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TECHNICAL SPECIFICATION

colour inside

Process management for avionics – Aerospace and defence electronic systems containing lead-free solder – Part 2: Mitigation of deleterious effects of tin

IEC/TS 62647-2:2012(E)

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

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

IEC/TS 62647-2, which is a technical specification, has been prepared by IEC technical committee 107: Process management for avionics.

The text of this technical specification is based on the following documents: IEC/PAS 62647-2 and GEIA-STD-0005-2 Revision A.

This technical specification cancels and replaces IEC/PAS 62647-2.

A list of all the parts in the IEC 62647 series, published under the general title *Process management for avionics – Aerospace and defence electronic systems containing lead-free solder*, can be found on the IEC website.

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

Enquiry draft	Report on voting
107/160/DTS	107/193/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.

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- withdrawn,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.

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INTRODUCTION

Due to a variety of real and potential health issues, many constituent materials used in the production of electronic products have come under scrutiny. The European Union (EU) has enacted two directives: 2002/95/EC Restriction of Hazardous Substances (RoHS) and 2002/96/EC Waste Electrical and Electronic Equipment (WEEE) that restrict or eliminate the use of various substances in a variety of products produced after July 2006. One of the key materials restricted is lead (Pb), which is widely used in electronic solder and electronic piece part terminations, and printed wiring boards. While these regulations may appear to only affect products for sale in the EU, due to the reduced market share of the aerospace, defence, and high performance industry in electronics, many of the lower tier suppliers are changing their products because their primary market is world-wide consumer electronics. Additionally, several Asian countries and United States (U.S.) states have enacted similar “green” laws. Many Asian electronics manufacturers have recently announced completely “green” product lines.

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

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

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

Part 2: Mitigation of deleterious effects of tin

1 Scope

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

This Technical Specification is applicable to aerospace, defence, and high performance (ADHP) electronic applications which procure equipment that may contain Pb-free tin finishes.

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/TS 62647-1:2012, *Process management for avionics – Aerospace and defence electronic systems containing lead-free solder – Part 1: Preparation for a lead-free control plan*[1]

IEC/PAS 62647-3, *Process management for avionics – Aerospace and defence electronic systems containing lead-free solder – Part 3: Performance testing for systems containing lead-free solder and finishes*[2]

IEC/PAS 62647-21, *Process management for avionics – Aerospace and defence electronic systems containing lead-free solder – Part 21: Program management – Systems engineering guidelines for managing the transition to lead-free electronics*[3]

IEC/PAS 62647-22, *Process management for avionics – Aerospace and defence electronic systems containing lead-free solder – Part 22: Technical guidelines*[4]

ANSI/GEIA-STD-0006, *Requirements for using solder dip to replace the finish on electronic piece parts*

ANSI Z1.4, *Sampling procedures and tables for inspection by attributes*

IPC J-STD-001, *Requirements for soldered electrical and electronic assemblies*

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1 Previously known as GEIA-STD-0005-1.

2 Previously known as GEIA-STD-0005-3. IEC/PAS 62647-3 is in the process of being revised and will be issued as IEC/TS 62647-3.

3 Previously known as GEIA-HB-0005-1. IEC/PAS 62647-21 is in the process of being revised and will be issued as IEC/TS 62647-21.

4 Previously known as GEIA-HB-0005-2. IEC/PAS 62647-22 is in the process of being revised and will be issued as IEC/TS 62647-22.

IPC-CC-830, *Qualification and performance of electrical insulating compounds for printed wiring assemblies*

JESD201, *Environmental acceptance requirements for tin whisker susceptibility of tin and tin alloy surface finishes*

JESD213, *Standard test method utilizing X-ray fluorescence (XRF) for analyzing component finishes and solder alloys to determine Tin (Sn) – Lead (Pb) content*

MIL-STD-1580, *Destructive physical analysis for electronic, electromagnetic, and electromechanical parts*

3 Terms, definitions and abbreviations

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

3.1 Terms and definitions

3.1.1
assemblies
electronic items that require electrical attachments, including soldering of wires or component terminations

EXAMPLE Circuit cards and wire harnesses.

[SOURCE: IEC/TS 62647-1:2012, 3.1]

3.1.2
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

[SOURCE: IEC/TS 62647-1:2012, 3.2]

3.1.3
control level
amount of attention that should be paid to the risk of tin whiskers (i.e., no restrictions on tin use, some restrictions on tin use, and prohibition of tin use)

3.1.4
conformal coat
insulating protective covering that conforms to the configuration of the objects coated (e.g., printed boards, printed board assembly) providing a protective barrier against deleterious effects from environmental conditions

3.1.5
COTS
commercial-off-the-shelf
item whose design and configuration is controlled by the manufacturer and on which the user has no control with regard to the design and configuration

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

3.1.6
COTS assemblies or sub-assembly
assembly or sub-assembly developed by a supplier for multiple customers, whose design and configuration is managed by the suppliers or an industry specification

[SOURCE: IEC/TS 62647-1:2012, 3.4]

3.1.7
customer
entity or organization that (a) integrates a piece part, soldered assembly, unit, or system into a higher control level system, (b) operates the higher control level system, or (c) certifies the system for use

EXAMPLE This may include end item users, integrators, regulatory agencies, operators, original equipment manufacturers (OEMs), and subcontractors.

[SOURCE: IEC/TS 62647-1:2012, 3.5]

3.1.8
EDS
energy dispersive (X-ray) spectroscopy
method for material composition analysis

3.1.9
encapsulation
process which involves the surrounding of (a) component(s) or an assembly with a liquid resin

3.1.10
gap
minimum line of sight distance between tin surface and the nearest adjacent conductor at a different potential.

Note 1 to entry: It refers to any conductors (leads, pads, connectors, contacts, or others).

3.1.11
high voltage
voltage level required to cause a plasma event

3.1.12
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.

[SOURCE: IEC/TS 62647-1:2012, 3.7]

3.1.13
lead-free
defined as less than 0,1 % by weight of lead in accordance with reduction of hazardous substances(RoHS) guidelines guidelines

[SOURCE: IEC/TS 62647-1:2012, 3.8]

3.1.14
mitigation
method to reduce the risk or consequence of a whisker failure over a period of several years.

Note 1 to entry: This does not imply that the risk is driven to zero, simply that the risk or consequence is reduced in some significant way.

3.1.15
Pb-free tin
pure tin or any tin alloy with < 3 % lead (Pb) content by weight

Note 1 to entry: Some Pb-free finishes other than pure 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 behaviour.

[SOURCE: IEC/TS 62647-1:2012, 3.11]

3.1.16
Pb-free tin finish
final finishes or underplates either external or internal to a device, board 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 boards. 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 (consistent with GEIA-STD-0006).

[SOURCE: IEC/TS 62647-1:2012, 3.12]

3.1.17
plasma event
destructive arcing event that can occur at altitudes from sea level to space depending on voltage and current levels

3.1.18
piece part
piece component
electronic component that is not normally disassembled without destruction and is normally attached to a printed wiring board to perform an electrical function

[SOURCE: IEC/TS 62647-1:2012, 3.14]

3.1.19
potting
encapsulation process which involves the surrounding of a component(s) or an assembly in a container with a liquid resin which is then cured in place

Note 1 to entry: The container usually becomes an integral part of the system such that the critical property that needs to be maintained is the interfacial adhesion between the cured resin system and the container substrate and critical components for an optimum long-lasting reliable package.

3.1.20
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.

[SOURCE: IEC/TS 62647-1:2012, 3.16]

3.1.21
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

[SOURCE: IEC/TS 62647-1:2012, 3.17]

3.1.22
risk
probability of a failure due to a tin whisker

Note 1 to entry: It is not used with regards to the risk of the presence of a whisker or nodule.

3.1.23
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

[SOURCE: IEC/TS 62647-1:2012, 3.22]

3.1.24
supplier
refers to an entity or organization that designs, manufactures, repairs, or maintains a piece part, unit, or system

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

[SOURCE: IEC/TS 62647-1:2012, 3.23]

3.1.25
system
one or more units that perform electrical function(s)

[SOURCE: IEC/TS 62647-1:2012, 3.24]

3.1.26
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).

[SOURCE: IEC/TS 62647-1:2012, 3.26]

3.1.27
unit
one or more assemblies within a chassis or higher level system to perform electrical function(s)

[SOURCE: IEC/TS 62647-1:2012, 3.27]

3.1.28
XRF
X-ray fluorescence
method for material composition analysis

3.2 Abbreviations

ADHP	Aerospace, defence and high performance
COTS	Commercial off the shelf
EDX	Energy-dispersive X-ray spectroscopy
FMEA	Failure mode effects analysis
FMECA	Failure mode effects and criticality analysis
FOD	Foreign object damage
IMC	Intermetallic compound
iNEMI	international Electronics Manufacturing Initiative

JEDEC	Joint Electron Device Engineering Council
MEMS	Micro-electro mechanical systems
OEM	Original equipment manufacturer
OSD	Odd-shaped eruptions
Pb	Lead
PLCC	Plastic leaded chip carrier
PQFP	Plastic quad flat pack
QFP	Quad flat pack
REE	Rare earth elements
SEM	Scanning electron microscope
Sn	Tin
Sn-Pb	Tin/lead
SOIC	Small outline integrated circuit
TQFP	Thin quad flat pack
TSOP	Thin small outline package
XRF	X-ray fluorescence

4 Technical requirement

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

This specification is intended to be used in concert with IEC/TS 62647-1, IEC/PAS 62647-21, and IEC/PAS 62647-22. This specification may be referenced in proposals, requests for proposals, work statements, contracts, and other documents. It may be used as a stand-alone specification or as part of compliance with IEC/TS 62647-1.

This specification addresses the risk of tin whiskers. However, the state of research into tin whisker risk still does not allow accurate quantitative estimates of the risk and reliability. It defines three baseline control levels that detail the amount of attention that should be paid to the risk of tin whiskers: no restrictions on tin use, some restrictions on tin use, and prohibition of tin use.

There are five informative annexes in this specification:

– Annex A provides guidance on selecting control levels and performing risk assessments;
– Annex B provides some background on various mitigation methods;
– Annex C provides guidelines for performing tin whisker inspections;
– Annex D provides some additional guidance on tin whisker risk analyses;
– Annex E provides information on whiskers growing from bulk solder and joints.

4.1 Control level requirements

4.1.1 General

The supplier shall clearly state the control levels and shall document agreement by the customer in appropriate requirement or lead-free control plan documents. Customers are responsible for determining the control level they are seeking and identify it in their request for proposal and contract when this specification is imposed.

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

In particular, it is recommended that the selection of control level involves consideration of the following questions:

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

More information on how these questions can be used to select an appropriate control level is provided in Annex A.

Overall, there are three approaches to tin whisker control:

– tin part avoidance;
– whisker risk mitigation;
– whisker risk acceptance.

Different control levels represent different emphasis on each of these approaches.

Control level 1: Under control level 1 tin whisker risks are accepted. It is expected that this control level will primarily apply to developmental models, test equipment, and other units that will not be fielded.

Control level 2: Under control level 2, Pb-free tin is sometimes acceptable. Tin whisker risk is managed primarily by a combination of design rules, mitigations, and avoidance. The sub-control level under control level 2 determines the emphasis given to each of these strategies. If only control level 2, with no sub-control level, is identified in a control document, the default level shall be assumed to be control level 2A.

Control level 2A: Under level 2A, tin whisker risks are managed primarily through the acceptance of tin whisker risk, and to a lesser extent upon the use of design rules. This control level was designed primarily for lower criticality applications. Tin is permitted for use in all applications except where specially restricted.

Control level 2B: Under control level 2B, tin whisker risks are managed primarily through the use of design rules, and to a lesser extent upon tin avoidance. This control level was primarily designed for non-critical boards or units or boards and units with good redundancy used in systems with moderate to high failure consequences.

Control level 2C: Under control level 2C, tin whisker risks are managed primarily by tin avoidance, and in exceptional cases, by design rules. This control level was primarily designed for critical boards with limited redundancy used in systems with moderate to high failure consequences.