress, as of 10/03/2002 survey forms have been received from; ACI, Raytheon, Sandia, Boeing Rockwell Collins and NAVAIR

LFS.02.08.11

Date Due: **09/16/02**
Responsibility: All
Required Action: Identify business POC, if different from technical POC, to attend business meeting
Comments: Boeing (Tom Woodrow) identified himself as the business POC
As of 10/03/2002 no other responses have been received

LFS.02.09.02

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: No response as of 10/03/2002

Closed Action Items

LFS.02.08.01

Date Due: **09/16/02**
Responsibility: Raytheon (Jeff Bradford)
Required Action: Develop revised test matrix showing other options to reduce costs
Comments: Closed: 9/20/2002

LFS.02.08.02

Date Due: **09/16/02**
Responsibility: NASA MSFC (Mark Strickland)
Required Action: Identify studies (past & present) within NASA dealing with lead-free solder. Provide to B. Greene for distribution.
Comments: Closed: 9/16/2002

LFS.02.08.03

Date Due: **09/16/02**
Responsibility: All
Required Action: Determine need for extended tests, and if so, include acceptance criteria
Comments: Action Item Closed: As of today the following extended test have been confirmed;
Salt Fog (MIL-STD-810F, Method 509.4)
Humidity (IPC-TM-650.2.6.3.2)
Required by; Mark Stibitz, John Nelson and Suresh Verma

LFS.02.08.04

Date Due: **09/16/02**
Responsibility: All
Required Action: Develop standard PWB inspection list and include in JTPs
Comments: Action Item Closed: Reminder sent by Kurt Kessel on 9/23/2002
Received responses from Raytheon (Jeff Bradford 9/23/2002) and Boeing (Tom Woodrow 9/23/2002)

LFS.02.08.05

Date Due: **09/16/02**
Responsibility: Rockwell Collins (Dave Hillman)
Required Action: Provide vibration testing information and HALT information from past testing programs.
Comments: Action Item Closed: Data Received 09/24/2002

LFS.02.08.06

Date Due: **09/16/02**
Responsibility: ACI (Lee Whiteman)
Required Action: Provide EMMA test procedures to Brian Greene
Comments: Action Item Closed: Data Received 09/24/2002 from Dave Hillman

LFS.02.08.08

Date Due: **09/16/02**
Responsibility: Raytheon (Jeff Bradford)
Required Action: Update test schedule based on revised number of thermal cycles
Comments: Closed: 9/20/2002

LFS.02.09.01

Responsibility: NASA MSFC (Jim Blanche) & Boeing (Tom Woodrow)
Required Action: Jim Blanche to write stepwise vibration specification and procedure for JTP Section 3.2.1.
Tom Woodrow to provide Jim Blanche with Boeing vibration testing procedure if possible.
Comment: Action Item Closed: Received response from Jim Blanche on 09/30/2002

LFS.02.09.03

Responsibility: ITB, Inc. (Brian Greene & Kurt Kessel)
Required Action: Kurt Kessel to send an email to project participants that completed the Lab Survey, asking how many I/O would be available for testing and who has mini wave/air vac solder pot equipment for attaching the PDIP components
Comments: Action Item Closed: Email sent by Kurt Kessel on 09/26/2002
Responses received from Lockheed Martin 09/26/2002 (Bob Vanderwiel), NAVAIR 09/26/2002 (Shawn Hertz), Boeing 09/30/2002 (Lety Campuzano-Contreras) and Raytheon 09/30/2002 (David Nelson)

LFS.02.09.04

Responsibility: Boeing (Tom Woodrow)
Required Action: Provide Boeing repair procedures to Brian Greene
Comments: Action Item Closed: Response received on 10/14/2002 from Lety Campuzano-Contreras

LFS.02.09.05

Responsibility: Raytheon (Jeff Bradford and Joe Felty)
Required Action: Update JTP Section 3.1.2 Combined Environments Test and provide revised version to Brian
Comments: Action Item Closed: Section 3.1.2 was received and incorporated into the JTP on 10/11/2002

LFS.02.09.06

Responsibility: ITB, Inc. (Brian Greene & Kurt Kessel)
Required Action: Kurt Kessel to send an email to stakeholders that requested humidity and salt fog test to determine their needs for SIR circuit pattern and comb patterns
Comments: Email sent 10/04/2002
Action Item Closed: Received response from Rockwell Collins (Dave Hillman) on 10/18/2002

LFS.02.09.07

Responsibility: Boeing (Tom Woodrow)
Required Action: Tom Woodrow will email to the group a proposal for staking resistors onto the test board
Comments: Action Item Closed: Boeing (Tom Woodrow) sent an email to the group on 09/26/2002