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INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Wearable electronic devices and technologies –
Part 201-2: Electronic textile – Measurement methods for basic properties of conductive fabrics and insulation materials**

**Technologies et dispositifs électroniques prêts-à-porter –
Partie 201-2: Textile électronique – Méthodes de mesure des propriétés fondamentales des étoffes conductrices et des matériaux isolants**

IEC 63203-201-2:2022-04(en-fr)

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Part 201-2: Electronic textile – Measurement methods for basic properties of conductive fabrics and insulation materials

FOREWORD

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

Draft	Report on voting
124/176/FDIS	124/181/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- withdrawn,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 the provisions for conductive fabrics and insulation materials used for electronic textiles and measurement methods for their properties. When a conductive fabric becomes a wearable electronics product, it plays the role of conductive traces, electrodes and the like in clothes-type wearable devices. Therefore, measurement methods are defined for the characteristics of such conductive fabrics.

The IEC 63203-2 series relates mainly to measurement methods for electronic textile (e- textile) of 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 201-2: Electronic textile – Measurement methods for basic properties of conductive fabrics and insulation materials

1 Scope

This part of IEC 63203-201 specifies the provisions for conductive fabrics and insulation materials used for electronic textiles and measurement methods for their properties.

Conductive fabrics covered by this document are basic materials in electronic textiles and are mainly used as conductive traces, electrodes and the like in clothes-type wearable devices. This document does not cover high-resistance conductive fabrics used for antistatic purposes and heater applications.

Insulating materials handled in this document are materials used for electrical insulation of conductive parts in electronic textiles. They include materials for covering the conductive parts, and general fabrics constituting the basic structure of clothes-type wearable devices.

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

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 60243-1:2013, *Electric strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

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

IEC 62631-3-1:2016, *Dielectric and resistive properties of solid insulating materials – Part 3-1: Determination of resistive properties (DC methods) – Volume resistance and volume resistivity – General method*

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 fabric
fabric, such as woven fabric, knitted fabric, or 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]

3.2
insulation material
insulant material used to prevent electric conduction between conductive elements

Note 1 to entry: In the field of electromagnetism the term "insulant" is also used as a synonym for "insulating medium".

[SOURCE: IEC 60050-151:2001, 151-15-35, modified – The terms "insulating material" and "insulant" have been replaced with "insulation material" and the word "insulant" added to the definition.]

3.3
sheet resistance
electrical resistance of a sheet of nominally uniform thickness, measured across the opposite ends of a square area

Note 1 to entry: The unit of sheet resistance is Ohm (Ω). However, in order not to confuse sheet resistance with bulk resistance, the use of Ohm per square (Ω/□) is recommended.

Note 2 to entry: If fabric thickness is known, the average bulk resistivity of the fabric material can be calculated as the product of sheet resistance and fabric thickness.

Note 3 to entry: In a conductive fabric whose resistance value can be regarded as isotropic, the fabric can be regarded as a sheet and the sheet resistance can be used as an expression of conductivity.

[SOURCE: IEC 62899-101:2019, 3.122, modified − In the definition, "thin film" has been replaced with "sheet"; in Note 2, "film" has been replaced with "fabric", and Note 3 has been added.]

4 Materials and structure

4.1 Classification of conductive fabric

"Fabric" is a generic term for fibre structures having planar shapes. Fabrics are classified as follows: woven fabric, knitted fabric, and nonwoven fabric. Electric conductive fabrics are fabrics that contain conductive yarns or fibres in their composition or fabrics that are coated by electro-conductive materials.

4.2 Classification of insulation materials

The insulating materials in this document are used for e-textile products with electric conductive fabrics or conductive yarns. Layers of fabrics used for the purpose of insulation materials are made of generic non-conductive yarns and are non-conductive fabrics, further, they may have non-conductive coating on one side or both sides. Such fabrics are used as substrate for arranging conductive thread materials consisting of conductive fabrics or yarns and the like.

The insulation materials include non-conductive polymer film and a non-conductive resin coating in addition to the non-conductive fabrics. These materials form protective layers over conductive threads and have the role of electric insulation. Electric insulation materials are classified as shown in Figure 1.

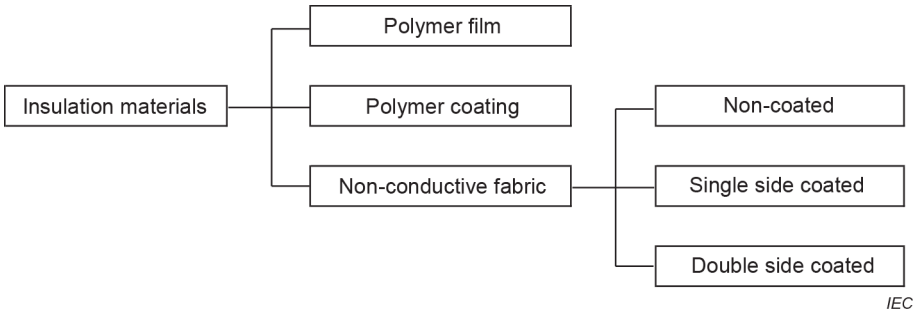

Figure 1 – Classification of electric insulation materials

5 Atmospheric conditions for measurement and conditioning

Preparation, and conditioning and measurement of the test specimens shall be compliant with ISO 139 according to the standard atmosphere of ISO 139 (i.e., 20 °C, 65 % RH).

6 Characteristics and measurement methods for conductive fabric

6.1 Electrical properties

6.1.1 Sheet resistance

6.1.1.1 Specimens

Cut out five test specimens from the conductive fabric. Each test specimen should have a width W: 10 mm and an effective length L: 100 mm or other size with similar or larger length-width ratio. If the entire fabric specimen is not conductive, conductive elements should extend the complete length of the specimen. Report alternate length-width ratio if used. Conductive fabrics are not homogeneous materials and may have directionality in electrical properties. A test specimen for which the direction is different from the original fabric may be cut out as necessary.

6.1.1.2 Pre-tensioning

Pre-tensioning is required to obtain flatness for good contact between the specimen fabric and the electrodes.

Pre-tensioning condition for the fabric without stretch characteristics is indicated at Table 1 with reference to EN 16812:2016.

Pre-tensioning condition for the fabric with stretch characteristics is 0,1 N per 10 mm of width with reference to EN 16812:2016.

Table 1 – Pre-tensioning for fabrics without stretch characteristics

Fabric mass per unit area (g/m^2)	**Applied tension** (N) **per 10 mm width**
≤ 200	0,4
> 200 and 500 ≤	1
> 500	2

6.1.1.3 Procedure

The conductivity of conductive fabric is measured by determining the sheet resistance R_S. The sheet resistance R_S is determined by the following the procedure.

a) Pre-tension is applied to the specimen according to 6.1.1.2.

b) Measure the resistance R in the longitudinal direction of the test specimen according to the four electrode four-wire method as defined in IEC 60468:1974 and EN 16812:2016.

c) Calculate the sheet resistance R_S by applying the following formula.

$$\text{Sheet resistance } R_S = R\ (W / L)$$

d) When the conductivity is anisotropic, the direction in which the specimen is cut out is determined by the user and supplier.

Calculate the linear resistance R_L by applying the following formula.

$$\text{Linear resistance } R_L = R/L$$

NOTE 1 The "user" can be any of the following: manufacturer of the yarn, manufacturer of the fabric, manufacturer of the semi-finished or end product, or end-user.

NOTE 2 The "supplier" can be any of the following: manufacturer of the raw material, manufacturer of the yarn, manufacturer of the fabric, manufacturer of the semi-finished or end product.

6.1.1.4 Report of the results

The report shall include the following items:

a) identification of measured conductive fabric;

b) test conditions (room temperature and humidity);

c) numbers of measured specimens;

d) average of sheet resistance and linear resistance;

e) standard deviation of sheet resistance and linear resistance.

6.1.2 Fusing current

6.1.2.1 General

This Subclause 6.1.2 describes how to determine at which value of current passing through the conductive fabric, the fabric melts or ignites by Joule heat. The fusing current is a fundamental value, to determine the permissible current that may be passed through the conductive fabric.

A safety margin should be determined on a case-by-case basis for the permissible current, since the surrounding conditions of the conductive fabric depend on the application and its use.

The measuring environment should be equipped with a non-flammable underground, safety measures to extinguish fires and appropriate ventilation to remove (toxic) fumes.

6.1.2.2 Procedure

a) Cut test specimen according to 6.1.1.1.

b) Clamp electrodes to both ends of the test specimen such that the effective length is 100 mm. Make sure the test specimen does not slacken in the windless air. Make sure that the test piece does not wiggle in windless air.

c) Apply a DC voltage such that the initial current becomes 1 mA.

d) Starting 10 s after applying the voltage, increase the voltage such that the current increase rate becomes 1 mA/s.

e) Determine the fusing current, which is the moment the test specimen melts or ignites.

   If the fusing current is below 10 mA, arrange multiple specimens of conductive fabric in parallel at step b), and determine the fusing current. Divide the measured value by the number of parallel specimens to get the fusing current. In this case, more than five test specimens are necessary.

f) Repeat the test for five specimens and calculate the average value of fusing current.

6.1.2.3 Report of the results

The report shall include the following items:

a) identification of test specimen;

b) test conditions (room temperature and humidity);

c) number of test specimens;

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

e) standard deviation of all fusing current measurements.

6.1.3 Electric insulation properties

6.1.3.1 General

The insulation performance is a basic property to understand the level of insulation between the conductive fabric and the outside. The electric strength is a basic value for understanding the resistance of the conductive fabric to external voltage.

This Subclause 6.1.3 describes how to measure the insulation performance of the insulation material and how the electric strength can be determined.

6.1.3.2 Insulation resistance of cover and insulation cover side

6.1.3.2.1 Procedure

a) Test specimens should be prepared as shown in Figure 2. The test specimens consist of a substrate, a rectangular stretchable conductor of 70 mm × 210 mm, and a cover insulation layer of 70 mm × 70 mm.

   The test specimen substrate shall have a margin of at least 5 mm on each side of the edges of the conductor. Dimensional errors of ±1 mm are allowed for stretchable conductors and cover insulation layer.

b) Use an electrode with a guard ring for volume resistivity measurement conforming to IEC 62631-3-1:2016.

   Insert the test specimen between the circular electrode E_C with the guard ring electrode E_R and the ground electrode E_G, as shown in Figure 3. Fold the specimen in half and sandwich it between both electrodes.

   Connect the measuring circuit as shown in Figure 4.

c) Apply a voltage of 500 V if not specified otherwise.

d) Measure the current 1 min after the voltage has been applied, the resistance is calculated from the current measured.