

TECHNICAL SPECIFICATION



**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**



THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2013 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

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

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

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you to find IEC publications by a variety of criteria (reference number, text, technical committee,...).

It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available on-line and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

Copyright © 2013 IEC, Geneva, Switzerland
preview generated by EVS

TECHNICAL SPECIFICATION



**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

PRICE CODE

ICS 03.100.50; 31.020; 49.060

ISBN 978-2-8322-1162-5

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	8
2 Normative references	8
3 Terms, definitions and abbreviations	9
3.1 Terms and definitions.....	9
3.2 Abbreviations.....	14
4 Pb-free concerns	16
4.1 General.....	16
4.2 Reliability.....	16
4.2.1 General	16
4.2.2 Mixed metallurgy reliability.....	16
4.3 Configuration management	17
4.4 Risk management	18
4.5 Tin whiskers.....	18
4.6 Copper dissolution (erosion)	18
5 Materials	18
5.1 Solder.....	18
5.1.1 General	18
5.1.2 Solder alloys.....	18
5.1.3 Solder forms	19
5.2 Fluxes.....	20
5.3 Piece parts	20
5.3.1 General	20
5.3.2 Termination finishes	20
5.3.3 Area arrays (BGA, CSP, etc.)	20
5.4 Printed circuit boards/printed wiring boards.....	21
5.4.1 Laminate material	21
5.4.2 Surface finish	21
5.5 Conformal coatings	21
6 Soldering equipment.....	22
6.1 General.....	22
6.2 Hand soldering equipment	22
6.2.1 General hand soldering equipment considerations.....	22
6.2.2 Tip selection	22
6.2.3 Soldering iron tip life.....	23
6.3 Fountain soldering	24
6.4 Convective soldering equipment	25
6.4.1 General	25
6.4.2 Thermal profile issues.....	25
7 General rework/repair considerations	26
7.1 General.....	26
7.2 Rework/repair procedure order of precedence.....	26
7.3 Technician training.....	27
7.4 Pb-free rework/repair considerations.....	27
7.4.1 General	27

7.4.2	General process considerations	27
7.4.3	Solder processing considerations	28
7.4.4	Flux considerations	28
8	Pre-rework/repair processes	29
8.1	Alloy identification	29
8.1.1	IPC/JEDEC J-STD-609A	29
8.1.2	X-ray fluorescence (XRF)	31
8.1.3	Pb swabs	31
8.2	Piece part and CCA preparation	31
8.2.1	General	31
8.2.2	Piece part preparation	31
8.2.3	CCA preparation	32
9	Rework/repair processes	32
9.1	General	32
9.2	Conductive hand soldering	32
9.3	Convective soldering process	34
9.3.1	General	34
9.3.2	Solder paste handling	34
9.3.3	Paste printing	34
9.3.4	Reflow process	34
10	Post-rework/repair processes	36
10.1	Cleaning	36
10.2	Inspection	36
10.3	Reapplication of conformal coating	36
Annex A (informative)	Termination finishes	37
Annex B (informative)	Tin whiskers	39
B.1	Tin whisker growth mechanisms	39
B.2	Tin whisker mitigation techniques	39
B.3	Hot solder dip	39
B.4	Conformal coatings	39
B.5	Specification of piece part termination finish	40
B.6	Under-platings/annealing	40
B.7	Piece part lead pitch	40
	Bibliography	44
	Figure 1 – Soldering iron tip construction	23
	Figure 2 – Worn soldering iron tip	23
	Figure 3 – Copper dissolution	24
	Table 1 – Assembly and piece part marking methods	30
	Table A.1 – Piece-part terminal and BGA ball metallization solder process compatibility risk (see IEC/TS 62647-22:2013)	37
	Table A.2 – BGA piece parts risk	38
	Table B.1 – Tin whisker information (see IEC/TS 62647-22:2013)	41
	Table B.2 – Piece part termination tin whisker risks (see IEC/TS 62647-22:2013)	42

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**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

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- 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.

The text of this technical specification is based on the following document: IEC/PAS 62647-23¹.

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.

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

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.

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/repared 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*