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# Strain Gage Test Procedure

## Overview

This document describes Oracle's minimum strain gage test requirements for board and system assembly and product shipment. This procedure enables Oracle's manufacturing partners to conduct required strain gage testing independently.

The topics covered include:

- Test setup and equipment requirements
- Strain measurement
- Report Format



## Audience

This document is for Oracle product engineers, supplier engineers, design engineers, and external manufacturers.

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## INTRODUCTION

Strain gage testing allows objective analysis of the strain and strain rate levels that a ball grid array (BGA) package or BGA-style surface mount (SMT) connector is subjected to during printed circuit board assembly (PCBA), test, and internal or external product shipment.

Characterization of worst-case PCBA strain is critical due to the susceptibility of BGA solder joints (including circuit board pad cratering) to strain-induced failures.

Testing includes applying strain gages to the board near specified components (body size larger than 27mm x 27mm), and subjecting the instrumented board to various test and assembly operations. Test and assembly steps associated with excessive PCBA strain and strain rate are identified.

By identifying areas sensitive to manufacturing variation, strain gage testing provides insight into the effects of a production ramp. Strain gage measurements become the baseline for future process improvement activities and quantify the effectiveness of adjustments.

Some assembly, test, and shipment steps that require characterization are as follows:

- Printed Circuit Board assembly (PCBA) after SMT reflow:
  - All manual handling processes including fixture installation for wave solder, x-ray, etc.
  - All rework processes
  - Pressfit connector installation
- Board test:
  - In-Circuit Test (ICT)
- Board Functional Test (BFT) or equivalent functional test
- Mechanical assembly:
  - Heatsink assembly
  - System board integration
  - Peripheral computer interface (PCI) card installation
  - Dual inline memory module (DIMM) installation
- Product shipment:
  - Inter-plant packaging (single box and bulk-pack)
  - Field replaceable unit (FRU) packaging (single box and pallet)
  - External customer packaging

## 1 EXPERIMENTAL REQUIREMENTS

Experimental requirements must be as defined in *Section 3, General Requirements or Guidelines of IPC/JEDEC-9704 Printed Wiring Board Strain Gage Test Guideline* (June 2005) and in *Section 5 (Drop Tests), Specification, Shipping Package Test, of Shipping Package Test*, 950-1291-xx.

## 2 DATA ANALYSIS AND REPORTING

Generate a test report once data collection is complete. The recommended report format is represented in *Appendix A*,

*Appendix A Strain Gage Test Report Template.*

All Strain gage reports will be archived.

### 2.1 Analysis Requirements

Generate a strain against strain rate plot for the detailed analysis. Compare the plot with Oracle's recommended guideline. Refer to *Appendix B, Appendix B Preliminary Strain or Strain Rate Guidance*, on page 5.

- Analysis data must highlight the following conditions:
- Strain or strain rate combinations that exceed the recommended guidelines



**Any high-risk areas, as defined in this section, must be brought to the immediate attention of the appropriate Oracle product engineer or supplier engineer.**

## 3 TEST FREQUENCY

Strain testing can be waived for a leveraged product with similar hardware and packaging to a previously tested configuration, assuming the changes do not significantly alter the strain profile. If a waiver is questionable, review the product and packaging with Oracle product engineering strain measurement experts.

New strain gage testing must be conducted for any of the following events:

- Before any test or assembly fixture is brought online
- Whenever there are modifications to a test fixture that can significantly alter the strain profile
- Whenever there are modifications to an assembly process that can significantly alter the strain profile
- In-process stiffener design validation
- Enclosure design validation prior to hard-tooling
- Whenever there are modifications to shipment packaging that can significantly alter the strain profile

In addition, strain gage tests must be conducted as part of the routine Preventative Maintenance (PM) process. All suppliers must develop a PM program that ensures that the strain profile is within Oracle specified limits at all times. The frequency of these tests must be determined by the supplier.

**NOTE 1: All test fixtures, including spares and backups, must be tested. Fixtures of identical design can possess very different strain and strain rate profiles.**

## 4 QUALITY RECORDS

Strain gage reports are considered to be a quality record and as such, suppliers must retain them according to the retention period defined in the relevant section of the Quality exhibit.

Oracle may also opt to save reports in current AML tool.

## Appendix A Strain Gage Test Report Template

### 1. Abstract

One paragraph executive summary of results. Use a pass or fail table to summarize the results.

### 2. Introduction

One paragraph explanation of test purpose, and general description of test.

### 3. Test Apparatus and Setup

Detailed description, using words and photographs, of the test equipment.

- Date of test
- Test board
- Strain gage
- Strain measurement equipment
- Details of each assembly process (such as revision and serial number of fixtures, if applicable)
- Details of packaging and drop conditions, if applicable

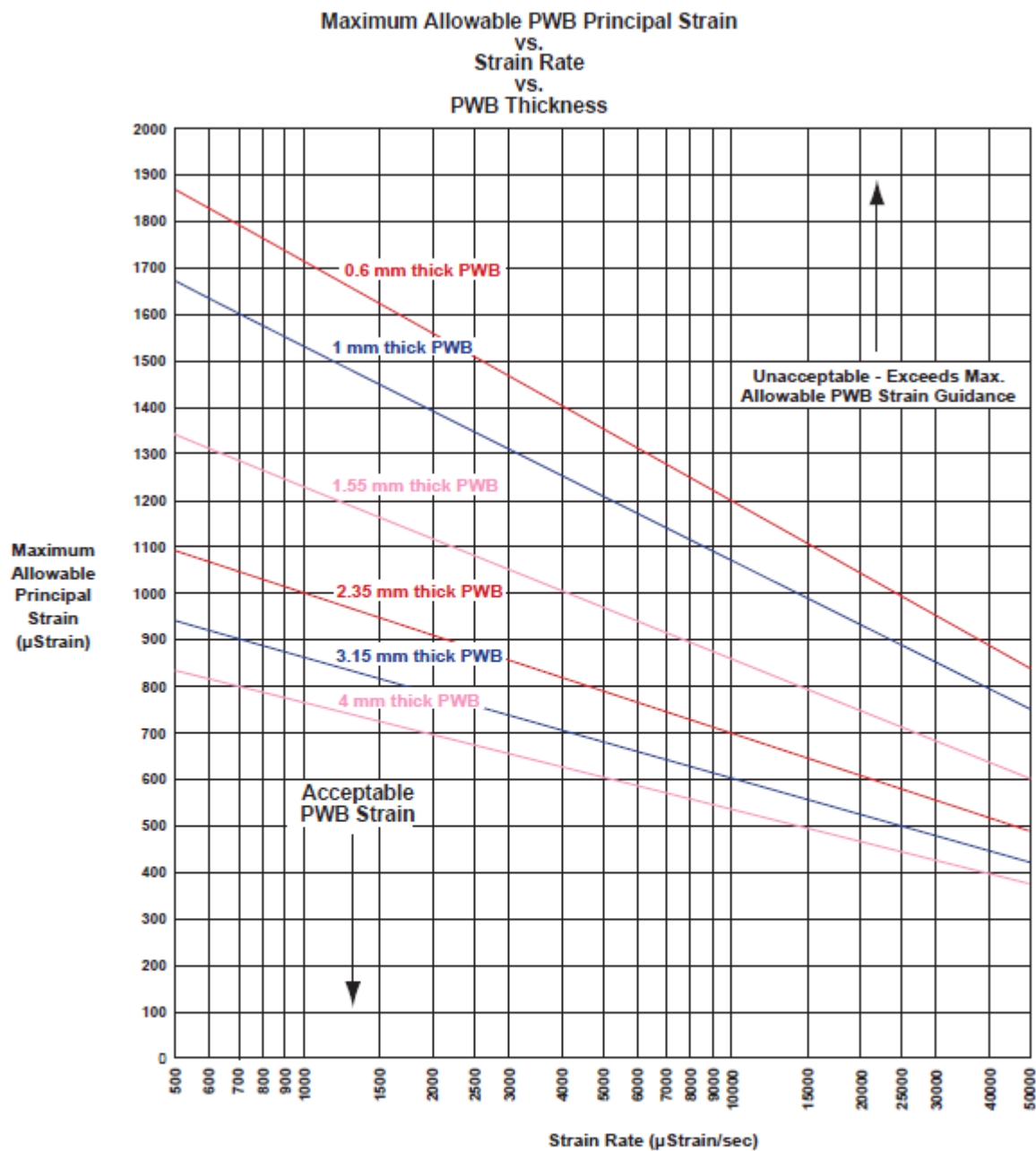
### 4. Results

Detailed summary of test results using words, tables, and graphs. If the experiments were used to determine the optimal setup or design, clearly define the experimental process and analysis outline. Compare results to historical data where available.

### 5. Conclusions

Detailed summary describing the most important experimental results and list of recommendations for further testing or changes in board assembly procedures, test fixtures, shipment packaging, or product design. Clearly explain justification for the recommendations.

## Appendix B Preliminary Strain or Strain Rate Guidance - Figure B-1 Strain Limits



PWB strain = max. principal strain (absolute value) measured immediately adjacent to cornermost solder joint

Strain rate = change in strain (absolute value) between consecutive readings

Max. allowable strain =  $\sqrt{2.35 / (\text{PWB thickness})} [1900 - 300 \cdot \log(\text{strain rate})]$

Units:

Strain [μStrain]

Strain rate [μStrain/sec]

PWB thickness [mm]

IPC-9704-a-01

## Strain Gage Test Procedure

Figure B-2 Data Reporting Example

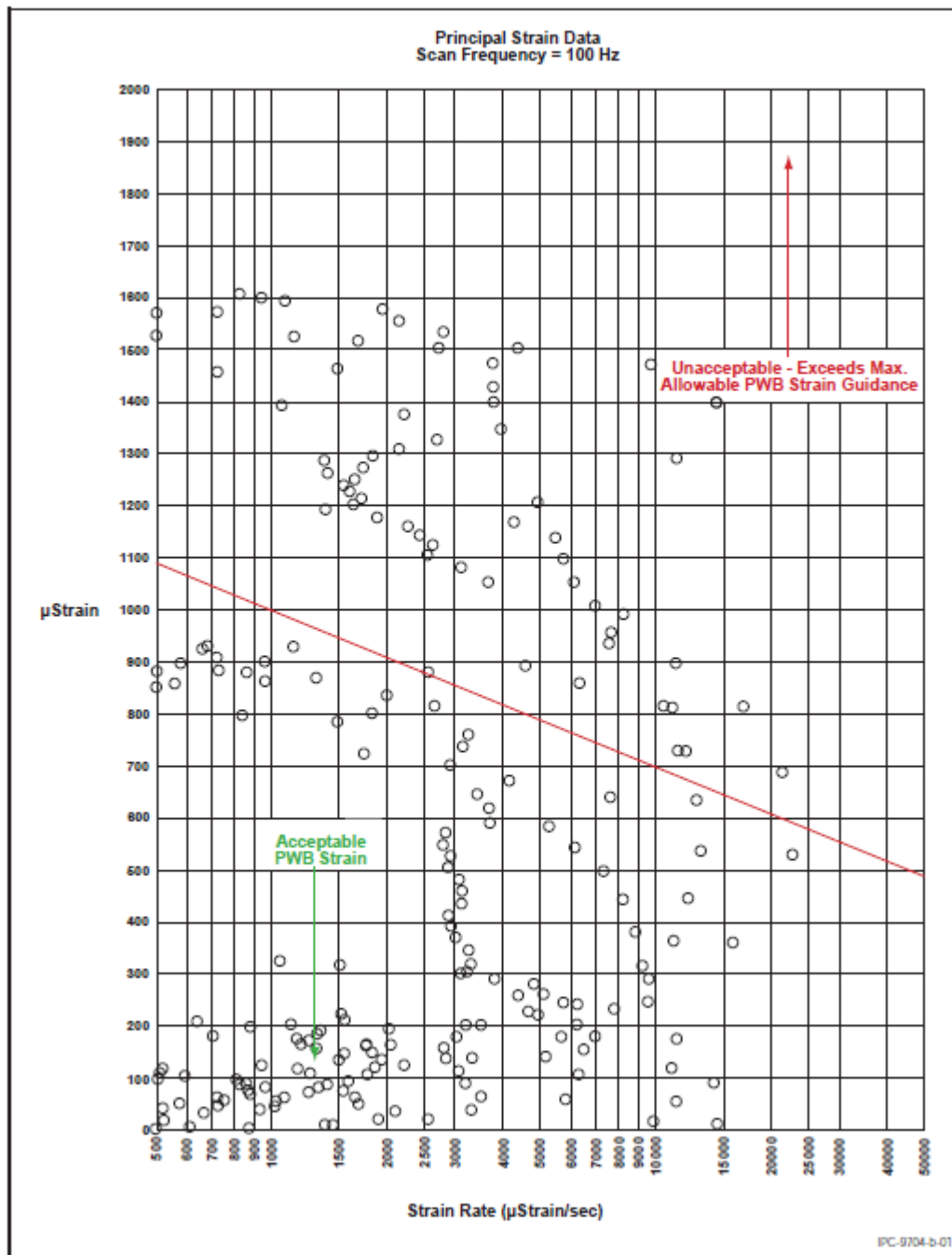


Figure B-1 Data Reporting Example for 2.35 mm Thick PWB

## Appendix C Strain Terminology

<b>Terminology</b>	<b>Notes</b>
Strain = $\Delta$ Length Increase / Original Length	Dimensionless Unit
$\mu$ Strain = $\mu$ x 10 <sup>-6</sup>	For example, 10,000 $\mu$ Strain = 0.01
Strain Rate = $\Delta$ Strain / $\Delta$ Time	$\Delta$ Time = 1 / Scan Frequency, typ. (Calculated with consecutive data readings)
Tensile Strain: $\Delta$ > 0	
Compressive Strain: $\Delta$ < 0	
Principal Strain = Maximum Strain	Usually determined using Mohr's Circle and strain gages stacked along three directions, for example, 0/45/90°

## Document History

<i>Dash</i>	<i>Rev</i>	<i>Date</i>	<i>Description of Change</i>	<i>Originator</i>
01	A	27 Aug 2003	Initial release.	N/A
02	A	04 Dec 2003	Added Appendix C and updated test frequency procedure.	N/A
03	A	02 June 2008	Deleted content for Section 1 - Experimental Requirement, and replaced with reference to IPC/JEDEC 9704 - Printed Wiring Board Strain Gage Test Guideline.	N/A
04	A	20 Oct 2009	Included product shipment, test waiver, and updated analysis requirements.	N/A
05	A	19 Feb 2010	Added new reference to Section 1 and added the strain gage test reports project folder location and the strain gage test reports email alias to Section 2.	N/A
Agile History				
<i>Rev</i>		<i>Date</i>	<i>Description of Change</i>	<i>Originator</i>
06		29 Sept 2014	Remove Sun for Oracle. Add Beehive repository and remove all Webdocs references.	N/A
Fusion History				
07		26 Apr 2022	Convert to corporate template	N/A
08		28 June 2024	Document cleanup and removal of expired references.	N/A

Reference Documents and Records

DOCUMENT TITLE	NUMBER
Shipping Package Test	950-1291
IPC/JEDEC-9702 Monotonic Bend Characterization of Board-Level Interconnects: <a href="http://www.jedec.org/download/search/IPC-JEDEC9702.pdf">http://www.jedec.org/download/search/IPC-JEDEC9702.pdf</a>	

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