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Standard for Mitigating the Effects of Tin Whiskers in
Aerospace and High Performance Electronic Systems

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TechAmerica Standard

Standard for Mitigating the Effects of Tin Whiskers in Aerospace and High Performance Electronic Systems

GEIA-STD-0005-2 Revision A

May 2012



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**Standard for Mitigating the Effects of Tin Whiskers in Aerospace and
High Performance Electronic Systems**

GEIA-STD-0005-2

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Foreword

This Standard is intended for use by those procuring, designing, building or repairing electronic assemblies that could use items with Pb-free tin finishes to document processes they use to assure performance, reliability, airworthiness, safety, and certifiability of those assemblies. It provides a framework to communicate and agree on the processes to be used to control and mitigate the use of Pb-free tin finishes in these applications.

The Aerospace Industries Association (AIA), the Avionics Maintenance Conference (AMC), and TechAmerica, formerly Government Electronics and Information Technology Association (GEIA) formed a joint working group with the express purpose of generating a series of industry standards documents for the use and handling of Pb-free solder, piece parts, and boards in aerospace, defense, and high performance applications. This Standard was prepared by that group. It was balloted and approved by TechAmerica G-12 (Solid State Subcommittee) and TechAmerica Avionics Management Conference (AMC Subcommittee).

This Standard is intended to work in concert with GEIA-STD-0005-1, GEIA-HB-0005-1, and GEIA-HB-0005-2. This Standard may be referenced in proposals, requests for proposals, work statements, contracts, and other documents. It may be used as a stand-alone standard or as part of compliance with GEIA-STD-0005-1.

This Standard addresses the risk of tin whiskers forming on Pb-free tin finishes. However, the state of research into tin whisker risk still does not allow accurate quantitative estimates of the risk and reliability. It defines three baseline Control Levels that detail the amount of attention that should be paid to the risk of tin whiskers: no restrictions on Pb-free tin finish use, some restrictions on Pb-free tin finish use, and prohibition of Pb-free tin finish use.

There are six informative annexes in this Standard:

- Annex A provides guidance on selecting Control Levels and performing risk assessments.
- Annex B provides some background on various mitigation methods.
- Annex C provides guidelines for performing tin whisker inspections
- Annex D provides some additional guidance on tin whisker risk analyses
- Annex E provides information on whiskers growing from bulk solder and joints
- Annex F provides a bibliography

Introduction

Many constituent materials used in the production of electronic products have come under scrutiny. The European Union (EU) has enacted two directives; 2002/95/EC Restriction of Hazardous Substances (RoHS) and 2002/96/EC Waste Electrical and Electronic Equipment (WEEE) that restrict or eliminate the use of various substances in a variety of products produced after July 2006. One of the key materials restricted is lead (Pb), which is widely used in electronic solder and electronic piece part terminations, and printed wiring boards. While these regulations only directly affect products for sale in the EU, due to the reduced market share of the Aerospace, Defense, and High Performance Industry in electronics, many suppliers are changing their products because their primary market is world-wide consumer electronics. Additionally, several Asian countries and

U.S. states have enacted similar “green” laws. Many Asian electronics manufacturers have recently announced completely “green” product lines.

The restriction of Pb use has generated a transition by many piece part and board suppliers from tin-lead (Sn-Pb) finishes to pure tin or other Pb-free finishes. Lead-free tin finishes can be susceptible to the spontaneous growth of crystal structures known as “tin whiskers” which can cause electrical failures, ranging from parametric deviations to short circuits to catastrophic arcing events, and may interfere with sensitive optical surfaces or the movement of Micro-ElectroMechanical Systems (MEMS) structures. Though studied and reported for decades, the mechanism behind their growth is not well understood, and tin whiskers remain a potential reliability hazard. Furthermore, the growing number of piece parts with pure tin finishes means there are more opportunities for whiskers to grow and to produce failures.

The nature and meaning of ‘risk’ posed by tin whiskers may vary considerably across the range of users of this Standard. As in any assessment of risk, the probability of occurrence and failure and consequence of occurrence and failure must be considered in each application. Potential whisker failure modes for a particular hardware/system application must be carefully considered when making the choice/determination of which Control Level(s) to apply. For example, whisker-prone leaded parts on a circuit card used in a system that is under frequent/continual power may only incur parametric deviations or interrupts as individual whiskers grow and short to an adjacent lead. On the other hand, the same circuit card, employed in a missile subject to years of dormant storage, could grow many long whiskers into potentially catastrophic shorting conditions but the shorts will not occur until the missile is launched toward its target and results in mission failure. For the purposes of this Standard, risk refers to the chance and consequence of a failure due to a whisker, not just the chance of the presence of a whisker.

1 Scope

This Standard establishes processes for documenting the mitigating steps taken to reduce the harmful effects of Pb-free tin finishes in electronic systems.

This Standard is applicable to Aerospace, Defense, and High Performance (ADHP) electronic applications which procure equipment that may contain Pb-free tin finishes.

2 Terms and Definitions

For purposes of this Standard, the following terms and definitions apply.

Assemblies are electronic items that require electrical attachments, including soldering of wires or component terminations; examples include circuit cards and wire harnesses. This may include soldered assemblies.

Critical item or function, if defective, will result in the system's inability to retain operational capability, meet primary objective, or affect safety.

Control Level details the amount of attention that should be paid to the risk of tin whiskers: no restrictions on Pb-free tin finish use, some restrictions on Pb-free tin finish use, and prohibition of Pb-free tin finish use.

Conformal coat is an insulating protective covering that conforms to the configuration of the objects coated (e.g., Printed Boards, Printed Board Assembly) providing a protective barrier against deleterious effects from environmental conditions

COTS (commercial off-the-shelf products) are one or more pieces, mechanical or electrical, developed for multiple commercial consumers, whose design and/or configuration is controlled by the supplier's specification or an industry standard. They can include piece parts, subassemblies, or top level assemblies.

COTS Assemblies are assemblies developed by a supplier for multiple customers, whose design and configuration is managed by the supplier's or an industry specification.

Customer refers to an entity or organization that (a) integrates a piece part, soldered assembly, unit, or system into a higher level system, (b) operates the higher level system, or (c) certifies the system for use. For example, this may include end item users, integrators, regulatory agencies, operators, original equipment manufacturers (OEMs), and subcontractors.

EDS is Energy Dispersive (X-ray) Spectroscopy, a method for material composition analysis.

Encapsulation is process which involves the surrounding of a component(s) or an assembly with a liquid resin.

FOD is Foreign Object Debris. FOD is a potential source of damage either by landing in places that allow for short circuits to occur or by causing mechanical interference with mechanisms.

Gap is minimum line of sight distance between Pb-free tin finished surface and the nearest adjacent conductor at a different electrical potential. It refers to any conductors (leads, pads, connectors, contacts, or others).

High performance System or Product requires continued high performance or performance on-demand, or equipment downtime cannot be tolerated, or end-use environment may be uncommonly harsh and the equipment must function when required, such as life support or other critical systems.

Mitigation is defined as a method to reduce the risk or consequence of a whisker failure. It does not mean that the risk is driven to zero, simply that the risk or consequence is reduced in some significant way nor does it mean that the mitigation is effective permanently.

Pb-free Tin is defined to be pure tin or any tin alloy with <3% lead (Pb) content by weight. This means that some Pb-free finishes other than pure tin, such as tin-bismuth and tin-copper, are considered to be “Pb-free tin” for the purposes of this Standard. Many of these alloys have not been assessed for whiskering behavior. Note that this definition is different than the typical electronic industry definition of Pb-free, based on RoHS. In those cases, the Pb-content is much lower. For the purposes of this document the higher Pb-content is required to reduce the tin whisker risk.

Finish is defined to be final finishes or underplates either external or internal to a device, board or other hardware. This includes all leads and surfaces, even those coated, encapsulated, or otherwise not exposed. It may include finishes on electrical piece parts, mechanical piece parts, and boards. It does not include bulk solders, assembly materials, solder balls, or those devices where the Pb-free tin finish has been completely replaced (consistent with GEIA-STD-0006).

Metal Vapor Arc is the electrical breakdown of metal vapor that produces a conductive plasma. Generally this refers to a sustained event. In circuits with less voltage, there can be non-sustaining sparking events, when a whisker (or other debris) vaporizes with a flash, but does not create a conductive, sustained plasma.

Piece part is defined as an electronic component that is not normally disassembled without destruction and is normally attached to a printed wiring board to perform an electrical function.

Plasma is a state of matter comprising of ionized gas.

Potting is an encapsulation process which involves the surrounding of a component(s) or an assembly in a container with a liquid resin which is then cured in place. The container usually becomes an integral part of the system such that the critical property that needs to be maintained is the interfacial adhesion between the cured resin system and the container substrate and critical components for an optimum long-lasting reliable package.

Rework is the act of reprocessing non-complying articles, through the use of original or equivalent processing in a manner that assures full compliance of the article with applicable drawings or specifications.

Repair is the act of restoring the functional capability of a defective article in a manner that precludes compliance of the article with applicable drawings or specifications.

Risk is used with regards to the probability of a failure due to a tin whisker. It is not used with regards to the risk of the presence of a whisker or nodule.

Shall indicates a mandatory requirement to be followed in order to conform to this standard.

Should indicates that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain course of action is discouraged but not prohibited.

Sub-contractor refers to an organization, within the given high-reliability industry, that supplies, maintains, repairs, or supports electronic systems, and is not the direct supplier to the customer or user of those systems.

Supplier refers to an entity or organization that designs, manufactures, repairs, or maintains a piece part, unit, or system. For example, this includes original equipment manufacturers (OEMs), repair facilities, subcontractors, and piece part manufacturers. In some cases, a single organization may be both a customer and a supplier. They should follow the requirements for suppliers when addressing their customer's contracts and should follow the requirements for customers when flowing down requirements to their lower tier suppliers.

System is defined as one or more units that perform electrical function(s).

Tin Whisker is a spontaneous crystal growth that emanates from a tin rich finishes. They may be cylindrical, kinked, or twisted. Typically they have an aspect ratio (length/width) greater than two, with shorter growths referred to as nodules or odd-shaped eruptions (OSEs).

Unit is defined as one or more assemblies within a chassis to perform electrical function(s).

XRF is X-ray Fluorescence, a method for material composition analysis.

3 Requirements

3.1 Control Level Selection

The supplier **shall** clearly state the Control Levels and **shall** document agreement by the customer in appropriate requirement or Lead-free Control Plan documents. The customer is responsible for determining the Control Level they are seeking and identify it in their request for proposal and contract when this Standard is imposed.

Higher control levels impose tighter controls and thereby reduce exposure to tin whisker risk. However, tin whisker risks are just one of many types of risks associated with component selection and assembly design. Controls imposed on tin whiskers should be commensurate with controls imposed to manage these other risks. Each program or system has the responsibility of determining the appropriate Control Level for their product. This document is not intended to imply that any category of ADHP application is more or less reliable or critical than any other category; nor is it intended to imply that any ADHP system will be more or less reliable, depending on the Control Level that is selected. Reliability is assured by a wide range of design, production, use, and support decisions and activities, of which tin whisker mitigation is only one. It is expected that, whatever Control Level is used, the system reliability will be assured by the totality of all the methods available to the producer and user of the system.

It is recommended that selection of Control Level involve consideration of the following questions:

- What are the consequences of performance anomalies in your system?
- Is it anticipated that the tin whiskers will produce a plasma event?
- Do local anomalies affect top-level system performance?
- Could a failure cause a critical failure or defeat redundancy?
- Are anomalies detectable and repairable?

More information on how these questions can be used to select an appropriate Control Level is provided in [Annex A](#).

Overall, there are three approaches to tin whisker control:

- Whisker Risk Acceptance
- Whisker Risk Mitigation
- Pb-free Tin Part Avoidance and Prohibition

Different Control Levels represent different emphasis on each of these approaches.

- Control Level 1: Under Level 1 tin whisker risks are accepted. It is expected that this Control Level will primarily apply to developmental models, test equipment, and other units that will not be used in the field.
- Control Level 2: Under Control Level 2, Pb-free tin finishes are sometimes acceptable. Tin whisker risk is managed primarily by a combination of avoidance and mitigations, including design rules. The sublevel under Control Level 2 determines the emphasis given to each of these strategies. If only Control Level 2, with no sub-level, is identified in a control document, the default Control Level **shall** be assumed to be Level 2A.

- Control Level 2A: Under Control Level 2A, tin whisker risks are managed primarily through the acceptance of tin whisker risk, and to a lesser extent upon the use of mitigations. It is intended primarily for low criticality and non-fielded applications. Pb-free tin finishes are permitted for use in all applications except where specially restricted.
- Control Level 2B: Under Control Level 2B, tin whisker risks are managed primarily through the use of mitigations, including design rules, and to a lesser extent upon Pb-free tin finish avoidance. It is primarily intended for non-critical boards or units or boards and units with good redundancy used in systems with moderate to high failure consequences.
- Control Level 2C: Under Control Level 2C, tin whisker risks are managed primarily by prohibiting Pb-free tin finishes, to a lesser extent through specific application of mitigations, and in exceptional cases, by design rules. It is primarily intended for critical boards with limited redundancy used in systems with moderate to high failure consequences.
- Control Level 3: Tin whisker risks are managed strictly by prohibiting Pb-free tin finishes. This Control Level is intended for units and boards where failures cannot be tolerated.

For units or boards that apply a mix of design rules and individual Pb-free tin finish evaluations, the unit or board **shall** be defined by the lowest Control Level applicable, with the rules defining the circumstances requiring higher Control Levels clearly called out.

Control Levels are expected to be applied at the unit or board level, consistent with the overall risk strategy for that unit or board. However, an overall strategy for higher levels of integration may be appropriate and is discussed in Section 3.1.1, below.

[Annex A](#) provides additional guidance on Control Level selection.

3.1.1 Control Levels and Levels of Integration

Control Levels were designed to be applied at the unit or board level, but customers may want to have an approach to Control Levels and Control Level selection at the subsystem, product, or system level. Some approaches at higher levels of integration and in system Lead-Free Control Plans:

- Define the criteria that are to be used to evaluate unit Control Levels, preferably with some general statements about what control levels are expected on most units and boards.
- Define Control Levels based on unit criticality, function, or some other design rule.
- Define the system level Control Level based on the expected control level of most units and define when the program will require higher control levels. A discussion of this process for requiring higher or allowing lower control levels should be included.

3.1.2 COTS and Control Level Selection

The imposition of Control Levels 2C or 3 will generally preclude the use of COTS assemblies. This is due to the difficulties in assuring that COTS assemblies will meet the rigorous requirements of Control Levels 2C and 3. It needs to be recognized that:

- COTS assemblies do not allow the same visibility into the parts selection process nor manufacturing process as non-COTS assemblies.
- COTS assembly manufacturers may make changes in their components, finishes, solders, and other manufacturing processes without notification to their customers.

If COTS assemblies are used in a program or system that is defined as Control Level 2C or 3 then at least one of the following **shall** be implemented:

- COTS assemblies be identified as exceptions to the Control Level
- Execution of a comprehensive material control and analysis plan consistent with the Control Level of the program
- Flowing down to an agreement of the material and mitigations requirements of this standard by the COTS supplier.

In a Control Level 2B application, the treatment of COTS **shall** be addressed in the list of families where Pb-free tin alloys will be used or the materials and mitigations requirements will be flowed down to and accepted by the COTS supplier.

COTS parts, as opposed to COTS assemblies, may be used under any control level but need to be evaluated as any part or finish and meet the requirements of the Control Level. COTS parts may lack finish uniformity requirements, and thus may require higher sample sizes during material identification testing.

3.2 Requirements for Control Levels

3.2.1 Control Level 1 Requirements

3.2.1.1 Control Level 1 Requirements for Documentation of Uses of Pb-free Tin Finishes

There are no requirements. The supplier should provide general information regarding types of platings, finishes, and solder used and plans for process controls on those processes.

3.2.1.2 Control Level 1 Requirements for Detecting and Controlling Pb-free Tin Finish Introduction

No requirements.

3.2.1.3 Control Level 1 Requirements for Tin Whisker Risk Mitigation

No requirements.

3.2.1.4 Control Level 1 Requirements for Parts Selection

No requirements.

3.2.1.5 Control Level 1 Requirements for Analysis and Documentation of Risk and Mitigation Effectiveness

No requirements.

3.2.2 Control Level 2A Requirements

3.2.2.1 Control Level 2A Requirements for Documentation of Uses of Pb-free Tin Finishes

The supplier **shall** document the design rules that are in place for determining when Pb-free tin finishes are not acceptable or when mitigations are required.

The customer is responsible for listing any applications where Pb-free tin finishes are not allowed.

3.2.2.2 Control Level 2A Requirements for Detecting and Controlling Pb-free Tin Finish Introduction

No requirements.

3.2.2.3 Control Level 2A Requirements for Tin Whisker Risk Mitigation

The plan should indicate any mitigations that are applied as part of the general process at the supplier.

The customer is responsible for defining any mitigation measures that are required.

3.2.2.4 Control Level 2A Requirements for Parts Selection

No requirements.

Unless the parts list or vendor list is provided by the customer, the supplier **should** have a part selection process that encourages the use of parts that have lower tin whisker risk, consistent with the requirements presented in Section [4.5](#)

3.2.2.5 Control Level 2A Requirements for Analysis and Documentation of Risk and Mitigation Effectiveness

This analysis is expected regardless of whether mitigations are applied.

For Control Level 2A, these analyses may be performed at the process level. For example, the analysis might address all devices with a particular mitigation technique employed.

3.2.2.6 Control Level 2A Exceptions

Specific piece parts, soldered assemblies, units, or applications may be required to meet a higher Control Level. These requirements **shall** be specified in contractual documents.

3.2.3 Control Level 2B Requirements

3.2.3.1 Control Level 2B Requirements for Documentation of Uses of Pb-free Tin Finishes

For Control Level 2B hardware, the control plans may cover families of piece part types, families of applications and assemblies, or individual piece part and assembly uses. Separate assessments and control plans for each individual item are NOT required for items within these classes. For example, one assessment might allow use of Pb-free tin-plated capacitors in a variety of applications. For Pb-free tin finished items not within the classes, specific plans and assessment are required.

The supplier **shall** provide lists of families of applications, assemblies, or piece parts classes where they would like to use Pb-free tin finish in accordance with Section 0. If there are other individual uses of Pb-free tin finishes, the supplier **shall** provide a list of additional specific applications of Pb-free tin finishes that fall outside these families. If the supplier is unable to determine some materials, this shall be stated.

The customer is responsible for listing any applications where Pb-free tin finishes are not allowed.

The definition of high voltage applications **shall** be documented. Pb-free tin finish usage in high voltage applications and their mitigations **shall** be documented separately and identified as high voltage.

3.2.3.2 Control Level 2B Requirements for Detecting and Controlling Pb-free tin Finish Introduction

The supplier should provide a plan for monitoring materials on a sample basis, including method of test and sampling scheme, in their product in accordance with Section [4.3.1](#).

3.2.3.3 Control Level 2B Requirements for Tin Whisker Risk Mitigation

Uses of Pb-free tin finishes require mitigation. For non-high voltage applications, mitigation requirements **shall** be fulfilled by **any one** of the following:

- Hard potting or encapsulation
- Physical barriers
- Circuit design and analysis showing low impact of tin whisker short or FOD
- Circuit design and analysis showing that areas sensitive to tin whisker shorts or FOD have at least a 1 cm gap
- Parylene conformal coating with validated coverage and gap size, prior to coating, greater than or equal to 150 microns (5.9 mils)
- Other, non-parylene, conformal coating with validated coverage and gap size, prior to coating, greater than or equal to 250 microns (9.8 mils)
- Pb-free tin electronic components with gaps greater than 2000 microns (78.7 mils) that have been installed with SnPb and are physically isolated from any Pb-free tin mechanical piece parts
- SnPb soldering process with validated complete coverage
- Mitigation or combination of mitigations approved by the customer

Specific requirements for each mitigation listed above are presented in Section [4.4](#).

High voltage applications **shall** have a mitigation or a combination of mitigations approved by the customer or customer representative.

3.2.3.4 Control Level 2B Requirements for Parts Selection

Unless the parts list or vendor list is provided by the customer, the supplier **shall** have a part selection process that encourages the use of parts that have lower tin whisker risk. The parts selection process **shall** document what specific part level characteristics are considered to be preferred. The process should describe how risks are evaluated when deciding if part level mitigations are applied or not. The documentation of the process **shall** be made available to customer upon request.

Recommendations about characteristics of lower risk Pb-free tin finished parts are presented in Section [4.5](#).

3.2.3.5 Control Level 2B Requirements for Assessment and Documentation of Risk and Mitigation Effectiveness

The supplier **shall** provide an analysis addressing the risk of tin whiskers in accordance with Section [4.6](#), including rationale for the selection of Control Level 2B, unless the control level selection was dictated by the customer.

The supplier **shall** have documentation covering the following elements:

- Methods of controlling vendor use and introduction of Pb-free Tin Finishes
- The mitigation measure(s) taken for each family of piece parts or applications of Pb-free tin finish in the product.
- The tests or analyses performed for each family of piece parts or applications using Pb-free tin finishes, to determine risk of whisker growth in accordance with Section [4.6](#).
- If there are other uses of Pb-free tin finishes outside the families, the mitigation measures taken for each piece part or application of Pb-free tin finish in the product outside the families.
- If there are other uses of Pb-free tin finishes outside the families, the tests and analyses performed for each of these piece parts or applications to determine risk of whisker growth in accordance with Section [4.6](#).
- Verification methods, including inspections and tests, that show their processes are under control.
- Provide the risk assessment and mitigation measures to the customer for their review, as requested or required by customer.

This documentation **shall** be made available for review, as requested or required by the customer.

3.2.4 Control Level 2C Requirements

Applications of Pb-free tin finishes must be reviewed and approved individually by an authorized customer representative in accordance with established design rules. Approval of exceptional cases can occur within the requirements of the plan. For example, instead of one assessment and mitigation plan covering all Pb-free tin-plated capacitors, each capacitor type and application must be reviewed and approved, even if the same strategy is applied to each situation.

3.2.4.1 Control Level 2C Requirements for Documentation of Uses of Pb-free Tin Finishes

The supplier **shall** avoid use of Pb-free tin finishes whenever possible. Individual uses of Pb-free tin finishes **shall** be documented and mitigated and require approval by the customer or customer designee.

The definition of high voltage applications **shall** be documented.

The supplier **shall** provide a plan for passing the requirement to lower level suppliers in accordance with Section [4.1](#).

3.2.4.2 Control Level 2C Requirements for Detecting and Controlling Pb-free Tin Finish Introduction

The supplier **shall** provide a plan for monitoring materials in their product in accordance with Section [4.3.1](#). The supplier and customer **shall** reach an agreement regarding this plan.

For critical piece parts, assemblies or systems, the plan should include sampling at least one part per lot unless the applications have been approved to allow Pb-free finishes.

3.2.4.3 Control Level 2C Requirements for Tin Whisker Risk Mitigation

For non-high voltage applications, mitigation requirements **shall** be fulfilled by at least one of the following:

- Hard potting or encapsulation
- Physical barriers
- Circuit design and analysis showing low impact of tin whisker short or FOD
- SnPb soldering process with validated complete coverage
- Parylene conformal coat with validated coverage and gap, prior to coating, greater than or equal to 250 microns (9.8 mils)
- Other, non-parylene, conformal coat with validated coverage and gap, prior to coating, greater than or equal to 500 microns (19.7 mils)
- A combination of mitigations approved by the customer

Specific requirements for each mitigation listed above are presented in Section [4.4](#).

High voltage applications **shall** have a mitigation or a combination of mitigations approved by the customer or customer representative.

3.2.4.4 Control Level 2C Requirements for Parts Selection

Unless the parts list or vendor list is provided by the customer, the supplier **shall** have a part selection process that encourages the use of parts that have lower tin whisker risk. The parts selection process **shall** document what specific part level characteristics are considered to be preferred. The process should describe how risks are weighed when deciding if part level mitigations are applied or not. The documentation of the process **shall** be made available to customer upon request.

Recommendations about characteristics of lower risk Pb-free tin finished parts are presented in Section [4.5](#).

3.2.4.5 Control Level 2C Requirements for Assessment and Documentation of Risk and Mitigation Effectiveness

The customer is responsible for describing the risk algorithm or other methods for evaluating mitigation measures in the request for proposal, if applicable. The customer is also responsible for communicating any documentation review or oversight requirements to the supplier.

The supplier **shall** have documentation covering the following elements:

- The mitigation measures taken for each piece part or application of Pb-free tin finish in the product.

- The tests and analyses performed for each piece part or application using Pb-free tin finishes, to determine risk of whisker growth in accordance with Section [4.6](#).
- Provide the risk assessment and mitigation measures to the customer for their review, as requested or required by customer.

3.2.5 Control Level 3 Requirements

The supplier **shall** not allow use of Pb-free tin finish.

No Pb-free tin finishes may be designed into the product or knowingly purchased without a plan to replace the finish. There will be cases where errors will be made in the finish determination or in the application of mitigation methods. Customers and suppliers should have processes in place to document and assess the impact of these errors.

Already existing deviation or waiver processes may be acceptable if technical experts on tin whiskers are consulted.

3.2.5.1 Control Level 3 Requirements for Documentation of Uses of Pb-free Tin Finishes

The supplier shall provide a plan for passing the requirement to lower level suppliers per Section [4.1](#).

Any use of Pb-free tin finish would represent a violation of requirements, which would require a waiver process based on program requirements, including risk management requirements.

3.2.5.2 Control Level 3 Requirements for Detecting and Controlling Pb-free tin Finish Introduction

The supplier shall monitor the material in their product per Section [4.3.2](#).

3.2.5.3 Control Level 3 Requirements for Mitigation of Tin Whisker Risk and Mitigation Effectiveness

Not applicable, as Pb-free tin finish is not allowed.

3.2.5.4 Control Level 3 Requirements for Parts Selection

Not applicable, as Pb-free tin finish is not allowed.

3.2.5.5 Control Level 3 Requirements for Assessment and Documentation of Risk and Mitigation Effectiveness

No requirements, as Pb-free tin finish is not allowed.

If Pb-free tin finish is to be completely replaced through solder dipping or some other method, the process for qualifying and evaluating the replacement process and any secondary risks should be documented.

3.2.6 Requirements for Mitigating Tin Whisker Risk for Solder Joints

The majority of requirements in this standard apply to Pb-free tin finishes, not Pb-free solders. This is because the level of understanding for tin whiskers growing from finishes is much higher than from solders. However, the data on the dangers of tin whiskers growing from Pb-free *and* SnPb solders when there are rare earth elements (REE) present is sufficient to consider these solders a risk.

For Control Level 2, use of Pb-free or SnPb solder with intentionally alloyed REE **shall** be disclosed to the customer and a risk assessment performed with regards to tin whiskers.

For Control Level 3, the use of Pb-free or SnPb solder with intentionally alloyed REE **shall** be prohibited.

It is expected that cleanliness is a major factor in whiskers growing from Pb-free solders. However, the data on this factor is not adequate to standardize practices or mitigations. Since all Pb-free solders may have some risk of whiskers growing related to cleanliness, the disclosures of use of Pb-free solders with regards to this risk are managed by the Pb-free control plans generated to comply with GEIA-STD-0005-1. Additional information and recommendations for preventing tin whiskers growing from Pb-free solder joints are presented in [Annex E](#).

4 Implementation Methods

4.1 Flowing Requirements to Lower Level Suppliers (applies to Control Level 2B, Control Level 2C, and Control Level 3)

Requirements for tin whisker control, analysis, and mitigation are applicable to all purchased and subcontracted elements and materials for the program. This may require flowing down these requirements to lower level supplier or performing extensive analysis of purchased material. The supplier should be prepared to document how they addressed the risk from purchased equipment if requested or required by the customer.

4.2 High Voltage Applications

High voltage applications are required to be treated separately because of the introduction of additional failure modes. Additional mitigations may be needed beyond the requirements for typical applications in this standard. Unfortunately, there is not a standardized definition of what constitutes a high voltage application. For this reason, this standard requires the supplier's definition to be reported.

Susceptibility of a system to non-contact high-voltage failure modes is a complex phenomenon that depends upon many variables. The electric field strength is an important risk factor. The field strength is a function of the magnitude of the electric potential and the conductor geometries including micro-asperities. For most typical applications, these modes will not become a serious concern until the applied voltages are in the kilovolt range. The formation of tin whiskers directly affects the geometry of the conductors and the effective surface finish in ways that can significantly reduce the resistance of a high-voltage system to failure. Therefore, for any system where an analysis has been performed or standard design rules have been followed to ensure resistance to high voltage failure modes, these analyses will need to be revisited if any of the critical components utilize a Pb-free tin finish.

4.3 Detecting and Controlling Pb-free Tin Finish Introduction

The use of screens to monitor Pb-free tin finish depends in part on the lot uniformity requirements. Many standard lot definitions do not address finishes, only internal features. The sampling or lot monitoring plan should take the finish uniformity requirements into consideration.

4.3.1 Sample Monitoring Plans (applies to Control Level 2B and Control Level 2C)

A monitoring plan, including method of inspection, test and sampling scheme, **should** be documented for Control Level 2B and **shall** be documented for Control Level 2C.

For Control Level 2B, the monitoring plan and sampling scheme should focus on critical hardware where Pb-free tin finish is not allowed.

For Control Level 2C critical hardware where approvals for use of Pb-free tin finish have not been obtained, the monitoring plan described in Section [4.3.2](#) **should** be used.

COTS parts may lack finish uniformity requirements, and thus may require higher sample sizes during material identification testing.