

TECHNICAL REPORT



Environmental testing –
Part 3-15: Supporting documentation and guidance – Vacuum-assisted reflow
soldering

Document Preview

IEC TR 60068-3-15:2024

<https://standards.iteh.ai/catalog/standards/iec/8e03f2b1-20ca-47bc-807d-5f03a43f7335/iec-tr-60068-3-15-2024>



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2024 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

International
Standards
Document Preview
iteh.ai

[IEC TR 60068-3-15:2024](https://standards.iteh.ai/catalog/standards/iec/8e03f2b1-20ca-47bc-807d-5f03a43f7335/iec-tr-60068-3-15-2024)

<https://standards.iteh.ai/catalog/standards/iec/8e03f2b1-20ca-47bc-807d-5f03a43f7335/iec-tr-60068-3-15-2024>

TECHNICAL REPORT



Environmental testing – iTeh Standards
Part 3-15: Supporting documentation and guidance – Vacuum-assisted reflow
soldering (<https://standards.iteh.ai>)

Document Preview

[IEC TR 60068-3-15:2024](https://standards.iteh.ai/catalog/standards/iec/8e03f2b1-20ca-47bc-807d-5f03a43f7335/iec-tr-60068-3-15-2024)

<https://standards.iteh.ai/catalog/standards/iec/8e03f2b1-20ca-47bc-807d-5f03a43f7335/iec-tr-60068-3-15-2024>

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 19.040; 31.190

ISBN 978-2-8322-8169-7

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 Voids in solder joints	7
4.1 Type of voids	7
4.2 Reasons for voids	8
4.3 Influence of voiding on solder joint performance	9
5 Vacuum-assisted soldering processes	9
5.1 Purpose	9
5.2 Combination of soldering process with vacuum	9
5.3 Typical temperature-pressure-time curves	10
5.3.1 Convection soldering with vacuum	10
5.3.2 Vapour phase soldering with vacuum	11
5.3.3 Contact soldering with vacuum	12
6 Effect of vacuum when reflow soldering	13
6.1 General.....	13
6.1.1 General description	13
6.1.2 Physical basics	13
6.1.3 Vacuum parameters.....	14
6.1.4 Vapour phase reflow soldering.....	14
6.2 Components in the vacuum reflow soldering process	15
6.2.1 Influence of pressure differences	15
6.2.2 Influence of temperature, time, and vacuum	18
7 Vacuum equipment restrictions	18
7.1 General.....	18
7.2 Chamber size.....	18
7.3 Time to reach vacuum level	19
7.4 Cycle time.....	19
7.5 Summary	19
8 Typical defects after vacuum-assisted reflow soldering.....	20
8.1 Typical defect modes occurring at components	20
8.2 Component defect modes – summary	24
8.3 Soldering defect modes	24
8.3.1 Dropping of components	24
8.3.2 Bridging	25
8.3.3 Splattering	25
Bibliography.....	27
Figure 1 – X-Ray examples of voids in solder joints in different SMD-Components	8
Figure 2 – Reduction of voids with low flux soldering & preforms	8
Figure 3 – Example of a product for vacuum-assisted soldering processes	10
Figure 4 – Typical profile – vacuum-assisted convection soldering.....	11
Figure 5 – Typical profile – vacuum-assisted vapour phase soldering	12

Figure 6 – Typical profile – vacuum-assisted contact soldering	13
Figure 7 – Vapour pressure curve of Galden®	15
Figure 8 – Pressures to be considered	16
Figure 9 – Vapour pressure curve of water.....	17
Figure 10 – Blow Hole Void in/out of metallization.....	20
Figure 11 – Gas bubbles at metallization interface	20
Figure 12 – Gas bubble caused by residues in metallization defect.....	21
Figure 13 – Blow out void in solder meniscus.....	21
Figure 14 – Aluminium electrolytic capacitors with non-solid electrolyte, bulged.....	22
Figure 15 – Composite housing bursts in case of overpressure	22
Figure 16 – Housing mainly made of plastic bursts in case of overpressure	23
Figure 17 – Relay lock (polymer dot) blown off.....	23
Figure 18 – Housing with adhesive joint bursts in case of overpressure	24
Figure 19 – An example of bridging on BGA during vacuum assisted soldering	25
Figure 20 – Optimization with stepwise applying of vacuum to reduce bridging	25
Figure 21 – Splattering due to explosive outgassing from the solder joint.....	26
Table 1 – Combination of soldering processes with vacuum.....	10
Table 2 – Molar mass	17
Table 3 – Combination of soldering processes with vacuum.....	19

Document Preview

[IEC TR 60068-3-15:2024](https://standards.iteh.ai/catalog/standards/iec/8e03f2b1-20ca-47bc-807d-5f03a43f7335/iec-tr-60068-3-15-2024)

<https://standards.iteh.ai/catalog/standards/iec/8e03f2b1-20ca-47bc-807d-5f03a43f7335/iec-tr-60068-3-15-2024>

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ENVIRONMENTAL TESTING –

**Part 3-15: Supporting documentation and guidance –
Vacuum-assisted reflow soldering**

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 Publication(s)"). 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 application of this publication.
- 9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC TR 60068-3-15 has been prepared by technical committee 91: Electronics assembly technology. It is a Technical Report.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
91/1916/DTR	91/1930/RVDTR

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

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 60068 series, published under the general title *Environmental testing*, 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 webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

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.

iTeh Standards (<https://standards.iteh.ai>) Document Preview

[IEC TR 60068-3-15:2024](#)

<https://standards.iteh.ai/catalog/standards/iec/8e03f2b1-20ca-47bc-807d-5f03a43f7335/iec-tr-60068-3-15-2024>

INTRODUCTION

As defined in ISO 857-2, reflow soldering is a joining process using an additional metal (solder) with a liquidus temperature of 450 °C or less, in which solder paste or preforms are reflowed.

Reflow soldering can be carried out with the technical processes of convection (air or nitrogen), condensation (vapour phase), radiation (e.g. infrared) or contact heat.

Sometimes it is not possible to achieve the required void level for an assembly only with methods listed above despite the use of all technical possibilities.

Regarding void-induced asymmetrical stress constellations, a reduction of voiding can lead to a mitigated stress condition within the solder joints.

Various technical requirements only tolerate very small void dimensions. To achieve these requirements, vacuum-assisted soldering can be applied with the above mentioned reflow soldering processes.

In some product applications, a hermetic seal is required. The reliable fulfilment of this requirement is very demanding to the process technology especially complex assemblies. Vacuum-assisted soldering creates significantly more consistency in the results here.

Further benefits of vacuum-assisted soldering are improved thermal management or high frequency performance (contour adaptation, mitigation of blow holes).

Vacuum-assisted soldering, however, requires a different equipment with more complex structure and process control. Since the vacuum process has an impact on the process time, the suitability of the components and solder paste that are used need to be checked.

ENVIRONMENTAL TESTING –

Part 3-15: Supporting documentation and guidance – Vacuum-assisted reflow soldering

1 Scope

This part of IEC 60068 describes vacuum-assisted soldering considering the thermal profiling, soldering methods, suitability of the components and vacuum features of soldering systems. It is based on practical experiences from manufacturers, component, material, and soldering systems suppliers. It supports manufacturers by providing information about the functionality of vacuum and effect of vacuum on components performance.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

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

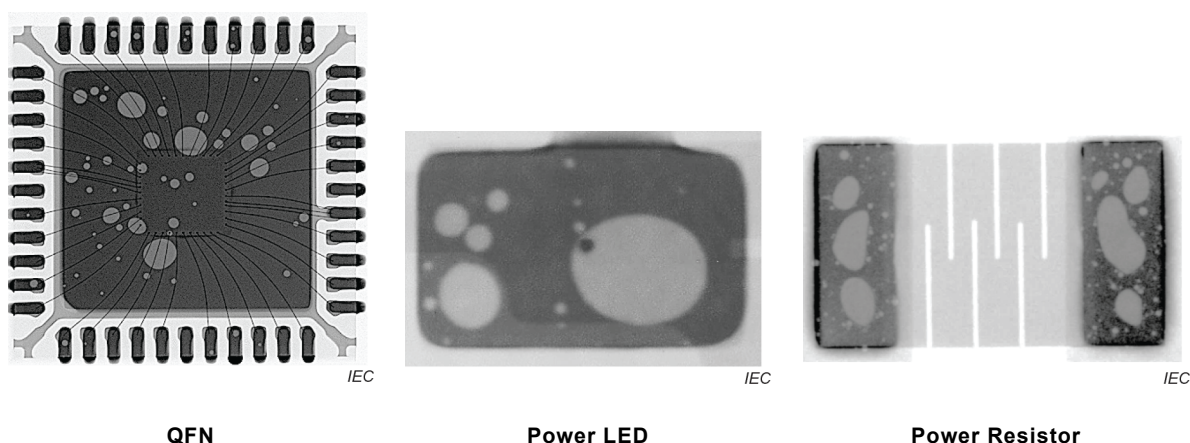
- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

4 Voids in solder joints

4.1 Type of voids

After soldering, many different macro and micro disturbances of the solder structure can be detected in the solder joints with e.g. X-Ray inspection, ultrasonic inspection or cross sectioning. Some of them represent the so-called voids which are divided according to their causes and type.

The definitions and classification of different void types can be found for example in IPC-7095, IPC-7093 or IEC TR 61191-8. This document describes the use of vacuum to prevent so-called macro voids. Figure 1 shows examples of macro voids in solder joints of different component types.

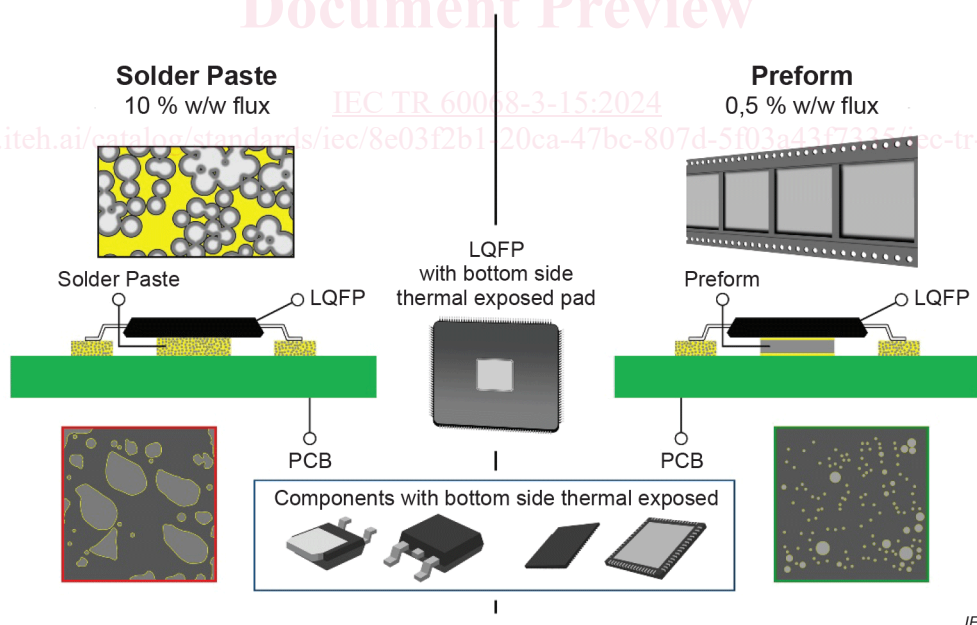


Reproduced with permission by Rehm Thermal Systems GmbH

Figure 1 – X-Ray examples of voids in solder joints in different SMD-Components

4.2 Reasons for voids

The research results to date lead to the essential finding that the mechanisms of void formation depend on many factors. When soldering with conventional solder pastes, the main factor is the use of flux. After remelting of the solder alloy, flux residues are trapped on the surfaces of the circuit board (PCB) and the soldered components. At high temperatures, these evaporate, and the products of these outgassing are trapped in the solder joint volume in the form of gas bubbles, i.e., voids. With a reduction of the flux amount, the proportion of voids can be reduced, as shown in the example in Figure 2.



Reproduced with permission by Indium Corporation of Europe

Figure 2 – Reduction of voids with low flux soldering & preforms

In addition, the void formation is influenced by the interaction of solder paste, quality and type of surface finish (PCB and component) and geometry of the solder joint. As a rule, void ratios in the range of 20 % to 50 % can occur by soldering under normal pressure / condition. Depending on the application and the required minimum void ratio, with vacuum-assisted soldering void ratios below 10 % can be realized.

4.3 Influence of voiding on solder joint performance

A solder joint has several functions on an assembly: electrical contact, mechanical fixation and thermal connection. These functions are classified here into two areas: mechanical integrity and thermal performance. Macrovoids in solder joints can have a negative impact on both areas. More information can be found in IPC-A-610, IPC-7095, IPC-7093, IEC TR 61191-8.

5 Vacuum-assisted soldering processes

5.1 Purpose

Vacuum has been used for many years in reflow soldering technology as an additional process step. Depending on the combination of soldering method with vacuum, the void content in solder joints of different products can be reduced.

In vacuum-assisted soldering, the pressure-time profile is recorded in addition to the temperature profile.

The parameters of vacuum profiling are:

- a) The vacuum steps and the vacuum level (the reached minimum pressure), pressure in Pascal (Pa) referred to zero;
- b) the frequency of vacuum use and the holding time of the specified vacuum level in seconds (s)

While in convection soldering with vacuum, the vacuum is applied above the liquidus temperature of the solder, in vapour phase and conduction soldering with vacuum the vacuum can be applied at any time of the process. Figure 4, Figure 5 and Figure 6 demonstrates examples of temperature-pressure time profiles for vacuum-assisted convection, condensation and conduction soldering. The so-called pre-vacuum can be used to change atmospheric gases, dry assemblies or even pastes.

To reduce voids, the vacuum is applied in all reflow soldering processes above the liquidus temperature of the solder. Since the application of vacuum requires additional time, the time above liquidus is extended. For the time above liquidus, however, the specifications given by common norms and standards must be complied with.

In general, the requirements and limitations of the temperature-time envelope curve apply to the profiles of vacuum-assisted soldering processes as well. More information can be found in IEC TR 60068-3-12. This applies in particular to the time above liquidus.

The cycle time of the complete soldering process depends on the vacuum level and the holding time of vacuum. Usually, the cycle time will be increased by addition of a vacuum step due to speed limitations of vacuum chamber for the opening and closing as well as for the evacuation and venting procedures.

5.2 Combination of soldering process with vacuum

All reflow soldering technologies, such as convection, condensation (vapour phase) and conductive (contact heat) processes are currently available on the market with additional vacuum technology.

Depending on the technology used, the vacuum process can be used before and during the preheating process as well as during the soldering process, in the molten phase of the solder joint. Table 1 contains different vacuum-assisted soldering processes and typical parameters. In Figure 3 an example of a product for the different vacuum-assisted soldering processes is shown.