



AEROSPACE RECOMMENDED PRACTICE

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Risk Mitigation for Pb-Free Solders Used Internally to Parts

RATIONALE

Piece part suppliers have been transitioning to using Pb-free solders within parts. However, aerospace and military programs are concerned about the risk from tin whiskers and the durability of these materials in their applications due to their special circumstances (see Introduction). This document will provide guidance on necessary tests and evaluations for parts using Pb-free solders to mitigate these risk concerns.

FOREWORD

GEIA-STD-0005-2 allows for the use of Pb-free tin alloys with mitigations, such as potting and encapsulations, in many applications. The requirements for these mitigations were not defined for use inside piece parts but instead for unit and board level mitigations. This document describes the application of mitigations within the parts.

INTRODUCTION

Environmental regulations on the use of certain substances, including lead (Pb), have resulted in a continuing global transition to Pb-free electronics. The commercial/consumer electronics industry, bound by European regulations deployed in 2006, made this conversion, manufacturing primarily Pb-free products. The Aerospace and Defense electronics sector has been more cautious in the adoption of Pb-free technologies. Aerospace and Defense products requirements not encountered by the commercial/consumer electronics industry include but are not limited to:

- Complex harsh environments;
- Safety critical or security-critical applications;
- Extremely long service life;
- In-field sustainment.

There are two concerns to be addressed with the Pb-free transition: tin whiskers and Pb-free joint integrity and durability. The Aerospace and Defense (A&D) industry has experienced a number of failures due to tin whiskers and have observed test failures due to loss of Pb-free joint integrity. A partial list of tin whisker failures can be found on <https://nepp.nasa.gov/whisker/index.html>. These have included multiple satellite losses and aircraft failures.

Much of the risk is addressed by the A&D industry at board-level and higher. The mitigations for these situations are described in GEIA-STD-0005-2 and include mitigations like conformal coat. However, this document is meant to address situations where the Pb-free solder and finishes are internal to parts and cannot be addressed by higher level mitigations.

Generally, the risk of whiskers occurring in bulk solder and solder joints is small. However, there have been examples reported. [1][2][3] There are known issues with whiskers growing from joints with small amounts of rare earth elements and with certain kinds of contamination. There have also been a limited number of cases where no known confounding factors were involved in the whisker growth. This practice recommends mitigations and evaluations that address the whisker risk, even if it is low.

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Documents

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Durability should be a low risk issue for most parts as well. The mass of the parts and the stress on the Pb-free solder should be small in most cases. However, this practice also recommends mitigations and evaluations to address the durability risk, even if it is low.

The goal of this document is to take advantage of practices that are best practice for high reliability part manufacturers and use them to mitigate the Pb-free risks in the parts. It is not expected that A&D customers will apply these mitigations post receipt of the parts. The standard should allow for better part selection and for better requirements for inclusion in source control drawings or other part requirements. Eventually these may also be incorporated into requirements for military standard devices which do not currently allow for the use of internal tin or Pb-free solder.

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1. SCOPE

This document provides risk mitigation for Pb-free solders used internal to parts used in Aerospace and Defense applications. It will include mitigations applicable to encapsulated and cavity devices as the needs arise in industry. Currently this revision only addresses devices with encapsulation or underfill. Mitigations for open cavity devices are still being discussed, and will be addressed in future revisions.

Microbumps with Thermal Compression Bonding (TCB) are not addressed by the mitigations in this document. The use of Pb-free microbumps with TCB are considered out of scope at this time.

It is expected that this document will be primarily used by Control Levels 3 and 2C (as defined in GEIA-STD-0005-2 for programs that do not allow use of Pb-free tin or only allow its use on an exception basis). It may be used by other levels, or by applications not using GEIA-STD-0005-2.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

GEIA-STD-0005-2 Standard for Mitigating the Effects of Tin Whiskers in Aerospace and High Performance Electronic Systems

2.2 ANSI Accredited Publications

Copies of these documents are available online at <http://webstore.ansi.org/>.

ANSI/ASQ Z1.4 Sampling Procedures and Tables for Inspection by Attributes

2.3 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E595 Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment

2.4 Other Publications

MIL-PRF-38535 General Specification for Integrated Circuits (Microcircuits) Manufacturing

MIL-STD-883 Microcircuits Test Method Standard

MIL-STD-1580 Destructive Physical Analysis for Electronic, Electromagnetic, and Electromechanical Parts

JESD22 Solid State Device Packaging Standard Series

J-STD-030 Selection and Application of Board Level Underfill Materials

J-STD-035 Joint IPC/JEDEC Standard for Acoustic Microscopy for Nonhermetic Encapsulated Electronic Components