

INTERNATIONAL STANDARD

**Printed electronics –
Part 202: Materials – Conductive ink**





THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2023 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 It also gives information on projects, replaced and withdrawn publications.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. 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 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.



IEC 62899-202

Edition 2.0 2023-05

INTERNATIONAL STANDARD

**Printed electronics –
Part 202: Materials – Conductive ink**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.180; 87.080

ISBN 978-2-8322-6936-7

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	9
4 Atmospheric conditions for evaluation and pre-conditioning	11
5 Summary characteristics and evaluation method of conductive ink	11
6 Evaluation of properties of conductive ink.....	12
6.1 Specimen.....	12
6.2 Contents	12
6.2.1 Solid content	12
6.2.2 Non-volatile content.....	12
6.2.3 Ash content	13
6.2.4 Foreign matter.....	13
6.3 Physical properties	14
6.3.1 Density	14
6.3.2 Rheology	14
6.3.3 Surface tension	15
6.3.4 Size of conductive materials	16
6.3.5 Flashpoint.....	17
6.3.6 Evaporation rate.....	18
6.3.7 Appearance of ink.....	19
7 Evaluation of the properties of a conductive layer.....	19
7.1 Test piece	19
7.1.1 General	19
7.1.2 Substrate.....	19
7.1.3 Conductive ink.....	19
7.1.4 Dimensions of test piece.....	19
7.1.5 Preparation of test piece.....	19
7.2 Electrical properties	20
7.2.1 Volume resistivity	20
7.2.2 Surface resistivity (based on the four-point probe method)	24
7.2.3 Surface resistivity (based on the contactless method).....	25
7.3 Mechanical properties	25
7.3.1 Bending test	25
7.3.2 Abrasion resistance	26
7.3.3 Adhesion strength.....	27
7.4 Optical properties	27
7.4.1 Overview	27
7.4.2 Luminous transmittance.....	27
7.4.3 Chromaticity	28
7.4.4 Uniformity of colour	28
7.4.5 Haze.....	30
7.4.6 Refractive index.....	30
8 Storage	31
8.1 Storage conditions	31

8.2	Method for measuring aged deterioration	31
8.3	Report of the results	31
Annex A (informative)	Example of four-point probe for applying an appropriate weight.....	32
A.1	Internal structure.....	32
A.2	Example of overall view	32
Annex B (informative)	Formula of correction factor F	33
B.1	General.....	33
B.2	Conditions for correction factor F	34
B.3	Formula of correction factor F	34
Annex C (informative)	Influence of the measuring position and size of the specimen on resistance	5
C.1	Influence of the measuring position on resistance	35
C.2	Influence of the size of the specimen on resistance	36
Bibliography	37
Figure 1	– Example of four-point probe measurement	20
Figure 2	– Example of four-probe measurement equipment	20
Figure 3	– Measuring positions of resistance (Type A)	22
Figure 4	– Measuring positions of resistance (Type B)	22
Figure 5	– Measuring positions of resistance (Type C).....	23
Figure A.1	– Example of the internal structure of probe.....	32
Figure A.2	– Example of the overall view of the probe.....	32
Figure B.1	– Schematic diagram of the geometry of the conductive layer and the configuration of probes A, B, C and D	33
Figure C.1	– Measurement model for the influence of the measuring position on sheet resistance	35
Figure C.2	– Model measurement of the influence of the specimen size.....	36
Table 1	– Test methods for conductive inks used in PE.....	11
Table 2	– Resistance range of the test piece and the applied current.....	21
Table 3	– List of the size of the specimen	22

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.
- 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.

IEC 62899-2-1 has been prepared by IEC technical committee 119: Printed electronics. It is an International Standard.

This second edition cancels and replaces the first edition published in 2016. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) definitions of conductive material, conductive ink and conductive layer have been revised;
- b) a summary of test methods is added;
- c) mechanical tests for conductive layer are added.

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

Draft	Report on voting
119/423/FDIS	119/428/RVD

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 International Standard 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 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 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.

INTRODUCTION

Printed electronics is a technology that spans the printing and electrical/electronic area, and it provides a variety of products. Since participants in this industry come from different areas, their backgrounds and customs can be barriers to smooth communication and transactions in the supply chain. The printed electronics industry continues to grow, but many barriers still remain. Particularly, the lack of standardised terms and evaluation methods is one of the major factors that inhibit smooth communication.

This document focuses on measurement and evaluation methods for conductive inks and provides tools to promote the smooth communication within the supply chain.

This document specifies the basic items to be communicated and their measurement and evaluation methods. This document includes the measurement methods for the basic properties of inks and electrical conductivity, which is obtained by the post treatment of inks. Additionally, storage methods, packaging and marking, and transportation conditions are also included.

This document is part of the IEC 62899-202 series and similar documents are available for other materials used in printed electronics.

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

- IEC 62899-201: Materials – Substrates
- IEC 62899-202: Materials – Conductive ink
- IEC 62899-203: Materials – Semiconductor ink
- IEC 62899-204: Materials – Insulator ink

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

PRINTED ELECTRONICS –

Part 202: Materials – Conductive ink

1 Scope

This part of IEC 62899 defines the terms and specifies the standard test methods for characterization and evaluation of conductive inks.

This document also provides measurement methods for evaluating the properties of conductive layers made both from an additive process using conductive inks and from a subtractive process used in printed electronics.

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 62899-202-3, *Printed electronics – Part 202-3: Materials – Conductive ink – Measurement of sheet resistance of conductive films – Contactless method*

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

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*

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 489:2022, *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 2409:2020, *Paints and varnishes – Cross-cut test*

ISO 2471, *Paper and board – Determination of opacity (paper backing) – Diffuse reflectance method*