

TECHNICAL REPORT

SSB-1™

REV. D

Revised 2020-01

Superseding SSB-1C

(R) Guidelines for Using Plastic Encapsulated Microcircuits and Semiconductors in Military, Aerospace, and Other Rugged Applications

RATIONALE

This document is intended to provide guidance for Using Plastic Encapsulated Microcircuits and Semiconductors (PEMs) in Military, Aerospace, and other rugged applications. This document addresses the various qualification and monitoring testing of plastic encapsulated microcircuits and discrete semiconductors suitable for potential use in military and aerospace applications. The users can use this document to evaluate the potential suitability of a PEM product or the manufacturer for its intended application. SSB-1 Rev D has been updated from SSB-1 Rev C to take into account the comments from various CE-12 members. The changes from SSB-1 Rev C to SSB-1 Rev D are shown in Appendix A: (informative) Differences between SSB-1 Rev C and SSB-1 Rev D.

ACKNOWLEDGMENT

Members of Task Groups for Plastic Encapsulated Microcircuits (PEMs) Screening and Lot Acceptance Testing of the SAE CE-12 Solid State Devices Committee developed this document. We would like to thank them for their dedication to this effort. To each of them, the members of the SAE CE-12 Solid State Devices Committee extend their gratitude.

INTRODUCTION

The military and aerospace electronics industries are experiencing an ever-increasing demand for the use of plastic encapsulated microcircuits (PEMs). This trend is the result of two major drivers:

- Acquisition Reform**
 On June 29, 1994 a government directive challenged DoD and industry to adopt commercial practices and to eliminate DoD specifications and standards where appropriate. While DoD expects original equipment manufacturers (OEMs) to continue to meet specific end-item performance requirements, part selection is frequently left to the discretion of the equipment designer. Largely due to the automotive and commercial aerospace industries, improvements in molding processes and encapsulants now make PEMs a viable option for military electronics manufacturers to reduce material costs.
- Reduced Demand for Military Standard Microcircuits**
 Over the past decade, the world-wide market for microcircuits has increased dramatically while the total demand for military standard devices has decreased. As a result, several microcircuit manufactures have abandoned the military and aerospace market. Fewer and fewer new products are introduced that are specified to perform to traditional military specification limits and assembled in ceramic packages. OEMs frequently use PEMs in cases where there are no ceramic packaged devices to replace discontinued military devices in existing equipment. PEMs are frequently the only packaging alternative available for new devices introduced to the market place.

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Plastic encapsulated microcircuits and semiconductors offer a number of inherent advantages over hermetically sealed ceramic packages, including:

- **Weight** Plastic packages generally weigh about half as much as ceramic
- **Size** Smaller configurations are available in plastic packages
- **Performance** Devices have better dielectric properties than ceramic parts; smaller package configurations allow higher circuit board packing density, therefore, reducing propagation delays
- **Unit price** Unit prices are lower than ceramic parts because of high volume, high yield, and high quality automated manufacturing; cost benefits decrease with higher integration levels and pin counts due to the high price of die
- **Availability** Devices are more readily available than hermetic devices due to market demand

The uncontrolled use of plastic encapsulated microcircuits and semiconductors can introduce a number of technical risks in military and aerospace equipment applications that are not associated with hermetic packaged devices. These potential risks include:

- Moisture ingress induced by humidity
- Electrolytic/galvanic corrosion, delamination, and crack propagation induced by combined effects of temperature cycling, humidity, and bias conditions
- Outgassing of volatile substances induced by vacuum
- Device manufacturers characterize electrical performance over limited temperature ranges (e.g., industrial temperature Range: -40 to +85 °C)
- “Popcorn” package cracks or in delamination induced by thermal effects during soldering
- Cumulative effects of mechanical and thermal stresses from assembly manufacturing, testing, and service conditions on device long term reliability

To mitigate these risks, the military and aerospace electronics industries are adopting risk mitigation techniques implemented by the automotive and commercial air electronics industries.

Traditional military part selection methods typically revolve around environmental standards for a general end-item equipment category. Military standard requirements for components were derived from these equipment level standards. Many military and aerospace equipment applications do not require component performance at these traditional, military standard environmental conditions.

Table 1 compares the military standard operating temperature range for microcircuits and semiconductors to other temperature ranges commonly applied to device characterization.

Table 1 - Standard temperature ranges

Standard Temperature Ranges	
Military	-55 to +125 °C
Automotive	-40 to +125 °C
Industrial	-40 to +85 °C
Commercial	0 to +70 °C

A recent survey conducted by the Government Electronics and Information Technology Association¹ reveals that many military and aerospace applications could potentially use commercially available components designed and characterized to perform over commercial, industrial, or automotive temperature ranges.

Fewer and fewer new products are introduced that are specified to perform to traditional military specification limits and assembled in hermetic packages. By selecting and evaluating components based on the specific application environment, original equipment manufacturers are not constrained by military standard requirements that may otherwise impede selecting the most suitable part for the application from both an equipment performance and economical perspective.

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¹ Survey conducted in April 1999 by Task Group G99-03 of the G-12 Solid State Devices Committee.  **Documents** Document Sharing Hub

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1. SCOPE

This Engineering Bulletin and its annexes provide guidance to Original Equipment Manufacturers (OEMs) in evaluating device manufacturer flows and in selecting cost effective, standard products that meet the performance objective for potential use in many rugged, military, space, extreme, or other environments.

2. REFERENCE DOCUMENTS

The latest issue of the following documents forms part of this document:

Note: New document or SSB-1 Annex document will be added as it gets developed.

SSB-1.001	Qualification and Reliability Monitors
SSB-1.002	Environmental Tests and Associated Failure Mechanisms
SSB-1.003	Acceleration Factors
SSB-1.004	Failure Rate Estimating
SSB-1.005	Radiation Hardness (in draft)
JEP122	Failure Mechanisms and Models for Semiconductor Devices
JESD47	Stress Test Driven Qualification of Integrated Circuits
JESD69	Information Requirements for the Qualification of Silicon Devices
IPC-SM-785	Guidelines for Accelerated Reliability Testing of Surface Mount Solder Joints
ANSI/EIA-599	National Electronic Process Certification Standard
ISO 9001	Quality Management and Quality Assurance Standards
ISO/TS 16949	Quality Management System - Automotive Industry
STACK 0001	General Requirements for Integrated Circuits
AS6294/1	Requirements for Plastic Encapsulated Microcircuits in Space Applications
AS6294/2	Requirements for Plastic Encapsulated Microcircuits in Military and Avionics Applications
AS6294/3	Requirements for Plastic Encapsulated Discrete Semiconductors in Space Applications
AS6294/4	Requirements for Plastic Encapsulated Discrete Semiconductors in Military and Avionics Applications

3. APPLICATION

This guideline provides guidance in selecting plastic encapsulated microcircuits and semiconductors based upon:

1. Understanding the potential failure mechanisms associated with end use application conditions
2. Understanding a specific device manufacturer's methodology for improving device reliability by continually evaluating product against potential failure mechanisms
3. Evaluating device capability versus the specific application environment, circuit function and equipment level reliability requirements

The user of this Bulletin and its annexes must determine the suitability of this guideline for a specific application. In addition to the following SSB-1 annexes, the AS6294/1 through /4 contain requirements for evaluating, screening, and qualification of plastic encapsulated devices for the intended use. These documents also contain information to consider for long-term dormant storage.

3.1 SSB-1.001: Qualification and Reliability Monitors

This annex recommends minimum qualification and monitoring testing of plastic encapsulated microcircuits and discrete semiconductors suitable for potential use in military and aerospace applications and should be used as a guide in evaluating device manufacturer test flows.

Device manufacturers may use this document as a guide to develop process flows to produce standard product for the above environments. "Best in Class" suppliers can easily meet these criteria and can readily supply the necessary data to demonstrate compliance.

This annex does not include all the tests typically included in device qualification and reliability monitoring, but focuses on those tests specifically designed to apply to (or have unique implications for) plastic encapsulated microcircuits and semiconductors.

The preferred approach is to select off-the-shelf product that, when evaluated to these guidelines, will meet the target application requirements without requiring supplementary qualification testing. In cases where design constraints preclude this preferred approach, this section should also be used to design supplemental device qualification test plans to establish the required confidence in expected device performance.

3.2 SSB-1.002: Environmental Tests and Associated Failure Mechanisms

This annex provides more detailed information concerning the environmental stresses associated with tests specifically designed to apply to (or have unique implications for) plastic encapsulated microcircuits and semiconductors, and the specific failures induced by these environmental stresses. This information is intended to provide further insight needed to evaluate a specific device manufacturer's statistical reliability monitoring (SRM) approach.

3.3 SSB-1.003: Acceleration Factors

This annex provides reference information concerning acceleration factors commonly used by device manufacturers to model failure rates in conjunction with statistical reliability monitoring. These acceleration factors are frequently used by OEMs in conjunction with physics of failure reliability analysis to assess the suitability of plastic encapsulated microcircuits and semiconductors for specific end use applications. This information is intended to provide the insight needed to properly interpret a specific device manufacturer's reliability data and, in turn, extrapolate performance under service life and storage conditions for the target application.

3.4 SSB-1.004: Failure Rate Estimating

This annex provides reference information concerning methods commonly used by the semiconductor industry to estimate failure rates from accelerated test results. These methods are frequently used by OEMs in conjunction with physics of failure reliability analysis to assess the suitability of plastic encapsulated microcircuits and semiconductors for specific end use applications.

3.5 SSB-1.005: Radiation Hardness (in draft)

This annex provides the framework for hardness assurance risk assessment for electronic parts that would be susceptible to radiation environment. The document contains the radiation test considerations for total dose, both high dose rate and low dose rate, displacement damage and single event effects. The definition of an acceptable radiation test report is provided and a decision process for conducting radiation tests are discussed.

3.6 SSB-1.00X: Untitled

Annexes will be added as they are written and will be included in future updates of SSB-1. For information on additional annexes consult the SAE International web site.