IEC 63203-201-1

Edition 1.0 2022-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Wearable electronic devices and technologies –
Part 201-1: Electronic textile – Measurement methods for basic properties of conductive yarns**

**Technologies et dispositifs électroniques prêts-à-porter –
Partie 201-1: Textile électronique – Méthodes de mesure des propriétés fondamentales des fils conducteurs**

IEC 63203-201-1:2022-04(en-fr)

IEC 63203-201-1

Edition 1.0 2022-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Wearable electronic devices and technologies – Part 201-1: Electronic textile – Measurement methods for basic properties of conductive yarns

Technologies et dispositifs électroniques prêts-à-porter – Partie 201-1: Textile électronique – Méthodes de mesure des propriétés fondamentales des fils conducteurs

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 59.080.80; 59.080.20 ISBN 978-2-8322-1103-6

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

WEARABLE ELECTRONIC DEVICES AND TECHNOLOGIES –

Part 201-1: Electronic textile –
Measurement methods for basic properties of conductive yarns

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 63203-201-1 has been prepared by IEC technical committee 124: Wearable electronic devices and technologies. It is an International Standard.

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

Draft	Report on voting
124/175/FDIS	124/180/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/standardsdev/publications.

A list of all parts in the IEC 63203 series, published under the general title *Wearable electronic devices and technologies*, 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

This document contains provisions for conductive yarns and defines measurement methods of properties of conductive yarns used in electronic textile (e-textile) in wearable electronics. A conductive yarn can be incorporated into the fabric which, in turn, can be used to manufacture a wearable electronics product. The conductive yarn can transmit electric signals and/or supply electric power. Therefore, measurement methods are defined for the characteristics of conductive yarns.

The IEC 63203-2 series relates mainly to measurement methods for electronic textile (e-textile) in wearable electronics.

The IEC 63203-2 series is divided into parts according to each category of electronic textile. Each part is prepared as a generic specification containing fundamental information for the area of printed electronics.

The IEC 63203-2 series consists of the following parts:

IEC 63203-201: E-textile materials

- IEC 63203-201-1: E-textile materials – Conductive yarn
- IEC 63203-201-2: E-textile materials – Conductive fabrics and insulation materials

IEC 63203-202: Passive electric parts for e-textiles

- IEC 63203-202-1: Passive e-textile parts – Connectors for e-textile applications

IEC 63203-203: E-textile functional elements

IEC 63203-204: E-textile systems (Evaluation method for garment-type wearable systems)

- IEC 63203-204-1: E-textile systems – Test method for assessing washing durability of leisurewear and sportswear e-textile systems

(Subsequent parts will be prepared according to other categories.)

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

WEARABLE ELECTRONIC DEVICES AND TECHNOLOGIES –

Part 201-1: Electronic textile – Measurement methods for basic properties of conductive yarns

1 Scope

This part of IEC 63203-201 specifies provisions and test methods for measurement of properties of conductive yarns. Conductive yarns covered in this document have conductivity of a level that can be used for transmission of electric signals, supply of electric power and electromagnetic shield. They do not include high-resistance conductive yarn used for anti-static and heating use. Conductive yarns are the basic material in electronic textiles and are mainly used as conductive traces in clothes-type wearable devices, as well as with secondary processing (woven, knitted, embroidered, nonwoven, etc.) to provide conductive fabrics.

This document does not define the required characteristics of the conductive yarn; rather, it specifies the handling and measurement methods for general and electrical properties of conductive yarn.

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 60468:1974, *Method of measurement of resistivity of metallic materials*

ISO 105-E04, *Textiles – Tests for colour fastness – Part E04: Colour fastness to perspiration*

ISO 139, *Textiles – Standard atmospheres for conditioning and testing*

ISO 6330, *Textiles – Domestic washing and drying procedures for textile testing*

EN 16812:2016, *Textiles and textile products – Electrically conductive textiles – Determination of the linear electrical resistance of conductive tracks*

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 fibre
fibre, such as staple or filament, having electrical conductivity

Note 1 to entry: Conductive fibre can be used for signal line, power transmission line, and electromagnetic shield.

Note 2 to entry: The conductive fibres can constitute conductive yarns.

[SOURCE: IEC 63203-101-1:2021, 3.16]

3.2
conductive yarn
yarn having electrical conductivity

Note 1 to entry: Conductive yarn can be used for signal line, power transmission line, and electromagnetic shield.

[SOURCE: IEC 63203-101-1:2021, 3.17]

3.3
conductive fabric
fabric, such as woven fabric, knitted fabric, nonwoven fabric, having electrical conductivity

Note 1 to entry: Conductive fabric can be used at the level of signal line, power transmission line, and electromagnetic shield.

[SOURCE: IEC 63203-101-1:2021, 3.18]

4 Materials and structure

4.1 Classifications of conductive fibres

4.1.1 Structure

Conductive fibres are typically classified as follows:

a) monolithic (conductive polymer and metal);

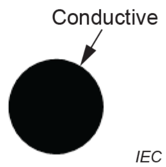
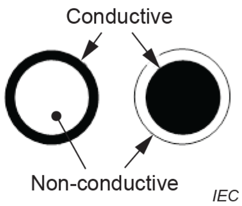
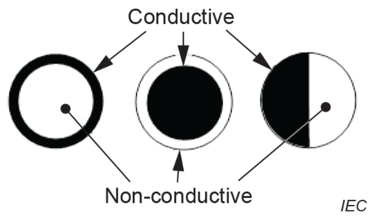
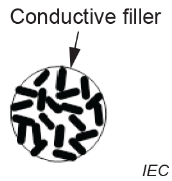
b) coated (conductive coating on non-conductive fibre, non-conductive coating on conductive fibre);

c) bi-component (conductive and non-conductive polymer);

d) conductive filler/composite.

These typical cross-sectional diagrams are shown in Table 1.

Table 1 – Typical cross-sectional diagrams of conductive fibres

Typical cross-sectional diagrams of conductive fibres			
 Monolithic (conductive polymer and metal)	 Coated (conductive coating on non-conductive fibre, non-conductive coating on conductive fibre)	 Bi-component (combination of conductive and non-conductive polymer)	 Conductive filler composite

4.1.2 Length

Conductive fibres are categorized into filament or staple fibres. Staple refers to a fibre of discrete length. Filament refers to a continuous length.

4.1.3 Basic materials for non-conductive components of fibre

The following materials are used for the non-conductive core, sheath and coating of the conductive fibres:

a) man-made polymer, for example, polyester, aliphatic polyamide, aromatic polyamide, polyacrylamide, elastomer, and others;

b) natural fibres, such as silk, wool, cotton, and others.

4.1.4 Conductive components for conductive fibres

Conductive materials are classified into metallic materials and non-metallic materials:

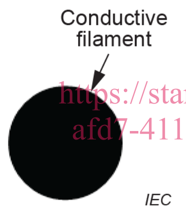
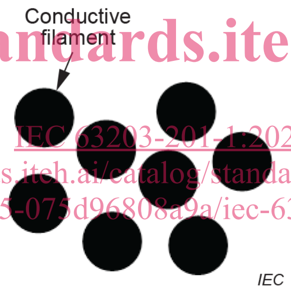
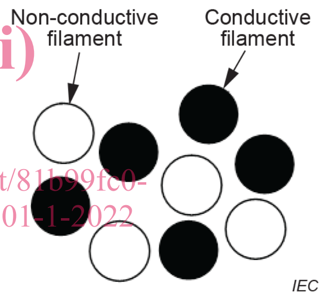
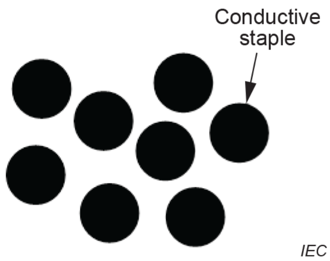
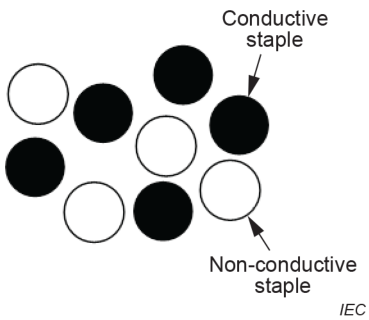
a) metallic materials, for example, silver, gold, copper, aluminium, stainless steel, other metals;

b) non-metallic materials, for example, carbon-based materials, conductive polymers, and others. Carbon-based materials include conductive carbon powder such as graphite, carbon nanotube and graphene.

4.2 Structure of conductive yarns

Conductive yarns are classified according to the type of their composing fibres as shown in Table 2.

Table 2 – Constructions of conductive yarns

<table>
<tr><th colspan="5">Construction of conductive yarns (schematic cross section)</th></tr>
<tr><td>Filament yarn</td>
<td>Mono-filament yarn consisting of one filament fibre</td>
<td colspan="2">Multi-filament yarn consisting of conductive filament fibre</td>
<td>Multi-filament yarn consisting of conductive and non-conductive filament fibre</td></tr>
<tr><td rowspan="2">Spun yarn</td>
<td colspan="2">Spun yarn consisting of conductive staple fibre</td>
<td colspan="2">Spun yarn consisting of conductive and non-conductive staple fibre</td></tr>
<tr><td colspan="4">Mixed yarn consisting of filament fibre and staple fibre.
Some or all of filament is conductive, and/or some or all of staple is conductive.</td></tr>
</table>

5 Atmospheric conditions for measurement and conditioning

Preparation, conditioning and measurement of the test specimens shall be carried out in accordance with the standard atmosphere of ISO 139 (i.e., 20 °C, 65 % RH).

6 Measurement methods for characteristics of conductive yarn

6.1 Electrical properties

6.1.1 Resistance of conductive yarn

6.1.1.1 General

The electrical resistance of conductive yarn is determined using the four-wire method as specified in IEC 60468:1974 and EN 16812:2016. The electrical resistance of conductive yarn is defined as the electrical resistance per unit length of the conductive yarn Ω / m. Yarns may be straightened by applying a weight to one end of the yarn. A pre-tension of 0,5 cN/tex is recommended, but other values can be agreed upon by the interested parties or in function of the tensile properties of the yarn. This can be important for yarns containing high amounts of metal according to EN 16812:2016.

6.1.1.2 Specimens

Prepare five specimens with an effective length of 0,5 m each according to EN 16812:2016.

6.1.1.3 Procedure

a) Measure the electrical resistance value of each five specimens according to IEC 60468:1974.

b) Calculate the average of five specimen's resistance values.

6.1.1.4 Report of results

The report shall include the following items:

a) identification of the measured conductive yarn;

b) test conditions (room temperature and humidity);

c) number of measured yarns;

d) average of measured resistance values;

e) standard deviation of measured resistance values.

6.1.2 Fusing current

6.1.2.1 General

In this Subclause 6.1.2, it is described how to obtain the minimum value when a conductive yarn melts or ignites by heat developed when current is passed through each conductive fibre.

The fusing current is a fundamental measurement value for obtaining the maximum permissible current for the conductive yarn. It should be noted that the safety factor for determining the maximum permissible current is determined on a case-by-case basis, since the surrounding condition of the conductive yarns in the situations in which the conductive yarns are used, depends on each application.

6.1.2.2 Procedure

a) Both ends of the conductive yarn are clamped with electrodes such that the effective length is 100 mm. Position and mount the conductive yarn such that it does not loosen in the windless air.

b) Apply a gradually increasing DC voltage until an initial current of 1 mA is reached.

c) 10 s after applying the voltage, gradually increase the voltage such that the current increase rate becomes 1 mA/s. The electrical current at the time when the conductive yarn melts or ignites is recorded, and this value is registered as the fusing current. When the fusing current is as low as 10 mA, several conductive yarns are arranged in parallel and clamped, and the obtained measurement value is divided by the number of yarns. Measure the fusing current value of at least 10 conductive yarns and calculate the average value and the standard deviation.

6.1.2.3 Report of the results

The report shall include the following items:

a) identification of the measured conductive yarn;

b) test conditions (room temperature and humidity);

c) number of measured yarns;

d) average of all fusing current (A) measurements;

e) standard deviation of all fusing current measurements.

6.2 Perspiration resistance

6.2.1 Specimens

Prepare five specimens with an effective length of 0,5 m each according to EN 16812:2016.

The outside of the effective length may be tied to prevent untwisting when immersed in a liquid.

6.2.2 Artificial perspiration

Artificial perspiration liquid (alkaline solution and acid solution) shall be prepared according to ISO 105-E04.

6.2.3 Procedure

a) Measure the initial resistance R_{p0} of the specimen using the method as described in 6.1.1.3.

b) Immerse the specimen in artificial perspiration alkaline solution adjusted to (37 ± 2) °C for 24 h. Spread out the specimen smoothly in a flat-bottomed dish and cover with the alkaline solution. Thoroughly wet the specimen in this solution at an approximate liquor ratio of 50:1.

c) Remove the specimen from the artificial perspiration liquid and rinse it thoroughly with running water.

d) Hang the specimen vertically for 24 h under standard environment (i.e., at (20 ± 2) °C and (65 ± 4) % RH) to dry.

e) Measure the resistance R_{pt} of the specimen using the method described in 6.1.1.3.

f) Calculate the resistance change ratio by applying following formula:

   Resistance change ratio = $100 \times (R_{pt} - R_{p0}) / R_{p0}$ [%]

   Here, R_{p0} is the resistance value before the test.

   R_{pt} is the resistance value after the perspiration treatment.

g) Repeat the above procedure (steps a) to f)) for five specimens and calculate the average value.

h) Apply the procedure from steps a) to g) using the artificial perspiration acid solution.

6.2.4 Report of the results

The report shall include the following items: