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INTERNATIONAL STANDARD

Printed electronics – Part 202: Materials – Conductive ink

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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PRINTED ELECTRONICS –

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FOREWORD

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IEC 62899-202 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- withdrawn,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 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.

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*

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*

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)

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]

4 Atmospheric conditions for evaluation and pre-conditioning

The standard atmosphere for evaluation (test and measurement) and storage of the specimen shall be a temperature of 23 °C ± 2 °C and relative humidity of (50 ± 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 °C ± 1 °C and relative humidity of (50 ± 5) %, conforming to standard atmosphere class 1 specified in ISO 291. Atmospheric pressure in test and measurement may be specified in a prior agreement of trade partners, but it shall be reported.

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

5 Summary characteristics and evaluation method of conductive ink

The conductive inks used in printed electronics shall be tested in accordance with the methods specified in Table 1. Unless there is a prior agreement between the user and supplier these test methods shall be applied without modification. In cases where the test has been modified, the changed condition shall be described in the report.

Table 1 – Test methods for conductive inks used in PE

Items		Standards for each test method
Ink properties	Non-volatile content	ISO 3251
	Ash content	ISO 3451-1 method A
	Foreign matter	ISO 4576
	Density	Pyknometer (specified in ISO 758, ISO 1183-1 or ISO 2811-1) Oscillation-type density meters (specified in ISO 15212-1) Immersed body (plummet) method (specified in ISO 2811-2)
	Rheology (viscosity)	Brookfield type rotational viscometer (specified in ISO 2555) Cone-and-plate viscometer (specified in ISO 2884-1) Rotational viscometer (specified in ISO 3219)
	Rheology (thixotropic index)	ISO 20379 using rotational viscometers
	Surface tension	Liquid film (Wilhelmy) method (specified in ISO 304)
	Size of conductive materials (spherical particles)	Electric sensing zone method (specified in ISO 13319) Laser diffraction method (specified in ISO 13320) Photon correlation method (specified in ISO 13321) Ultrasonic attenuation spectroscopy method (specified in ISO 20998-1)
	Size of conductive materials (rods, wires and tubes)	Static image analysis method (specified in ISO 13322-1)
	Size of conductive materials (other shapes)	ISO 9276-6
	Flashpoint	Open system; ISO 2592 Closed system; ISO 2719, ISO 3679
	Evaporation rate	Subclause 6.3.6 in this document
	Appearance of ink	Absorbance is measured by equipment specified in ISO 13468-1 or ISO 13468-2.