

INTERNATIONAL STANDARD

Printed electronics –
Part 202: Materials – Conductive ink

ITeH STANDARD PREVIEW
(standards.iteh.ai)

IEC 62899-202:2016

<https://standards.iteh.ai/catalog/standards/sist/95d94e09-a826-4538-a678-d288d3d1bd70/iec-62899-202-2016>



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2016 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
Fax: +41 22 919 03 00
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 corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

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 It also gives information on projects, replaced and withdrawn publications.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 also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

65 000 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 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: csc@iec.ch.

INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC STANDARD PREVIEW
(standards.ch.ai)
IEC 62899-402:2016
<https://standards.iec.ai/catalog/standards/sud/62899-402/iec-62899-402-2016>
d288d3d1bd70/iec-62899-402-2016



IEC 62899-202

Edition 1.0 2016-02

INTERNATIONAL STANDARD

Printed electronics –
Part 202: Materials – Conductive ink

STANDARD PREVIEW
(standards.iteh.ai)

[IEC 62899-202:2016](https://standards.iteh.ai/catalog/standards/sist/95d94e09-a826-4538-a678-d288d3d1bd70/iec-62899-202-2016)

<https://standards.iteh.ai/catalog/standards/sist/95d94e09-a826-4538-a678-d288d3d1bd70/iec-62899-202-2016>

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.180; 87.080

ISBN 978-2-8322-3197-5

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	8
4 Atmospheric conditions for evaluation and conditioning	10
5 Evaluation of properties of conductive ink	10
5.1 Specimen.....	10
5.2 Contents	10
5.2.1 Solid content.....	10
5.2.2 Non-volatile content	10
5.2.3 Ash content.....	11
5.2.4 Foreign matter	11
5.3 Physical properties.....	12
5.3.1 Density	12
5.3.2 Rheology	12
5.3.3 Surface tension.....	13
5.3.4 Size of conductive materials.....	13
5.3.5 Flashpoint.....	15
5.3.6 Evaporation rate	15
6 Evaluation of the properties of a conductive layer.....	16
6.1 Test piece.....	16
6.1.1 General	16
6.1.2 Substrate	16
6.1.3 Conductive ink	16
6.1.4 Dimensions of test piece	16
6.1.5 Preparation of test piece	16
6.2 Electrical properties	16
6.2.1 Volume resistivity.....	16
6.2.2 Surface resistivity	21
6.3 Optical properties.....	22
6.3.1 Overview	22
6.3.2 Luminous transmittance	22
6.3.3 Chromaticity.....	22
6.3.4 Uniformity of colour.....	23
6.3.5 Haze.....	24
6.3.6 Refractive index.....	25
7 Storage	25
7.1 Storage conditions	25
7.2 Method for measuring aged deterioration	25
7.3 Report of the results.....	25
Annex A (informative) Examples of the four-point probe for applying an appropriate weight	26
A.1 Internal structure.....	26
A.2 Example of the general view.....	26

Annex B (informative) Equation of correction factor F	27
B.1 General.....	27
B.2 Conditions for correction factor F	27
B.3 Equation of correction factor F	28
Annex C (informative) Influence of the measuring position and the size of specimen on resistance.....	29
C.1 Influence of the measuring position on resistance	29
C.2 Influence of the size of the specimen on resistance.....	29
Bibliography	31
Figure 1 – Example of four-point probe measurement	17
Figure 2 – Example of four-probe measurement equipment.....	17
Figure 3 – Measuring positions of resistance (Type A).....	19
Figure 4 – Measuring positions of resistance (Type B).....	19
Figure 5 – Measuring positions of resistance (Type C).....	20
Figure A.1 – Example of the internal structure of probe.....	26
Figure A.2 – Example of the general view of the probe	26
Figure B.1 – Schematic diagram of the geometry of the conductive layer and the configuration of probes A, B, C, and D	27
Figure C.1 – Measurement model for the influence of the measuring position on sheet resistance.....	29
Figure C.2 – Model measurement of the influence of the specimen size	30
Table 1 – Resistance range of the test piece and the applied current	18
Table 2 – List of the size of the specimen	18

IEC 62899-202:2016

<http://standards.iteh.ai/catalog/standards/sic/95101-09-826-4538-a678-d288d3d1bd70/iec-62899-202-2016>

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRINTED ELECTRONICS –

Part 202: Materials – Conductive ink

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.
<https://standards.iteh.ai/catalog/standards/si/05494-09-e826-4538-a678-20200101-iec-62899-202-2016>
- 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 62899-2-1 has been prepared by IEC technical committee 119: Printed electronics.

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

FDIS	Report on voting
119/88/FDIS	119/101A/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.

This publication 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 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

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

A bilingual version of this publication may be issued at a later date.

iTeh STANDARD PREVIEW (standards.iteh.ai)

[IEC 62899-202:2016](https://standards.iteh.ai/catalog/standards/sist/95d94e09-a826-4538-a678-d288d3d1bd70/iec-62899-202-2016)

<https://standards.iteh.ai/catalog/standards/sist/95d94e09-a826-4538-a678-d288d3d1bd70/iec-62899-202-2016>

INTRODUCTION

The IEC 62899-20x series relates mainly to evaluation methods for materials of printed electronics. The series also include storage methods, packaging and marking, and transportation conditions.

The IEC 62899-20x series is divided into parts for each material. Each part is prepared as a generic specification containing fundamental information for the area of printed electronics.

The IEC 62899-20x series consists of the following parts:

Part 201: Materials – Substrates

Part 202: Materials – Conductive ink

Part 203: Materials – Semiconductor ink¹

(Subsequent parts will be prepared for other materials.)

Furthermore, sectional specifications, blank detail specifications, and detail specifications of each material will follow these parts.

This part of IEC 62899 is prepared for conductive materials used in printed electronics and contains the test conditions, the evaluation methods and the storage conditions.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

[IEC 62899-202:2016](https://standards.iteh.ai/catalog/standards/sist/95d94e09-a826-4538-a678-d288d3d1bd70/iec-62899-202-2016)

<https://standards.iteh.ai/catalog/standards/sist/95d94e09-a826-4538-a678-d288d3d1bd70/iec-62899-202-2016>

¹ Under consideration.

PRINTED ELECTRONICS –

Part 202: Materials – Conductive ink

1 Scope

This part of IEC 62899 defines the terms and specifies the standard methods for characterisation and evaluation.

This International Standard is applicable to conductive inks and conductive layer that are made from conductive inks.

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.

ISO 5-2, *Photography and graphic technology – Density measurements – Part 2: Geometric conditions for transmittance density*

ISO 5-3, *Photography and graphic technology – Density measurements – Part 3: Spectral conditions*

[IEC 62899-202:2016](https://standards.iteh.ai/catalog/standards/sist/95d94e09-a826-4538-a678-62899-202-2016)

[https://standards.iteh.ai/catalog/standards/sist/95d94e09-a826-4538-a678-](https://standards.iteh.ai/catalog/standards/sist/95d94e09-a826-4538-a678-62899-202-2016)

ISO 124, *Latex, rubber – Determination of total solids content*

ISO 291, *Plastics – Standard atmospheres for conditioning and testing*

ISO 304, *Surface active agents – Determination of surface tension by drawing up liquid films*

ISO 489:1999, *Plastics – Determination of refractive index*

ISO 758, *Liquid chemical products for industrial use – Determination of density at 20 degrees C*

ISO 1183-1, *Plastics – Methods for determining the density of non-cellular plastics – Part 1: Immersion method, liquid pycnometer method and titration method*

ISO 2555, *Plastics – Resins in the liquid state or as emulsions or dispersions – Determination of apparent viscosity by the Brookfield Test method*

ISO 2592, *Determination of flash and fire points – Cleveland open cup method*

ISO 2719, *Determination of flash point – Pensky-Martens closed cup method*

ISO 2811-1, *Paints and varnishes – Determination of density – Part 1: Pycnometer method*

ISO 2811-2, *Paints and varnishes – Determination of density – Part 2: Immersed body (plummet) method*

ISO 2884-1, *Paints and varnishes – Determination of viscosity using rotary viscometers – Part 1: Cone-and-plate viscometer operated at a high rate of shear*

ISO 3219, *Plastics – Polymers/resins in the liquid state or as emulsions or dispersions – Determination of viscosity using a rotational viscometer with defined shear rate*

ISO 3451-1, *Plastics – Determination of ash – Part 1: General methods*

ISO 3664, *Graphic technology and photography – Viewing conditions*

ISO 3679, *Determination of flash no-flash and flash point – Rapid equilibrium closed cup method*

ISO 4576, *Plastics – Polymer dispersions – Determination of sieve residue (gross particle and coagulum content)*

ISO 9276-6, *Representation of results of particle size analysis – Part 6: Descriptive and quantitative representation of particle shape and morphology*

ISO 13319, *Determination of particle size distributions – Electrical sensing zone method*

ISO 13320, *Particle size analysis – Laser diffraction methods*

ISO 13321, *Particle size analysis – Photon correlation spectroscopy*

ISO 13322-1, *Particle size analysis – Image analysis methods – Part 1: Static image analysis methods*

[IEC 62899-202:2016](https://standards.iteh.ai/catalog/standards/sist/95d94e09-a826-4538-a678-9288d3d1bd70/iec-62899-202-2016)

ISO 13468-1:1996, *Plastics – Determination of the total luminous transmittance of transparent materials – Part 1: Single beam instrument*

ISO 13468-2:1999, *Plastics – Determination of the total luminous transmittance of transparent materials – Part 2: Double-beam instrument*

ISO 13655, *Graphic technology – Spectral measurement and colorimetric computation for graphic arts images*

ISO 14488, *Particulate materials – Sampling and sample splitting for the determination of particulate properties*

ISO 14782, *Plastics – Determination of haze for transparent materials*

ISO 14887, *Sample preparation – Dispersing procedures for powders in liquids*

ISO 20998-1, *Measurement and characterization of particles by acoustic methods – Part 1: Concepts and procedures in ultrasonic attenuation spectroscopy*

3 Terms and definitions

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

NOTE The terms in italic font are those defined in Clause 3.

3.1**conductive material**

ingredient of a printing or coating material, which itself is electrically conductive or becomes electrically conductive by post treatment such as heating

3.2**conductive ink**

fluid in which one or more small molecules, polymers, or particles are dissolved or dispersed, and which becomes an electrically *conductive layer* (3.3) by post treatment such as heating

3.3**conductive layer**

film-like electrically conductive body made of *conductive ink* (3.2), which is printed or coated on a substrate, followed as necessary by post treatment such as heating

3.4**conductive film**

substrate (sheet or roll) with *conductive layer* (3.3)

3.5**solid content**

mass fraction of an ingredient which effectively functions as a conductive substance, in *conductive ink* (3.2)

3.6**non-volatile content**

mass fraction of residue obtained by evaporation of the volatile solvent under specific conditions, in *conductive ink* (3.2)

3.7**ash content**

mass fraction of residue excluding ingredients which are combusted or carbonised by pyrolysis, in *conductive ink* (3.2)

3.8**foreign matter**

substances and/or particles of aggregated grains, filmed ink and ingredients which do not function as a part of *conductive ink* (3.2)

3.9**spherical particle**

particle with three approximately equal dimensions of length, width and height

3.10**rod**

substance with thin elongated cylindrical shape

3.11**wire**

substance with thin long fibre-like shape having electrically conductive or semi-conductive property

3.12**tube**

substance with fiber-like hollow cylindrical shape

3.13

dispersion

heterogeneous system in which fine separated materials are distributed uniformly in other materials

3.14

flash point

lowest liquid temperature at which, under certain standardized conditions, a liquid gives off vapours in quantity such as to be capable of forming an ignitable vapour/air mixture

[SOURCE: IEC 60050-212:2010, 212-18-05]

4 Atmospheric conditions for evaluation and conditioning

The standard atmosphere for evaluation (test and measurement) and storage of the specimen shall be a temperature of $23\text{ °C} \pm 2\text{ °C}$ and relative humidity of $(50 \pm 10)\%$, conforming to standard atmosphere class 2 specified in ISO 291. If a polymer substrate is used for a test piece coated with a conductive layer, the standard atmosphere for evaluation shall be a temperature of $23\text{ °C} \pm 1\text{ °C}$ and relative humidity of $(50 \pm 5)\%$, conforming to standard atmosphere class 1 specified in ISO 291.

If conditioning is necessary, the same standard atmosphere specified above shall apply.

5 Evaluation of properties of conductive ink

5.1 Specimen

The specimen for evaluation shall be prepared according to ISO 14488 or an equivalent method. If necessary, dilution by a compatible solvent may be allowed.

5.2 Contents

5.2.1 Solid content

5.2.1.1 Determination of solid content

Solid content of conductive materials and non-conductive materials shall be determined by the theoretical mass fraction (expressed as a percentage) of functional ingredients to the total ink mass. Functional ingredients include conductive materials, their precursors or binders, or any additives.

5.2.1.2 Report of the results

The report shall include the following items:

- a) unique specimen identification;
- b) atmospheric conditions of test;
- c) solid content;
- d) tester, test place, and test time (ex. company name, city, year).

5.2.2 Non-volatile content

5.2.2.1 Principle

Non-volatile content is determined by measuring the mass of residue after evaporation of the volatile ingredients and calculating the mass fraction (expressed as a percentage) to the total ink mass.