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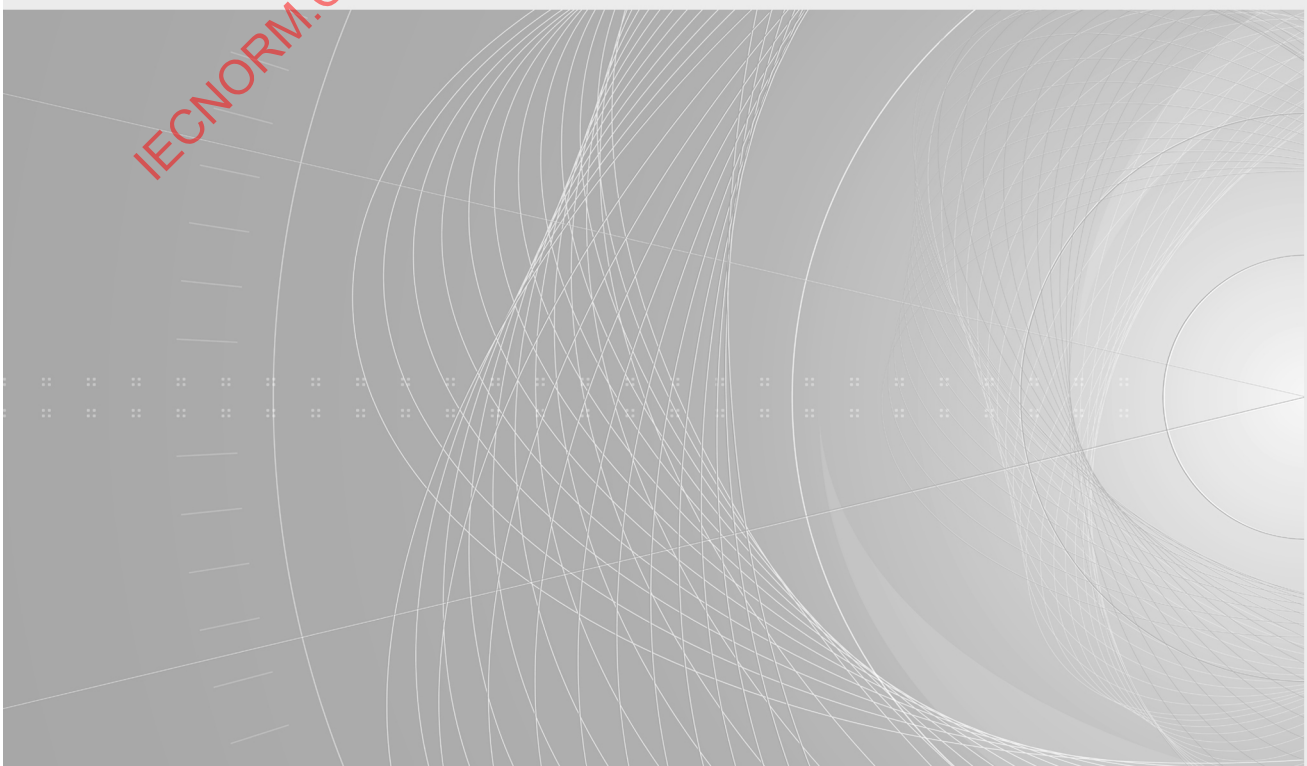
Edition 1.0 2013-07

TECHNICAL SPECIFICATION

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



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

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 62647-21, 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 62647-21 and GEIA-HB-0005-1.

This technical specification cancels and replaces IEC/PAS 62647-21, 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 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
107/204/DTS	107/215/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 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.

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 started a process with 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 produced after July 2006. Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment is an updated / recast version of the Directive 2002/95/EC.

One of the key materials restricted is lead (Pb), which is widely used in electronic solder and electronic piece part terminations. 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 (ADHP) electronics industry, many of the lower tier suppliers have changed their products because their primary market is consumer electronics. Additionally, several U.S. states have enacted similar “green” laws and many Asian electronics manufacturers have recently announced completely green product lines.

Since the ADHP electronics industry is one of the few major industrial sectors that still repair circuit card assemblies (CCAs) and since Pb-free materials and processes are relatively immature and poorly understood, an aerospace-wide approach to the transition was deemed to be highly valuable.

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

1 Scope

This part of IEC 62647 is designed to assist program management and/or systems engineering management in managing the transition to lead-free (Pb-free) electronics to assure product reliability and performance.

Manufacturers of Aerospace, Defence and High Performance (ADHP) electronics may inadvertently introduce Pb-free elements (including piece part finish, printed wiring board (PWB) or printed circuit board (PCB) finish, or assembly solder) if careful coordination between buyer and supplier is not exercised. For example, piece part manufacturers may not always change part numbers to identify Pb-free finishes, especially if the previous tin-lead (Sn-Pb) finished piece part has been discontinued. Detailed examination of piece parts and documents at receiving inspection, while crucial, may not be sufficient to identify Pb-free piece parts.

NOTE 1 Pb-free technology can impact any program regardless of whether the program itself is exempt or bound by environmental regulations. The industry conversion to Pb-free solder technology may affect an ADHP program in one or both of the following ways:

1) if the program is required to implement Pb-free technology (contract requirement, environmental regulation, etc), then the program manager/lead systems engineer will need to assess the impact of in-house transition with respect to design (performance of products using Pb-free) and process (processes to build Pb-free products);

2) if the program purchases COTS (commercial-off-the-shelf) items for its products/systems, then there is a very good chance that these items will contain Pb-free solder or Pb-free finishes on parts, printed wiring boards (PWBs), printed circuit boards (PCB), or circuit cards assemblies (CCA).

The basic principles delineated in this document can be used for program management and/or systems engineering management of any aerospace and/or high performance program. The annexes in the document describe tools that can be used in conjunction with this document.

1) Annex A describes a matrix of product tier level versus associated risks with respect to a Pb-free transition.
2) Annex B contains links to the European Union Directives and Executive Order 13148.
3) Annex C contains a general program manager checklist for dealing with Pb-free issues that summarizes the content of this document.
4) Annex D contains a general manufacturing process assessment checklist to assess supplier compliance to IEC/TS 62647-1.
5) Annex E describes a recommended program language to assure performance, reliability, airworthiness, safety, and certifiability of Pb-free product(s).

This document is designed to assist a program in assuring the performance, reliability, airworthiness, safety, and certifiability of product(s), in accordance with IEC/TS 62647-1. Please note that the program manager and systems engineer (along with their respective organizations), and the appropriate enterprise authority work together in ensuring that all impacts of Pb-free technology insertion are understood and risks mitigated accordingly.

For the purposes of this document, “program management (or manager) and/or systems engineering management (or manager) and/or the appropriate enterprise authority” are defined as “program manager”.

NOTE 2 The implications are that the program manager and systems engineering manager (along with their respective organizations) and the appropriate enterprise authority work together in ensuring that all impacts of Pb-free technology insertion are understood and risks mitigated accordingly.

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*

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

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
COTS
commercial-off-the-shelf
item whose design and configuration is controlled by the manufacturer 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.

[SOURCE: IEC/TS 62647-1:2012, 3.3]

3.1.3
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]

3.1.4
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 sub-contractors.

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

3.1.5
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]

3.1.6
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]

3.1.7
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]

3.1.8
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]

3.1.9
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]

3.1.10
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

3.1.11
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]

3.1.12
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]

3.1.13
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]

3.1.14
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]

3.1.15
supplier
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, sub-contractors, and piece part manufacturers.

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

3.1.16
system
one or more units that perform electrical function(s)

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

3.1.17
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]

3.1.18
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]

3.2 Abbreviations

ADHP	Aerospace, defence and high performance
ATP	Acceptance test procedure
CCA	Circuit card assembly
COTS	Commercial off-the-shelf
ENIG	Electroless nickel/gold
EU	European Union
FMECA	Failure mode effects and criticality analysis
GEIA	Government Electronics and Information Technology Association
IR	Infra-red
LFCP	Lead-free control plan
OEM	Original equipment manufacturer
OSP	Organic solderability preservative
Pb-free	Lead-free
PMP	Parts, materials, and processes
PWB	Printed wiring board
PCB	Printed circuit board
SEMP	System engineering management plan
Sn-Pb	Tin/lead (e.g. 63 % tin/37 % lead)

4 General discussion of program management/systems engineering management concerns

4.1 General

A program manager's role is to be aware of how changes will affect the program, whether the program is on the system level, unit level, assembly level, or piece part level. The change from Sn-Pb solder to Pb-free solder will affect all electronics programs, regardless of level or size. The program manager also needs to understand where Pb-free is being introduced in the program (piece part finishes only, assembly soldering, etc.). Annex A differentiates the various tier levels and the associated risk to consider. The concerns described in 4.2 and 4.3 need to be considered for a successful transition.

4.2 Concerns in accordance with IEC/TS 62647-1

4.2.1 General

In accordance with IEC/TS 62647-1, program concerns include reliability, configuration control, risk management, effects of tin in the system, and rework/repair and maintenance.

4.2.2 Reliability

The program manager should understand how the transition to Pb-free may affect the reliability of the program. The program manager or a designee should understand the effects of mixing Sn-Pb and Pb-free solder, the effects on package types/geometry, how Pb-free may react to the program's use environment, if units and/or systems will include Sn-Pb and Pb-free assemblies, piece parts, etc. In addition, the program manager should consider a common reliability data collection during all phases of the program to facilitate systems performance improvement.

4.2.3 Configuration control

The need for configuration control is paramount to the Pb-free transition. Studies have shown that mixing Sn-Pb and Pb-free solders or the mixing of Pb-free solders of different alloys and/or piece parts (solders or finishes of different alloys) may have detrimental impact on the long-term reliability under high stress (e.g., defence, commercial aerospace, or space) environments. The program manager should understand the appropriate configuration controls (e.g., traceability) that are necessary for the program's environment. Note that the program manager shall decide the configuration control measures that shall be taken for the various levels (i.e., piece part, assembly, unit, system).

The material content of the terminations (component leads) is critical in assuring adequate reliability and performance of the finished product. The program manager should ensure that appropriate and demonstrated processes are in place at the suppliers' that will accurately identify the material content of piece parts used in soldered assemblies and that the material content is compatible with the supplier's soldering processes.

The program manager may require a parts, materials, and processes plan to be in place at the supplier's which reflects appropriate quality control procedures. The plan should include sub-contractor controls that affect the reliability of the end product.

4.2.4 Risk management

Risk identification and risk assessment need to be performed for the Pb-free transition for the particular environmental conditions of the program. Risks need to be identified early and a mitigation strategy engaged. The program manager has a responsibility to conduct a complete risk management plan.

4.2.5 Detrimental effects of tin

Pb-free tin finishes in an avionics or high performance system can have detrimental effects on functionality of the system as tin whiskers can spontaneously grow from the surfaces. Piece parts with Pb-free tin finishes have already been introduced into ADHP systems with minimal understanding of the effects that they will have. Program managers need to have a plan for either eliminating the use of Pb-free tin in their product, through life-time buys or re-finishing piece parts, or a plan for addressing and mitigating the risks.

IEC/TS 62647-2 provides standard methods for controlling and mitigating the use of Pb-free tin finished piece parts. It defines three basic levels, with additional sublevels, for controlling and mitigating the use of Pb-free tin finishes with accurate regard to tin whiskers. These levels can be summarized as follows.

Level 1: No restrictions on Pb-free tin finish use.

Level 2: Pb-free tin finish is allowed under some circumstances.

- Level 2A. Use of Pb-free tin finish without explicit controls is acceptable under most circumstances but the likelihood of whiskers and the methods used to estimate their impact and mitigation strategies will be documented. Pb-free tin finish may be prohibited in some specific circumstances called out in contractual documents.
- 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 piece parts and applications within the system. Pb-free tin finish may be prohibited in some specific circumstances called out in contractual documents.
- Level 2C. Restricted use of Pb-free tin finish. Pb-free tin finish is prohibited unless an exception with customer approval is made. Specific instruction on use of Pb-free tin finish and required control measures are to be provided and reviewed on a case-by-case basis.

Level 3: Use of Pb-free tin finish is prohibited and measures shall be taken to verify compliance.

These levels are designed to be used in requests for proposals and control documents. The customers should determine the appropriate control level or levels for their product, based on criticality, their comfort with the risk, and other mitigating features of their program, such as redundancy and repairability. For many larger programs, different subsystems or units may need different control levels that can be based on customer and supplier discussions and agreement regarding both application and supplier mitigation solution knowledge.

In most cases, it would be appropriate for OEMs to have general policies that aid in the selection of the appropriate control level. Program managers should work with their companies to develop the policy to aid in consistent requirements across programs.

Program managers also need to be prepared for handling errors in finish determination or mitigation application. This may simply be a variation in the program's normal process waiver process or may require a more in-depth risk assessment, depending on the criticality level.

4.2.6 Rework/repair and maintenance

Rework/repair and maintenance becomes a concern if Sn-Pb and Pb-free solders and/or piece parts are used on the same assemblies. As stated before, studies have shown that reliability of the joints/junctions of mixed lead and Pb-free solder may decrease in high stress environments. A program manager should make the customer aware of the higher risks associated with field rework/repair and maintenance when standard solder materials (i.e. 60 % tin/40 % lead or 63 % tin/37 % lead) are used on Pb-free assemblies and/or piece parts.

4.3 Additional program management/system engineering management concerns

4.3.1 General

The program manager also has additional concerns from a programmatic point of view. These include cost, parts obsolescence, COTS, quality, contract language, other existing program constraints, and updating of the program system engineering management plan (SEMP). Other concerns can be addressed based on specific program needs.

4.3.2 Cost

The costs of the Pb-free transition need to be quantified and decisions need to be made as to who will assume the costs. The program manager should be aware that the situation is likely to be dynamic over the next several years. Added costs may come from additional risk management determination, configuration controls, rework/repair and maintenance changes, drawing changes, possible redesign, requalifying/delta qualifying, etc.

4.3.3 Commercial off-the-shelf

4.3.3.1 General

Commercial-off-the-shelf (COTS) is always a critical concern for a program manager. The very nature of COTS may allow Pb-free substitution irrespective of program requirements.

4.3.3.2 COTS piece parts and parts obsolescence or COTS piece parts

The supplier may request substitution of Pb-free finished piece parts on a program. This occurs not only because of the piece part supplier obsolescing standard Sn-Pb-finishes, but also due to a COTS piece part substitution. The program manager or a designee should have controls in place and understand IEC/TS 62647-2, to mitigate the risks associated with Pb-free finished piece parts and COTS. The program manager needs to ensure that the parts, materials, and processes (PMP) control plan for the program is updated and addresses how lead-free piece parts will be identified and tracked. If a PMP control plan is not available for the program, the program manager should ensure that the PMP functional group is aware of each parts substitution and is adequately addressing the issue of lead-free piece parts.

4.3.3.3 COTS assemblies

The product may contain COTS assemblies, as well. The program manager should be aware of the possible risks due to COTS assemblies containing either Pb-free piece parts and/or Pb-free soldered assemblies. The program manager needs to ensure that the parts, materials, and processes (PMP) control plan for the program is updated and addresses how lead-free assemblies will be identified and tracked. If a PMP control plan is not available for the program, the program manager should ensure that the PMP functional group is aware of each parts substitution and is adequately addressing the issue of lead-free assemblies.

4.3.4 Quality

Quality is a critical consideration in the transition to Pb-free and the program manager needs to be assured that the final product meets the technical and operational requirements with the specified reliability at all levels. This includes the flow of requirements, implementation and documentation through and to sub-contractors.

4.3.5 Contractual language

Appropriate contractual language needs to be included in new contracts that describe the customer requirements regarding Pb-free parts. An example contractual language is included in Annex E.

4.3.6 Program constraints

The program manager needs to be proactive in understanding all of the impacts to the program schedule (including all integrated master schedule line items). Consideration needs to be particularly paid to changes in the delivery schedule due to requalification/delta qualification of Pb-free parts and additional reliability testing. Also, if risk mitigation plans include lifetime buys of long-lead Sn-Pb-finish parts (due to obsolescence), the updated schedule needs to reflect the changes appropriately.

4.3.7 System engineering management plan

The program manager should reassess the program's system engineering management plan, if one exists, and update to include the Pb-free transition controls for the program.

5 Requirements definition

5.1 General

A re-evaluation of the program requirements should be performed to determine the impact of the Pb-free transition.

5.2 Customer requirements

5.2.1 General

The program manager should include all of the Pb-free transitions in a thorough risk assessment/mitigation plan and present it to the customer. The purpose of the plan is to help the customer understand the risks associated with the transition.

5.2.2 WEEE and RoHS Directives

The program manager should understand the implications of the WEEE and RoHS Directives (Annex B).

5.2.3 Executive Order 13148 (green initiative)

Even though this generally applies only to facility operations issues, weapon system maintenance by the customer may come under this category. The program manager should be aware of the customer's requirements in this area (Annex B).

5.3 Additional prime contractor requirements

Additional prime contractor requirements need to be re-assessed with regard to a possible Pb-free transition.

5.4 Change control

The program manager should determine if any change from Sn-Pb to Pb-free constitutes a change for which customer approval is needed. The purpose is to assure that configuration control, traceability, and marking are properly controlled.

6 Use environment(s)

6.1 Impact on use environment(s)

The use environment(s) is(are) defined by the program requirements. The program manager needs assurance from the supplier that the transition from Sn-Pb to Pb-free solder will not impact reliability of the product in the use environment. The consideration here is whether or not Pb-free solder will behave differently than Sn-Pb solder in the use environment.

6.2 Impact on storage and transport

The program manager or a designee should evaluate the storage and transport requirements with respect to any Pb-free implementation. The impact of Sn-Pb versus Pb-free solder on long-term storage or transport environment could be significant and needs to be evaluated as part of the risk management plan.

7 Decision criteria

7.1 Program decision concerning Pb-free

The program manager shall choose whether or not any Pb-free will be accepted. This decision should be based on customer feedback, risk analyses, system engineering analyses, and supplier information. Annex C describes a checklist for the program manager to use for ascertaining the effects of a Pb-free transition to the program.

7.2 Compliance to IEC/TS 62647-1

The program manager or a designee should require a supplier to show compliance to IEC/TS 62647-1. Annex D describes a checklist for a program to use to determine a supplier's compliance to IEC/TS 62647-1.

7.3 Solder alloy chosen

The program manager or a designee should request a summary of the data that the supplier's decision was based on for making the transition to Pb-free. It should summarize the results of the supplier's studies and may include results from internal research and development, external test results and studies, trade studies, reliability/durability tests, FMECA (failure mode effects and criticality analysis), manufacturing infrastructure to segregate solder, processes, materials, manufacturing capabilities, manufacturing controls, etc.

The use of Pb-free tin plating (piece part leads, CCAs, etc.) can pose some risks due to the formation of tin whiskers (see IEC/TS 62647-2). To avoid these risks, high performance programs may prohibit the use of Pb-free tin plating. The program manager needs to understand the required reliability levels of the program and, if necessary: (1) implement a plan to prevent acquisition of Pb-free tin plated piece parts or (2) generate a plan to mitigate the risk of being forced to acquire Pb-free tin plating (e.g., re-finishing or other approaches).

7.4 Other programs

7.4.1 General

To understand the supplier's Pb-free decision, the program manager or designee may request the supplier to give additional information.

7.4.2 Percentages of product

The program manager may want to request information from the supplier about what percentage of their deliverable products are being converted to Pb-free. This will help evaluate the maturity of the supplier's process.

7.4.3 Supplier awareness

The supplier should have an awareness of what other programs in their industry are requesting or requiring with regard to Pb-free to make sure that their requirements achieve some commonality with other programs.

8 Supplier's lead-free control plan

8.1 General

The program manager should consider whether or not to require a lead-free control plan (LFCP) from the supplier making the Pb-free transition (see IEC/TS 62647-1). The elements considered in 8.2 through 8.6 may be included in such a plan. If the program manager does not wish to require a formal LFCP from the supplier, the supplier should demonstrate, as a minimum, the supplier's sub-contractor control (8.2), their manufacturing risk management

(8.5), and the schedule of Pb-free implementation (8.6). The LFCP also needs to be referenced in the program's PMP control plan for complete coordination.

8.2 Supplier procurement and sub-contractor control

8.2.1 General

The program manager or designee should request and review the supplier's procurement and sub-contractor control plan to assure that the supplier is mitigating the risks of the Pb-free transition of its sub-tier suppliers. Elements of the sub-contractor control plan need to include acquisition decisions regarding piece parts, procured printed wiring boards (PWBs), printed circuit boards (PCBs), procured assemblies, and peripheral hardware (including cables, wiring, etc.).

8.2.2 Supplier procurement

The supplier should have available for review by the program manager or designee, a procurement assessment of their sub-tier suppliers that are transitioning to Pb-free. All risks from sub-tier suppliers concerning the Pb-free transition should be included in the supplier's sub-contractor control plan.

8.2.3 Supplier sub-contractor control plan

8.2.3.1 General

The program manager or designee should request and review the supplier's sub-contractor control plan to assure that the supplier is mitigating the risks of the Pb-free transition of its sub-tier suppliers. Elements of the sub-contractor control plan need to include piece parts, procured printed wiring boards (PWBs), printed circuit boards (PCBs), procured assemblies, and peripheral hardware (including cables, wiring, etc.).

8.2.3.2 Procured piece parts

The sub-contractor control plan should include piece parts that have been transitioned to Pb-free finishes. Elements should include updates to the program parts obsolescence plan, if available, use of COTS piece parts and data that verifies that piece parts can tolerate Pb-free assembly and repair processes.

8.2.3.3 Procured printed wiring boards (PWBs) and printed circuit boards (PCBs)

The sub-contractor control plan should include procured printed wiring boards (PWBs) and printed circuit boards (PCBs) that have transitioned to Pb-free finishes. Elements should include data that verifies that printed wiring boards (PWBs) and printed circuit boards (PCBs) can tolerate Pb-free assembly and repair processes.

8.2.3.4 Procured assemblies

The sub-contractor control plan should include procured and build-to-print assemblies and modules that have transitioned to Pb-free soldering. Elements should include data that the Pb-free solder joints meet the program reliability requirements. It should also include supplier recommendations regarding rework and repair materials and processes.

8.2.3.5 Peripheral hardware

The sub-contractor control plan should include procured peripheral hardware, including cables, wiring, etc., that have transitioned to Pb-free soldering. Elements should include data that the Pb-free soldering meets the program reliability requirements. It should also include supplier recommendations regarding rework and repair materials and processes.

8.3 Productibility plan

The program manager or designee should understand any changes in supplier productibility that has occurred as a result of the Pb-free transition. This should include identification and plan to control new key characteristics.

8.4 Manufacturing changes

The program manager or designee should understand the process changes that have occurred as a result of the change of solder alloy. This should include both fabrication processes and rework/repair processes. This should also include changes to fabrication equipment (e.g., wave soldering unit, mass reflow unit, hand soldering equipment, cleaning equipment, inspection stations). This should also include how changes to the fabrication processes will be controlled, updates to the process control plan (including statistical process control), and changes to production readiness.

8.5 Manufacturing risk management

The supplier should identify, assess, and have a mitigation plan for all risks associated with its own Pb-free transition, as well as its sub-tier suppliers. This information should be given to the program manager or designee in a timely manner. The program manager should understand the added manufacturing risks and update the program risk management plan appropriately. As a minimum, the supplier identification, assessment, and mitigation that affect end-item reliability, schedule, or cost should be included in the program risk management plan. Also, the supplier plan for identification of Pb-free products should be included.

8.6 Supplier schedule of Pb-free implementation

The program manager should understand changes to the program schedule that have resulted from supplier Pb-free transitions. Schedule changes might be impacted due to development of Pb-free processes and controls. Time to adequately address issues during development should be provided.

9 Requalification/test plan

9.1 General

The program manager with customer concurrence should determine if the product that is transitioning with Pb-free solder should be requalified, delta qualified, accepted by analysis/test, or accepted by similarity. Delta qualification is a subset of a full qualification, when only the part that has been changed is requalified. The decision criteria should be quantified with respect to the associated risks of requalification, delta qualification, acceptance by analysis/test, and acceptance by similarity.

9.2 Delta qualification or requalification

If the decision is to delta qualify or requalify the product, the program manager or designee should review the updated qualification plan from the supplier. This plan should include the product to be delta qualified or requalified, the criteria for acceptance, the updated test procedures (including changes to the acceptance test procedure (ATP)), the updated schedule, and in case of delta qualification the responsible party shall be identified.

9.3 Acceptance by analysis/test

If the decision is to accept the product by analysis/test, the program manager or designee should review the results and validate for applicability to the designated program.

9.4 Acceptance by similarity

If the decision is to accept the product by similarity, the program manager or designee should review the updated qualification plan from the supplier. This plan should include the product to be accepted by similarity, the rationale for acceptance, the criteria for acceptance, and the data that supports the decision.

10 Rework/repair and maintenance

10.1 General

The program manager should request rework/repair procedures from the supplier for Pb-free soldering process. The program manager may also refer to ARINC Project Paper 671 for guidance.

10.2 Supplier recommendations for rework/repair of Pb-free products

The repair procedures from the supplier of rework/repair of Pb-free products should include the recommended alloy type, the recommended soldering process, the recommended cleaning process, and all the supporting data. The repair procedures should also include a risk assessment of the use of Sn-Pb solder in the rework/repair of the Pb-free product.

10.3 Maintenance and training documentation

The program manager or a designee should review all maintenance and training documentation for changes in rework/repair procedures. These changes should be communicated prior to delivery of the Pb-free product(s).

11 Risk management

11.1 General

The program manager or a designee should determine the possible additional risks associated with the transition to Pb-free. The program manager or a designee should use the supplier risk management plan(s), if available, to reassess the program-level risk.

11.2 Program-level identification of program-level risks

The program manager or designee should identify all risks associated with the transition to Pb-free in the program risk management plan, including manufacturing risks that have been communicated by the supplier.

11.3 Risk analyses

The program manager or designee should analyse all risks associated with the transition to Pb-free in the program risk management plan, including manufacturing risks that have been communicated by the supplier.

11.4 Risk mitigation

The program manager or designee should mitigate all risks associated with the transition to Pb-free in the program risk management plan, including manufacturing risks that have been communicated by the supplier.

12 Cost

The program manager should conduct a program cost impact analysis with respect to the Pb-free transition. It should include as a minimum, risk management, requalification/delta qualification impact, rework/repair/maintenance impact, warranties, and schedule impact. The

cost impact analysis should also include the impact to both recurring and non-recurring costs, as well as any cost savings and cost avoidance. Cost savings and/or avoidance may result from using less expensive piece parts. However, the program manager should anticipate additional costs due to possible requalification/delta qualification efforts.

13 Presentation to customer

13.1 General

The program manager should brief the customer on the program-level aspects of the Pb-free transition.

13.2 Compliance to IEC/TS 62647-1

It should be shown how the Pb-free product complies with IEC/TS 62647-1. Note that an approved lead-free control plan meets the requirements of IEC/TS 62647-1.

13.3 System engineering management plan

The system engineering management plan (SEMP), if applicable, should be updated.

13.4 Other deliverables to the customer

The customer briefing should include the supplier Pb-free implementation plan, the updated program risk management plan, the configuration control of the Pb-free product, the recommended rework/repair procedures, the cost impact analysis, the performance and/or reliability impact, and the schedule of the program implementation of the Pb-free.

Annex A
(informative)

Matrix of tier level versus associated risk

Clause/ subclause	Title	Level			
		Piece part	Assembly	Unit	System
4	General discussion of program management/systems engineering management concerns				
4.1	General	X	X	X	X
4.2	Concerns in accordance with IEC/TS 62647-1				
4.2.1	General	X	X	X	X
4.2.2	Reliability	X	X	X	X
4.2.3	Configuration control	X	X	X	X
4.2.4	Risk management		X	X	X
4.2.5	Detrimental effects of tin	X	X	X	X
4.2.6	Rework/repair and maintenance		X	X	X
4.3	Additional program management/systems engineering management concerns				
4.3.1	General	X	X	X	X
4.3.2	Cost			X	X
4.3.3	Commercial-off-the-shelf	X	X	X	X
4.3.4	Quality	X	X	X	X
4.3.5	Contractual language			X	X
4.3.6	Program constraints			X	X
4.3.7	System engineering management plan			X	X
5	Requirements definition		X	X	X
6	Use environment(s)				
6.1	Impact on use environment(s)	X	X	X	X
6.2	Impact on storage and transport	X	X	X	X
7	Decision criteria				
7.1	Program decision concerning Pb-free				
7.2	Compliance to IEC/TS 62647-1		X	X	X
7.3	Solder alloy chosen	X	X	X	X
7.4	Other programs			X	X
8	Supplier's lead-free control plan				
8.1	General		X	X	X
8.2	Supplier procurement and sub-contractor control				
8.2.1	General		X	X	X
8.2.2	Supplier procurement		X	X	X
8.2.3	Supplier sub-contractor control plan				
8.2.3.1	General		X	X	X
8.2.3.2	Procured piece parts		X	X	
8.2.3.3	Procured printed wiring boards (PWBs) and printed circuit boards (PCBs)		X	X	
8.2.3.4	Procured assemblies			X	X
8.2.3.5	Peripheral hardware			X	X

Clause/ subclause	Title	Level			
		Piece part	Assembly	Unit	System
8.3	Productibility plan		X	X	X
8.4	Manufacturing changes	X	X	X	X
8.5	Manufacturing risk management	X	X	X	X
8.6	Supplier schedule of Pb-free implementation	X	X	X	X
9	Requalification/test plan	X	X	X	X
10	Rework/repair and maintenance		X	X	X
11	Risk management		X	X	X
12	Cost		X	X	X
13	Presentation to customer			X	X

Annex B
(informative)

Links to the European Union Directives and Executive Order 13148

WEEE Directive

Directive 2003/108/EC of the European Parliament and of the Council of 8 December 2003 amending Directive 2002/96/EC on waste electrical and electronic equipment (WEEE) [http://www.environ.ie/en/Legislation/Environment/Waste/WEEE/FileDownLoad,1358,en.pdf]

RoHS Directive

Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (commonly known as the RoHS (Restriction of Hazardous Substances) Directive). The directive bans the use of lead, mercury, cadmium, chromium (VI) and certain bromine containing materials.
[http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:037:0019:0023:en:PDF]

RoHS Directive

Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast; commonly known as RoHS 2). [http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:174:0088:0110:en:PDF]

Executive Order 13148

Executive Order 13148 of April 21, 2000 – Greening the Government Through Leadership in Environmental Management. The head of each Federal agency is responsible for ensuring that all necessary actions are taken to integrate environmental accountability into agency day-to-day decision making and long-term planning processes, across all agency missions, activities, and functions. Consequently, environmental management considerations must be a fundamental and integral component of Federal Government policies, operations, planning, and management.
[http://ceq.hss.doe.gov/nepa/regs/eos/eo13148.html]

Annex C
(informative)

General program manager checklist for dealing with Pb-free issues

Requirements issues

- ❑ Determine the impact on performance requirements.
- ❑ Reallocate system requirements; determine if this changes the scope of any contracts.
- ❑ Assess the impact on reliability of the piece part, assembly, unit and the system.
- ❑ Assess safety issues.
- ❑ Review maintainability requirements and determine the impact on frequency of maintenance.
- ❑ Assess the impact on the components of the system that interface with the delivered product.
- ❑ Assess the impact on test equipment and/or test facilities.
- ❑ Determine any required changes in support equipment.
- ❑ Identification of the hardware, piece parts, and shipping containers.
- ❑ Determine any changes to the drawing requirements, solder callouts, process specifications and conformal coatings.

Supplier management issues

- ❑ Determine the availability of alternative suppliers.
- ❑ Determine the feasibility of a lifetime buy of the old part.
- ❑ Controls are in place for screening/receiving Pb-free finishes piece parts.
- ❑ Evaluate the supplier's internal delivery schedule for any new parts.
- ❑ Assess the relationships of supplier to vendor:
  - ❑ is the supplier's vendor new or existing?
  - ❑ if new, can the former vendor continue delivering the old part?
- ❑ Evaluate the risks due to changes of suppliers and vendors:
  - ❑ schedule
  - ❑ cost
  - ❑ technical
- ❑ Assess any opportunities for schedule or cost savings.

Schedule issues

- ❑ Evaluate the impact on the following:
  - ❑ critical path
  - ❑ activities on the near-critical paths
  - ❑ deliveries to test and evaluation activities
- ❑ Assess the schedule impact due to any additional required tests or equipment.
- ❑ Determine and evaluate risks due to any change in schedule.

Cost issues

- ❑ Determine if any cost savings will be shared by the supplier.

- Assess the cost impact due to any schedule or technical requirements changes:
  - supplier costs
  - internal labor costs
  - costs of additional testing/qualification (facility, labor, equipment)

Configuration management

- Ensure new part is included in CM documentation.
- Alert other programs within the organization that use the same part.
- Ensure processes are in place to handle field returns and rework or repair of field returns.

Annex D
(informative)

General manufacturing process assessment checklist for assessing supplier compliance to IEC/TS 62647-1

This tool may be used for assessing a supplier's compliance to the requirements of IEC/TS 62647-1. However, it may also be used to assess a supplier's compliance with the intent of IEC/TS 62647-1, if the supplier is not familiar with the standard.

IEC/TS 62647-1 VERIFICATION CHECKLIST

(A) Documentation:

	YES	NO	N/A
1. Does the facility recognize IEC/TS 62647-1 for mitigating the risks associated with Pb-free products, processes, and piece parts? If yes, what revision? If not, what is the status of document recognition?	☐	☐	☐
2. Does the facility recognize IEC/TS 62647-2 for mitigating the effects of tin finishes on piece parts? If yes, what revision? If not, what is the status of document recognition?	☐	☐	☐
3. Does the facility have a lead-free control plan based on the requirements of IEC/TS 62647-1?	☐	☐	☐
4. If not, does the facility have a Pb-free soldering performance plan?	☐	☐	☐
5. Does the documentation that travels with the product during fabrication delineate all uses of Pb-free in the product(s) and processes?	☐	☐	☐
6. Are work instructions adequate so that identified personnel can recognize where Pb-free piece parts and/or processes are introduced?	☐	☐	☐
7. Record which processes the manufacturing facility considers key or critical to Pb-free risk mitigation:	☐	☐	☐

_____

_____

_____

_____

	YES	NO	N/A
8. Does the supplier have procedures that ensure that Pb-free processes meet the drawing requirements? Describe the method(s) that the supplier uses:	☐	☐	☐
_____			
_____			
_____			
_____			
_____			
9. Are certifications/records available indicating that solderability and piece part finishes have been tested?	☐	☐	☐
10. Are the piece parts tested by lot date code? Record the frequency and sampling plan:	☐	☐	☐
_____			
_____			
11. Do procedures require that defects on Pb-free-finished piece parts be specifically documented prior to any rework or repair action?	☐	☐	☐
12. Do maintenance instructions identify critical areas/surfaces that need to be maintained on critical Pb-free process equipment, such as the following:			
a) Hot air solder leveler, if applicable?	☐	☐	☐
b) Wave solder unit?	☐	☐	☐
c) Convection, infra-red (IR), or convection IR reflow unit?	☐	☐	☐
d) Rework or repair equipment?	☐	☐	☐
e) Other?	☐	☐	☐

(B) Materials:

(B1) Material – Piece parts:	YES	NO	N/A
1. Are there established acceptance criteria for piece parts used by the supplier? List the reference document(s).	☐	☐	☐
2. What are the finishes of the piece parts used by the supplier:			
a) Sn-Pb? Approximate % of production piece parts = _____	☐	☐	☐
b) Tin? Approximate % of production piece parts = _____	☐	☐	☐
c) Gold? Approximate % of production piece parts = _____	☐	☐	☐
d) Pb-free (no specific Pb-free callout) or RoHS-compliant? Approximate % of production piece parts = _____	☐	☐	☐
e) Other? Approximate % of production piece parts = _____	☐	☐	☐
3. Explain how piece parts with Pb-free finishes are controlled* in storage:	☐	☐	☐
a) Sn-Pb?	☐	☐	☐
b) Pb-free tin?	☐	☐	☐
c) Gold?	☐	☐	☐
d) Pb-free (no specific Pb-free callout) or RoHS-compliant?	☐	☐	☐
e) Other?	☐	☐	☐
* As verified in accordance with manufacturer's instructions or internal standard process or customer requirements.			
4. Explain how piece parts with Pb-free finishes are controlled* on the manufacturing floor (i.e. kitting, soldering processes, assembly):			
a) Sn-Pb?	☐	☐	☐
b) Pb-free tin?	☐	☐	☐
c) Gold?	☐	☐	☐
d) Pb-free (no specific Pb-free callout) or RoHS compliant?	☐	☐	☐
e) Other?	☐	☐	☐
* As verified in accordance with manufacturer's instructions or internal standard process or customer requirements.			
5. Does the supplier re-identify the piece part (either on the piece part or the packaging or both) if the piece part finish is Pb-free?	☐	☐	☐