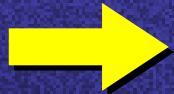




Agenda

1. Lead Free Transition and Impacts
2. **Lead Free Failure Modes**
3. A Comprehensive Lead Free Strategy
4. **GEIA Lead Free Standards and Handbooks**
 - GEIA-STD-0005-1 Performance Standard
 - **GEIA-STD-0005-2 "Tin Whisker Document"**
 - GEIA-HB-0005-1 Program Management Guidelines
 - GEIA-HB-0005-2 Technical Guidelines
 - GEIA-STD-0005-3 Performance Testing
 - GEIA-HB-0005-3 Rework and Repair
 - GEIA-HB-0005-4 Reliability Assessment
5. **Summary**
 - Acknowledgements
 - Lead Free Links
 - Points of Contact





GEIA-STD-0005-2

- **GEIA-STD-0005-2 Standard for Mitigating the Effects of Tin in Aerospace and High Performance Electronic Systems**

- Describes processes for mitigating the detrimental effects of tin whiskers in electronic systems used in military, aerospace, and other high-reliability applications.
- Intended for use to document processes used to assure performance, reliability, airworthiness, safety, and certifiability of electronic systems in which harmful forms of tin may be introduced into the production or maintenance process.



Document Concept

- Tin whisker risk cannot be accurately quantified
 - Models exist for whisker growth and shorting, but are still immature
 - Risk algorithms exist for comparing applications but do not map to probability of failure
- Different programs and applications have different tolerances for the ambiguous tin whisker risk
 - Programs that have seen a tin whisker failure tend to be extremely (overly?) conservative
 - Programs that have not had documented tin whisker failures tend to be (overly?) optimistic
 - Tolerance needs to take into account possible risk of whiskers and possible impact of whiskers



Document Concept (cont)

- Document designed to provide a framework by which suppliers and customers can communicate more clearly about how big a risk they consider whisker and what actions they are taking as a result
- Not a step-by-step cookbook for removing tin whisker risk entirely



Defining Tin

- ***Pb-free Tin*** is defined to be any tin alloy with <3% lead (Pb) content by weight
- Frequently defined by >97% tin but not sure research supports other alloys yet
- Need to consider whether for testing purposes (lot screens) whether need more margin for “rough” tests
- Standard only deals with finishes, not attachment solder
 - Assumption has been that whiskers do not form from bulk solder joint, only from original finishes due to stresses
 - May need to revisit assumption based on recent data
 - STD will be revised to include bulk joint materials if needed



Overview of Control Levels

- **Level 1.** No restrictions on Pb-free tin finish use.
- **Level 2.** Pb-free tin finish is allowed under some circumstances.
 - **Level 2A.** Use of **Pb-free tin finish without explicit controls is acceptable under most circumstances** but the likelihood of whiskers and methods used to estimate their impact and mitigation strategies will be documented. Pb-free tin finish may be prohibited in some specific circumstances called out in contractual documents.
 - **Level 2B.** **Pb-free tin finishes may be used but only with customer approved and specified control measures. These Pb-free tin finish approvals may be blanket approvals** for multiple components and applications within the system. Pb-free tin finish may be prohibited in some specific circumstances called out in contractual documents.
 - **Level 2C.** **Restricted use of Pb-free tin finish.** Pb-free tin finish is prohibited unless an exception is made. Specific instruction on use of Pb-free tin finish and required control measures to be provided and reviewed on a case-by-case basis.
- **Level 3.** Use of **Pb-free tin finish is prohibited** and measures must be taken to verify compliance.



Lead Free Control Levels

	Documentation of Tin Use	Detection and Control	Mitigation	Risk Analysis
Level 1	Supplier: General information on finishes used.	None.	None.	None.
Level 2A	Supplier: General information on finishes used. Customer: List of any applications where tin is not allowed.	None.	None.	At the process level: analyses showing: risk assessment.
Level 2B	Supplier: List of families and categories that will use tin Customer: List of any applications where tin is not allowed.	Should have sampling of receipts material tested	Should have at least two mitigation methods be employed.	At the family level: analyses: analyses showing: risk assessment.
Level 2C	Supplier: List of all instances of pure tin. Customer: List of any applications where tin is not allowed.	Shall have sampling of receipts material tested	Shall have at least two mitigation methods	At the instance level: analyses showing: risk assessment.
Level 3	Supplier: Documentation of lot screen results.	Shall tests at least one part per lot / batch received	Not applicable. No tin is to be used so no risk analysis is required.	Not applicable. No tin is to be used so no risk analysis is required.



Level Selection

- 5 factors to consider
 1. Propensity of the tin surface in question to grow whiskers of a given length, in a given abundance, in a given time frame.
 2. Ability of whiskers growing from that surface to create an electrical short
 3. Ability of whiskers to break off and to migrate to a different location in the system
 4. Vulnerability of the system to suffer performance degradation due to electrical shorts such as are created by tin whiskers (including plasma events).
 5. Vulnerability of the system to suffer performance degradation to micromechanical dysfunction that could be created by tin whiskers.



Level Selection

- Programs with risk of plasma events will probably want to pick a very high level
- Programs with infrequent test and maintenance schedules and/or very long missions will probably want to pick a very high level
- Programs with shorter missions, more tolerant circuits, and frequent test and maintenance may be able to select lower levels



Level Usage

- There are several ways to use the control levels
 - Some programs may chose a level for the entire program
 - Some programs may chose levels for individual hardware elements / units
 - Some programs may chose levels for hardware based on previously defined criticality levels
 - Etc.

- Any of these methods can work, but plans should always be very clear in the way the control levels will be utilized



Agreement of Level with Customer

- **Level selection will likely be a negotiation with your customers**
- Pick a level that will be applicable to most of your customers
 - If you are building a lot of space product, plan on a level 3 or 2C
 - If you are building a lot of commercial avionics, you can probably plan on a lower level 2 category
- **TALK TO YOUR CUSTOMERS BEFORE YOU FINALIZE YOUR DECISION**
 - Tell them what you are thinking and why to get their input
- May need to have different plans and levels for different product lines
- Negotiate additional work for higher levels with special customers
 - If you have one customer that wants a higher level than all your others, set your baseline plan for the majority of your customers and negotiate customization with the special customer
- Make sure to get level agreement in writing with the customer



Flow Down of Requirements

- Requirements for control levels 2B, 2C, and 3 apply to lower tier suppliers
- That means the level and/or its requirements are required to be flowed to the lower tier suppliers

OR

- It means that the supplier needs to document how they are going to verify that the requirements are being met

- Control plan should address

- How requirements are flowed to lower tier suppliers

OR

- How the supplier will verify received product and repair / rework if necessary



Level Requirements: Documentation of Tin Use

- Levels 2B and 2C require maintenance of lists of applications and / or components with tin
 - 2B requires list of any part or application families with approvals and any specific cases that go beyond those families
 - 2C requires lists of every part AND every application the part is used in
- Control Plan should address:
 - How list maintained
 - Where list stored
 - How approvals will be obtained
- For Level 1 and 2A, the control plan should list any general rules about tin use
 - For example, if the company only buys tin parts that have been through the JEDEC / iNEMI test protocol successfully or only selects matte tin parts, that should be listed in this section



Level Requirements: Detection and Control of Pb-free Finishes

- Even with requirements for Pb in contracts and POs and even with CoC's showing Pb, there are frequent escapes of pure tin parts
- To prevent escapes, verification of materials is required for some levels
- Methods might include XRF, EDX, or other analysis techniques
- Level 2C requires sample monitoring (recommended for 2B)
 - Control Plan should explain sampling plan (size, frequency, etc.), state basic method for analysis, and reference method / process documents
- Level 3 requires Lot Monitoring
 - Control plan should state basic method for analysis and reference method / process documents
- If different processes are used for different types of materials (e.g. mechanical vs. hi-rel, DPA-ed vs. not DPA-ed) the control plan should explain these variations
- State whether exception to screening made for gold-colored finishes



Level Requirements: Risk Mitigation

- Levels 2B and 2C require use of at least 2 mitigation categories
- Types of mitigations
 - Design for Impact Reduction
 - Lower Risk Finish Selection
 - E.g., Matte tin over nickel
 - Other finishes with accompanying documentation as to why it reduces risk
 - Heat treatments (reflow, annealing, etc)
 - Tin Finish Replacement
 - Solder dip but not 100% replacement (i.e., parts get hand-dipped before installation)
 - Documentation of amount of tin finish covered by solder during installation
 - Conformal Coat
 - Finish coated AND other surface coated



Level Requirements: Risk Mitigation (cont)

- Control Plan should document:
 - Any standard mitigations that are always used
 - Order of preference for mitigation categories (if exists)
 - List of platings that are considered to be low risk (if applicable)
 - Type of conformal coating used
 - References to processes that institute design rules or implement techniques for mitigation
 - Process by which mitigations are checked to exist
 - Documentation and data retention process for specific mitigations for each tin application (if applicable)



Warning about Mitigations

- Almost all mitigations are known to have examples of whiskers
 - Lengths and densities of whiskers vary
 - Some mitigations are more effective than others
- More than two mitigations are always better
- For any mitigation selected, it is necessary to understand WHY the mitigator is adequate for the application
 - Don't assume that just saying "We have nickel underplate and conformal coat" is good enough for everything
 - You'll need to justify the appropriateness of the mitigation for your application in the analysis portion of the requirements



Level Requirements: Analysis and Test of Mitigation Effectiveness

- Three basic approaches to standardized risk assessment
 1. Assignment of "cognizant subject matter experts" or board to review, record rationale, and signoff each risk assessment.
 2. Establishment of a set of rules-based criteria that define conditions under which the risks are deemed to be acceptable.
 3. Development of an algorithm that encompasses risk factors of concern that can be used to define a metric of risk on a standard basis.
- Many companies use a combination of the three techniques
- Control Plan should document the assessment process
- Control plan or assessment process should document
 - Who makes the assessment decision
 - Rules or criteria for assessing whisker risk
 - Rules or criteria for assessing whisker impact
 - Test methods/field data evaluated and evaluation process
 - Algorithms or other quantitative assessment performed
 - Where detailed reports on specific parts and/or applications are maintained



Overview of Tin Whisker Control Plan

- Document what level you plan on achieving
- Document any exceptions / variations on the requirements
 - E.g., maybe you are going to follow Level 2C but you want a general exception for tin-silver finishes for use in high temp applications
- Document any activities to control and monitor Pb-free finish introduction
- Document mitigation strategies used
- Document test and analysis process
 - Reference company process if exists
 - Any rules for mitigation strategy effectiveness
 - Any rules for addressing whisker impact
- Document where detailed reports and approvals are maintained



Conclusions

- Compliance to GEIA-STD-0005-2 is flexible
- That flexibility means more information needs to be documented by the supplier
- The control plan should document the overall process, any standard rules, and information about how to find more detail
- Detailed processes should explain how mitigations applied and how analyses performed
- Detailed reports should show what mitigations are in place and why they are effective for a specific application or family