# IEC 61189-3-913

Edition 1.0 2016-01

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

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## Test methods for electrical materials, printed boards and other interconnection structures and assemblies – Part 3-913: Test method for thermal conductivity of printed circuit boards for high-brightness LEDs



## Méthodes d'essai pour les matériaux électriques, les cartes imprimées et autres structures d'interconnexion et ensembles – Partie 3-913: Méthodes d'essai pour la conductivité thermique des circuits imprimés pour les LED à forte luminosité

IEC 61189-3-913:2016-01(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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CONTENTS

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# TEST METHODS FOR ELECTRICAL MATERIALS, PRINTED BOARDS AND OTHER INTERCONNECTION STRUCTURES AND ASSEMBLIES –

## Part 3-913: Test method for thermal conductivity of printed circuit boards for high-brightness LEDs

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International Standard IEC 61189-3-913 has been prepared by IEC technical committee 91: Electronics assembly technology.

This first edition cancels and replaces the first edition of IEC PAS 61189-3-913 published in 2011. This edition constitutes a technical revision. This edition focused only on the test methods for thermal conductivity specific to printed circuit boards for high-brightness LEDs.

The text of this standard is based on the following documents:

| FDIS | Report on voting |
|---|---|
| 91/1304A/FDIS | 91/1328/RVD |

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

A list of all parts in the IEC 61189, published under the general title *Test methods for electrical materials, printed boards and other interconnection structures and assemblies*, can be found on the IEC website.

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

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

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- replaced by a revised edition, or
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# TEST METHODS FOR ELECTRICAL MATERIALS, PRINTED BOARDS AND OTHER INTERCONNECTION STRUCTURES AND ASSEMBLIES –

## Part 3-913: Test method for thermal conductivity of printed circuit boards for high-brightness LEDs

## 1 Scope

This part of IEC 61189 specifies the test methods for thermal conductivity specific to printed circuit boards for high-brightness LEDs. The test applies to printed circuit boards for high-brightness LEDs with surface mounted LEDs or with device embedded LEDs in electronic control devices (ECDs).

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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*



IEC 62326-20, *Printed boards – Part 20: Printed circuit boards for high-brightness LEDs*



## 3 Terms and definitions

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

## 4 Pre–conditioning

Pre-conditioning described in a) or b) below shall be carried out in accordance with the specific standard.

a) Leave a specimen for 24 h in the standard condition.

b) Leave a specimen for 60 min in a thermostat chamber at 85 °C and then leave the specimen for 24 ± 4 h in the standard atmospheric condition.

## 5 Test methods

### 5.1 General

In this standard, the following test methods are specified in order to classing the printed circuit board in accordance with Table 1 in IEC 62326-20.

### 5.2 Thermal conductivity

#### 5.2.1 Measurement of thermal resistance on the plane

In this subclause, the measurement of thermal resistance on the plane (horizontal direction of the specimen) is addressed as follows.

a) Apparatus

Use the apparatus specified in EIA/JEDEC STD 51-2, or equivalent. The equipment shall have a set of a specimen and a thermocouple in the centre of a cubic chamber of 30 cm side length. An apparatus is shown in Figure 1.

b) Specimen

Unless otherwise specified, use the specimen illustrated in Figure 2. All the dimensions in Figure 2 shall be requirements. This specimen uses a TEG chip (5 mm × 5 mm) with a temperature measuring sensor, which is wire-bonded to the centre of the specimen board as a heat source. The detail specification of the printed board shall be in accordance with Annex A.

c) Pre-conditioning

Pre-conditioning shall be in accordance with Clause 4. And, the test specimen shall be fixed horizontally in the chamber of the equipment.

d) Thermal resistance and heat transfer parameter on the plane (horizontal direction of the specimen). The following procedure shall be respected:

- provide a specimen assembled with a heater with a TEG chip with a temperature measuring sensor;
- specify the temperature coefficient of the sensor prior to the measurement;
- operate the heater and arrange the applied power ($P$) based upon the range of thermal resistance on the plane (horizontal direction of the specimen) as shown in Table 1;
- measure the temperature of the TEG chip with a temperature measuring sensor ($T_s$) and the temperature inside the chamber ($T_a$) after the temperature of the TEG chip with a temperature measuring sensor has reached a stable state;
- calculate the thermal resistance on the plane (horizontal direction of the specimen) ($R_p$) with the following equation:



$$R_p = (T_s - T_a) / P$$

- using the thermal resistance ($R_p$), calculate the thermal transfer parameter ($he$) by the following equation:

$$he = \frac{1}{R_p \times 0{,}002\ 5} \qquad \text{W/m}^2\text{K}$$

Equilibrium verification shall be in accordance with Annex B.

**Table 1 – Applied power ($P$) that corresponds to a range of thermal resistance on the plane**

| Applied power<br><br>W | Range of thermal resistance on the plane (horizontal direction of the specimen) ($R_p$)<br>K/W |
|---|---|
| 0,1 | $300 > R_p$ |
| 0,2 | $200 < R_p < 300$ |
| 0,3 | $150 < R_p < 200$ |
| 0,4 | $100 < R_p < 150$ |
| 0,75 | $60 < R_p < 100$ |
| 1,0 | $30 < R_p < 60$ |
| 2,0 | $20 < R_p < 30$ |
| 3,0 | $15 < R_p < 20$ |
| 5,0 | $5 < R_p < 15$ |
| 10,0 | $R_p < 5$ |

### 5.2.2 Measurement of thermal resistance across the thickness

In this subclause, the measurement of thermal resistance across the thickness is addressed as follows.



a) Apparatus

The testing apparatus is as shown in Figure 3. The apparatus shall consist of a metal block (aluminium or copper) which can hold the specimen specified in 5.2.1 b) and a cooling system to keep the temperature of the metal block constant.



b) Specimen

Specimen shall be as specified in 5.2.1 b).

c) Pre-conditioning

Pre-conditioning shall be in accordance with Clause 4.

d) Test

The procedure shall be as follows:

- provide a specimen, which is screwed to the metal block, assembled with a heater that contains a TEG chip with a temperature measuring sensor;
- specify the temperature coefficient of the sensor prior to the measurement;
- apply thermal conductive materials such as thermal grease between the specimen and the metal block to reduce thermal resistivity;
- install a thermocouple within a 10 mm distance from the edge of the specimen;
- install another thermocouple in the water sink;
- fix the metal block to the cooling system;
- keep the water temperature constant by the water-cooled system as shown in Figure 3;
- operate the heater and arrange the applied power ($P$) based on the thermal resistance across the thickness, as shown in Table 2;
- measure the temperature of the TEG chip with a temperature measuring sensor ($T_s$) and the temperature on the metal block ($T_b$) as soon as the temperature of the TEG chip with a temperature measuring sensor has reached the stable state;
- calculate the thermal resistance across the thickness ($R_t$) by the following equation:

$$R_t = (T_s - T_b)\,/P \quad \text{(K/W)}$$

The thermal conductivity parameter ($Ke$) shall be calculated with the following equation using $R_t$.

$$Ke = \frac{t}{R_t \times 2{,}5 \times 10^{-5}} \qquad \text{W/m}^2\text{K}$$

where

$t$ is the thickness (m);

$2{,}5 \times 10^{-5}$(m$^2$) is the area of the TEG chip with a temperature measuring sensor.

**Table 2 – Applied power ($P$) that corresponds to a range of thermal resistance across the thickness (K/W)**

| Applied power<br>W | Range of thermal resistance across the thickness ($R_t$)<br>K/W |
|---|---|
| 0,1 | $300 > R_t$ |
| 0,2 | $200 < R_t < 300$ |
| 0,3 | $150 < R_t < 200$ |
| 0,4 | $100 < R_t < 150$ |
| 0,75 | $60 < R_t < 100$ |
| 1,0 | $30 < R_t < 60$ |
| 2,0 | $20 < R_t < 30$ |
| 3,0 | $15 < R_t < 20$ |
| 5,0 | $5 < R_t < 15$ |
| 10,0 | $R_t < 5$ |

Dimensions in millimetres

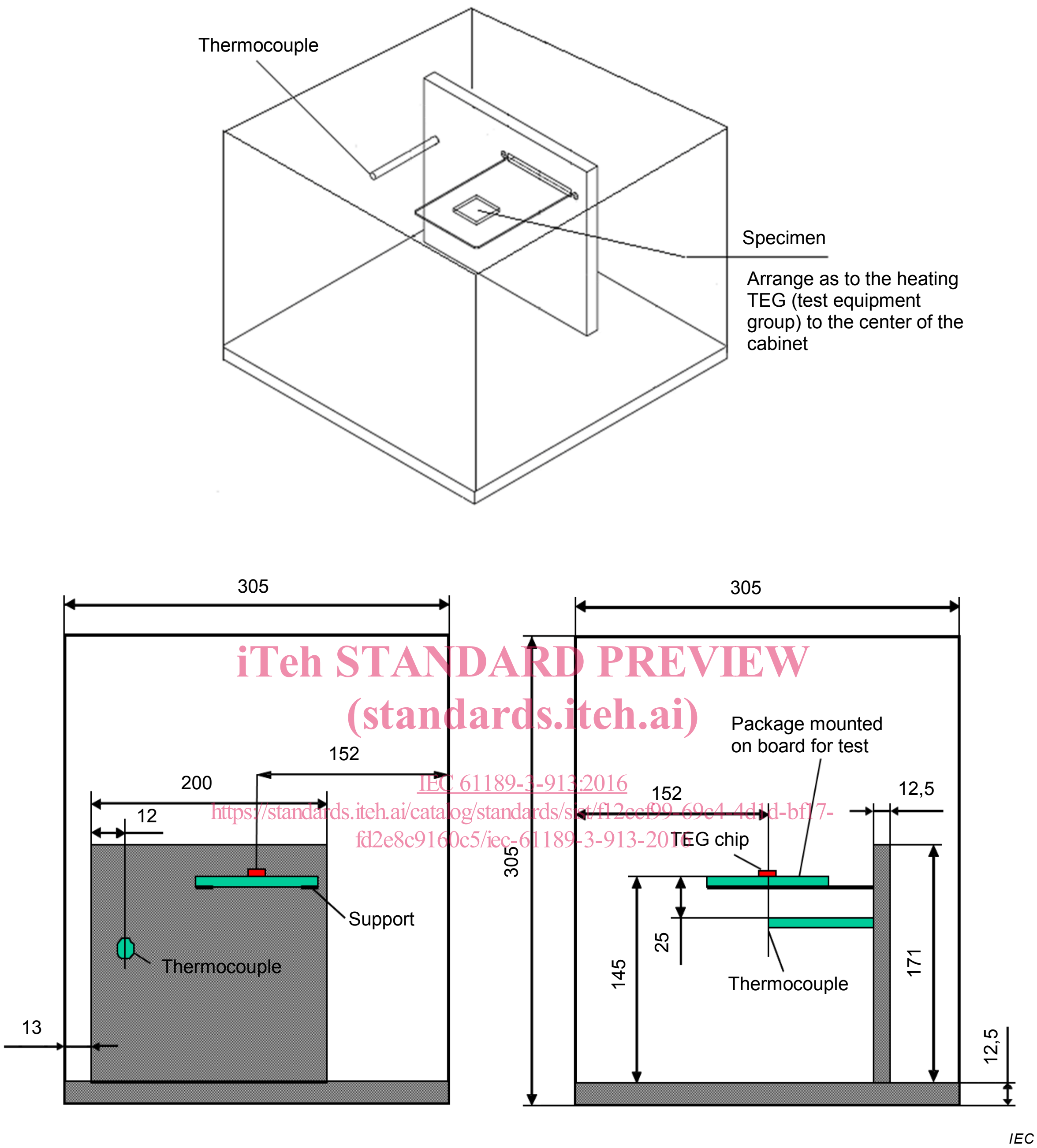





**Figure 1 – Illustration of an apparatus for the thermal conductivity test**

Dimensions in millimetres

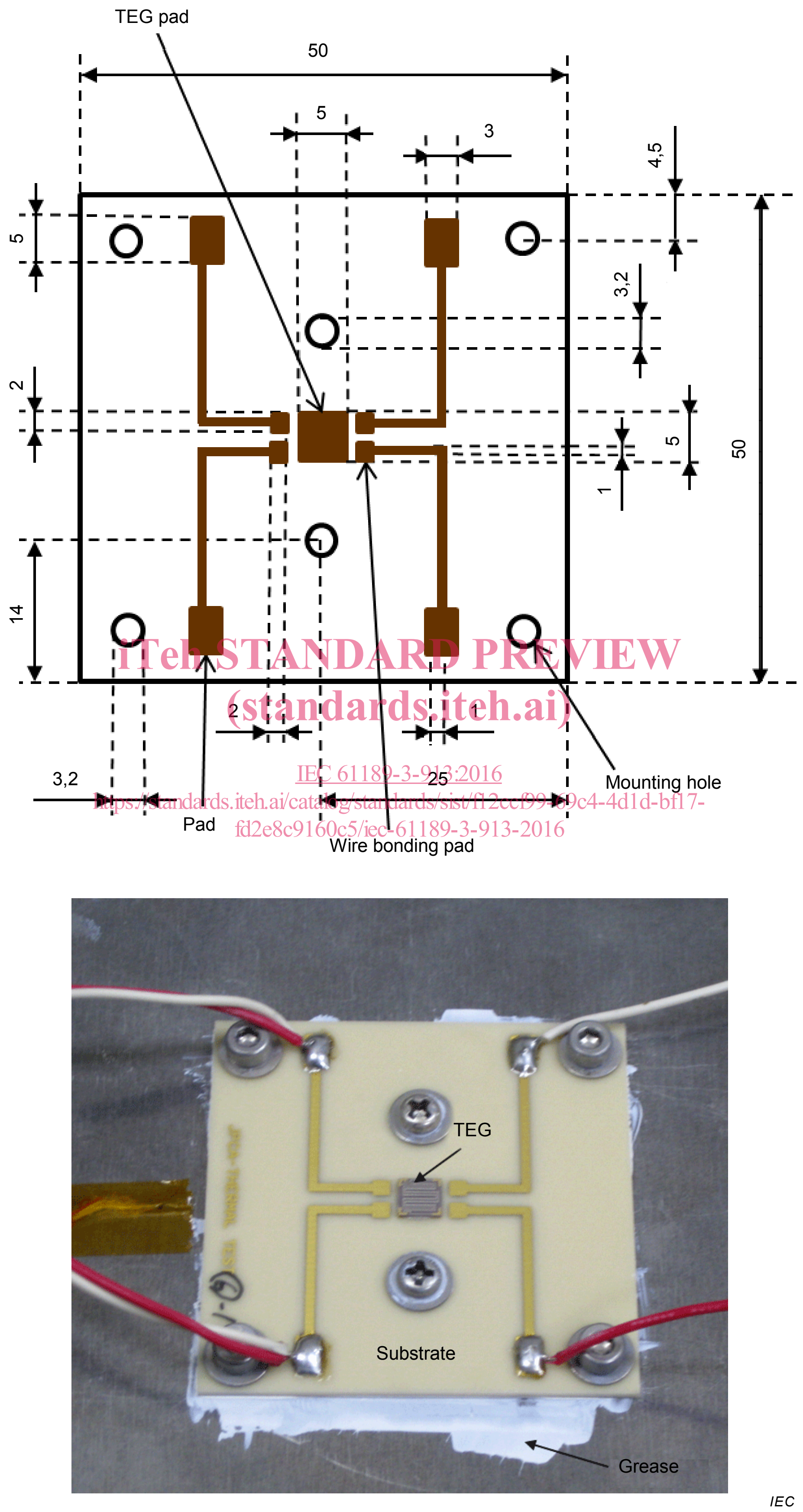





**Figure 2 – Surface layer specimen pattern for thermal conductivity test**

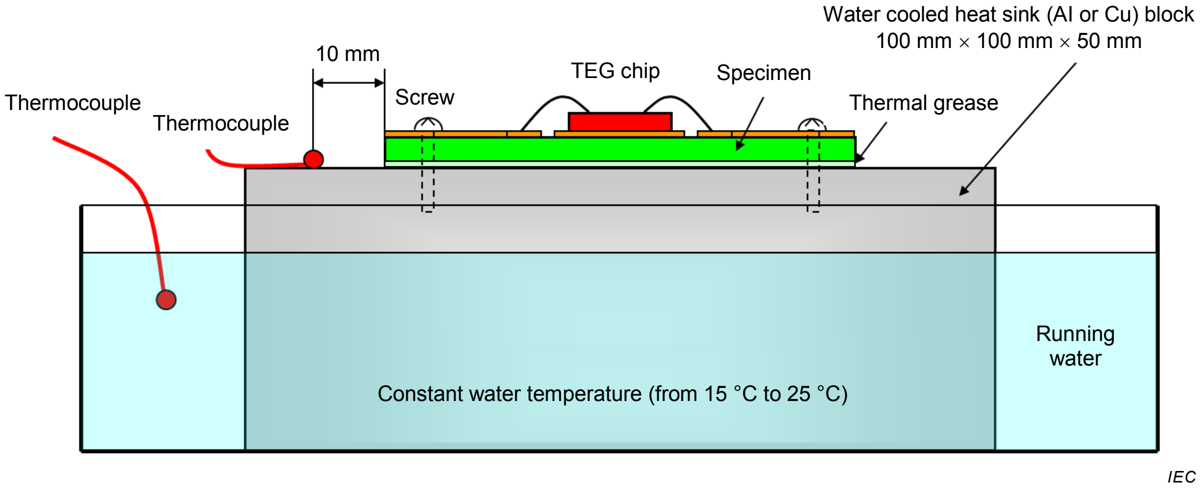



**Figure 3 – Test equipment for thermal resistance to the thickness direction**

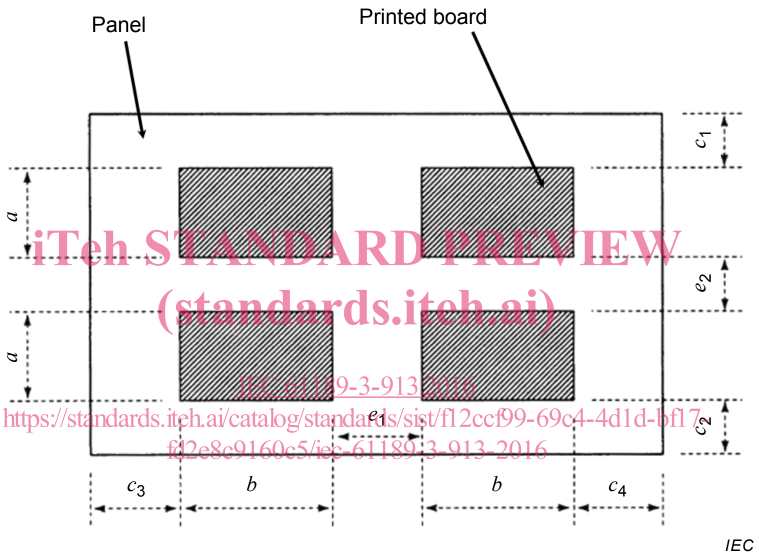
# Annex A
(normative)

# Boards and panels

## A.1 Panel and board sizes

### A.1.1 Board size

This subclause is given for reference only. The size of the board of the product ($a \times b$) illustrated in Figure A.1 should be selected so that the boards can be arranged efficiently within a panel with a size as specified in Table A.1. These dimensions are given for information only. Or, a proper panel with a size given in Table A.1 shall be selected so as to satisfy the required efficient arrangement of the boards.






**Key**

Board size of the product: $a \times b$

Space between board and panel edges: $c_1$, $c_2$, $c_3$, $c_4$

Space between boards: $e_1$, $e_2$

**Figure A.1 – Board arrangement in a panel**

**Table A.1 – Panel dimensions**

| Size of a CCL (copper clad laminate) panel | Division | | | |
|---|---|---|---|---|
| | 4 | 6 | 8 | 9 |
| 1 000 × 1 000 | 500 × 500 | 333 × 500 | 250 × 500 | 333 × 333 |
| 1 000 × 1 200 | 500 × 600 | 333 × 600<br>400 × 500 | 300 × 500 | 333 × 400 |
| Dimensions are in millimetres. | | | | |

### A.1.2 Allowance of dimensions

The allowance of dimensions of a board or a panel is given in Table A.2.