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TECHNICAL REPORT

colour inside

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

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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.

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- withdrawn, or
- revised.

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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/
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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.

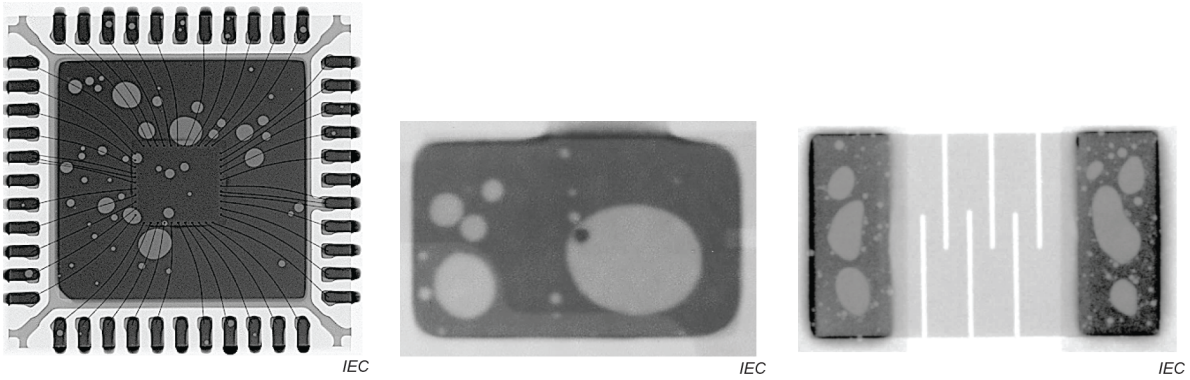

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Figure 1 – X-Ray examples of voids in solder joints in different SMD-Components

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.

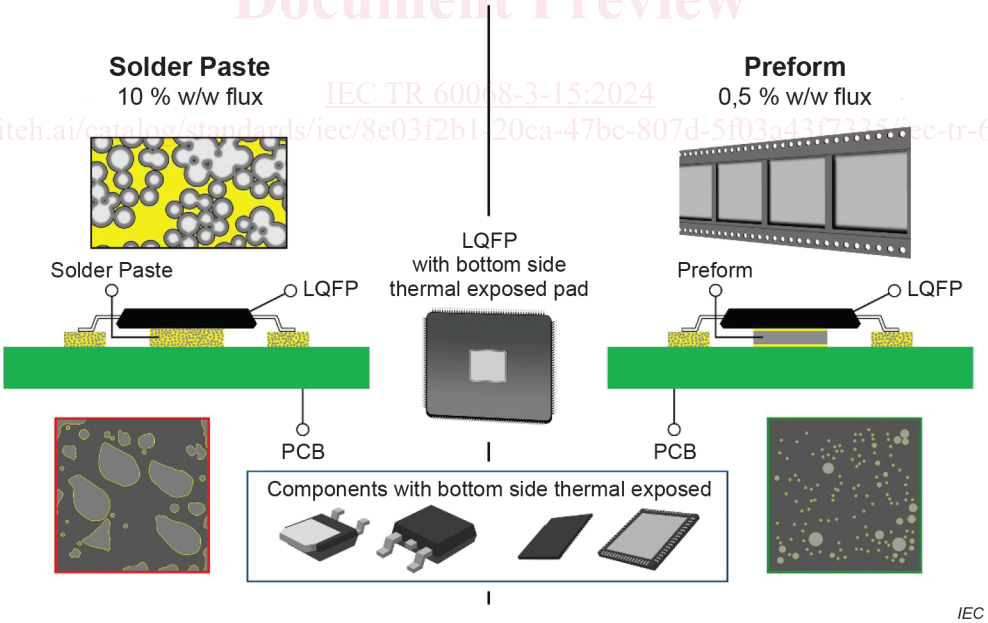

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Figure 2 – Reduction of voids with low flux soldering & preforms

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.