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PUBLICLY AVAILABLE SPECIFICATION

PRE-STANDARD

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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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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

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IEC-PAS 62647-23 has been processed by IEC technical committee 107: Process management for avionics.

The text of this PAS is based on the following document:	This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document
Draft PAS	**Report on voting**
107/132/PAS	107/140A/RVD

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This PAS is based on GEIA-HB-0005-3 and is published as a double logo PAS. GEIA, Government Electronics and Information Technology Association, has been transformed into TechAmerica Association.

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INTRODUCTION

0.1 General

This PAS is intended to facilitate the development of procedures and processes for use when undertaking the rework/repair of Aerospace and High Performance (AHP) electronics systems. It is intended to contain sufficient information to support the processing of equipment that incorporates either Tin-Lead (SnPb) or Lead-Free (Pb Free) solder alloy, SnPb or Pb-Free piece parts and printed wiring board finishes, or a combination thereof.

This PAS 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.

The purpose of this Working Group is to generate a series of industry standards and documents intended to facilitate the maintenance of suitable equipment quality and reliability standards within the AHP industries during the general industry migration to Pb-Free.

This PAS is intended to work in concert with IEC/PAS 62647-1 (GEIA-STD-0005-1), IEC/PAS 62647-2 (GEIA-STD-0005-2), and IEC/PAS 62647-21 (GEIA-HB-0005-1).

This PAS may be referenced in proposals, requests for proposals, work statements, contracts, and other aerospace and high performance industry documents.

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 (SnPb) solder used in piece part attachment and 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 SnPb solder alloys, multiple Pb-Free alloys have emerged in the manufacturing industry as replacements. These multiple replacement alloys are being used in Printed Wiring Boards (PWB) / Printed Circuit Boards (PCB) 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 61 °F to 79°F (34 °C to 44 °C) higher than that of SnPb 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 Sn that grow under compressive force from surfaces where Sn [especially electroplated 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 Pb to 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/PAS 62647-2 (GEIA-STD-0005-02) further discusses Tin Whisker issues and mitigation techniques.

This document will provide guidance to the organization performing rework/repair on various combinations of SnPb, Pb-Free and mixed technology assemblies likely to be seen as the global transition to Pb-Free solder continues. The organization typically consists of program

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management, procurement, process engineering, bench technician, and quality assurance personnel.

Procedurally, conductive Pb-Free rework/repair is similar to that of SnPb. However, adjustments must 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 for error in comparison to SnPb. With the proper materials, preparation, skill, and the use of fundamentally sound procedures, Pb-Free rework/repair can be successfully and reliably accomplished[1].

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1 http://www.solder.net/leadfreerepair.asp

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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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1 Scope

This PAS 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 SnPb or Pb-Free alloys, or a combination of both solders and surface finishes. This PAS 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 PAS focuses on the removal and replacement of piece parts. For the purposes of this PAS, the term “Rework/Repair” is used as applicable.

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

2 Normative references

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

IEC/PAS 62647-1, *Process management for avionics – Aerospace and defence electronics systems containing lead free solder – Part 1: Lead-free management*

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

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

IEC/PAS 62647-22, *Process management for avionics – Aerospace and defence electronic systems containing lead-free solder – Part 21: Technical guidelines*

GEIA-STD-0005-1, *Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-free Solder*

GEIA-STD-0005-2, *Standard for mitigating the effects of tin in aerospace and high performance electronic systems*

GEIA-HB-0005-1, *Program management / Systems engineering guidelines for managing the transition to lead-free electronics*

GEIA-HB-0005-2, *Technical guidelines for aerospace and high performance electronic systems containing lead-free solder*

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3 Terms and definitions

For purposes of this PAS, the following terms and definitions apply:

3.1
alloy composition
is stated as weight in percent. For instance 63Sn-37Pb corresponds to a mixture of 63 % by weight of Tin (Sn) and 37 % by weight of Lead (Pb)

3.2
assemblies
are electronic items that require electrical attachments, including soldering of wires or piece part terminations; examples include circuit cards and wire harnesses

3.3
backwards compatibility
refers to Pb-Free materials compatible with a SnPb process

3.4
ball grid array
BGA
is a surface mount package type that uses a grid of solder balls arranged in an array to provide direct electrical interconnection between the part substrate and the circuit board

3.5
coefficient of thermal expansion
CTE
is the linear dimensional change of a material per unit change in temperature

3.6
conductive
refers to the use of a contact heat source such as a soldering iron, hot bar, or resistance to transfer heat to the assembly

3.7
convective
refers to the use of a non-contact heat source usually heated air, Nitrogen or infrared light to transfer heat to the assembly

3.8
copper dissolution
is the 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

3.9
critical
item or function, if defective, will result in the system's inability to retain operational capability, meet primary objective, or affect safety

3.10
customer
refers to an entity or organization that (a) integrates a piece part, soldered assembly, unit, or system into a higher level system, (b) operates the higher level system, or (c) certifies the system for use. For example, this may include end item users, integrators, regulatory agencies, operators, original equipment manufacturers (OEMs), and Subcontractors

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3.11
delamination
is a 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

3.12
depot level maintenance
D
is 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. Depot maintenance serves to support lower categories of maintenance by providing technical assistance and performing that maintenance beyond their responsibility

3.13
dissolution
is the process in which one substance is dissolved in another by chemical action

3.14
electroless nickel / immersion gold
ENIG
is a two technology process for the application of a desired finish where Nickel is applied using Electroless plating, requiring the presence of a proper reducing agent in a plating bath that converts the metal salts into metal and deposits them onto the substrate. The immersion plating process deposits a new metal surface (Gold) by replacing the base metal; in this process, plating stops when the surface of the base metal is completely covered, thus only a limited coating thickness can be obtained through the immersion process. The control of the kinetics associated with both processes is vital to plating results

3.15
eutectic *(Solder)*
is the alloy composition at which a solder alloy melts/freezes completely without going through a pasty (partially solid) phase

3.16
high performance system
requires continued performance or performance on demand, or equipment down time cannot be tolerated, or end-use environment may be uncommonly harsh, and the equipment must function when required, such as life support or other critical systems

3.17
intermediate level maintenance
I
includes limited repair of commodity-orientated piece parts and end items, job shop, bay, and production line operations for special mission requirements; repair of printed circuit boards, software maintenance, and fabrication or manufacture of repair parts, assemblies, piece parts. Intermediate maintenance consists of repair of aircraft and engine components, WRAs, and LRUs forwarded to the Intermediate level by the organizational level flight-line activities. WRA and LRU repair is accomplished by the removal, troubleshooting, and replacement of faulty SRA and SRU, pieces, and parts within the WRA/LRU

3.18
lead
Pb
in this PAS, if the element “Lead” is implied, it will be stated as either Pb or as Lead (Pb)

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3.19
lead-free
Pb-Free
is defined as less than 0,1 % by weight of Pb in accordance with Waste Electrical and Electronic Equipment (WEEE) guidelines

3.20
lead-free control plan
LFCP
refers to an aerospace or military system Supplier's document that defines the processes that assure the plan owners, their Customers, and all other stakeholders that aerospace and high performance high-reliability electronics systems containing Pb-Free solder will continue to be reliable, safe, producible, affordable, and supportable. Technical guidance for a LFCP can be found in IEC/PAS 62647-21 (GEIA-HB-0005-1)

3.21
line replaceable unit
LRU
is a black box of electronics removed and replaced at the flight-line level

3.22
liquidus
is the minimum temperature at which all components of a mixture (such as an alloy) can be in a liquid state. Below liquidus, the mixture will be partly or entirely solid

3.23
measling
is a condition that occurs in laminated base material in which internal glass fibers are separated from the resin at the weave intersection. This condition manifests itself in the form of discrete white spots or "crosses" that are below the surface of the base material

3.24
organic solderability preservative
OSP
is a thin organic compound that selectively bonds with Copper (Cu) used to preserve the solderability of bare Cu on printed wiring boards (PWB's)

3.25
organizational level maintenance
O
is maintenance normally performed by an operating unit on a day-to-day basis in support of its own operations. Organizational-level maintenance typically includes "inspections," "servicing," "handling," and "preventive maintenance" and is limited to the replacement of electronics assemblies at the WRA and LRU (black box) level of major aircraft and engine components. There can be an exception is where troubleshooting and piece parts level repair are accomplished at the Organizational level

3.26
Pb-Free tin
is any Tin alloy with <3 % Lead (Pb) content by weight. This means that 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 document. Many of these alloys have not been assessed for whiskering behavior

3.27
Pb-Free tin finish
is Pb-Free Tin final finishes or underplating either external or internal to a device, PWB, or other hardware. This includes all terminations and surfaces, even those coated, encapsulated, or otherwise not exposed. It may include finishes on electrical piece parts

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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

3.28
piece part
is an electronic component that is not normally disassembled without destruction and is normally attached to a printed wiring board to perform an electrical function

3.29
procurement
is the process of obtaining services, supplies, and equipment

3.30
plated-through-hole
PTH
is a Cu-plated hole in a circuit board used to accommodate a through-hole piece part termination

3.31
quality assurance
is a planned and systematic set of activities to ensure that requirements are clearly established and that the defined process or product complies with these requirements

3.32
repair
is the act of restoring the functional capability of a defective article in a manner that precludes compliance of the article with applicable drawings or specifications

3.33
rework
is the act of reprocessing non-complying articles, through the use of original or equivalent processing in a manner that assures full compliance of the article with applicable drawings or specifications

3.34
rework/repair
is the term used in this PAS where the processes identified apply to either rework or repair

3.35
SAC (Tin Silver Copper)
refers to the family Pb-Free alloys containing Tin (Sn), Silver (Ag), and Copper (Cu) used in surface mount technology or sometimes in wave solder processes. The alloys typically have a composition near the eutectic (Sn3.5Ag0.9Cu)

3.36
shop replaceable assembly
SRA
is a component assembly inside a black box (LRU or WRA) typically consisting of individually replaceable circuit cards

3.37
shop replaceable unit
SRU
is a component assembly inside a black box (LRU or WRA) typically consisting of individually replaceable circuit cards

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3.38
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 deprecated but not prohibited

3.39
SnCu (Tin Copper)
solder or alloy refers to Pb-Free alloys that are comprised of Tin-Copper (Sn-0.7Cu)

3.40
SnCuNi (Tin Copper Nickel)
solder or alloy refers to Pb-Free Tin-Copper with trace Nickel concentration alloy (Sn0.7Cu0.05Ni). Some formulations also include other minor additions such as Germanium (Ge)

3.41
SnPb (Tin Lead)
solder or alloy refers to Tin-Lead alloys at or near the eutectic composition (63Sn37Pb)

3.42
soldered assembly
is an assembly of two or more basic parts interconnected by a solder alloy. A Pb-based soldered assembly is one in which the solder alloys are solely Pb-based. A Pb-Free soldered assembly is one in which the solder alloys are solely Pb-Free

3.43
system
is one or more units that perform electrical function(s)

3.44
termination
is the term used in this document to identify the area to be soldered of the piece part termination, castellations, or metallized surface(s) of an electronic device

3.45
ternary alloy
is a solder alloy containing three component metals

3.46
Tg
refers to the glass transition temperature of laminate material

3.47
High Tg
refers to the glass transition temperature of laminate material ≥ 338°F (170 °C)

3.48
tin whisker
is a spontaneous crystal growth that emanates from a Sn surface. They may be cylindrical, kinked, or twisted. Typically they have an aspect ratio (length/width) greater than two, with shorter growths referred to as nodules or odd-shaped eruptions. See IEC/PAS 62647-2 (GEIA-STD-0005-2) for further description of Tin Whiskers and their physical attributes

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