IEC/TS 62647-1

Edition 1.0 2012-08

TECHNICAL SPECIFICATION

colour inside

Process management for avionics – Aerospace and defence electronic systems containing lead-free solder – Part 1: Preparation for a lead-free control plan

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRICE CODE V

ICS 03.100.50; 31.020; 49.060

ISBN 978-2-83220-298-2

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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PROCESS MANAGEMENT FOR AVIONICS – AEROSPACE AND DEFENCE ELECTRONIC SYSTEMS CONTAINING LEAD-FREE SOLDER –

Part 1: Preparation for a lead-free control plan

FOREWORD

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- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC/TS 62647-1, which is a technical specification, has been prepared by IEC technical committee 107: Process management for avionics.

This technical specification cancels and replaces IEC/PAS 62647-1 published in 2011. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to:

a) the addition of requirements for the use of Pb-free solder alloys,

b) the addition of requirements for the use of COTS,

c) the update of Annex B.

The text of this technical specification is originally based on the following document: GEIA-STD-0005-1 Revision A.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
107/159/DTS	107/180/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in the IEC/TS 62647 series, published under the general title *Process management for avionics*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The European Union (EU) 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. Other countries have also enacted similar legislation. One of the key materials restricted is lead (Pb), which is widely used in electronic solder and electronic piece part terminations. These regional regulations affect the global market place. However, due to the reduced market share of the Aerospace, Defence and High Performance (ADHP) industries, many of the lower tier suppliers to those industries will change their products to serve their primary, non-ADHP markets. Additionally, several United States (US) 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.

The products of ADHP companies developing and/or managing Pb-free electronics 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 that 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 due to potential differences in fatigue characteristics under thermal cycling and vibration relative to traditional solders;
2) the 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; and
3) the use of lead-free technology can result in higher processing temperatures associated with lead-free solders.

PROCESS MANAGEMENT FOR AVIONICS – AEROSPACE AND DEFENCE ELECTRONIC SYSTEMS CONTAINING LEAD-FREE SOLDER –

Part 1: Preparation for a lead-free control plan

1 Scope

This part of the IEC/TS 62647 series 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 PWBs will satisfy the applicable requirements for performance, reliability, airworthiness, safety, and certifiability throughout the specified life of performance.

This specification aims to communicate requirements for a lead-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 to 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 specification 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 need to 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 specification applies to the ADHP electronics system supply chain.

The control of the Pb-free activities will 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 original equipment manufacturer (OEM), and their respective supply chains, to the lowest level possible. This should 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 specification. The extended scope should be covered separately.

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

This document may be used by other high-performance and high-reliability industries, at their discretion.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC/PAS 62647-2[1], *Process management for avionics – Aerospace and defence electronic systems containing lead-free solder – Part 2: Mitigation of the deleterious effects of tin*

IEC/TS 62647-2[2], *Process management for avionics – Aerospace and defence electronic systems containing lead-free solder – Part 2: Mitigation of deleterious effects of tin*

IEC/PAS 62647-22[3], *Process management for avionics – Aerospace and defence electronic systems containing lead-free solder – Part 22: Technical guidelines*

IEC/PAS 62647-23[4], *Process management for avionics – Aerospace and defence electronic systems containing lead-free solder – Part 23: Rework and repair guidance to address the implications of lead-free electronics and mixed assemblies*

3 Terms and definitions

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

3.1
assemblies
electronic items that require electrical attachments, including soldering of wires or component terminations

EXAMPLE Circuit cards and wire harnesses.

3.2
critical
state of an item or function, which if defective, will result in the system's inability to retain operational capability, meet primary objective, or affect safety

3.3
COTS
commercial-off-the-shelf
item whose design and configuration is controlled by the manufacture and on which the user has no control as to design and configuration

Note 1 to entry: An item may be a component, a subassembly, an assembly, a system.

3.4
COTS assembly or sub-assembly
assembly or sub-assembly developed by a supplier for multiple customers, whose design and configuration are managed by the suppliers or an industry specification

3.5
customer
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

EXAMPLE This may include unit (SRU/LRU/system) users, integrators, regulatory agencies, operators, original equipment manufacturers (OEMs), and subcontractors.

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1 This is equivalent to GEIA-STD-0005-2.This will be superseded by IEC/TS 62647-2.

2 To be published. This will supersede IEC/PAS 62647-2.

3 This is equivalent to GEIA-HB-0005-2. It is the intention of the technical committee to supersede this by a future IEC/TS 62647-22.

4 This is equivalent to GEIA-HB-0005-3. It is the intention of the technical committee to supersede this by a future IEC/TS 62647-23.

3.6
FFF
form, fit and function
description of an item's identifying characteristics which is commonly used to determine if a proposed change to a part will be “minor” (no impact on form, fitness and function) or “major” (no impact on form, fitness and function)

3.7
high performance
continued performance or performance on demand where an application (product, equipment, electronics, system, program) down time cannot be tolerated in an end-use environment which can be uncommonly harsh, and the application must function when required

EXAMPLE: Examples of high performance applications are life support or other critical systems.

3.8
Pb-free
less than 0,1 % by weight of Pb in accordance with reduction of hazardous substances (RoHS) guidelines

3.9
Pb-free control plan
(LFCP)
aerospace or military system supplier’s document that defines the processes that assure the Plan owners, their customers and all other stakeholders that aerospace, defence and high performance high-reliability electronics systems containing Pb-free solder and Pb-free piece part and PWB finishes will continue to be reliable, safe, producible, affordable, and supportable

3.10
may
indicates a course of action that is permissible within the limits of this specification, but not required

3.11
Pb-free tin
tin or any tin alloy with < 3 % lead (Pb) content by weight

Note 1 to entry: Some Pb-free finishes other than Pb-free tin, such as tin-bismuth and tin-copper, are considered to be “tin” for the purposes of this specification. Many of these alloys have not been assessed for whiskering behavior.

3.12
Pb-free tin finish
final finishes or under-plates either external or internal to a device, PWB or other hardware, including all leads and surfaces, even those coated, encapsulated, or otherwise not exposed

Note 1 to entry: It may include finishes on electrical piece parts, mechanical piece parts, and PWBs. 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.

3.13
PCN
part change notice
document used to record a change in a part

3.14
piece part
electronic piece part that is not normally disassembled without destruction and is normally attached to a PWB to perform an electrical function

3.15
PN
part number
number assigned to a part for tracking and identification purposes

3.16
rework
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 by making repairs

Note 1 to entry: Also used to define 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.

3.17
repair
act of restoring the functional capability of a defective article in a manner that precludes compliance of the article with applicable drawings or specifications

3.18
shall
indicates a mandatory requirement to be followed in order to comply with this specification

3.19
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

3.20
solder ball technology
family of components that employ solder balls or bumps to make mechanical and electrical connections between components and PWBs

EXAMPLE Ball grid arrays (BGAs), flip chips, and chip scale interconnections.

3.21
soldered assembly
assembly of two or more basic parts interconnected by a solder alloy

Note 1 to entry: 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.

3.22
sub-contractor
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

3.23
supplier
entity or organization that designs, manufactures, repairs, reworks, or maintains a piece part, unit, or system

Note 1 to entry: This includes original equipment manufacturers (OEMs), repair and rework facilities, subcontractors, and piece part manufacturers.

3.24
system
one or more units that perform electrical function(s)

3.25
system design authority
entity responsible for producing and/or maintaining the design of the system

3.26
tin whisker
spontaneous crystal growth that emanates from a tin (Sn) surface and which may be cylindrical, kinked, or twisted

Note 1 to entry: Typically tin whiskers have an aspect ratio (length/width) greater than two, with shorter growths referred to as nodules or odd-shaped eruptions (OSEs).

3.27
unit
one or more assemblies within a chassis or higher level system to perform electrical function(s)

4 Symbols and abbreviated terms

ADHP	Aerospace, Defence and High Performance
BGA	Ball Grid Array
CCA	Circuit Card Assembly
COTS	Commercial-Off-The-Shelf
FFF	Form, Fit and Function
GEIA	Government Engineering and Information Technology Association
GIDEP	Government Industry Data Exchange Program
IPC	member-driven organization and leading source for industry standards
LFCP	Pb-free Control Plan
LRU	Line Replaceable Unit
OEM	Original Equipment Manufacturer
Pb	lead
PCN	Part Change Notice
PN	Part Number
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

5.1 General

This document describes a Pb-free Control Plan (LFCP) that records the processes used to ensure that ADHP electronic systems are produced, supplied, reworked, repaired, or maintained by the Plan owner, and that the Pb-free solder, piece parts, or PWBs they contain will satisfy the applicable requirements for performance, reliability, safety, and certifiability throughout the specified life of performance of the system. 5.2 through 5.6 list the specific objectives to be accomplished.

5.2 Reliability

Demonstrate 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.

5.3 Configuration control and product identification

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

5.4 COTS assemblies and sub-assemblies

Assure that COTS assemblies and sub-assemblies are identified, marked and controlled, and reliability objectives are met.

5.5 Deleterious effects of tin whiskers

Mitigate the deleterious effects of tin whiskers.

5.6 Repair, rework, maintenance, and support

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

6 Technical requirements

6.1 General

This clause defines the technical requirements for the LFCP.

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

- how the Plan owner intends 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.

Plan owners shall include within their LFCP a table or matrix (see sample in Annex B) showing compliance to all technical requirements.

Depending on program or product line requirements, the Plan owner may, with appropriate justification, amend the objectives of Clause 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 the requirements shall be concurred upon between Plan owner and customer. Annex A provides a tailoring template that can be used in this regard.

6.2 Reliability

6.2.1 General

The Plan shall document processes that are capable of assuring the reliability of the equipment when using substrate metallization finish materials, termination solder materials and finishes, assembly solder alloys, fluxes, cleaning agents, PWB materials, piece parts, and soldering processes in the given application.

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, repair, rework and maintenance of systems.

Users of this specification should address unique reliability requirements such as long life, rugged operating environments, high consequences of failure, etc.

NOTE 1 Materials and assembly processes can be qualified prior to use in the product.

NOTE 2 This specification addresses issues that are unique to ADHP products. In the case of COTS assemblies, information related to materials and assembly processes possibly will not be available or verifiable. Therefore, new or modified verification/qualification processes can be necessary to assure reliability of the products which integrate such COTS assemblies.

NOTE 3 COTS assemblies that meet reliability objectives in non-ADHP applications can be verified as acceptable for ADHP applications.

6.2.2 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.

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 IEC/PAS 62647-22 (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.

6.2.3 Environmental and operating conditions

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 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 Sn-Pb 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.

6.2.4 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 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. The data shall be representative of parts and materials processed by assembly, rework or repair processes comparable to the construction being assessed.

NOTE 1 Example sources of test data include:

– University-led consortia including the Computer-Aided Life Cycle Engineering Electronics Packaging and Systems Center, University of Maryland and the Center for Advanced Vehicle Electronics, Auburn UniversityIndustrial consortia including Universal Instruments Corporation's Area Array Consortium

– IPC – Association Connecting Electronics Industries

– JEDEC – Global Standards for the Microelectronics Industry

– 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 thereof, are included in IEC/PAS 62647-3 (GEIA-STD-0005-3).

6.2.5 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 shall convert results to equivalent use conditions for 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.

6.3 Configuration control and product identification

6.3.1 General

6.3 defines the configuration control and product identification requirements for the Plan. A Plan meeting the requirements of this subclause will ensure that users and maintainers of ADHP systems will have all the information needed to assure 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 subclause. The guidance in Annex C is focused on helping the Plan owner to consistently manage configuration control and product identification of components and soldered assemblies during the transition to Pb-free technology.

Meeting the requirements in 6.3 may not be possible for certain types of COTS assemblies that use Pb-free materials and do not disclose this information. 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 (solder alloy, printed wiring board, etc.) and assembly processes need to be known in order to meet requirements, then these COTS assemblies may not be acceptable for the intended application(s).

6.3.2 Termination materials and finishes

Using appropriate controlled documents that ensure configuration identification and control, the Plan shall document processes to identify all termination materials and finishes (PCB, piece parts) for which reliability, compatibility, processing, or other issues, may exist.

NOTE 1 Examples of finishes that could be problematic are: solder alloys with high melting temperatures (e.g. > 250 °C); piece parts supplied with solder ball technology, solder alloys containing bismuth, piece parts with Pb-free tin termination materials or finishes; and PCB finishes. This list is not all inclusive and may change with time and further accumulated knowledge.

NOTE 2 To accomplish this, the Plan owner can 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 specification, 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 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.

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.

6.3.3 Solder alloys used in the assembly process

6.3.3.1 General

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.

NOTE IPC/JEDEC J-STD-609 provides information that can assist in this.

6.3.3.2 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. Assemblies assembled with Pb-free solders should be identified per industry standards such as the IPC/JEDEC J-STD-609 or other identification specified by the customer.

6.3.3.3 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.

6.3.4 Wiring and connector assemblies

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

6.3.5 Changes in solder alloys

The Plan shall document processes to assure that no changes to the solder alloys or finishes are made without prior written authorization and approval by the Plan owner.

6.3.6 Identification

Where required by contract, all Pb-free sub-assemblies, assemblies, and equipment shall be identified appropriately.

NOTE An industry standard that contains marking requirements is the IPC/JEDEC J-STD-609.

6.3.7 Part number changes

Part number changes related to 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.

6.4 COTS assemblies and sub-assemblies

6.4.1 General

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

COTS assemblies are "readily available" in the commercial market and may not be designed or manufactured specifically to meet the requirements of ADHP electronic systems. Also, it is necessary to 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.

6.4.2 COTS assembly and sub-assembly configuration control and product identification

All the requirements of 6.3 of this specification shall apply to COTS assemblies. If the COTS assembly is repairable, then the requirements of 6.3.3 that pertain to assemblies shall apply. If not repairable, then the requirements of 6.3.2 that pertain to components shall apply.

6.5 Deleterious effects of tin whiskers

The Plan shall include mitigation of the deleterious effects of tin whiskers in compliance with the applicable requirements of IEC/PAS 62647-2 (GEIA-STD-0005-2) or IEC/TS 62647-2 that will supersede IEC/PAS 62647-2.

6.6 Repair, rework, maintenance, and support

The Plan shall apply to original equipment manufacturing and repair, rework, maintenance and support activities. IEC/PAS 62647-23 (GEIA-HB-0005-3) provides guidance for compliance with this subclause.

The Plan shall document the processes to:

- ensure that all data and information required to comply with the requirements of this specification are available to those responsible for repair, rework, maintenance, and support;

- 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;
- ensure that all repair, rework, maintenance, and support processes are documented, including limitations/ exceptions, and are in compliance with the requirements called out in the Plan.

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 Clause 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 contained in Clause 3 of this specification, 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 following responsibilities:

a) act as the primary interface between the Plan owner and outside parties in matters pertaining to the Plan;

b) ensure that the Plan is reviewed and updated as necessary; and

c) ensure that all technical and administrative issues are resolved in a timely manner.

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 specification or applicable requirements of this specification 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
(informative)

Template for tailoring requirements of IEC/TS 62647-1

Table A.1 provides a template for tailoring the requirements for IEC/TS 62647-1.

Table A.1 – Template for tailoring requirements

Requirement No.	Clause / subclause	Requirement description	Tailored requirement	Plan user sign-off	Customer representative sign-off
Add additional lines as needed					

Annex B
(informative)

Requirements matrix for IEC/TS 62647-1

Table B.1 provides the requirement matrix for IEC/TS 62647-1.

Table B.1 – Requirement matrix

Requirement No.	Clause / subclause in IEC/TS 62647-1	Requirement	LFCP cross reference clause	Demonstrated by (supporting document references and brief descriptions)	Record of compliance (evidence documents are followed)
1	6.1	The ADHP system Plan owner shall have a Plan that states clearly, concisely, and unambiguously: • how the Plan owner intends 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.			
2	6.1	Plan owners shall include within their LFCP a table or matrix (see sample in Annex B) showing compliance to all technical requirements.			
3	6.1	Tailoring of requirements shall be concurred upon between Plan owner and customer. Annex A provides a tailoring template that can be used in this regard.			
4	6.2.1	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, PWB materials, piece parts, and soldering processes in the given application.			
5	6.2.2	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.			
6	6.2.3	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.			

Requirement No.	Clause / subclause in IEC/TS 62647-1	Requirement	LFCP cross reference clause	Demonstrated by (supporting document references and brief descriptions)	Record of compliance (evidence documents are followed)
7	6.2.4	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.			
8	6.2.4	The data shall be representative of parts and materials processed by assembly, rework or repair processes comparable to the construction being assessed.			
9	6.2.5	The Plan shall document processes and methods to determine and quantify the relevant environmental use conditions and reliability requirements for specific products.			
10	6.2.5	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 shall convert results to equivalent use conditions for the given system, using appropriate identified acceleration factors.			
11	6.3.1	Design and change authority shall be defined in the Plan.			
12	6.3.2	Using appropriate controlled documents that ensure configuration identification and control, the Plan shall document processes to identify all termination materials and finishes (PCB, piece parts) for which reliability, compatibility, processing, or other issues, may exist.			
13	6.3.3.1	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.			
14	6.3.3.2	Solder alloys, fluxes, cleaning agents, and assembly processes (including time-temperature reflow profiles) shall be documented in the appropriate controlled document system.			
15	6.3.3.3	Solder alloys, fluxes, cleaning agents, and assembly processes (including time-temperature reflow profiles) shall be documented in the appropriate controlled document system.			
16	6.3.3.3	A description or pictorial layout of the CCA, identifying the locations of each solder alloy, shall be included in the appropriate controlled document system.			
17	6.3.4	When applicable, the processes described above shall be documented in the Plan for wiring and similar applications.			

Requirement No.	Clause / subclause in IEC/TS 62647-1	Requirement	LFCP cross reference clause	Demonstrated by (supporting document references and brief descriptions)	Record of compliance (evidence documents are followed)
18	6.3.5	The Plan shall document processes to assure that no changes to the solder alloys or finishes are made without prior written authorization and approval by the Plan owner.			
19	6.3.6	Where required by contract, all Pb-free sub-assemblies, assemblies, and equipment shall be identified appropriately.			
20	6.3.7	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.			
21	6.4.1	All of the technical requirements and associated objectives of this specification shall apply to COTS assemblies containing Pb-free materials when selected for use in ADHP electronic systems.			
22	6.4.2	All the requirements of 6.3 of this specification shall apply to COTS assemblies.			
23	6.4.2	If the COTS assembly is repairable, then the requirements of 6.3.3 that pertain to assemblies shall apply.			
24	6.4.2	If not repairable, then the requirements of 6.3.2 that pertain to components shall apply.			
25	6.5	The Plan shall include mitigation of the deleterious effects of tin whiskers in compliance with the applicable requirements of IEC/PAS 62647-2 (GEIA-STD-0005-2) or IEC/TS 62647-2 that will supersede IEC/PAS 62647-2.			
26	6.6	The Plan shall apply to original equipment manufacturing and repair, rework, maintenance and support activities. IEC/PAS 62647-23 (GEIA-HB-0005-3) provides guidance for compliance with this subclause.			

Requirement No.	Clause / subclause in IEC/TS 62647-1	Requirement	LFCP cross reference clause	Demonstrated by (supporting document references and brief descriptions)	Record of compliance (evidence documents are followed)
27	6.6	The Plan shall document the processes to: • ensure that all data and information required to comply with the requirements of this specification are available to those responsible for repair, rework, maintenance, and support; • 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; • ensure that all repair, rework, maintenance, and support processes are documented, including limitations/ exceptions, and are in compliance with the requirements called out in the Plan.			
28	7.1	The Plan shall be organized in such a manner that each of the requirements of Clause 6 are addressed clearly, concisely, unambiguously; and in a manner that is verifiable by the customer or the customer's representative.			
29	7.2	The terms and definitions used in the Plan shall be those contained in Clause 3 of this specification, unless they are clearly defined otherwise in the Plan.			
30	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.			
31	7.4	The Plan shall contain or reference applicable process documentation.			
32	7.5	The Plan owner shall ensure that suppliers and sub-contractors have a LFCP meeting the requirements of this specification			
33	7.5	or applicable requirements of this specification shall be flowed down so that the Plan owner's objectives are achieved.			
34	7.6	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.			
35	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.			

Annex C
(informative)

Guidance on configuration control and product identification

C.1 General

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 as to 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.

A list of definitions and terms used throughout this document is contained in Clause 3 of this specification.

C.2 Overview

This annex provides guidance to industry for meeting the configuration control and product identification requirements of IEC/TS 62647-1 (GEIA-STD-0005-1). The IEC/TS 62647-1 (GEIA-STD-0005-1) 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/GEIA-649-A) 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 rigour when deciding if a change to Pb-free technology requires a new company 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 or specifications, the latest Pb-free technical knowledge and other industry best practices.

C.3 Related documents

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

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

IEC/PAS 62647-2 (GEIA-STD-0005-2), *Process management for avionics – Aerospace and defence electronic systems containing lead-free solder – Part 2: Mitigation of the deleterious effects of tin*

IEC/TS 62647-2, *Process management for avionics – Aerospace and defence electronic systems containing lead-free solder – Part 2: Mitigation of the deleterious effects of tin*

IPC/JEDEC J-STD-609, *Marking and Labeling of Components, PCBs and PCBAs to Identify Lead (Pb), Pb-Free and Other Attributes*.

C.4 Configuration control and product identification

C.4.1 Overview

The Pb content of an item may change at the component, board, or equipment level. Depending on the extent of the change, the FFF (form, fit and 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 (GEIA-HB-649:2005, Principle 2-3C) at each affected level of an assembly.

C.4.2 Configuration control requirements

C.4.2.1 General

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 unit (SRU/LRU/system) should be considered. If the impact to component, soldered assembly and unit (SRU/LRU/system) 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 equipment part number.

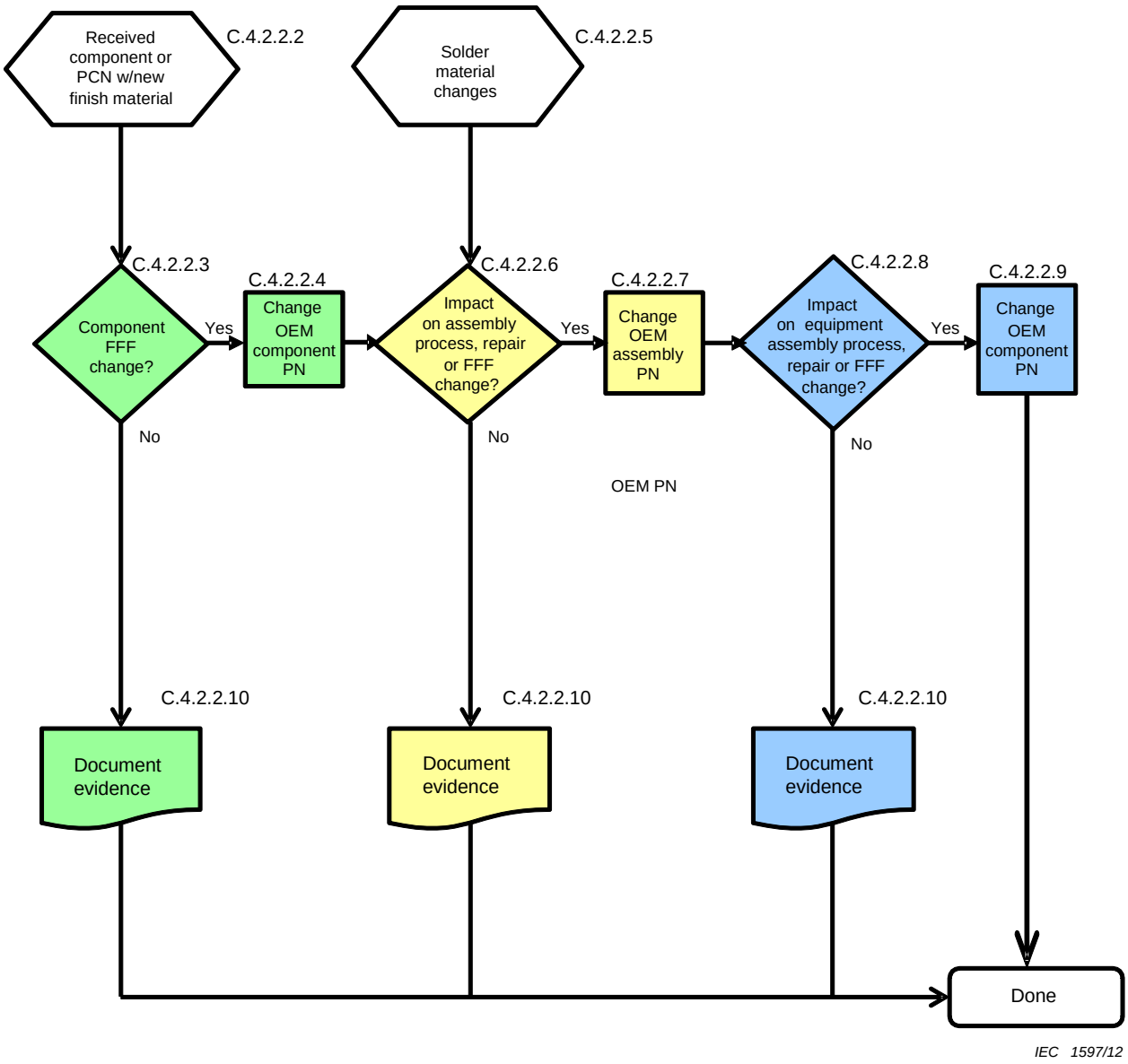

Figure C.1 – Decision flow chart

C.4.2.2 Decision process for part number changes

C.4.2.2.1 General

Each step in the decision process is discussed in detail in the following paragraphs. It is important to note that component changes should be considered separately from assembly solder changes.

C.4.2.2.2 Receive component or PCN with new finish material

Equipment OEM acknowledges receiving a component (vigilance is required by the equipment OEM as a component supplier may change the termination finish without formal notification and without changing their component PN) or PCN from a component supplier indicating the finish material on the electrical terminations has changed. The equipment OEM should initiate the process of determining whether or not it is required to change the Equipment OEM part number. Proceed to C.4.2.2.3.

C.4.2.2.3 Component FFF change

The equipment OEM evaluates the component finish change taking into account the manufacturing, reliability, maintenance and tin whisker considerations discussed in C.4.2.3. If the new component finish is compatible with the equipment OEMs tin-lead finish process, meets reliability and maintainability requirements, and any tin whisker risk is mitigated, proceed to C.4.2.2.10. If not, proceed to C.4.2.2.4.

C.4.2.2.4 Change unit (SRU/LRU/system) OEM part number

Whether the unit (LRU/SRU/system) OEM assigns unique part numbers to components or uses component manufacturer assigned part numbers, configuration management with respect to FFF issues, outlined in C.4.2.2.3, should be assured by the unit (LRU/SRU/system) OEM. The guidance in this document assumes the former applies, however the same discipline should be applied in the decision to use component manufacturer assigned part numbers. Component part numbers will change when there is a change to the component FFF, thus assuring configuration control. Proceed to C.4.2.2.6.

C.4.2.2.5 Solder material changes

Equipment OEM implements a solder material change and initiates the process of determining whether or not it is required to change the soldered assembly part number. Proceed to C.4.2.2.6.

C.4.2.2.6 Impact on assembly process, repair or FFF change?

The Equipment OEM evaluates the component and/or solder material change taking into account the manufacturing, reliability, maintenance and tin whisker considerations discussed in C.4.2.3. If changes at the component level (including PWBs) or solder material impact the form, fit, function, interchangeability, reparability, maintainability, or reliability of the assembly, then the question is answered “yes” and the part number of the assembly should be changed. Proceed to C.4.2.2.7. If the solder material is compatible with all component lead finishes, meets reliability and maintainability requirements, and any tin whisker risk is mitigated, answer the question “no”, revise the assembly PN to capture that there was a change at the assembly level, and document the evidence (C.4.2.2.10) compiled to support this decision.

C.4.2.2.7 Change assembly part number

Equipment OEM changes the assembly part number to differentiate the component finish material and/or solder material from that of the legacy part number. Proceed to C.4.2.2.8.

C.4.2.2.8 Impact on unit (SRU/LRU/system) assembly, repair or FFF change?

The Equipment OEM evaluates the component and/or solder material change taking into account the manufacturing, reliability, maintenance and tin whisker considerations discussed in C.4.2.3. If changes at the component level or solder material impact the form, fit, function, interchangeability, reparability, maintainability, or reliability of the unit (SRU/LRU/system) assembly, then the question is answered “yes” and the part number of the unit (SRU/LRU/system) assembly should be changed. Proceed to C.4.2.2.9. If the solder material is compatible with all component lead finishes, meets reliability and maintainability requirements, and any tin whisker risk is mitigated, answer the question “no”, revise the equipment assembly PN to capture that there was a change at the equipment assembly level, and document the evidence (C.4.2.2.10) compiled to support this decision.

C.4.2.2.9 Change unit (SRU/LRU/system) part number

Equipment OEM changes the equipment part number to differentiate the component finish material and/or solder material from that of the legacy part number.

C.4.2.2.10 Document evidence

The requirements for documenting the evidence for part number changes are not unique to "Pb-free" and are governed by the normal contractual requirements agreed between the supplier and the customer, often in a "notice of change" document. In the absence of contractual requirements, the supplier's internal process requirements should be followed. However, due to the sensitivity to any change to "Pb-free", it would be prudent to retain as much documentation (test data, analysis, etc.) as is feasible to support the decision that "no change in part number" is required.

C.4.2.3 Decision flow chart tailoring

C.4.2.3.1 General

The following paragraphs provide guidance in the form of decision flow charts (Figures C.2 and C.3).

The decision flow charts require the manufacturer to consider four major areas of concern when determining whether or not a part number change is required. The major areas of concern are manufacturing, maintenance, reliability and tin whisker risk. The flow charts list several considerations that should be evaluated; however this list is not all inclusive. This should be considered a minimum list, as other considerations may be needed to meet customer requirements. The considerations are written in the form of a question. If the answer to any consideration is "yes", then a part number change is required. However, any remaining considerations should still be evaluated for potential impact at all levels of assembly. All considerations should be answered "no" for a part number to remain unchanged.

Figure C.3 is based on the tin whisker control levels defined in IEC/PAS 62647-2 (GEIA-STD-0005-2) or IEC/TS 62647-2 that will supersede IEC/PAS 62647-2.

Control level 1 – No controls on Pb-free tin finishes.

Control levels 2A, 2B, 2C – Some controls on Pb-free tin finishes.

Control level 3 – Prohibition on Pb-free tin finishes.

Manufacturers should use the IEC/PAS 62647-2 (GEIA-STD-0005-2) or IEC/TS 62647-2 that will supersede IEC/PAS 62647-2, to determine the appropriate control level based on equipment criticality. The tin whisker considerations in Figure C.3 are tailored based on the requirements of each tin whisker control level.

C.4.2.3.2 Control level 1

This level has no restrictions on the use of Pb-free tin.

C.4.2.3.3 Control level 2A

Use of Pb-free tin finish without explicit controls is acceptable under most circumstances. Pb-free tin finish may be prohibited in some specific circumstances called out in contractual documents.

C.4.2.3.4 Control 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.

C.4.2.3.5 Control level 2C

Pb-free tin finish is prohibited unless an exception with customer approval is made. Specific instructions on use of Pb-free tin finish and required control measures are to be provided and reviewed on a case-by-case basis. Refer to IEC/PAS 62647-2 (GEIA-STD-0005-2) or IEC/TS 62647-2 that will supersede IEC/PAS 62647-2 for the required number of mitigation methods.

C.4.2.3.6 Control level 3

Use of Pb-free tin finish is prohibited and measures should be taken to verify compliance.

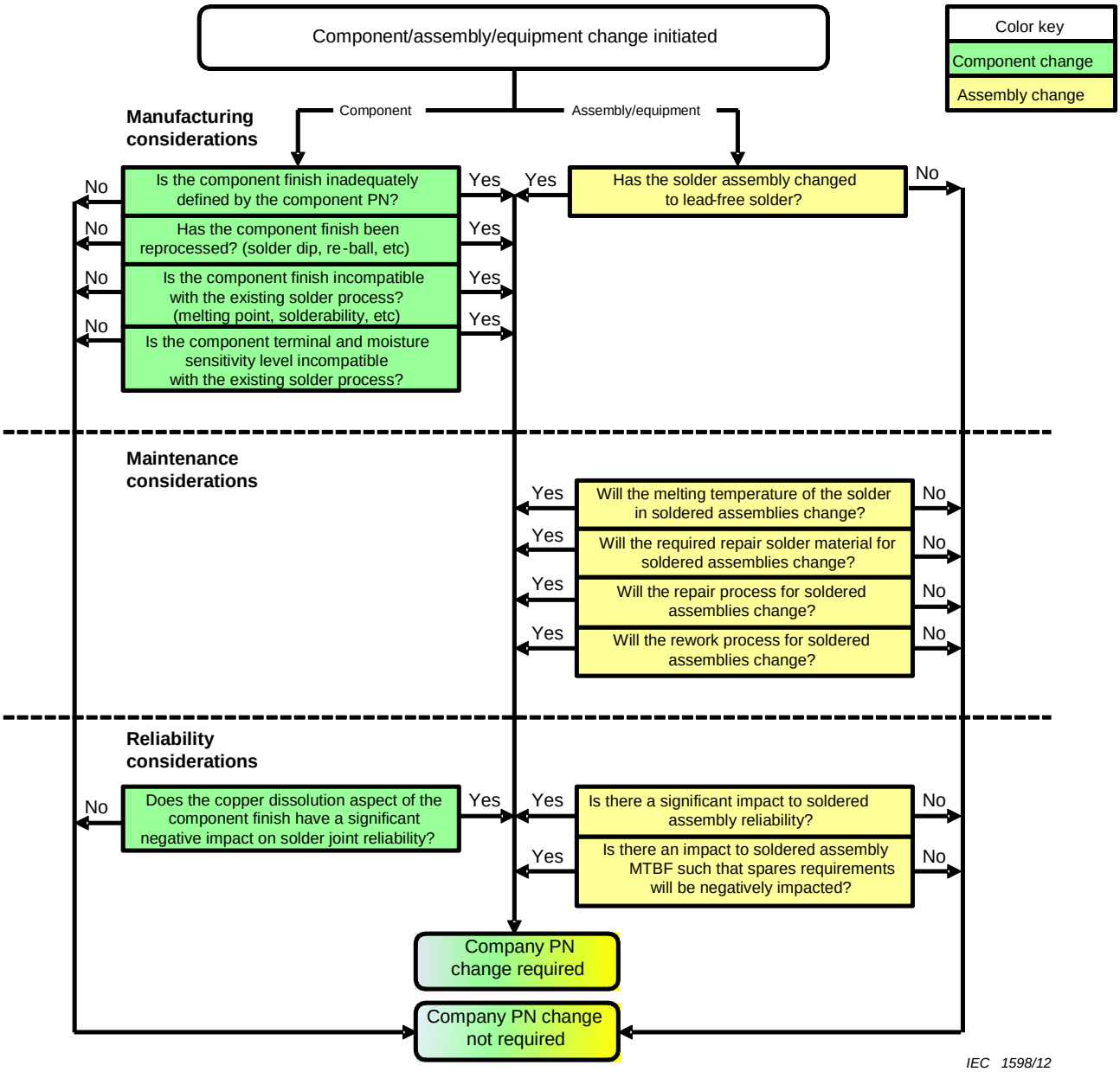

Figure C.2 – Manufacturing, maintenance and reliability considerations

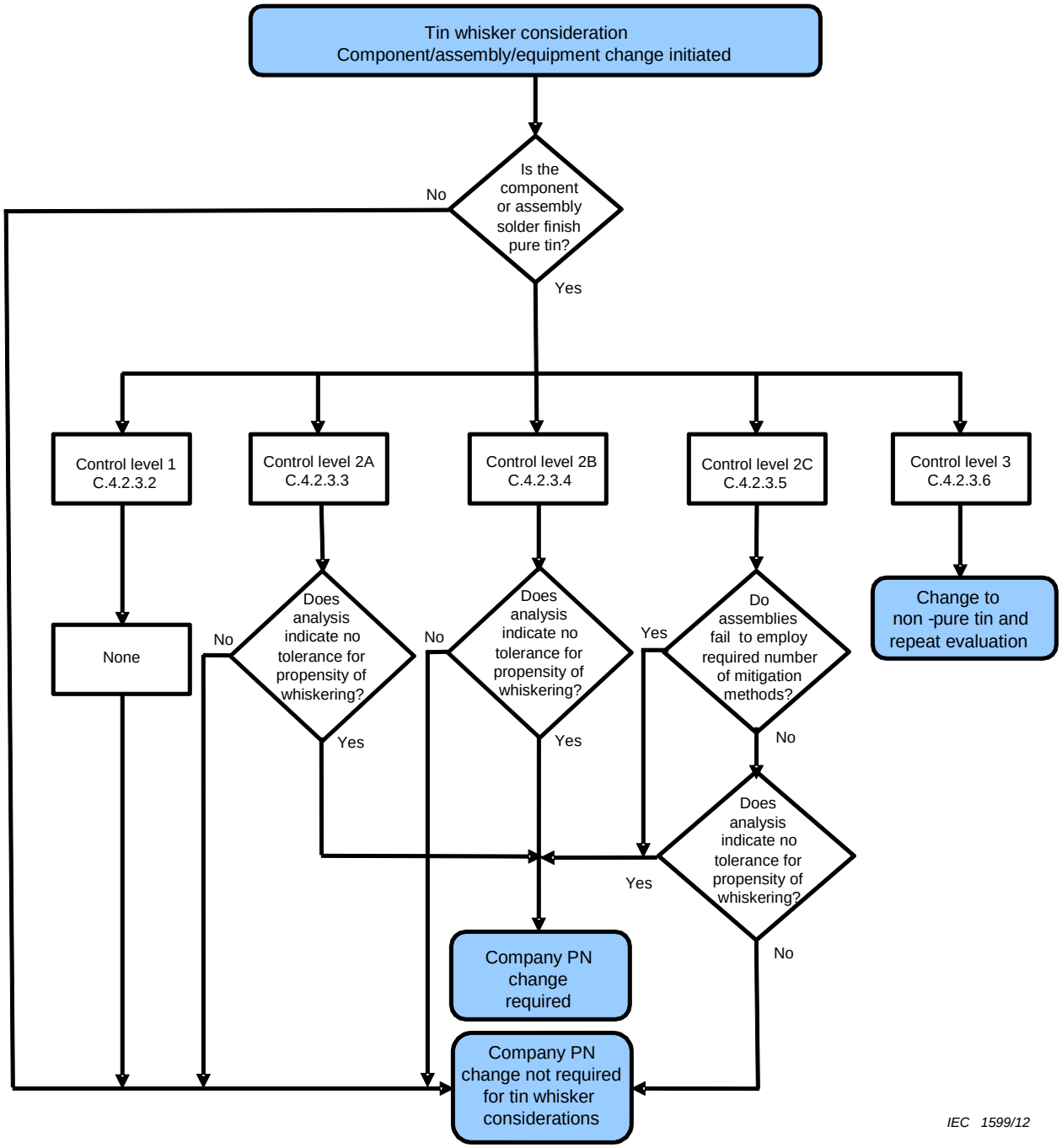

Figure C.3 – Tin whisker considerations

C.4.3 Product identification

In order to properly manage equipment configuration, users should be able to distinguish Pb-free assemblies from assemblies containing Pb without resorting to detailed research. To enable easy identification of equipment configuration, the following should be considered.

- A mixed technology LRU, containing Pb-based and Pb-free soldered assemblies, should have a change in part number from the original configuration unless it can be shown form, fit and function remain unchanged per the decision flow charts.
- A mixed technology Pb-based soldered assembly, containing Pb-based and Pb-free components should have no change in part number from the original configuration where form, fit and function remain unchanged per the decision flow charts.

- Pb-free soldered assemblies should have unique part numbers, from the equivalent mixed technology assemblies.
- Pb-free assemblies may also have additional labelling for Pb-free. IPC/JEDEC J-STD-609 contains acceptable methods for labelling Pb-free assemblies. Labelling should not be used in lieu of unique part number identification, and, if present, is there as a visual aid to the user.

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[5] It is the intention of the technical committee to supersede this by a future IEC/TS 62647-3.

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

3, rue de Varembé
PO Box 131
CH-1211 Geneva 20
Switzerland

Tel: + 41 22 919 02 11
Fax: + 41 22 919 03 00
info@iec.ch
www.iec.ch