Federal Aviation Administration

Memorandum

Date:	JUL 2 8 2011
To:	All Directorates Managers, Aircraft Certification Offices Managers, Manufacturing Inspection District Offices Mike Monroney Aeronautical Center
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Memo No:	AIR100-2011-120-003
Subject:	<u>ACTION</u>: Assessing the Reliability and Certification Procedures for Electrical and Electronic Equipment and Systems Using Lead-Free Solder and Lead-Free Finishes on Components

PURPOSE:

This Memorandum is to communicate an awareness regarding the potential product integrity concerns due to use of solder and/or component finishes that are lead free. Certification applicants should ensure that their systems and programs minimize the impacts due to the global transition to lead free. Each applicant should assess and mitigate the applicable risks in order to meet and comply with the applicable airworthiness requirements.

One means of assessing the impact of lead free components and/or solder is by the development of a Lead-Free Control Plan (LFCP) for each applicant organization or for each affected program. GEIA-STD-0005-1 and -2, along with the supporting handbooks, provides a basis by which the plan and mitigation strategy may be developed. This is not the only means. The applicant can propose an alternative means that will be reviewed and accepted by the FAA.

BACKGROUND:

In 2002, the European Union issued a directive (EU Directive 2002/95/EC), which required that new electrical and electronic equipment and systems put on the market after 1 July 2006 shall not contain lead (Pb) or other environmentally hazardous materials. This European directive as well as other similar legislative prohibitions to using or importing Lead in electronic systems are causing manufacturers worldwide to transition from Tin-Lead (Sn-Pb) to Lead-free (Pb-free) solders and termination finishes.

Lead is used as surface plating for soldering purposes (e.g. tin/lead solder alloys) on discrete electrical and electronic components, including integrated circuits, semiconductors, capacitors, resistors, and other electronic circuitry. Currently the largest volume of lead in many of these electronic assemblies is in the tin-lead Sn-Pb eutectic and near eutectic alloys used in wiring, printed circuit board assemblies, wiring harnesses, and electrical and electronic equipment and systems.

To date, no single lead-free alloy is a drop-in replacement for the tin-lead Sn-Pb eutectic alloys in widespread use in electronic and electrical industry over the last 50 plus years. Eutectic tin-lead (at 183 deg C melting point) is the predominant alloy used in the electronics/electrical industry. Many of the proposed alternative materials have higher melting points than current eutectic Sn-Pb, while some of the lower temperature materials will not be able to withstand the extreme aerospace and aviation operating environments.

Using such solders require higher processing temperatures, which can result in damage to the printed circuit board and/or components. Reliability testing mechanisms for lead-free alloys are still being developed. Results from thermal cycling reliability testing conducted to date, comparing lead-free to Sn-Pb alloys have yielded inconclusive results for aerospace applications of lead-free alloys. The results have shown that some alloys in mild environmental conditions are more reliable, while the same alloys are much less reliable in harsher environments. Thus depending upon the lead-free alloy type and the application, tests have shown that their usable life may be shortened due to greater fatigue than the Sn-Pb alloy it is substituting. In addition to the general lack of applicable Pb-free thermal cycling testing, there is little vibration and shock modeling or durability test data available for the lead-free alloys.

Pb-free solders and finishes may decrease the reliability of systems or subsystems. The following may impact safety and system performance:

- Pb-free solders may be common in commercial-off-the-shelf piece parts.
- SnPb solders and finishes on assembly piece parts may be difficult to procure.
- SnPb solders and finishes may not be available regardless of contract or specification.
- SnPb versus Pb-free piece parts may be difficult to identify in pre-assembled subsystems.

- System production and maintenance personnel may inadvertently mix SnPb and Pb-free solders.

Studies have shown that the elimination of lead in surface finishes may re-introduce a phenomenon known as "tin whiskers." Tin whiskers are conductive crystalline growths from near-pure tin coatings, with a potential for stationary or free-floating conductive metal needle-like structures wherever near-pure tin coatings are applied. At present this phenomenon is not clearly understood by industry and no known solutions exist to completely preclude tin whisker growth.

Other risks associated with the use of Pb-free components, especially on printed circuit boards, is higher processing temperature that enhances Coefficient of Thermal Expansion (CTE) effects, which could reduce component service life in comparison to Sn-Pb components. Another risk is that lead contamination can negatively influence the properties of Pb-free solders. For example, if a PCB was originally manufactured with Sn-Pb solder, and during a repair operation the Sn-Pb solder was not adequately removed, then the introduction of Pb-free solder with certain alloys may result in a flawed solder joint.

The FAA is aware that some aviation products and appliances already contain component parts with pure tin surface finishes as well as other lead-free finishes. However, the results of some electronic and avionics equipment and systems manufacturer's qualification tests, including environmental stress screening, and field failure analyses, indicates that there have been no identified failures related to the introduction of these lead-free finishes as a result of the electronics industry transition away from lead on electronic parts. The FAA believes that the test protocols that have been traditionally used in these qualifications tests may or may not be appropriate protocols to determine if the new materials will withstand the rigorous environment. Product performance is and will continue to be reviewed with our applicants periodically and supported by root cause analysis of any field failures (service difficulty reports).

LEAD-FREE IMPACTS:

The aerospace electronics, with its unique environmental and qualification requirements, has five key areas that the Lead Free transition is known to impact:

Solder Joint Reliability/Line Replaceable Units (LRU) Qualification:

As the aerospace industry reacts to and finds means to accommodate the electronics industry change over to Pb-free products, a transition to Pb-free materials within solder joints has been shown by industry testing to impact the reliability of these solder joints. Aerospace electronic and electrical products can be critical elements in the safety of the aircraft. In addition, material changes in LRU that may affect the reliability of the product can lead to re-qualification of the product.

Tin Whisker Susceptibility:

In the near term, particularly during the transition to Pb-free electronics, one of the more significant threats to proper operation is tin whisker susceptibility. As the semiconductor and passive component manufacturers' cease-using lead in the component finishes, the risk grows. One common solution for Pb-free finishes is the use of near-pure tin. Testing has shown that this significantly increases the risk of tin whisker growth.

Maintenance/Repair Methodology:

As the industry transitions to Pb-free electronics and electrical systems, it is vitally important to maintain proper maintenance procedures and materials. As of this writing, there is no single or universal material solution for the replacement of Sn-Pb solder and finish. In addition, at this point it is not clear that the mixing of each of various materials results in an unreliable solder joint.

The manufacturer must clearly call out maintenance and repair methodologies so that all maintenance shops can follow proper steps in their processes.

Configuration Control:

One of the more difficult issues identified at this time by the above referenced working groups is that of configuration control. As the component device manufacturers are transitioning to lead-free finishes, they are not consistently, if at all, identifying the new finish materials. This has lead to a configuration control difficulty for the aerospace industry. Aerospace has rather strict policies and procedures for configuration control. These policies must be adhered to including the device finish materials.

Component Availability:

The availability of components or devices as it relates to the transition to Pb-free electrical/electronics components appears to primarily link to the configuration control issue. It is not obvious that the transition to Pb-free will in itself cause an obsolescing of components, but rather will lead to unavailability of Sn-Pb based components.

INDUSTRY AND GOVERNMENT ACTIONS TAKEN:

The Lead-free Electronics in Aerospace Project Working Group (LEAP WG), which was formed in 2004, and was sponsored jointly by the Aerospace Industries Association (AIA), the Avionics Maintenance Conference (AMC), and the Government Electronics and Information Technology Association(GEIA). The task of the LEAP WG is to address aerospace issues related to the global elimination of lead from electrical and electronic equipment put on the market after July 1, 2006.

Their major deliverables were standards and handbooks to assist and guide industry in the transition to Pb-free solder and finishes. These documents are currently the best resource for guidance in getting through the transition to lead free avionics and they are listed in the table below. FAA employees can obtain access to these documents by contacting Georgia Koutsaris, AIR-120, 202-385-6337.

Table 1.
Standards and Handbooks for Lead-free Transition

GEIA-STD-0005-1	**Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-free Solder**	Used by aerospace electronic system "customers" to communicate requirements to aerospace electronic system "suppliers"
GEIA-STD-0005-2	**Standard for Mitigating the Effects of Tin Whiskers in Aerospace In High Performance Electronic Systems**	Used by electronic system "suppliers" as a guide in the design and evaluation of designs that need to be robust to the effects of tin whiskers
GEIA-STD-0005-3	**Performance Testing for Aerospace and High Performance Electronic Interconnects Containing Lead-Free Solder and Finishes**	Used by aerospace electronic system "suppliers" to develop reliability test methods and interpret results for input to analyses
GEIA-HB-0005-1	**Program Management / Systems Engineering Guidelines For Managing The Transition To Lead-Free Electronics**	Used by program managers to address all issues related to lead-free electronics, e.g., logistics, warranty, design, production, contracts, procurement, etc.
GEIA-HB-0005-2	**Technical Guidelines for Aerospace and High Performance Electronic Systems Containing Lead-Free Solder and Finishes**	Used by aerospace electronic system "suppliers" to select and use lead-free solder alloys, other materials, and processes. It may include specific solutions, lessons learned, test results and data, etc.
GEIA-HB-0005-3	**Repair and Rework of Aerospace and High Performance Electronic Systems Containing Lead-Free Solder (draft)**	Used by technicians and the planners in the repair and rework end of the life cycle to assure that the proper techniques are followed

REFERENCES:

a. NASA Advisory NA-044: Parts Advisory on Tin Whiskers

b. Air Force Airworthiness Advisory AA-05-01, Lead-Free Solder

c. GEIA GEB-0002: Reducing the Risk of Tin Whisker-Induced Failures in Electronic Equipment

d. Directive 2002/95/EC of the European Parliament and of the Council, The Restriction of the use of certain Hazardous Substances in electrical and electronic equipment, 27 January 2003

e. Directive 2002/96/EC of the European Parliament and of the Council, Waste Electrical and Electronic Equipment, 27 January 2003