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# Pb-free Design & Assembly Implementation Guide

Developed by the Research Coordination and Technical Guidance Task Group (8-81D) of the PERM Council (8-80) of IPC

Users of this publication are encouraged to participate in the development of future revisions.

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## 1 INTRODUCTION

**1.1** The European Union's Restriction of Hazardous Substances (RoHS) legislation [1], which went into effect July 2006, has had a profound impact on the electronics industry. One of the restricted substances, lead (Pb), is commonly used in alloys with tin for component finishes, printed board finishes and solders. While a great deal of historical knowledge exists relating to tin-lead (Sn-Pb) based electronic systems and products, the rapid transition of the electronics industries towards Pb-free (hereon denoted as Pb-free) has altered that experience base. Unless otherwise indicated, SnPb in this document refers to eutectic 63Sn37Pb solder systems.

Pb-free materials directly affect product performance, reliability and service life in many ways. There have been numerous, documented failures of electronics due to Pb-free materials in both commercial and Aerospace, Defense and High Performance (ADHP) products. The failure mechanisms for Pb-free materials are significantly different than SnPb based materials [2, 3]. Some failure mechanisms have not been experienced before. The ADHP industry has tried to avoid the use of Pb-free materials to the extent possible but the cost for doing so is increasing for product design, materials and manufacturing. It is currently cost prohibitive to require SnPb for all Commercial Off the Shelf (COTS) parts and assemblies used in ADHP products. Eventually it will become more affordable to incorporate Pb-free technology as the knowledge base improves. When Pb-free solders are used for ADHP electronics hardware, controls should be implemented in accordance with IPC J-STD-001 and its related Space Applications Electronic Hardware Addendum.

ADHP systems and products have a broad range of performance requirements, operating environments and service life. The guidelines presented in this document may not provide solutions for all products. Currently, not all Pb-free material risks have solutions that reduce the risk to acceptable levels. On-going research targeted for the ADHP industry and experience with Pb-free materials in commercial and industrial products continue to improve the knowledge base (see IPC-WP-012).

The significant differences between SnPb and Pb-free (many alloy types) solders has warranted the need for an industry guide to aid the electronic hardware design engineer in understanding and appreciating mechanical and physical behaviors and providing avenues for risk mitigation (see IPC-WP-014).

This guide is meant to be used by design engineers but may also be used by quality assurance, materials, components, and manufacturing engineers who contribute, in any way, toward the ultimate production of printed board assemblies and next level assemblies (e.g., power converters, controllers, or any other "box" containing multiple printed board assemblies).

**NOTE:** In accordance with IPC-T-50, the term "printed board assembly" will be used to denote a circuit card assembly.

Where applicable, a bulletized list of design suggestions is provided to aid the designer in identifying actions that can be taken to minimize risk.

### 1.2 SCOPE

**1.2.1** The intent of this design guide is to assist design engineers in developing electronics that are completely Pb-free and meet the demanding requirements of ADHP systems and products. (For the present time, wiring/cabling is not included in the scope.) It is assumed that the design engineers using this guide are competent and experienced with SnPb based electronics but may not be fully conversant with the detailed vagaries of Pb-free materials, components or manufacturing processes or how these impact equipment reliability and longevity.

a. This guide has been generated to address those 'delta' differences between SnPb and Pb-free solder technologies. Information/guidance that pertain to both technologies are not necessarily included. Any redundant information may be the result of completion or context.

b. The "delta" differences are generally categorized as described in GEIA-HB-0005-3 as follows:

   i) Typically poorer wetting ability

   ii) Differences in appearance and inspection criteria

   iii)Typically higher melting temperature

   iv) Potential tighter process window for repair/rework