BS IEC 62899-202:2023

BSI Standards Publication

Printed electronics

Part 202: Materials — Conductive ink

Documents
Document Sharing Hub

Full document details: BS IEC 62899-202:2023

National foreword

This British Standard is the UK implementation of IEC 62899-202:2023. It supersedes BS IEC 62899-202:2016, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee AMT/9, Printed Electronics.

A list of organizations represented on this committee can be obtained on request to its committee manager.

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

© The British Standards Institution 2023
Published by BSI Standards Limited 2023

ISBN 978 0 539 15812 0

ICS 31.180; 87.080

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2023.

Amendments/corrigenda issued since publication

Date	Text affected

Documents
Document Sharing Hub

Full document details: BS IEC 62899-202:2023

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.

® Registered trademark of the International Electrotechnical Commission

Documents
Document Sharing Hub

Full document details: BS IEC 62899-202:2023

Documents
Document Sharing Hub

Full document details: BS IEC 62899-202:2023

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

AVA Documents
Document Sharing Hub

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 35
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

Documents
Document Sharing Hub

Full document details: BS IEC 62899-202:2023

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.

Documents
Document Sharing Hub

Full document details: BS IEC 62899-202:2023

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.

Documents
Document Sharing Hub

Full document details: BS IEC 62899-202:2023

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 or 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.

Documents
Document Sharing Hub

Full document details: BS IEC 62899-202:2023

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*

Documents
Document Sharing Hub

Full document details: BS IEC 62899-202:2023

ISO 2555, *Plastics – Resins in the liquid state or as emulsions or dispersions – Determination of apparent viscosity using a single cylinder type rotational viscometer method*

ISO 2592, *Petroleum and related products – 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 3251, *Paints, varnishes and plastics – Determination of non-volatile-matter content*

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 11664-4, *Colorimetry – Part 4: CIE 1976 L*a*b* colour space*

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*

ISO 13468-1:2019, *Plastics – Determination of the total luminous transmittance of transparent materials – Part 1: Single beam instrument*

ISO 13468-2:2021, *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*

Documents
Document Sharing Hub

Full document details: BS IEC 62899-202:2023

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 15212-1, *Oscillation-type density meters – Part 1: Laboratory instruments*

ISO 18947-1:2021, *Imaging materials and prints – Abrasion resistance – Part 1: General rub testing methods*

ISO 20379, *Fine ceramics (advanced ceramics, advanced technical ceramics) – Measurement of thixotropic behaviour of ceramic slurry by use of a rotational viscometer*

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.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

NOTE Words in italics are defined within Clause 3.

3.1
conductive material
ingredient of a printing or coating component with intrinsic property providing electrical conductivity

Note 1 to entry: The ingredient can be one or more small molecules, precursors, polymers, or particles.

Note 2 to entry: The ingredient can require post treatment to provide electrical conductivity

3.2
conductive ink
fluid in which one or more *conductive materials* (3.1) are dissolved or dispersed, and which is used to form an electrically conductive structure

3.3
conductive layer
film-like structure formed by printing or coating and *post treatment* (3.4) of *conductive ink* (3.2) on a substrate, which is electrically conductive

3.4
post treatment
process step following the deposition of ink to generate the intended functionality

Note 1 to entry: Process steps can be evaporation, annealing, curing or sintering

3.5
conductive film
substrate (sheet or roll) with *conductive layer* (3.3)

Documents
Document Sharing Hub

Full document details: BS IEC 62899-202:2023

3.6
solid content
mass fraction of an ingredient which effectively functions as a conductive substance, in *conductive ink* (3.2)

3.7
non-volatile content
mass fraction of residue obtained by evaporation of the volatile solvent under specific conditions, in *conductive ink* (3.2)

3.8
ash content
mass fraction of residue in *conductive ink* (3.2) excluding ingredients which are combusted or carbonised by pyrolysis

3.9
foreign matter
substances, particles of aggregated grains, solidified ingredients of ink and ingredients which do not function as a part of *conductive ink* (3.2)

3.10
spherical particle
particle with three approximately equal dimensions of length, width and height

3.11
rod
substance with thin elongated cylindrical shape

3.12
wire
flexible cylindrical conductor, with or without an insulating covering, the length of which is large with respect to its cross-sectional dimensions

Note 1 to entry: The cross-section of a wire may have any shape, but the term "wire" is not generally used for ribbons or tapes.

[SOURCE: IEC 60050-151:2001, 151-12-28]

3.13
tube
substance with fiber-like hollow cylindrical shape

3.14
dispersion
system consisting of two or more phases one of which is continuous and at least one other is finely dispersed

[SOURCE: IEC 62899-101:2019, 3.31]

3.15
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]

Documents
Document Sharing Hub

Full document details: BS IEC 62899-202:2023