TECHNICAL REPORT

GEIA-STD-0005-1	REV. A
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Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-free Solder

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TechAmerica Standard

Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-free Solder

GEIA-STD-0005-1-REV A

March 2012

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(Formulated under the cognizance of the TechAmerica (APMC) Avionics Process Management Committee and the (G-12) Solid State Devices Committee. This is a joint activity of the Aerospace Industries Association (AIA), Avionics Maintenance Conference (AMC), and TechAmerica, to address aerospace issues related to the global elimination of lead from electrical and electronic equipment put on the market after July 1, 2006. Formed in 2004, this coalition includes all stakeholders (market segments, supply chain, geographic regions.))

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TechAmerica

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GEIA-STD-0005-1-REV A

Revision	Description of change	Date
-	Initial Release	Jun 2006
A	Rewrite	Mar 2012

Contents

Forward

This standard is intended for use by Aerospace, Defense and High Performance (ADHP) electronics system customers,- [i.e., aerospace and defense integrators, operators, and regulatory organizations],- and their suppliers,- [i.e., system original equipment manufacturers (OEMs) and system maintenance facilities] as they incorporate lead (Pb)-free solder, piece part and printed wiring board (PB) finishes. This standard was developed primarily for aerospace products; however, it also may be applicable, at the discretion of the user, to other products with similar characteristics. These characteristics include low-volume, use in rugged environments, and requirements for high reliability, long lifetime, and reparability. An example would be ground-based, mission-critical military electronics. Other industries may use this standard by substituting the name of their industry for the word “aerospace” in this standard.

The Aerospace Industries Association (AIA), the Avionics Maintenance Conference (AMC), and Government Electronics and Information Technology Association (GEIA) formed the Pb-free Electronics in Aerospace Project Working Group (LEAP WG) to generate a series of industry standards and handbooks for the use and handling of Pb-free solder, piece parts and PBs in ADHP systems. This standard was prepared by the LEAP WG; and was balloted and approved by GEIA G-12 (Solid State Subcommittee) and the GEIA Avionics Process Management Committee.

This standard is intended to work in concert with GEIA-HB-0005-1, GEIA-HB-0005-2, GEIA-HB-0005-3, GEIA-STD-0005-2, and GEIA-STD-0005-3.

This standard may be referenced in proposals, requests for proposals, work statements, contracts, and other ADHP industry documents.

Acknowledgments

This document was revised by a team of subject matter experts (SMEs) from industry and the DoD. The core working group team members are:

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Introduction

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 that are put on the market after July 2006. These were later updated by directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast). One of the key materials restricted is lead (Pb), which is widely used in electronic solder and electronic piece part terminations. These regulations may appear to affect only products for sale in the EU. However, due to the reduced market share of the ADHP industries, many of the lower tier suppliers to those industries will change their products to serve their primary, non-ADHP markets. Additionally, several U.S. states have enacted similar "green" laws and many Asian electronics manufacturers have recently announced completely green product lines. Since ADHP is one of the few major industrial sectors that still repair Circuit Card Assemblies (CCAs) and the Pb-free materials and processes are relatively immature and not fully understood, an aerospace-wide approach to their application is desired.

ADHP companies may be developing and/or managing Pb-free electronics and whose products fall into one of the five categories below:

1. Products that have been designed and qualified with traditional tin-lead (SnPb) electronic piece parts, materials, and assembly processes, and that will need to be maintained in the SnPb configuration.
2. Products that have been designed and qualified with traditional SnPb electronic piece parts, materials and assembly processes, and have incorporated Pb-free electronic piece parts;
3. Products that have been designed and qualified with SnPb materials, and are re-designed and re-qualified with Pb-free materials;
4. Products that have been designed and qualified with Pb-free electronic piece parts, materials, and assembly processes, and that will need to be maintained in the Pb-free configuration.
5. Commercial-Off-The-Shelf (COTS) assemblies built with Pb-free materials.

The risks with Pb-free technology include:

1. For some service conditions, use of Pb-free solder may compromise electronic interconnection performance and, due to differences in fatigue characteristics under thermal cycling and vibration relative to traditional solders.
2. Use of Pb-free surface finishes such as pure tin can lead to the formation of tin whiskers which in turn can result in various levels of product and system failure.

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1 Scope

This standard defines the objectives of, and requirements for, documenting processes that assure customers and regulatory agencies that ADHP electronic systems containing Pb-free solder, piece parts, and PBs will satisfy the applicable requirements for performance, reliability, airworthiness, safety, and certifiability throughout the specified life of performance.

It is intended to communicate requirements for a Pb-free Control Plan (LFCP), hereinafter referred to as the Plan, and to assist the Plan Owners in the development of their own Plans. The Plan documents the Plan Owner's processes that assure their customers, and all other stakeholders that the Plan Owner's products will continue to meet their requirements**,** given the risks stated in the Introduction.

This standard does not contain detailed descriptions of the processes to be documented but lists high-level requirements for such processes, and areas of concern to the ADHP industries that must be addressed by the processes.

Pb-free risk management should be accomplished through specific requirements added to the Plan Owner's existing infrastructure of product management and control.

This standard applies to the ADHP electronics system supply chain.

The control of the Pb-free activities ***shall*** be accomplished by the Plan Owner addressing the requirements of their Customer. These activities include, but are not limited to, those performed by the System Integrator, the OEM, and their respective supply chains, to the lowest level possible. This must be done with the knowledge that, at the component level, the aerospace industry may not have a great influence over those suppliers. In such cases, the Plan Owner assumes responsibility.

Some applications may have unique requirements that exceed the scope of this standard. The extended scope should be covered separately.

The requirements of this standard may be tailored to address unique/specific program needs. If tailoring is performed, the user ***shall*** obtain documented customer concurrence. Annex A provides a tailoring template that may be used.

2 References

2.1 Normative

ANSI/GEIA-649-*A, National Consensus Standard for Configuration Management*

ASME Y14.100, *Engineering Drawing Practices*

GEIA-HB-649, *Implementation Guide for Configuration Management*

GEIA-HB-0005-1, *Program Manager's Handbook for Managing the Transition to Lead-free Electronics, June 2006*.

GEIA-HB-0005-2, *Technical Guidelines for Using Lead-free Solder in Aerospace, and High Performance Applications, November 2007*.

GEIA-STD-0005-2, *Standard for Mitigating the Effects of Tin Whiskers in Aerospace and High Performance Electronic Systems, June 2006*.

GEIA-STD-0005-3, Performance Testing for Aerospace and High Performance Electronic Interconnects Containing Pb-free Solder and Finishes, June 2008

GEIA-HB-0005-3, Rework/Repair Handbook to Address the Implications of Lead-Free Electronics and Mixed Assemblies in Aerospace and High Performance Electronic Systems, September 2008.

IPC/JEDEC J-STD-609, *Marking and Labeling of Components, PB's and PB Assemblies to Identify Lead (Pb), Pb-Free and other Attributes.*

2.2 Informative

IPC J-STD-001, *Requirements for Soldered Electrical and Electronic Assemblies.*

IPC/EIA J-STD-002, *Solderability Tests for Component Leads, Terminations, Lugs, Terminals, and Wires.*

IPC/EIA J-STD-0003, *Solderability Tests for Printed Boards.*

IPC/EIA J-STD-005, *Requirements for Soldering Pastes.*

IPC/EIA J-STD-006, *Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications.*

IPC/JEDEC J-STD-020, *Moisture/Reflow Sensitivity Classification for Non-Hermetic Solid State Surface Mount Devices.*

IPC/EIA J-STD-028, *Performance Standard for FlipChip/Chip Scale Bumps.*

IPC/JEDEC J-STD-033, *Standard for Handling, Packing, and Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices.*

ARINC Project Paper 671: *Guidelines for Lead-free Soldering, Repair, and Rework*, draft 1, 31 March 2005.

IEC 60068-2, *Environmental Testing.*

IEC 61188-5, *Design Guide for Printed Boards and Board Assemblies.*

IEC 61190-1, *Attachment Materials for Electronic Assemblies.*

IEC 61191-1, *Printed Circuit Board Assemblies.*

IEC 61192, *Assembly Product Performance Requirements.*

IPC-SPV-WP-006, *Round Robin Testing and Analysis – Lead-free Alloys – Tin, Silver and Copper.*

IPC-9701, *Performance Test Methods an Qualification Requirements for Surface Mount Solder*

Attachments.

IPC –A-610, *Acceptability of Electronic Assemblies.*

IPC-6012, *Qualification and Performance Specifications for Rigid Printed Boards.*

IPC-6013, *Qualification and Performance Specifications for Flexible Printed Boards.*

IPC-6015, *Qualification and Performance Specifications for Organic Multichip Modules Mounting and Interconnecting Structures.*

IPC-2221, *Generic Standard on Printed Board Design.*

IPC-2222, *Sectional Standard on Rigid Organic Printed Boards.*

IPC-2223, *Sectional Design Standard for Flexible Printed Boards.*

IPC-2225, *Sectional Design Standard for Organic Multichip Modules (MCM-L) and MCM-L Assemblies.*

JESD-97, *Marking, Symbols, Labels for Identification of Lead (Pb) Free Assemblies, Components, and Devices.*

3 Terms and Definitions

For purposes of this standard, the following terms and definitions apply

ANSI **-** American National Standards Institute

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

BGA – Ball Grid Array

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

COTS (Commercial-Off-The-Shelf) - 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 – An assembly 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.

Demonstrate – Demonstrate indicates a requirement that shall be considered and it must be verifiable in documentation (i.e. test reports, standards, practices, processes, procedures, or etc.) that the objective is met.

GEIA – Government Electronic Industry Association

High Performance System or Product – requires continued performance or performance on demand, or equipment down-time 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.

IEC – International Electrotechnical Commission

Modified/Custom COTS – Commercial-Off-The-Shelf Assemblies or Subassemblies that are customized or modified after purchase.

Pb-free – is defined as less than 0.1% by weight of Pb in accordance with Waste Electrical and Electronic Equipment (WEEE) guidelines.

Pb-free control plan (LFCP) – refers to an aerospace or military system supplier's document that defines the processes that assure the Plan Owners, their customers, and all other stakeholders that aerospace, defense and high performance high-reliability electronics systems containing Pb-free solder and Pb-free piece part and PB finishes will continue to be reliable, safe, producible, affordable, and supportable.

May – indicates a course of action that is permissible within the limits of this standard, but not required.

Printed Board (PB) – The general term for completely processed printed circuit and printed wiring configurations (This includes single-sided, double-sided and multilayer boards with rigid, flexible and rigid-flex base materials).

Printed Circuit Board (PCB) – A Printed Board (PB) that provides both point-to-point connections and printed components in a predetermined arrangement on a common base. (Also see "Printed Wiring Board").

Printed Circuit Board Assembly – An assembly that uses a printed circuit board for component mounting and interconnecting purposes.

Printed Wiring Board (PWB) – A Printed Board (PB) that provides point-to-point connections but not printed components in a predetermined arrangement on a common base. (Also see "Printed Circuit Board").

Printed Wiring Board Assembly – An assembly that uses a printed wiring board for component mounting and interconnecting purposes.

Pb-free tin finish – is defined to be Pb-free tin final finishes or under-plates either external or internal to a device, PB 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 PBs. It does not include Pb-free bulk solders, assembly materials, solder balls, or those devices where the Pb-free tin finish has been completely replaced.

Piece part – is defined as an electronic piece part that is not normally disassembled without destruction and is normally attached to a PB to perform an electrical function.

Rework – is an action taken to return a unit (SRU/LRU/system) to a state meeting all requirements of the engineering drawing, including both functionality and physical configuration. Or is the act of reprocessing non-complying articles, through the use of original or equivalent processing in a manner that ensures 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.

Shall – indicates a mandatory requirement to be followed in order to comply with 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.

Solder ball technology – identifies a family of components that employ solder balls or bumps to make mechanical and electrical connections between components and PBs. Examples are ball grid arrays (BGAs), flip chips, and chip scale interconnections.

Soldered Assembly – is an assembly of two or more basic parts interconnected by a solder alloy. A (Pb)-based soldered assembly is one in which the solder alloys are solely (Pb)-based. A (Pb)-free soldered assembly is one in which the solder alloys are solely (Pb)-free.

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, reworks, or maintains a piece part, unit, or system. For example, this includes original equipment manufacturers (OEMs), repair and rework facilities, subcontractors, and piece part manufacturers.

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

System design authority – is the entity responsible for producing and/or maintaining the design of the system.

Tin Whisker – is a spontaneous crystal growth that emanates from a tin (Sn) surface. 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 or higher level system to perform electrical function(s).

4 Symbols and Abbreviated Terms

ADHP – Aerospace, Defense and High Performance

AIA - Aerospace Industries Association

AMC - Avionics Maintenance Conference

BGA - Ball Grid Array

CCA- Circuit Card Assembly

COTS – Commercial Off The Shelf

DoD – Department of Defense

GEIA - Government Engineering and Information Technology Association

GIDEP - Government Industry Data Exchange Program

IPC - A member-driven organization and leading source for industry standards

LEAP WG - Pb-free Electronics in Aerospace Project Working Group

LFCP - Pb-free Control Plan

LRU - Line Replaceable Unit

OEM - Original Equipment Manufacturer

Pb - Lead

PB – Printed Board

PCB – Printed Circuit Board

PWB - Printed Wiring Board

SAC - Tin Silver Copper (SnAgCu)

Sn - Tin

SRU - Shop Replaceable Unit

JCAA/JG-PP - Joint Council on Aging Aircraft Joint Group on Pollution Prevention

5 Objectives

This document describes a Pb-free Control Plan (LFCP) that documents the processes used to ensure that ADHP electronic systems are produced, supplied, reworked, repaired, or maintained by the Plan Owner, and that contain Pb-free solder, piece parts, or PBs will satisfy the applicable requirements for performance, reliability, safety, and certifiability throughout the specified life of performance of the system. Specific objectives to be accomplished are cited in Sections 5.1 through 5.5.

5.1 Reliability

Ensure that the processes and materials using Pb-free solder and finishes are capable of producing reliable products. Identify methods for the mitigation and control of risks associated with Pb-free tin surfaces finishes. Identify methods for demonstrating the reliability of Pb-free solders or mixed solder alloy interconnects.

5.2 Configuration control and product identification

Ensure that the configurations of systems, equipment, assemblies, sub-assemblies and piece parts are identified and controlled.

5.3 COTS Assemblies

Ensure that COTS assemblies are identified, marked and controlled, and reliability objectives are met.

5.4 Deleterious effects of tin whiskers

Ensure that the deleterious effects of tin whiskers are mitigated.

5.5 Repair, rework, maintenance, and support

Ensure that repair, rework, maintenance, and support activities are specified, documented and controlled in a manner that controls effects of Pb-free solder materials and processes.

6 Technical requirements

This section defines the technical requirements for the LFCP.

The ADHP system Plan Owner ***shall*** have a Plan that states clearly, concisely, and unambiguously:

- What the Plan Owner does to accomplish each of the objectives;
- The process by which compliance to the Plan is demonstrated;
- The evidence that shows the objectives have been accomplished.

Included within their LFCP, the Plan Owner ***shall*** show how their LFCP complies with all technical requirements. Annex B contains a requirements matrix which allows mapping of the requirements of this standard to the Plan Owner's LFCP.

Depending on program or product line requirements, the Plan Owner may, with appropriate justification, amend the objectives of Section 5 by adding to or deleting them. If this is done, then the Plan will be assessed according to the amended list of requirements, as stated in the Plan. Tailoring of requirements ***shall*** be concurred upon between Plan Owner and customer. Annex A provides a tailoring template that can be used.

6.1 Reliability

The Plan ***shall*** document processes that are capable of assuring the reliability of the system's equipment using the substrate metallization finish materials, termination solder materials and finishes, assembly solder alloys, fluxes, cleaning agents, PB materials, piece parts, and soldering processes in the given application. Some aspects of reliability that should be considered are durability under thermal cycling, vibration, shock, the impact of thermal aging and effects of installation process temperatures.

NOTE 1: MATERIALS AND ASSEMBLY PROCESSES SHOULD BE QUALIFIED PRIOR TO USE IN THE PRODUCT.

NOTE 2: THIS STANDARD ADDRESSES ISSUES THAT ARE UNIQUE TO ADHP PRODUCTS. IN THE CASE OF COTS ASSEMBLIES, INFORMATION RELATED TO MATERIALS AND ASSEMBLY PROCESSES MAY NOT BE AVAILABLE OR VERIFIABLE. THEREFORE, NEW OR MODIFIED VERIFICATION/QUALIFICATION PROCESSES MAY BE NECESSARY TO ENSURE RELIABILITY OF THE PRODUCTS WHICH INTEGRATE SUCH COTS ASSEMBLIES.

NOTE 3: COTS ASSEMBLIES THAT MEET RELIABILITY OBJECTIVES IN NON-ADHP APPLICATIONS MUST BE VERIFIED AS ACCEPTABLE FOR ADHP APPLICATIONS.

NOTE 4: USERS OF THIS STANDARD SHOULD ADDRESS UNIQUE RELIABILITY REQUIREMENTS SUCH AS LONG LIFE, RUGGED OPERATING ENVIRONMENTS, HIGH CONSEQUENCES OF FAILURE, ETC.

This requirement also applies to mixed solder alloys or combinations of substrate metallization finish materials, termination solder materials and finishes, and assembly solder alloys used in the given application.

This requirement applies to original production and repair and rework of systems.

6.1.1 Test and analysis methods

The Plan ***shall*** document methods to test assemblies made with the Pb-free alloys and finishes, and combinations thereof, to provide data to assess their reliability in the given application.

NOTE: THE TEST METHODS SHOULD IMPOSE CONDITIONS AND DURATIONS TO EVALUATE MAJOR POTENTIAL FAILURE MECHANISMS FOR THE MATERIALS AND CONSTRUCTION OF THE ASSEMBLY. FOR SOLDER JOINTS THIS SHOULD INCLUDE CRACK PROPAGATION CAUSED BY ACCUMULATED FATIGUE DAMAGE, AND THE FORMATION OF BRITTLE INTERMETALLIC PHASES OR VOIDS. GUIDELINES AND EXAMPLES FOR PLANNING AND CONDUCTING TESTS, AND FOR ANALYZING AND USING RESULTS THERE-FROM, ARE INCLUDED IN GEIA-HB-0005-2. FAILURE ANALYSIS BY METALLOGRAPHIC EXAMINATION AND/OR COMPOSITION ANALYSIS IS CRITICAL TO INTERPRETING RESULTS FROM THESE TESTS.

Analysis methods may be used in lieu of testing, provided the analysis methods have been verified by testing.

6.1.2 Environmental and operating conditions

The expected life cycle environmental and operating conditions for the given application (for the individual assembly) ***shall*** be documented, and used in assessing the reliability of the given materials and assembly processes for the given application. This information should be agreed upon by the Plan Owner and the customer.

In cases where a given Pb-free solder alloy or finish in a comparable application has been shown to be reliable for a given set of environmental conditions and service life, it may be considered reliable in other, less severe, environmental conditions and service lives.

A given Pb-free solder alloy or finish in a given application may be considered reliable if its reliability is shown to be equal to or better than a Sn-Pb alloy or finish in parallel testing in comparable environmental conditions, provided that the SnPb alloy or finish satisfies the reliability requirements. The test conditions should be shown to correlate to actual life cycle environmental and operating use conditions and should consider test acceleration factors appropriate for the specific solder alloy or finish utilized.

6.1.3 Data

The Plan ***shall*** document methods to include the use of archived and retrievable reliability data from at least one of the following: (a) in-service data from similar Pb-free solder-based systems in comparable applications and environmental conditions; or (b) test data from studies conducted on the Pb-free solder or finish compositions used in the given system design, or a comparable one, under comparable conditions. The data ***shall*** represent parts and materials processed by assembly, rework or repair processes comparable to the construction being assessed.

NOTE 1: EXAMPLE SOURCES OF TEST DATA INCLUDE:

- **RESULTS FROM ACADEMIC STUDIES AND PAPERS, GOVERNMENT AND INDUSTRIAL CONSORTIA, AND STANDARDS BODIES.**
- **INDUSTRIAL CONSORTIA**
- **IPC - ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES**
- **JEDEC**
- **JAPAN ENGINEERING AND INFORMATION TECHNOLOGY ASSOCIATION (JEITA)**
- **JOINT COUNCIL ON AGING AIRCRAFT JOINT GROUP ON POLLUTION PREVENTION (JCAA/JG-PP)**
- **NASA/DOD PB-FREE ELECTRONICS PROJECT**

NOTE 2: GUIDELINES FOR PLANNING AND CONDUCTING TESTS AND FOR ANALYZING AND USING RESULTS THERE OF, ARE INCLUDED IN GEIA-STD-0005-3.

6.1.4 Conversion of results from available data to applicable conditions

The Plan ***shall*** document processes and methods to determine and quantify the relevant environmental use conditions and reliability requirements for specific products. In the event that the above data are obtained from service or test environmental conditions that are different from those expected for the use conditions of a given system, the documented processes and methods must convert results to use conditions of the given system, using appropriate identified acceleration factors.

NOTE: THE PURPOSE OF THIS REQUIREMENT IS TO ENSURE THAT THE ACTUAL USE CONDITIONS OF THE GIVEN PRODUCT ARE CONSIDERED IN THE APPLICATION OF DATA.

6.2 Configuration control and product identification

This section defines the configuration control and product identification requirements for the Plan. A Plan meeting the requirements of this section will ensure users and maintainers of ADHP systems will have all the information needed to ensure the appropriate traceability of the ADHP system throughout the specified life of performance. Design and change authority ***shall*** be defined in the Plan.

Annex C provides guidance to the Plan Owner for meeting the configuration control and product identification requirements of this section. The guidance in Annex C is focused on helping the Plan Owner consistently manage configuration control and product identification of components and soldered assemblies during the transition to Pb-free technology.

NOTE: MEETING THE REQUIREMENTS IN SECTION 6.2 MAY NOT BE POSSIBLE FOR CERTAIN TYPES OF COTS ASSEMBLIES THAT USE PB-FREE MATERIALS AND WHOSE SUPPLIERS DO NOT DISCLOSE THIS INFORMATION. FURTHER, THERE ARE MANY PB-FREE SOLDER ALLOYS AND MATERIALS AND IT IS ANTICIPATED THAT NEW ONES WILL CONTINUE TO BE INTRODUCED INTO THE MARKET. THEREFORE, IF THE MATERIALS AND ASSEMBLY PROCESSES MUST BE KNOWN IN ORDER TO MEET REQUIREMENTS, THEN THESE COTS ASSEMBLIES MAY NOT BE ACCEPTABLE FOR THE INTENDED APPLICATION(S).

6.2.1 Termination material and finish alloy compositions of piece parts

Using appropriate controlled documents that ensure configuration identification and control, the Plan ***shall*** document processes to identify all piece part and assembly materials for which reliability, compatibility, processing, or other issues, may exist. Piece Parts with Pb-free finishes should be identified per industry standards such as the IPC/JEDEC J-STD-609.

NOTE 1: EXAMPLES OF ALLOYS AND FINISHES THAT COULD BE AN ISSUE ARE SOLDER ALLOYS WITH HIGH MELTING TEMPERATURES, E.G., >250°C; PIECE PARTS (E.G., AREA ARRAYS) SUPPLIED WITH SOLDER BALL TECHNOLOGY; SOLDER ALLOYS CONTAINING BISMUTH; PIECE PARTS WITH PB-FREE TIN TERMINATION MATERIALS OR FINISHES; AND PB FINISHES. THIS LIST IS NOT ALL INCLUSIVE AND MAY CHANGE WITH TIME AND FURTHER ACCUMULATED KNOWLEDGE.

NOTE 2: TO ACCOMPLISH THIS, THE PLAN OWNER MAY CONTACT PIECE PART MANUFACTURERS AND SUPPLIERS, CONSULT DATA SHEETS, OR USE EXTERNAL RESOURCES INCLUDING DATABASES (E.G., Q-STAR, PART MINER). AT THE TIME OF PUBLICATION OF THIS STANDARD, IT IS NOT CLEAR WHETHER OR NOT THIS WILL BE ADEQUATE, OR WHETHER ADDITIONAL TESTING OR ANALYSIS OF THE PIECE PARTS WILL BE REQUIRED.

NOTE 3: IT IS RECOMMENDED THAT PLAN OWNERS SUBSCRIBE TO A PART CHANGE NOTICE (PCN) SERVICE, (E.G., PCN ALERT, PART MINER, TOTAL PARTS PLUS, ARROW RISK MANAGER, AVNET POMIERE, GIDEP, ETC.), IN ADDITION TO MAINTAINING AN ACTIVE INTERFACE WITH PIECE PART MANUFACTURERS, MANUFACTURERS' REPRESENTATIVES, AND PIECE PART DISTRIBUTORS. CHANGES IN TERMINATION FINISH WILL REQUIRE RE-EVALUATION OF THE PIECE PART AND ITS COMPATIBILITY WITH OTHER MATERIALS AND ASSEMBLY PROCESSES.

NOTE 4: ONE PURPOSE OF THIS REQUIREMENT IS TO ENSURE THAT THE INFORMATION NECESSARY FOR RELIABLE REPAIR AND REWORK OF THE EQUIPMENT IS AVAILABLE TO THE REPAIR AND REWORK FACILITIES, SO THAT THE REPAIR AND REWORK MATERIALS AND PROCESSES CAN BE APPROPRIATE FOR THE GIVEN PIECE PART TERMINATION OR FINISH ALLOY.

6.2.2 Solder alloys used in the assembly process

The Plan ***shall*** document processes that identify and record in a controlled manner, the solder alloys, fluxes, cleaning agents, and soldering processes used in the assembly process, both by in-house and contract manufacturers. This applies to both original and repaired hardware.

6.2.2.1 Assemblies containing a single solder alloy

Solder alloys, fluxes, cleaning agents, and assembly processes (including time-temperature reflow profiles) ***shall*** be documented in the appropriate controlled document system. This information may be identified on a label or included in the maintenance manual, or other similar means.

6.2.2.2 Assemblies containing more than one solder alloy

Solder alloys, fluxes, cleaning agents, and assembly processes (including time-temperature reflow profiles) ***shall*** be documented in the appropriate controlled document system.

A description or pictorial layout of the CCA, identifying the locations of each solder alloy, ***shall*** be included in the appropriate controlled document system. A parts list for the CCA identifying finishes and solders along with an assembly specification identifying as-required materials (e.g., solder wire, solder paste or bulk solder from wave-soldering or solder fountain processes) may satisfy this requirement.

This information may be identified on a label or included in the maintenance manual, or by other similar means. The practice of using more than one solder alloy on an assembly should be discouraged.

6.2.3 Wiring and Connector Assemblies

When applicable, the processes described above ***shall*** be documented in the Plan for wiring and similar applications.

6.2.4 Changes in Solder Alloys

The Plan ***shall*** document processes to ensure that no changes to the solder alloys are made without prior written authorization and approval by the Plan Owner.

6.2.5 Identification

Where required by contract, all Pb-free sub-assemblies, assemblies, and equipment ***shall*** be identified appropriately, per industry standards such as the IPC/JEDEC J-STD-609.

6.2.6 Part number changes

Part number changes related in changes in solders and finishes ***shall*** be determined by the requirements of the specific program. Examples of changes to be considered are contained in Annex C.

6.3 COTS Assemblies

All of the technical requirements and associated objectives of this standard ***shall*** apply to COTS assemblies containing Pb-free materials when selected for use in ADHP electronic systems. During the selection of COTS assemblies it should be assumed COTS assemblies contain some Pb-free content.

NOTE: COTS ASSEMBLIES ARE 'READILY AVAILABLE' IN THE COMMERCIAL MARKET AND MAY NOT BE DESIGNED OR MANUFACTURED SPECIFICALLY TO A MEET THE REQUIREMENTS OF ADHP ELECTRONIC SYSTEMS. ALSO, RECOGNIZE THAT:

- **COTS ASSEMBLIES ARE READILY AVAILABLE THROUGH ONE OR MORE SUPPLIERS. MANY ARE PURCHASED THROUGH VENDORS OR BROKERS AND NOT DIRECTLY FROM THE COTS ASSEMBLY MANUFACTURER.**
- **COTS ASSEMBLIES REPRESENT A RISK IN TIN-WHISKER FORMATION DUE TO A LACK OF VISIBILITY OF THE PART SELECTION PROCESS AT THE COTS ASSEMBLY MANUFACTURER.**
- **COTS ASSEMBLY MANUFACTURERS MAY MAKE CHANGES IN COMPONENTS, FINISHES AND SOLDERS WITHOUT NOTIFICATION TO THEIR CUSTOMERS.**
- **COTS ASSEMBLIES MAY NOT HAVE BEEN QUALIFIED TO ADHP ELECTRONICS STANDARDS FOR RELIABILITY.**

6.3.1 COTS Assembly Configuration Control and Product Identification

The requirements of the Header of Section 6.2 (excluding sub-sections) of this specification ***shall*** apply to COTS Assemblies. If the COTS Assembly is repairable, then the requirements of Section 6.2.2 that pertain to assemblies ***shall*** apply. If not repairable, then the requirements of Section 6.2.1 that pertain to components ***shall*** apply.

6.4 Deleterious effects of tin whiskers

The Plan ***shall*** include mitigation of the deleterious effects of tin whiskers in compliance with the applicable requirements of GEIA-STD-0005-2.

6.5 Repair, rework, maintenance, and support

The requirements of this standard ***shall*** apply to original equipment manufacturing and repair, rework, maintenance and support activities. GEIA-HB-0005-3 provides guidance for compliance with this section.

The design authority ***shall:***

- Ensure that all data and information required to comply with the requirements of this standard are available to those responsible for repair, rework, maintenance, and support; and
- Ensure that repair, rework, and maintenance documents issued by the design authority are consistent with the design authority's Plan.
- Ensure that sufficient information is provided to enable the repair and rework facility to use alloys, materials, finishes, and processes that are compatible with the item being repaired or reworked.

The repair, rework, maintenance, and support facility ***shall:***

- Ensure that all repair; rework, maintenance, and support processes are documented, including limitations/ exceptions, and are in compliance with the requirements of the design authority.

NOTE: THE PLAN SHOULD FACILITATE AWARENESS AND IDENTIFY NECESSARY MITIGATION PRACTICES OF CHANGING TERMINATION FINISHES IN COMPONENTS THAT MAY BE AVAILABLE AT THE TIME OF REPAIR.

7 Plan Administrative Requirements

7.1 Plan organization

The Plan ***shall*** be organized in such a manner that each of the requirements of Section 6 are addressed clearly, concisely, unambiguously; and in a manner that is verifiable by the customer or the customer's representative.

7.2 Terms and definitions

The terms and definitions used in the Plan ***shall*** be those of Section 3 of this standard, unless they are clearly defined otherwise in the Plan.

7.3 Plan point of contact

The Plan ***shall*** identify a Plan point of contact with the responsibility to act as the primary interface between the Plan Owner and outside parties in matters pertaining to the Plan.

7.4 References

The Plan ***shall*** contain or reference applicable process documentation.

7.5 Requirements for Suppliers and Sub-contractors

The Plan Owner ***shall*** ensure that suppliers and sub-contractors have a LFCP meeting the requirements of this standard *or* applicable requirements ***shall*** be flowed down so that the Plan Owner's objectives are achieved.

7.6 Plan acceptance

The Plan ***shall*** be accepted when the Plan Owner and the customer agree that it is acceptable to both parties, if the customer chooses to exercise the right of acceptance.

7.7 Plan modifications

In the event that a Plan is changed, a process ***shall*** be in place to notify all entities that are affected by the change.

Annex A. Template for Tailoring Requirements of GEIA-STD-0005-1-REV A

Requirement No.	Section	Requirement Description	Tailored Requirement	Plan User Sign-off	*Customer Rep. Sign-off
Add additional lines as needed					

*Customer representative

Annex B. Requirements Matrix for GEIA-STD-0005-1-REV A

Req. #	Clause in GEIA-STD-0005-1-REV A	Requirement	LFCP Cross Ref. Clause	Documentation Expected	Demonstrated by Procedure (LFCP document numbers)	Record of Compliance (Evidence procedures are followed)	Assessment Compliance report
1	1 Scope	The control of the Pb-free activities ***shall*** be accomplished by a supplier addressing the requirements from their Customer.					Approved Yes ☐ No ☐
2	1 Scope	If tailoring is performed, the user ***shall*** obtain documented customer concurrence.					Approved Yes ☐ No ☐
3	6	The AHP system supplier ***shall*** have a Plan that states clearly, concisely, and unambiguously: • What the Plan Owner does to accomplish each of the objectives; • The process by which compliance to the Plan is demonstrated;					Approved Yes ☐ No ☐
4	6	Included within their LFCP, the Plan Owner ***shall*** provide a table or matrix (see sample in Annex B) to show compliance to all technical requirements.					Approved Yes ☐ No ☐
5	6	Tailoring of requirements ***shall*** be concurred upon between Plan Owner and customer. Annex A provides a tailoring template that can be used.					Approved Yes ☐ No ☐
6	6.1	The Plan ***shall*** document processes that are capable of assuring the reliability of the equipment using substrate metallization finish materials, termination solder materials and finishes, assembly solder alloys, fluxes, cleaning agents, PB materials, piece parts, and soldering processes in the given application.					Approved Yes ☐ No ☐
7	6.1.1	The Plan ***shall*** document methods to test assemblies made with the Pb-free alloys and finishes, and combinations thereof, to provide data to assess their reliability in the given application.					Approved Yes ☐ No ☐

Req. #	Clause in GEIA-STD-0005-1-REV A	Requirement	LFCP Cross Ref. Clause	Documentation Expected	Demonstrated by Procedure (LFCP document numbers)	Record of Compliance (Evidence procedures are followed)	Assessment Compliance report
8	6.1.2	The life cycle environmental and operating conditions for the given application (for the individual assembly) ***shall*** be known, and used in assessing the reliability of the given materials and processes in the given application.					Approved Yes ☐ No ☐
9	6.1.3	The Plan ***shall*** document methods to include the use of archived and retrievable reliability data from at least one of the following: (a) in-service data from similar systems in comparable applications and environmental conditions; or (b) test data from studies conducted on the solder or finish compositions used in the given system design, or a comparable one, under comparable conditions.					Approved Yes ☐ No ☐
12	6.1.3	The data ***shall*** represent parts and materials processed by assembly, rework or repair processes comparable to the construction being assessed.					Approved Yes ☐ No ☐
13	6.1.4	The Plan ***shall*** document processes to determine and quantify the relevant environmental use conditions and reliability requirements for specific products.					Approved Yes ☐ No ☐
14	6.2	Design and change authority ***shall*** be defined in the Plan.					Approved Yes ☐ No ☐
15	6.2.1	The Plan ***shall*** document processes to identify (on appropriate controlled documents that ensure configuration identification and control) all piece part and assembly materials for which reliability, compatibility, processing, or other issues, may exist.					Approved Yes ☐ No ☐
16	6.2.2	The Plan ***shall*** document processes that identify, and record in a controlled manner, the solder alloys, fluxes, cleaning agents, and soldering processes used in the assembly process, both by in-house and contract manufacturers.					Approved Yes ☐ No ☐

Req. #	Clause in GEIA-STD-0005-1-REV A	Requirement	LFCP Cross Ref. Clause	Documentation Expected	Demonstrated by Procedure (LFCP document numbers)	Record of Compliance (Evidence procedures are followed)	Assessment Compliance report
17	6.2.2.1	Solder alloys, fluxes, cleaning agents, and processes (including time-temperature reflow profiles) ***shall*** be documented in the appropriate controlled document system.					Approved Yes ☐ No ☐
18	6.2.2.2	Solder alloys, fluxes, cleaning agents, and processes (including time-temperature reflow profiles) ***shall*** be documented in the appropriate controlled document system.					Approved Yes ☐ No ☐
19	6.2.2.2	A description or pictorial layout of the CCA, identifying the locations of each solder alloy, ***shall*** be included in the appropriate controlled document system.					Approved Yes ☐ No ☐
20	6.2.3	When applicable, the processes described above ***shall*** be documented in the Plan for wiring and similar applications.					Approved Yes ☐ No ☐
21	6.2.4	The Plan ***shall*** document processes to ensure that no changes to the solder alloys or finishes are made without prior written authorization and approval by the Plan Owner.					Approved Yes ☐ No ☐
22	6.2.5	Where required by contract, all Pb-free sub-assemblies, assemblies, and equipment ***shall*** be identified appropriately.					Approved Yes ☐ No ☐
23	6.2.6	Part number changes ***shall*** be determined by the requirements of the specific program. Examples of changes to be considered are contained in Annex C.					Approved Yes ☐ No ☐
24	6.3	All of the technical requirements and associated objectives of this standard ***shall*** apply to COTS assemblies containing Pb-free materials when selected for use in AHP electronic systems..					Approved Yes ☐ No ☐
25	6.3.1	All the requirements of Section 6.2 of this specification ***shall*** apply to COTS Assemblies.					Approved Yes ☐ No ☐
26	6.3.1	If the COTS Assembly is repairable, then the requirements of 6.2.2 that pertain to assemblies ***shall*** apply.					Approved Yes ☐ No ☐

Req. #	Clause in GEIA-STD-0005-1-REV A	Requirement	LFCP Cross Ref. Clause	Documentation Expected	Demonstrated by Procedure (LFCP document numbers)	Record of Compliance (Evidence procedures are followed)	Assessment Compliance report
27	6.3.1	If not repairable, then the requirements of 6.2.1 that pertain to components ***shall*** apply.					Approved Yes ☐ No ☐
28	6.4	The Plan ***shall*** include mitigation of the deleterious effects of tin whiskers in compliance with the applicable requirements of GEIA-STD-0005-2.					Approved Yes ☐ No ☐
29	6.5	The requirements of this standard ***shall*** apply to original equipment manufacturing and repair, rework, maintenance and support activities. GEIA-HB-0005-3 provides guidance for complying with this section.					Approved Yes ☐ No ☐
30	6.5	The design authority ***shall:*** • Ensure that all data and information required to comply with the requirements of this standard are available to those responsible for repair, rework, maintenance, and support; and • Ensure that repair, rework, and maintenance documents issued by the design authority are consistent with the design authority's Plan. • Ensure that sufficient information is provided to enable the repair and rework facility to use alloys, materials, finishes, and processes that are compatible with the item being repaired or reworked.					Approved Yes ☐ No ☐
31	6.5	The repair, rework, maintenance, and support facility ***shall:*** • Ensure that all repair; rework, maintenance, and support processes are documented, including limitations/ exceptions, and are in compliance with the requirements of the design authority.					Approved Yes ☐ No ☐
32	7.1	The Plan ***shall*** be organized in such a manner that each of the requirements of Section 6 are addressed clearly, concisely, unambiguously; and in a manner that is verifiable by the customer or the customer's representative.					Approved Yes ☐ No ☐

Req. #	Clause in GEIA-STD-0005-1-REV A	Requirement	LFCP Cross Ref. Clause	Documentation Expected	Demonstrated by Procedure (LFCP document numbers)	Record of Compliance (Evidence procedures are followed)	Assessment Compliance report
33	7.2	The terms and definitions used in the Plan ***shall*** be those of Section 3 of this standard, unless they are clearly defined otherwise in the Plan.					Approved Yes ☐ No ☐
34	7.3	The Plan ***shall*** identify a Plan point of contact with the following responsibilities***:*** • Act as the primary interface between the Plan Owner and outside parties in matters pertaining to the Plan; • Ensure that the Plan is reviewed and updated as necessary; and • Ensure that all technical and administrative issues are resolved in a timely manner.					Approved Yes ☐ No ☐
35	7.4	The Plan ***shall*** contain or reference applicable process documentation.					Approved Yes ☐ No ☐
36	7.5	The Plan Owner ***shall*** ensure that suppliers and sub-contractors have a LFCP meeting the requirements of this standard					Approved Yes ☐ No ☐
37	7.6	***or*** applicable requirements ***shall*** be flowed down so that the Plan Owner's objectives are achieved.					Approved Yes ☐ No ☐
38	7.7	In the event that a Plan is changed, a process ***shall*** be in place to notify all entities that are affected by the change.					Approved Yes ☐ No ☐

Annex C: Guidance on Configuration Control and Product Identification

C.1 Introduction

The global transition to Pb-free solder has a significant impact on the electronics industry. The transition is disruptive to the aerospace industry, which requires products with continued high performance and maintainability.

A robust configuration management process is required to ensure the consistency and traceability of a product's performance, functional and physical attributes with its requirements, and design and operational information throughout its life.

This is a particular challenge in the transition away from Pb-based solders because of the relatively low experience level with their replacements and the often times incompatibility between the solder used in the manufacture of previously delivered configurations and the new configuration. Configuration Management should recognize these issues and ensure proper application of product identification principles so that the correct manufacturing processes and maintenance processes are employed.

This annex provides guidance for when a new part number (also called a new dash number) is required so that customers of the product definition data (e.g., the manufacturing shop, an airline, a government entity, a maintenance facility) will know that a configuration's Pb content has been changed.

C.1.1 Scope

This annex provides guidance to industry for meeting the configuration control and product identification requirements of GEIA-STD-0005-1-REV A. GEIA-STD-0005-1-REV A "defines the objectives of, and requirements for, documenting processes that assure customers and regulatory agencies that ADHP electronic systems containing Pb-free solder, piece parts, and boards will satisfy the applicable requirements for performance, reliability, airworthiness, safety, and certifiability throughout the specified life of performance." By following these guidelines the requirements of the customer, the OEM, and, to the extent possible their respective supply chains, to the lowest component should be met. The guidance will take into account:

- The complexity of the change to Pb-free and current understanding of the risk, based on industry research and best practices at the time of the change
- The knowledge that, at the component level, the aerospace industry may not have a great influence over those suppliers' configuration control methodologies
- Industry standards (e.g., ASME Y14.100, ANSI/EIA-649 current revision B) and best practices

The guidance in this annex is focused on helping industry consistently manage configuration control and product identification of components and soldered assemblies during the transition to Pb-free technology. The terms Pb-based and Pb-free refer to termination finishes on components, and solder alloys used in soldered assemblies.

The primary purpose for this guidance is to help ensure Electronic Systems manufacturers apply a consistent amount of rigor when deciding if a change to Pb-free technology requires a new Plan Owner part number for components and/or soldered assemblies.

This annex is not a stand-alone document. It is intended to be used with the referenced industry standards, the latest Pb-free technical knowledge and other industry best practices.

C.2 Configuration Control and Product Identification

C.2.1 Introduction

The Pb content of an item may change at the component, board, or end-item level. Depending on the extent of the change, the form, fit, function, interchangeability, reparability, or reliability may be changed at each level of the assembly. In the absence of specific contractual requirements the configuration management process should enforce the product identification principle to change product identifiers to reflect a change to the product configuration (ANSI/EIA-649-B, principle CI-5 and section 5.2.2.2) at each affected level of an assembly.

C.2.2 Configuration Control Requirements

Figure C.1 describes the basic decision process for deciding whether or not a change in Pb content in the material finish or assembly solder requires a part number change. Most changes toward Pb-free have been to the component termination finish as supplied by component manufacturers. As Pb-free finishes are introduced, the impact on the assembly processes and the ultimate reliability of the end item should be considered. If the impact to component, soldered assembly and end item is determined to be insignificant, a part number change is not required and the electronics manufacturer is only required to document the evidence in accordance with the industry or government best practices. However, if the change does have an impact on form, fit, function, interchangeability, reparability, maintainability, or reliability, then the part number should be changed. Also note that a part number change at the component or lower level assembly does not always require a change to the next higher assembly part number, up to and including the end-item part number. In accordance with ANSI/EIA-649 policy, part numbers are changed up until the level of interchangeability is re-established.

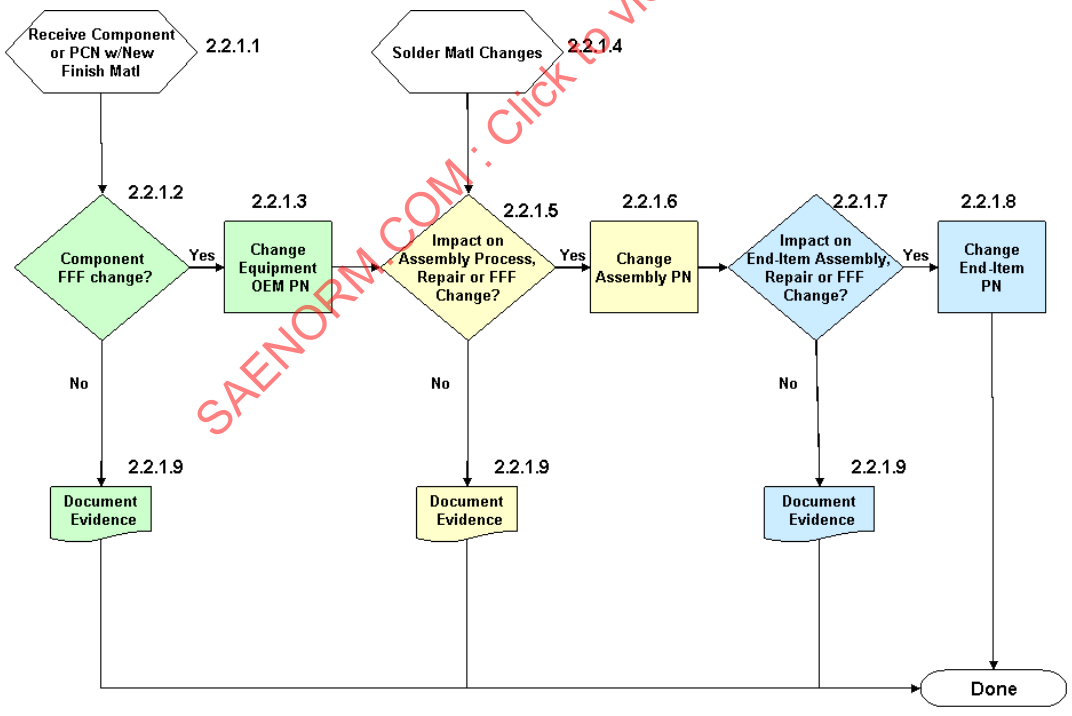

Figure C.1 – Decision Flow Chart