PD IEC/TS 62647-23:2013

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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

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee GEL/107, Process management for avionics.

A list of organizations represented on this committee can be obtained on request to its secretary.

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colour inside

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

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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

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 62647-23, which is a technical specification, has been prepared by IEC technical committee 107: Process management for avionics.

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The text of this technical specification is based on the following document: IEC/PAS 62647-23[1].

This technical specification cancels and replaces IEC/PAS 62647-23, published in 2011. This edition constitutes a technical revision.

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

a) Coherence with IEC/TS 62647-1, IEC/TS 62647-2 and IEC/TS 62647-21 definitions.

b) Reference to IEC 62647 documents when already published.

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

Enquiry draft	Report on voting
107/206/DTS	107/219/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 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 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.

[1] IEC/PAS 62647-23, which served as a basis for the present document, is also known as GEIA-HB-0005-3.

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INTRODUCTION

0.1 General

The global transition to lead-free (Pb-free) electronics impacts the aerospace, defence and high performance (ADHP) industry and other industries having high reliability applications in various ways.

This document is intended to facilitate the development of procedures and processes for use when undertaking the rework/repair of aerospace, defence, and high performance (ADHP) electronics systems. It is intended to contain sufficient information to support the processing of equipment that incorporates either tin-lead (Sn-Pb) or lead-free (Pb-free) solder alloy, Sn-Pb or lead-free (Pb-free) piece parts and printed circuit board (PCB)/printed wiring board (PWB) finishes, or a combination thereof.

This document may be used by original equipment manufacturers (OEMs), contract manufacturers (CMs) and commercial depots. This document may also be used by personnel performing rework/repair at the organizational (O) level, intermediate (I) back shop level, and depot (D) overhaul level.

0.2 Pb-free and legislation

Recent directives and legislation by nations around the world mandated elimination of lead and other hazardous material usage in sectors of the electronics industry by 2006. In electronics, lead (Pb) has been a primary component of tin-lead (Sn-Pb) solder used in piece part attachment and PCB/PWB finishes for over 50 years, and more recently in the solder spheres for attachment of ball grid array (BGA) packages. Since there is no “drop-in” replacement for Sn-Pb solder alloys, multiple Pb-free alloys have emerged in the manufacturing industry as replacements. These multiple replacement alloys are being used in printed circuit boards (PCBs)/printed wiring boards (PWBs) finish, piece part termination finish and as solder alloys, leaving the rework/repair technician with literally hundreds of possible combinations of metallurgy in the finished repair.

The majority of the Pb-free alloys being considered have melting temperatures 34 °C to 44 °C (61 °F to 79 °F) higher than that of tin-lead (Sn-Pb) eutectic solder. These higher Pb-free processing temperatures require significant changes to convective rework/repair procedures and minor adjustments in conductive hand soldering procedures to ensure that quality products will be produced.

Another major concern is the potential re-emergence of tin whiskers as an additional equipment failure mechanism. Tin whiskers are electrically conductive, crystalline structures of tin (Sn) that grow under compressive force from surfaces where tin (Sn) (especially electroplated tin (Sn)) is used as a final finish. Tin whiskers have been observed to grow to lengths of several millimeters (mm). Numerous electronic system failures have been attributed to short circuits caused by tin whiskers that bridge closely-spaced circuit elements. Tin whiskers have been successfully suppressed for decades by the addition of lead (Pb) to tin (Sn) plating used in high reliability applications. With the global shift to Pb-free solders, tin whiskers have re-emerged as a major concern to reliability. IEC/TS 62647-2:2012 further discusses tin whisker issues and mitigation techniques.

Procedurally, conductive Pb-free rework/repair is similar to that of Sn-Pb. However, adjustments should be made to accommodate the generally poorer wetting ability of Pb-free solders as well as differences in appearance and inspection criteria. Convective rework/repair will require redevelopment of profiles to accommodate the higher melting temperature of Pb-free alloys. Also, Pb-free rework/repair has a tighter process window leaving a smaller margin

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for error in comparison to Sn-Pb. With the proper materials, preparation, skill, and the use of fundamentally sound procedures, Pb-free rework/repair can be successfully and reliably accomplished [28][2].

2 Numbers in square brackets refer to the Bibliography.

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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

1 Scope

This part of IEC 62647 provides technical background, procurement guidance, engineering procedures, and guidelines to assist organizations reworking/repairing aerospace and high performance electronic systems, whether they were assembled or previously reworked/repaired using traditional alloys such as Sn-Pb or Pb-free alloys, or a combination of both solders and surface finishes. This document contains a review of known impacts and issues, processes for rework/repair, focused to provide the technical structure to allow the repair technician to execute the task.

This document focuses on the removal and replacement of piece parts. For the purposes of this document, the term “rework/repair” is used as defined in 3.1.29 and 3.1.30.

The information contained within this document is based on the current knowledge of the industry at the time of publication. Due to the rapid changing knowledge base, this document should be used for guidance only.

NOTE 1 For the purposes of this document, if the element “lead” is implied, it will be stated either as Pb, as lead (Pb), or as tin-lead. If a piece part terminal or termination “lead” is referred to, such as in a flat pack or a dual-inline package, the nomenclature lead/terminal or lead-terminal will be used.

NOTE 2 Processes identified in the document apply to either rework or repair.

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 electronics systems containing lead free solder – Part 1: Preparation for a lead-free control plan*

IEC/TS 62647-2:2012, *Process management for avionics – Aerospace and defence electronic systems containing lead-free solder – Part 2: Mitigation of deleterious effects of tin*

IEC/TS 62647-22:2013, *Process management for avionics – Aerospace and defence electronic systems containing lead-free solder – Part 22: Technical guidelines*

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3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

3.1.1
alloy composition
whole ingredients of an alloy whose weight is defined in percent

Note 1 to entry: For instance 63Sn-37Pb corresponds to a mixture of 63 % by weight of tin (Sn) and 37 % by weight of lead (Pb).

[SOURCE: IEC/TS 62647-22:2013, 3.1.1]

3.1.2
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]

3.1.3
backwards compatibility
Pb-free materials compatible with an Sn-Pb process

3.1.4
CTE
coefficient of thermal expansion
degree of expansion of a material divided by the change in temperature

Note 1 to entry: PCB/PWB CTE (x-y axis) is measured in the direction in the plane of the piece part mounting surface and is used to quantify the stresses in the solder joint arising from the differences in CTE between the piece parts and the PCB/PWB during thermal cycling. CTE (z axis) is measured in the “thickness” direction and is typically used to quantify plated through hole stress.

[SOURCE: IEC/TS 62647-22:2013, 3.1.8]

3.1.5
conductive
use of a contact heat source such as a soldering iron, hot bar, or resistance to transfer heat to the assembly

3.1.6
convective
use of a non-contact heat source, usually heated air, nitrogen or infrared light to transfer heat to the assembly

3.1.7
copper dissolution
excessive loss of copper from plated through hole barrels and pads caused by wave or solder fountain processing primarily with high tin (Sn) content solders

3.1.8
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

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

3.1.9
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]

3.1.10
delamination
separation between plies within a base material, between a base material and a conductive foil, or any other planar separation with a printed board that may propagate under thermal stress

3.1.11
D
depot level maintenance
maintenance requiring major overhaul or a complete rebuilding of parts, assemblies, subassemblies, and end items, including the manufacture of parts, modifications, testing, and reclamation as required.

Note 1 to entry: Depot maintenance serves to support lower categories of maintenance by providing technical assistance and performing that maintenance beyond their responsibility.

3.1.12
dissolution
process in which one substance is dissolved in another by chemical action

3.1.13
eutectic
mixture of two or more metals at a composition that has the lowest melting point, and where the phases simultaneously crystallize from molten solution at this temperature

Note 1 to entry: A non-eutectic mixture will exhibit a pasty range during cooling where both liquid and solid phases are present prior to reaching the mixture's solidus temperature.

[SOURCE: IEC/TS 62647-22:2013, 3.1.12]

3.1.14
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]

3.1.15
I
intermediate level maintenance
repair operation of aircraft and engine components, WRAs, and LRUs forwarded to the intermediate level by the organizational level flight-line activities

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Note 1 to entry: This consists either in limited repair operation of commodity-orientated piece parts and end items, job shop, bay, and production line operations for special mission requirements or in repair of printed circuit boards (PCBs)/printed wiring boards (PWBs), software maintenance, and fabrication or manufacture of repair parts, assemblies, piece parts. WRA and LRU repair is accomplished by the removal, troubleshooting, and replacement of faulty SRA and SRU, pieces, and parts within the WRA/LRU.

3.1.16
lead-free
Pb-free
less than 0,1 % by weight of lead (Pb) in accordance with reduction of hazardous substances (RoHS) guidelines

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

3.1.17
lead-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

[SOURCE: IEC/TS 62647-1:2012, 3.9]

3.1.18
liquidus
minimum temperature at which all components of a mixture (such as an alloy) can be in a liquid state

Note 1 to entry: Below liquidus, the mixture will be partly or entirely solid.

3.1.19
measling
condition that occurs in laminated base material in which internal glass fibers are separated from the resin at the weave intersection

Note 1 to entry: This condition manifests itself in the form of discrete white spots or "crosses" that are below the surface of the base material.

3.1.20
organization
organizational structure typically consisting of program management, procurement, process engineering, bench technicians, and quality assurance personnel

3.1.21
O
organizational level maintenance
maintenance normally performed by an operating unit on a day-to-day basis in support of its own operations

Note 1 to entry: Organizational level maintenance typically includes "inspections", "servicing", "handling" and "preventive maintenance" and is limited to the replacement of electronic assemblies at the WRA and LRU (black box) level of major aircraft and engine components. There can be an exception when troubleshooting and piece parts level repair are accomplished at the organizational level.

3.1.22
Pb-free tin
pure tin or any tin alloy with < 3 % lead (Pb) content by weight

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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]

3.1.23
Pb-free tin finish
final finishes or under-plates 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.

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

3.1.24
PCB
printed circuit board
PWB
printed wiring board
substrate using conductive pathways, tracks or signal traces etched from copper sheets laminated, and allowing to connect electrically a set of electronic components to realize a circuit card.

[SOURCE: IEC/TS 62647-21:2013, 3.1.10]

3.1.25
piece part
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]

3.1.26
procurement
process of obtaining services, supplies, and equipment

3.1.27
PTH
plated through hole
plated through holes used on printed circuit boards (PCBs)/printed wiring boards (PWBs) for interconnecting between layers and for component attachment

[SOURCE: IEC/TS 62647-22:2013, 3.1.26]

3.1.28
quality assurance
planned and systematic set of activities to ensure that requirements are clearly established and that the defined process or product complies with these requirements

3.1.29
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]

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3.1.30
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]

3.1.31
SAC
family of Pb-free alloys containing tin, silver and copper used in surface mount technology or sometimes in wave solder processes

Note 1 to entry: The alloys typically have a composition near the eutectic (95,6Sn-3,5Ag-0,9Cu)

[SOURCE: IEC/TS 62647-22:2013, 3.1.29]

3.1.32
SRA
shop replaceable assembly
SRU
shop replaceable unit
component assembly inside a black box (LRU or WRA) typically consisting of individually replaceable circuit card assemblies

3.1.33
Sn-Cu
solder or alloy referring to Pb-free alloys that are comprised of tin-copper (Sn-0,7Cu)

[SOURCE: IEC/TS 62647-22:2013, 3.1.32]

3.1.34
Sn-Cu-Ni
solder or alloy referring to tin-copper with nickel trace (Sn-0,7Cu-0,05Ni)

Note 1 to entry: Some formulations also include other minor additions such as germanium (Ge).

[SOURCE: IEC/TS 62647-22:2013, 3.1.33]

3.1.35
Sn-Pb
solder generally referring to the family of tin-lead alloys at or near the eutectic composition with or without silver added (Sn-37Pb, Sn-40Pb, or Sn-36Pb-2Ag)

[SOURCE: IEC/TS 62647-22:2013, 3.1.34]

3.1.36
soldered assembly
assembly of two or more basic parts interconnected by a solder alloy

Note 1 to entry: A lead (Pb)-based soldered assembly is one in which the solder alloys are solely lead (Pb)-based. A lead-free soldered assembly is one in which the solder alloys are solely lead-free.

[SOURCE: IEC/TS 62647-22:2013, 3.1.36]

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