



BSI Standards Publication

Printed board assemblies

Part 8: Voiding in solder joints of printed board assemblies for use in automotive electronic control units - Best practices

National foreword

This Published Document is the UK implementation of IEC TR 61191-8:2021.

The UK participation in its preparation was entrusted to Technical Committee EPL/501, Electronic Assembly Technology.

A list of organizations represented on this committee can be obtained on request to its committee manager.

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

© The British Standards Institution 2021
Published by BSI Standards Limited 2021

ISBN 978 0 539 17089 9

ICS 31.180; 31.190

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 March 2021.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------



TECHNICAL REPORT



**Printed board assemblies –
Part 8: Voiding in solder joints of printed board assemblies for use in automotive
electronic control units – Best practices**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.180; 31.190

ISBN 978-2-8322-9575-5

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	7
3 Terms and definitions	7
4 Technical background of voiding in solder joints and potential impact on assembly reliability.....	8
4.1 Void categories.....	8
4.2 Void occurrence in surface-mount technology solder joints	11
4.3 Influence of voiding on solder joint performance	14
4.3.1 Introductory remarks.....	14
4.3.2 Thermomechanical reliability	15
4.3.3 Mechanical reliability	17
4.3.4 Thermal functionality	18
4.3.5 Electrical functionality.....	19
5 Determination of voiding levels in solder joints	20
5.1 Instrumentation available for investigation of voiding in solder joints.....	20
5.1.1 General	20
5.1.2 X-ray inspection equipment operating in two-dimensional mode.....	20
5.1.3 X-ray inspection equipment operating in three-dimensional mode.....	21
5.2 Challenges for the X-ray inspection of voiding – two case studies.....	22
5.2.1 Influence of shadowing effects on measuring reproducibility – first results for 3D X-ray inspection equipment.....	22
5.2.2 Influence of X-ray parameters.....	23
5.2.3 Manual determination of voiding levels in solder joints in sample production	24
6 Recommendations for sample qualification	25
7 Recommendations for mass production	26
7.1 General remarks	26
7.2 Ramp-up quality assurance for voiding	26
7.3 X-ray sampling inspection	26
7.3.1 General	26
7.3.2 Control limits	26
7.3.3 Exceeding the control limits	26
7.4 Process control without X-ray sampling inspection.....	27
Annex A (informative) Types of voids and guidelines for acceptability.....	28
A.1 Types of voids – Summary	28
A.2 Typical voiding levels of components and guidelines for acceptability	29
A.2.1 General	29
A.2.2 Ball-grid array (BGA) components with collapsing balls	30
A.2.3 Bottom-termination components involving a lead-frame construction, as quad-flat no lead packages, dual-flat no lead packages	30
A.2.4 Exposed pads of components with gull wing solder joints as quad-flat packages.....	31
A.2.5 Transistors with thermal plane as D2PAK and TOLL (TO lead-less).....	31
A.2.6 Rectangular or square end chip components (2, 3 or 5 side terminations)	32

A.2.7 Light-emitting diodes	32
A.3 Further components currently under discussion	32
A.4 Tabular summary	32
Bibliography.....	34
Figure 1 – Example of inclusion/macro void	8
Figure 2 – Example of design induced void	9
Figure 3 – Example of shrinkage void	9
Figure 4 – Example of planar micro voids	10
Figure 5 – Example of intermetallic voids	10
Figure 6 – Example of pinholes	11
Figure 7 – Example of blowhole voids	11
Figure 8 – Theoretical model for voiding behaviour of preballled components	12
Figure 9 – Online X-ray images and trend of void level during melting phase	13
Figure 10 – Principal influencing parameters affecting solder joint reliability	14
Figure 11 – Correlation of BGA lifetime with average and maximum void levels	16
Figure 12 – Correlation void level standoff chip resistor 1206 and shear force after TC.....	17
Figure 13 – Sketch of heat transfer with exposed pad solder joints	18
Figure 14 – Calculation of void influence within exposed pads on overall R^{th}	19
Figure 15 – Average voiding results for different shadowing conditions	22
Figure 16 – Gauge reproducibility of void measurement with different shadowing	23
Figure 17 – Void measurement of BGA region with varying X-ray parameters	24
Table A.1 – Types of voids with indication of root cause, occurrence in automotive electronic assemblies, detectability, effect on thermomechanical reliability, thermal and electrical function and overall assessment	28
Table A.2 – Recommendations for acceptable minimum solder coverage or maximum void level as well as ranges for process indicators	33

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRINTED BOARD ASSEMBLIES –

**Part 8: Voiding in solder joints of printed board assemblies
for use in automotive electronic control units – Best practices**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publications"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct interpretation of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC TR 61191-8, which is a technical report, has been prepared by IEC technical committee 91: Electronic assembly technology.

The text of this technical report is based on the following documents:

DTR	Report on voting
91/1665/DTR	91/1689/RVDTR

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61191 series, published under the general title *Printed board assemblies*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This document applies to electronic and electromechanical automotive printed board assemblies and describes current best-practices for dealing with voiding in solder joints of surface-mount components soldered onto printed boards.

This document is an informative document which serves to illustrate the technically feasible options and to provide a basis for customer and supplier discussions and agreements. It is not intended to be regarded as a specification or standard.

Related standards are gathered in the bibliography.

This document has been prepared based on material provided by the working group AKL AK682.0.7 (Assembly and interconnect technology in automotive electronics).

Currently in preview, click buy full version

PRINTED BOARD ASSEMBLIES –

Part 8: Voiding in solder joints of printed board assemblies for use in automotive electronic control units – Best practices

1 Scope

This part of IEC 61191 gives guidelines for dealing with voiding in surface-mount solder joints of printed board assemblies for use in automotive electronics. This technical report focuses exclusively on voids in solder joints connecting packaged electronic or electromechanical components with printed boards (PBs). Voids in other solder joints (e.g. in a joint between a silicon die and a substrate within an electronic component, solder joints of through-hole components, etc.) are not considered. The technical background for the occurrence of voids in solder joints, the potential impact of voiding on printed board assembly reliability and functionality, the investigation of voiding levels in sample- and series-production, by use of X-ray inspection as well as typical voiding levels in different types of solder joints are discussed. Recommendations for the control of voiding in series production are also given.

Annex A collects typical voiding levels of components and recommendations for acceptability.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60194, *Printed board design, manufacture and assembly – Terms and definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60194 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 Design authority

individual, organization, company, contractually designated authority, or agency responsible for the design of electrical / electronic hardware, having the authority to define variations or restrictions to the requirements of applicable standards, i.e., the originator/custodian of the applicable design standard and the approved or controlled documentation

3.2 manufacturer

individual, organization, or company responsible for the assembly process and verification operations