

# INTERNATIONAL STANDARD



**Printed electronics –  
Part 202-6: Materials – Conductive ink – Measurement method for resistance  
changes under high temperature and humidity – Printed conductive layer on a  
flexible substrate**

**STANDARD PREVIEW**  
(standards.iteh.ai)  
IEC 62899-202-6:2020  
<https://standards.iteh.ai/catalog/standards/sist/1153431f-7a6e-4453-9e4a-218ee11be148/iec-62899-202-6-2020>



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2020 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 Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://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](http://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 It also gives information on projects, replaced and withdrawn publications.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](http://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](http://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](mailto:sales@iec.ch).

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

#### IEC Glossary - [std.iec.ch/glossary](http://std.iec.ch/glossary)

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

[IEC 62899-202-6:2020](https://standards.iteh.ai/catalog/standards/sis/1153431f-7a6c-4453-9c4a-218ee11be148/iec-62899-202-6-2020)

<https://standards.iteh.ai/catalog/standards/sis/1153431f-7a6c-4453-9c4a-218ee11be148/iec-62899-202-6-2020>

# INTERNATIONAL STANDARD



**Printed electronics –  
Part 202-6: Materials – Conductive ink – Measurement method for resistance  
changes under high temperature and humidity – Printed conductive layer on a  
flexible substrate**

**STANDARD PREVIEW**  
(standards.iteh.ai)  
<https://standards.iteh.ai/catalog/standards/sist/1153431f-7a6e-4453-9e4a-218ee11be148/iec-62899-202-6-2020>

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 31.180; 87.080

ISBN 978-2-8322-9092-7

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

## CONTENTS

FOREWORD.....	3
INTRODUCTION.....	5
1 Scope.....	6
2 Normative references .....	6
3 Terms and definitions .....	6
4 Test sample and measurement equipment.....	7
4.1 General.....	7
4.2 Sample shape and size for measuring resistance change .....	7
5 Test conditions .....	7
5.1 General.....	7
5.2 Test conditions under temperature and humidity .....	7
5.3 Test conditions at high temperature .....	7
5.4 Test conditions for thermal cycling .....	7
6 Test method and test apparatus .....	8
6.1 General.....	8
6.2 Test apparatus.....	9
6.3 Test procedure.....	9
6.4 Measurement.....	10
7 Data analysis.....	10
7.1 Reporting the electrical property .....	10
7.2 Reporting of results.....	11
Annex A (informative) An example of environmental test.....	12
Bibliography.....	15
Figure 1 – Schematic diagram of environmental test jig of printed conductive film for two-wire measurement.....	8
Figure 2 – Schematic diagram of environmental test jig of printed conductive film for four-wire measurement .....	8
Figure 3 – Schematic diagram of environmental test jig of printed conductive film with screws for a four-wire measurement .....	9
Figure 4 – Image of metal grip for connection .....	9
Figure A.1 – Image of environment reliability test sample.....	12
Figure A.2 – Resistance change at a temperature of 85 °C and a humidity of 85 %.....	14
Table 1 – Options for duration time and interval of collecting data .....	10
Table 2 – Resistance range of the test piece and applied current (see IEC 62899-202) .....	10
Table A.1 – Test result.....	13

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## PRINTED ELECTRONICS –

**Part 202-6: Materials – Conductive ink –  
Measurement method for resistance changes under high temperature  
and humidity – Printed conductive layer on a flexible substrate**

## 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) 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.

International Standard IEC 62899-202-6 has been prepared by IEC technical committee 119: Printed Electronics.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
119/323/FDIS	119/331/RVD

Full information on the voting for the approval of this International Standard 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 62899 series, published under the general title *Printed electronics*, 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 publication 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 STANDARD PREVIEW (standards.iteh.ai)

[IEC 62899-202-6:2020](https://standards.iteh.ai/catalog/standards/sist/1153431f-7a6e-4453-9e4a-218ee11be148/iec-62899-202-6-2020)

<https://standards.iteh.ai/catalog/standards/sist/1153431f-7a6e-4453-9e4a-218ee11be148/iec-62899-202-6-2020>

## INTRODUCTION

The printing process is a highly promising technology for fabricating flexible devices due to its high conductivity and productivity. In particular, a printed conductive layer on a flexible substrate will be widely employed as an electrode or an interconnect for flexible devices. It will be dealt with and commercialized as a sort of composite material in which the conductive layer is formed on the substrate as a conductor.

For conductive films, silver/copper nanowires or metal mesh on flexible substrate are a key component for many recently developed electronic products, from smart phones to the keypads of appliances such as refrigerators and washing machines. Although the conventional material for transparent conductive films is indium tin oxide (ITO), transparent conductive films, enabled by printed electronics technologies, have arisen as a replacement. For application of conductive films, the electrical property under environmental conditions such as temperature, humidity, light, etc., is very important because it is highly sensitive to the environment because of oxidation, dissolution, melting, etc [1]<sup>1</sup>. The conductive films should be stored on a shelf and should be environmentally stable during their operation in electronic devices. Therefore, a method and environment for transferring, storing, and processing the conductivity film are sometimes provided by the supplier and include environmental measurements for printed devices. Although some environmental conditions for testing already exist, the unique characteristics of the printed conductive films should be considered, because they are fabricated on a polymer substrate which is susceptible to temperature, humidity, light, etc., unlike the conventional ITO transparent conductive films.

In this document, an environment reliability test is proposed to evaluate the electrical property and resistance change of a printed conductive film on a flexible substrate.

<https://standards.iteh.ai/catalog/standards/sist/1153431f-7a6e-4453-9e4a-218ee11be148/iec-62899-202-6-2020>

---

<sup>1</sup> Numbers in square brackets refer to the Bibliography.

## PRINTED ELECTRONICS –

### Part 202-6: Materials – Conductive ink – Measurement method for resistance changes under high temperature and humidity – Printed conductive layer on a flexible substrate

#### 1 Scope

This part of IEC 62899 provides a method of in-situ measurement for the resistance change of a conductive layer formed by printing methods on a flexible substrate under specified temperature and humidity conditions.

#### 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 62899-201, *Printed electronics – Part 201: Materials – Substrates*

IEC 62899-202, *Printed electronics – Part 202: Materials – Conductive ink*

IEC 62899-202-5, *Printed electronics – Part 202-5: Materials – Conductive ink – Mechanical bending test of a printed conductive layer on an insulating substrate*

#### 3 Terms and definitions

For the purposes of this document, the following terms and definitions 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

##### **conductive ink**

ink using metal particles as a main conductive component, in which one or more small molecules, oligomers, polymers, or particles are dissolved or dispersed, and which becomes an electrically conductive layer by post-treatment such as annealing by heating, lighting or chemical treating

Note 1 to entry: Metal particles are specified in IEC 62899-202.

##### 3.2

##### **conductive layer**

electrically conductive film-like layer fabricated with conductive ink, which is printed or coated on a substrate, followed as necessary by post-treatment such as annealing by heating, lighting or chemical treating



### 3.3

#### **flexible substrate**

flexible substrate on which conductive ink is printed, such as a plastic film

## **4 Test sample and measurement equipment**

### **4.1 General**

The test sample for environmental testing shall be prepared using a conductive ink on a substrate.

### **4.2 Sample shape and size for measuring resistance change**

A sample with a rectangular shape with a ratio over 20 is recommended.

The tolerance of width and length is 5 % (see IEC 62899-201 and IEC 62899-202).

The recommended sample size is 200 mm × 10 mm.

Another sample size of which the ratio of the longer side over the shorter side is at least 20 may be used for in situ environmental test.

## **5 Test conditions**

### **5.1 General**

The electrical resistance changes of a conductive film shall be measured during the environmental test inside a temperature and humidity controlled chamber. The test shall be measured under atmospheric pressure.

### **5.2 Test conditions under temperature and humidity**

Unless otherwise specified, the test temperature and humidity shall be  $(85 \pm 2) ^\circ\text{C}$  and  $(85 \pm 5) \%$ , respectively (see Annex A).

When testing at another temperature and humidity, the tolerance range for the test temperature shall be within  $\pm 2 ^\circ\text{C}$  and the tolerance for the test humidity shall be within  $\pm 5 \%$ .

### **5.3 Test conditions at high temperature**

Unless otherwise specified, test temperature shall be  $(120 \pm 2) ^\circ\text{C}$ .

However, the test temperature shall not exceed the glass transition temperature ( $T_g$ ) of the polymer used in the substrate of the test specimen. When  $T_g$  is lower than  $120 ^\circ\text{C}$ , the test temperature shall be  $15 ^\circ\text{C}$  lower than  $T_g$  in the substrate, with a tolerance of  $\pm 2 ^\circ\text{C}$ .

### **5.4 Test conditions for thermal cycling**

Unless otherwise specified, the thermal cycling test shall be carried out at the following temperature cycle:

- 1) keep at  $(-20 \pm 2) ^\circ\text{C}$  for 30 min,
- 2) increase to  $(80 \pm 2) ^\circ\text{C}$  within 30 min,
- 3) keep at  $(80 \pm 2) ^\circ\text{C}$  for 30 min,
- 4) decrease to  $(-20 \pm 2) ^\circ\text{C}$  within 30 min.

Repeat 1) to 4).

The relative humidity shall be kept at  $(50 \pm 5) \%$  throughout the test and condensation on the sample should be avoided.

## 6 Test method and test apparatus

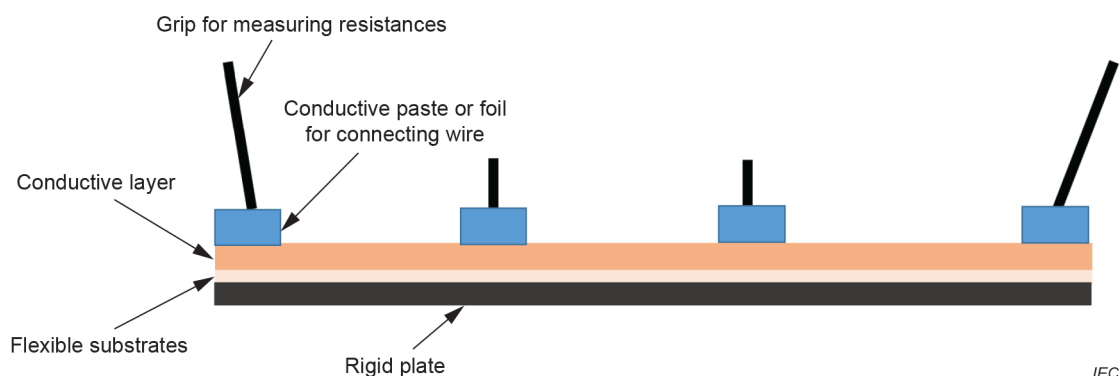
### 6.1 General

A printed conductive film is placed in a chamber which can control the temperature and humidity. Place the sample paying attention to the humidity distribution in the chamber.

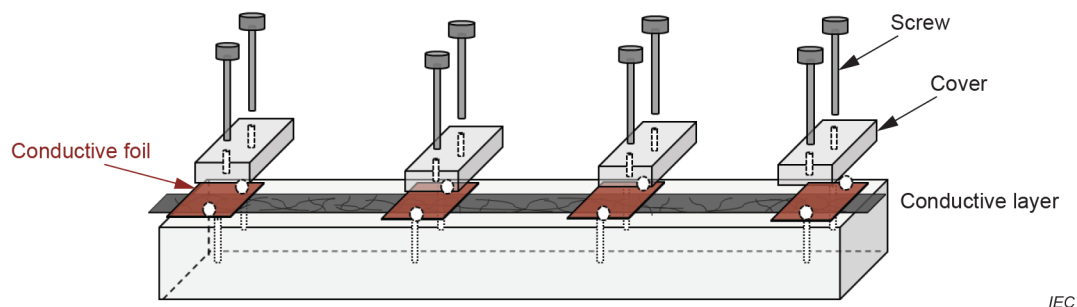
To measure resistance change, test sample can be placed on a rigid plate and fixed with screws for connection with the measuring equipment, as shown in Figure 1 to Figure 3. The test sample is connected with two or four conductive wires to the measuring equipment.



**Figure 1 – Schematic diagram of environmental test jig of printed conductive film for two-wire measurement**



**Figure 2 – Schematic diagram of environmental test jig of printed conductive film for four-wire measurement**



**Figure 3 – Schematic diagram of environmental test jig of printed conductive film with screws for a four-wire measurement**

NOTE The sample is placed paying attention to the humidity distribution in the chamber.

## 6.2 Test apparatus

As shown in Figure 1, for the environmental test, the conductive film shall be placed on a plate to reduce the interference from flexibility.

The plates shall be clean, smooth, and rigid to avoid damaging the samples. For the electrical measurement, the grip, shown in Figure 4, shall be made from a conductive metal grip for electrical connection, but the plate shall be made from insulating materials such as resin, polycarbonate, mono cast nylon, etc. The covers and the screws in Figure 1 to Figure 3 shall have the same properties as the plates. The plate and cover shall have a resistance larger than  $10^6 \Omega$ , and no deformation shall be allowed during the temperature and humidity test.

IEC 62899-202-6:2020  
<https://standards.iteh.ai/catalog/standards/sist/1153431f-7a6e-4453-9e4a-218ee11be148/iec-62899-202-6-2020>



IEC

**Figure 4 – Image of metal grip for connection**

All plates and materials shall be stable at a temperature from  $-30\text{ }^{\circ}\text{C}$  to  $150\text{ }^{\circ}\text{C}$  with 90 % relative humidity for the test duration.

## 6.3 Test procedure

The test procedure is as follows:

- Prepare the conductive film.
- Place the conductive film on a rigid plate and grip the sample.
- Place the sample inside the chamber with controllable temperature and humidity.
- Connect the two- or four-wire electrical connections for measuring resistance to the measurement equipment, which should be outside of the chamber.
- Measure the initial resistance.
- For the test method given in 5.2 to 5.4, set up the temperature and humidity to reach the target temperature and humidity.
- Measure the resistance.