IEC 63203-204-2

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Wearable electronic devices and technologies –
Part 204-2: Electronic textile – Test method to characterize electrical resistance change in knee and elbow bending test of e-textiles

Technologies et dispositifs électroniques prêts-à-porter –
Partie 204-2: Textile électronique – Méthode d'essai pour caractériser la variation de la résistance électrique lors de l'essai de flexion du genou et du coude des textiles électroniques

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FOREWORD

IEC 63203-204-2 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
124/299/FDIS	124/306/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 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- withdrawn, or
- revised.

WEARABLE ELECTRONIC DEVICES AND TECHNOLOGIES –

Part 204-2: Electronic textile – Test method to characterize electrical resistance change in knee and elbow bending test of e-textiles

1 Scope

This part of IEC 63203 specifies a test method for e-textiles for measuring the change of electrical resistance during bending of the knee and elbow joints. It uses a dynamic method. This document is applicable to e-textiles.

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.

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

ISO 5084, *Textiles – Determination of thickness of textiles and textile products*

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 terminology 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

3.1
electrode
contact between the measurement wire and the specimen

[SOURCE: EN 16812:2016, 3.5]

3.2
bending rate
number of bending cycles per minute, with one cycle comprising one bending/unbending

Note 1 to entry: The bending rate is expressed in cpm (cycles per minute).

3.3
R_L
linear electrical resistance
electrical resistance per unit length of a track

Note 1 to entry: Linear electrical resistance is expressed in Ω/m (ohms per metre).

[SOURCE: EN 16812:2016, 3.3, modified – Note 1 to entry has been added.]

4 Environmental conditions

Standard atmospheric conditions for measurement shall apply, as specified in ISO 139.

5 Test specimen preparation

5.1 General

The specimen for mechanical tests shall be e-textile made of conductive yarn or fabric in a cylindrical shape. A measurement of the specimen shall be prepared by placing a cylindrical type of e-textile on a specimen holder. A strip-type e-textile shall be attached to a fabric with a cylindrical shape.

5.2 Size of test specimen

For the mechanical bending test of joint movement of e-textile, a specimen with a cylindrical shape shall be used. The specimen size of a cylindrical shape shall be selected from Table 1. The specimen shall be attached to the cylindrical shape with two grips, which are illustrated in Figure 3. The effective specimen length shall be the length of the specimen between the inner edges of the two grips (the grips are excluded from the effective specimen length). The two types of specimen circumference were set based on the average circumference of elbows and knees. The diameter of the specimen holder is 80 mm for type A (elbow) and 110 mm for type B (knee).

Table 1 – List of the size of the specimen

Type	Effective specimen length mm	Diameter mm
A (elbow)	200 ± 2	86 ± 4
B (knee)	200 ± 2	118 ± 5

The thickness of the e-textile shall be measured in accordance with ISO 5084.

6 Testing method and test apparatus

6.1 General

A prepared e-textile specimen shall be placed on the cylindrical specimen holder as shown in Figure 1, wrapping around the holder. To measure e-textile on skin-like conditions, the specimen holder shall be covered with silicone. The thickness of the silicone layer is 3 mm for type A and 4 mm for type B. The diameter of the specimens to be measured shall be prepared in order to fit the specimen holder. Examples of specimen preparation are described in Annex D and Annex E.

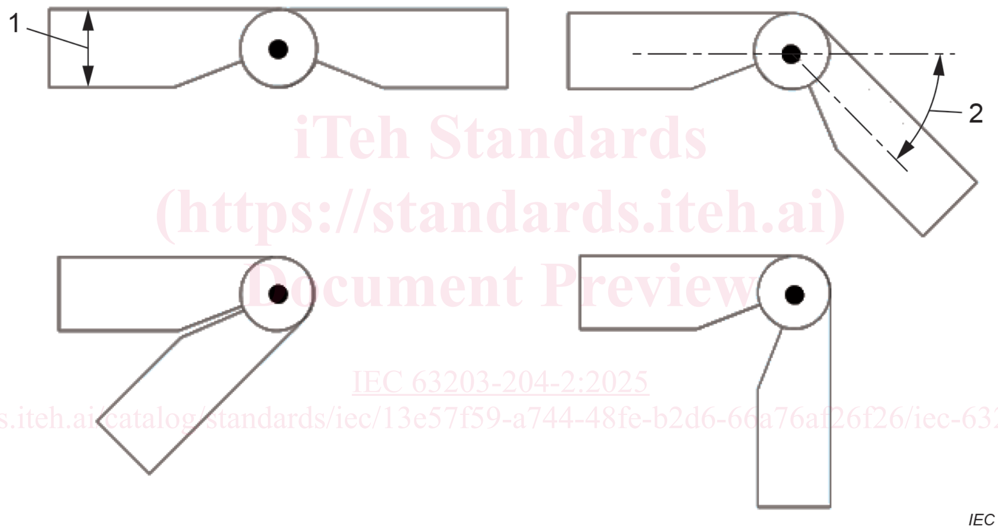
Both ends of the specimen shall be secured with a cylindrical circumferential grip for tight fixation. The specimen shall be fixed so that the location of the specimen cannot move during the measurement. When the middle portion of the cylindrical specimen holder moves as the joint bends, the specimen surrounding the specimen holder shall be bent together with the joint. The electrical property of the e-textile shall be evaluated by electrodes of electrical connection.

a) <side view> **b) <top view>**

Figure 1 – Schematic diagram of specimen holder and specimen fixation

6.2 Test apparatus

6.2.1 General



Key

1 diameter = elbow (86 ± 5) mm, knee (118 ± 5) mm

2 bending angle 45°, 90°, 135°

Figure 2 – Apparatus for bending test

A bending tester is used to apply a repeated bending motion on specimens. The bending angle, as defined in Figure 2, shall be adjustable to the target value and shall be variable from 0° to 135°. Details of specimen holder are described in Annex D. Figure D.1 shows a top view of the specimen holder and Table D.1 defines the dimensions of it. Figure D.2 shows a front view of the specimen holder and Table D.2 defines the dimensions of it. Figure D.3 shows a side view of the specimen holder and Table D.3 defines the dimensions of it. A three-dimensional view of the specimen holder is shown in Figure D.4.

The grips shall be shaped like a circumference of the specimen holder to hold the cylindrical specimen perfectly as shown in Figure 3. The specimen holder and grips shall be clean and smooth to avoid mechanical damage on specimens. The specimen holder shall be made from insulating materials such as resin-based materials, polycarbonate, mono-cast polyamide, or paper.

The middle portion of the specimen holder shall repeat the reciprocating bending motion while both ends of the specimen are stationary/fixed. An example of the bending machine with the specimen holder attached is shown in Annex C and an example of the bending machine with the specimen holder detached is shown in Annex F.

The direction of the specimen can be both directions (course/wale direction for knit specimens, warp/weft direction for woven specimens), but it should be specified in the result.

Bending deformation accompanied with stretching shall be applied to the specimen as explained in Annex B.

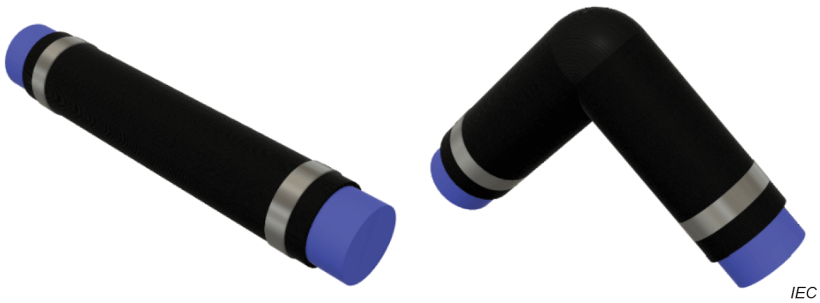


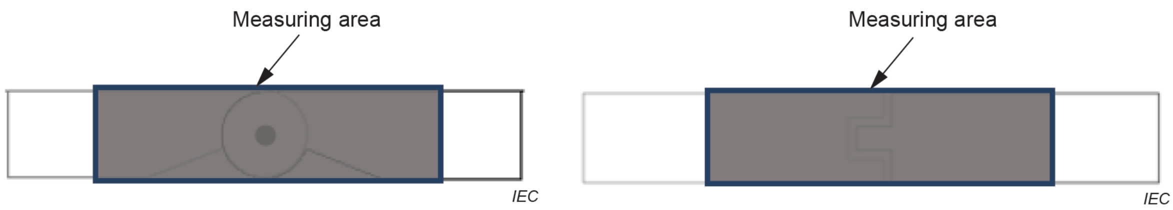
Figure 3 – Example of bending test using apparatus

6.2.2 Preparation of e-textile specimens made with conductive fibre and fabric

If a cylindrical fabric specimen is made by knitting, weaving or any other textile, and the conductive fibre or fabric is embedded in the middle, the specimen shall be produced as follows.

The conductive fabric undergoing bending shall be centrally positioned on the outer side of the specimen over the joint in the longitudinal direction, as shown in Figure 4. In the case of tubular knitting that partially uses conductive yarn, as shown in Figure A.1, the conductive yarn shall be centrally positioned on the outer side of the specimen above the joint, where maximum bending is achieved. EN 16812:2016 shall be followed to make electrical contact.

When the bending motion is repeated, the specimen shall remain at the centre of the longitudinal direction of the specimen so that electrical measurements can be performed reproducibly when comparing multiple specimens.



a) <side view> **b) <top view>**

Figure 4 – Embedded e-textile in the specimen

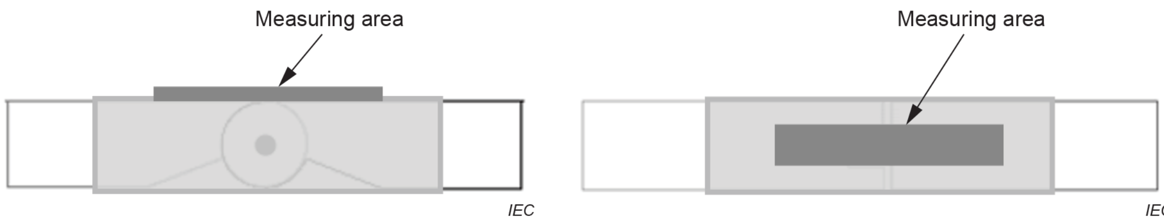
6.2.3 Preparation of e-textile specimens with strip-type devices

When a strip-type device is attached to a cylindrical fabric, a specimen shall be prepared as follows.

The strip-type device undergoing bending shall be located in the centre of the longitudinal direction of the cylindrical specimen and be positioned on the outer side of the specimen in the longitudinal direction, as shown in Figure 5.

When a strip-type device is attached to a cylindrical fabric, an adhesive for textiles or sewing shall be used as the attaching method. When attaching using sewing, the entire border of the strip-type device shall be stitched. When using adhesive, the entire surface of the strip-type device shall be attached on fabric with adhesive.

Electrical contacts shall be made by following EN 16812:2016.



a) <side view> b) <top view>

Figure 5 – Strip-type device attached to specimen

6.3 Test procedure

The test procedure is as follows.

a) The specimen shall be put on a cylindrical specimen holder in the same way as a garment, and the ends shall be gripped firmly. The specimen shall be spread evenly and tightly on the specimen holder, and not concentrated on one side.
b) Set the bending angle to be repeated, and check whether the specimen is bent according to the bending of the specimen holder by manual operation.
c) Fix the angle as a proper bending angle and measure the initial electrical resistance of the specimen before the bending test. Start the repeated bending motions.
d) Real-time electrical resistance is measured while the bending operation is repeated, and resistance after the set cycle is completed is also measured.
e) At least three specimens shall be measured to acquire the result for a test result.

For mechanical tests of e-textile, the bending angle and the bending rate of one bending/unbending (measured in cpm) shall be selected from a combination of parameters in Table 2.

Table 2 – Combination of parameters for measurement

Type	Specimen holder diameter mm	Bending angle °(degree)	Bending rate cpm
A	86 ± 5	45, 90, 135	10, 30, 50
B	118 ± 5	45, 90, 135	10, 30, 50

For the number of bending cycles, three categories are specified in Table 3. Category I is when the number of bending cycles is 100 or less, category II is when the number of bending cycles is more than 100 and less than 1 000, and category III is when the number of bending cycles is 1 000 or more.

Table 3 – Categories of number of bending cycles

Category	Number of bending cycles
I	≤ 100
II	100 < x < 1 000
III	≥ 1 000

6.4 Measurement

The electrical resistance change of an e-textile shall be measured before, after and during the cyclic bending test. The electrical resistance of e-textile shall be measured in-situ, during mechanical deformations.

To measure the variation of resistance, either a two-wire or a four-wire measurement can be used. For a specimen that has too little variation to be detected by a two-wire method with the electrical resistance measurement device being used in the test, the four-wire method shall be used to eliminate contact-wire and lead-wire resistance.

To measure the variation of resistance of conductive fabric of e-textile, a grip with electrical contacts in accordance with IEC 62899-202-4 can be used. A metallic grip can also be used, and its surface shall be coated with conductive materials such as gold, silver and copper in order to reduce the contact resistance.

The electrical resistance of conductive yarns of e-textile can be measured in-situ during mechanical deformations. For the exact electrical resistance measurement, both electrodes of the specimen shall be held as tightly as possible using grips. For e-textile specimens with conductive yarn, which is not strong enough to be gripped tightly by the electrodes, a metal tape or conducting paste with a lower resistance than the conductive yarn may be coated on each end of the electrodes of the e-textile in accordance with EN 16812:2016.

6.5 Determination of the electrical properties

6.5.1 General

In order to measure resistance change due to mechanical deformation of e-textile, electrical resistance shall be collected in real time while the bending motion cycles are in progress.

6.5.2 Linear resistance of e-textile with conductive yarn

Linear resistance (R_L) shall be measured to test e-textiles made of conductive yarn. The initial value ($R_{L,0}$) and the relative ratio of resistance change (ΔR_L / $R_{L,0}$) of electrical resistance shall be reported, as shown in Formula (1):

$$\frac{\Delta R_L}{R_{L,0}} = \frac{R_L - R_{L,0}}{R_{L,0}} \qquad (1)$$

where

ΔR_L is the change in the electrical linear resistance;

R_L is the linear resistance under mechanical test;

$R_{L,0}$ is the initial linear resistance before mechanical test.

6.5.3 Average, standard deviation, and effective variation of resistance

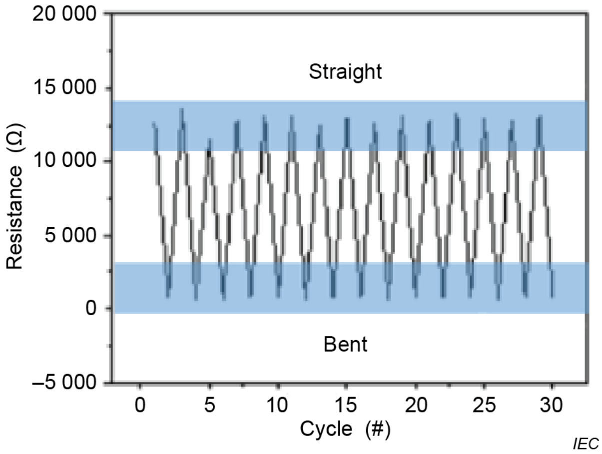


Figure 6 – Example of a graph of resistance variation from a bending test

The measurement condition shall be decided by choosing the speed among 10 cpm, 30 cpm and 50 cpm, the bending angle among 45°, 90° and 135°, and the number of bending cycles among category I, II and III, which are described in Table 2 and Table 3. Figure 6 demonstrates the exemplary measurement result of the change in resistance along the test.

In order to verify whether the resistance change remains stable during the cycles of bending test, the average and standard deviation of R_{bent} and R_{straight} shall be presented. In addition, effective variation of R_{bent} and effective variation of R_{straight} considering the influence of the standard deviation according to the bent/straight resistance ratio shall be indicated.

- $\overline{R_{\text{bent}}}$: average of resistance in bent state.
- σ_{bent} : standard deviation of resistance in bent state.
- $\overline{R_{\text{straight}}}$: average of resistance in straight state.
- σ_{straight} : standard deviation of resistance in straight state.

$\overline{R_{\text{bent}}}$ and $\overline{R_{\text{straight}}}$ values should be calculated using Formula (2):

$$\overline{R_{\text{bent}}} = \frac{R_{\text{bent},1} + R_{\text{bent},2} + \cdots + R_{\text{bent},n}}{n}, \quad \overline{R_{\text{straight}}} = \frac{R_{\text{straight},1} + R_{\text{straight},2} + \cdots + R_{\text{straight},n}}{n} \qquad (2)$$

It shall be shown in the following equations that the resistance has a stable and repeatable value in the bent and straight states along the bending cycles.

- Resistance in bent state: $R_{\text{bent}} = \overline{R_{\text{bent}}} \pm \sigma_{\text{bent}}$ [Ω]
- Resistance in straight state: $R_{\text{straight}} = \overline{R_{\text{straight}}} \pm \sigma_{\text{straight}}$ [Ω]