
Light conveyor belts — Determination of electrical resistances

*Courroies transporteuses légères — Détermination des résistances
électriques*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 41, *Pulleys and belts (including veebelts)*, Subcommittee SC 3, *Conveyor belts*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 188, *Conveyor belts*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 21178:2013), which has been technically revised. The main changes compared to the previous edition are as follows:

- addition of terms and definitions;
- modifications to the figures and formulas;
- technical changes to the [Clauses 5, 6 and 7](#);
- deletion of Annex A;
- editorial modifications.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Light conveyor belts — Determination of electrical resistances

1 Scope

This document specifies test methods for determining the electrical resistances of light conveyor belts according to ISO 21183-1. The resistances are surface resistance, volume resistance perpendicular to the belt plane, and longitudinal and transverse volume resistance parallel to the belt plane. This document also specifies two test methods for determining the surface resistivity and the volume resistivity.

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 18573, *Conveyor belts — Test atmospheres and conditioning periods*

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:

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

3.1

electrical surface resistance

quotient of a direct-current voltage applied between two electrodes on the same surface of a test piece and the current between the electrodes

Note 1 to entry: It is expressed in ohms (Ω).

3.2

electrical surface resistivity

measured surface resistance calculated to apply to a square

Note 1 to entry: It is expressed in ohms (Ω) and the size of the square is immaterial.

3.3

electrical volume resistance

quotient of a direct-current voltage applied between two electrodes in contact with opposite faces of a test piece and the current between the electrodes, excluding current along the surface

Note 1 to entry: It is expressed in ohms (Ω).

3.4

electrical volume resistivity

measured volume resistance calculated to apply to a cube of unit side

Note 1 to entry: It is expressed in ohm metres (Ωm).

4 Symbols

Symbol	Description	Unit
R_{OA}	Electrical surface resistance, method A	Ω
R_{OB}	Electrical surface resistance, method B	Ω
R_{OG}	Electrical surface resistance for the determination of ρ_s	Ω
R_D	Electrical volume resistance perpendicular to the plane of the belt	Ω
R_{Di}	Electrical volume resistance in longitudinal and transverse direction parallel to the plane of the belt	Ω
ρ_s	Electrical surface resistivity	Ω
ρ_D	Electrical volume resistivity	Ωm
$d_{1/2/3}$	Diameter of electrode	mm
d_m	Middle of the gap diameter	mm
g	Width of the gap	mm
A	Surface of the electrode	mm^2
$h_{1/2}$	Thickness of test piece	mm

NOTE The SI unit of surface resistivity, ρ_s , is the ohm (Ω). In practice, this is sometimes referred to as “ohm/square” or “ Ω/sq ”. The size of the square is immaterial.

5 Electrical surface resistances

5.1 Method A: Measurement of surface resistance, R_{OA} , omni-directionally

5.1.1 Applicability

This method is applicable to belts which are electrically two-dimensionally isotropic in the plane of the belt.

5.1.2 Principle

An electric current of specified voltage is passed via electrodes through a suitably prepared test piece taken from the belt.

5.1.3 Apparatus (see [Figure 1](#))

5.1.3.1 Sheet of insulating material, a little larger than the test piece.

5.1.3.2 Two cylindrical and coaxial electrodes (see [Figure 1](#)), with contact surfaces machined flat and polished, as follows.

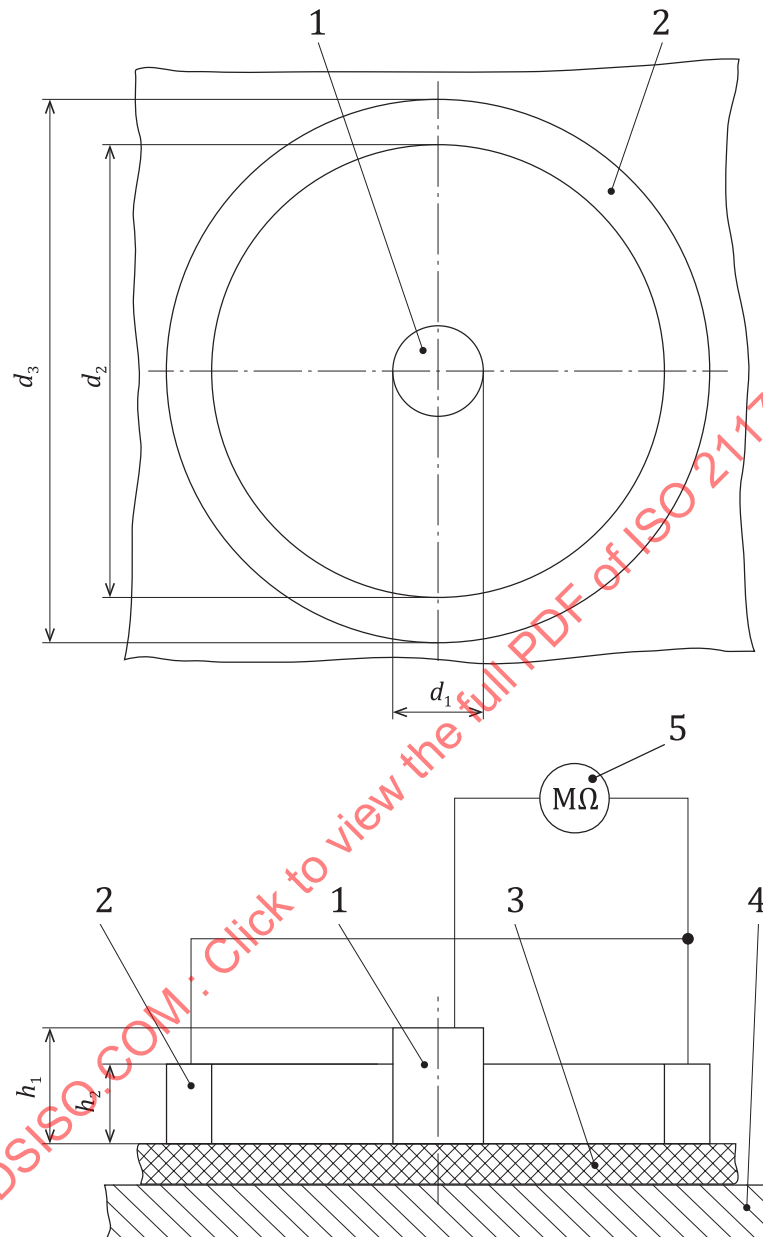
5.1.3.2.1 Electrode 1, circular.

5.1.3.2.2 Electrode 2, annular.

5.1.3.2.3 Material of electrodes, either brass or stainless steel.

5.1.3.3 Ohmmeter, having a measuring range up to $10^{10} \Omega$ and accurate to within $\pm 5 \%$.

5.1.3.4 Source of direct current, adjustable up to 500 V, and not permitting a current greater than 10 mA.



Key

- 1 electrode 1
- 2 electrode 2
- 3 test piece
- 4 sheet of insulating material
- 5 ohmmeter

Figure 1 — Test arrangement for measurement of electrical surface resistance R_{OA}

5.1.4 Test piece

5.1.4.1 Material

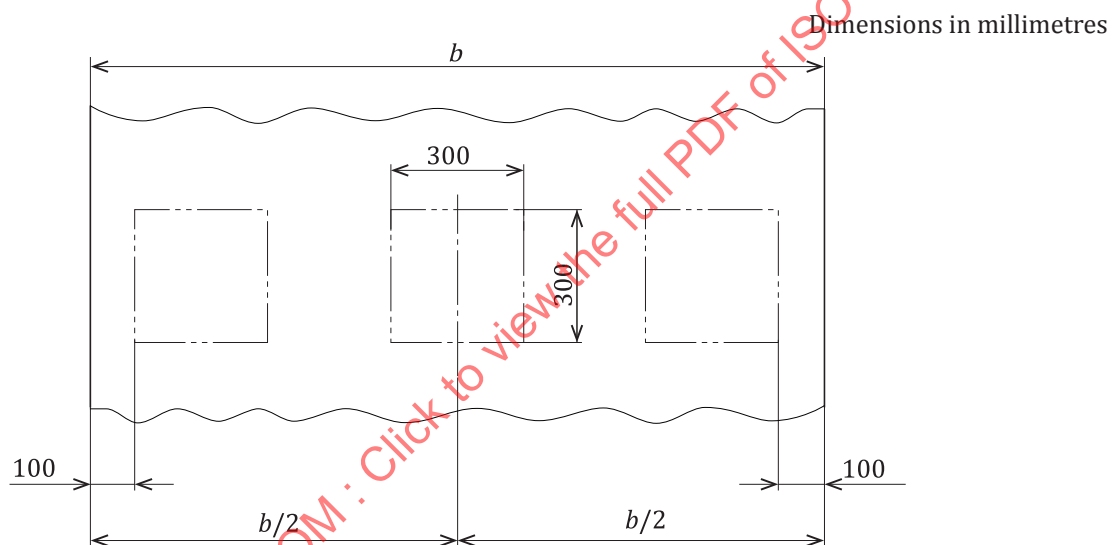
Test piece material shall be new, unused ("virgin"), but shall not be tested sooner than five days after manufacture. It shall be free from contamination and superficial damage.

5.1.4.2 Dimensions

The test pieces shall be square, 300 mm × 300 mm minimum, and shall be cut from the full thickness of the belt.

5.1.4.3 Number

Three test pieces shall be taken. One test piece shall be taken from the middle of the belt, the other two test pieces shall be taken in the area between 100 mm to 400 mm from each of the belt edges. The test pieces shall be selected in accordance with [Figure 2](#).



Key

b belt width

Figure 2 — Distribution of test piece selection

5.1.4.4 Cleaning

If necessary, clean both surfaces of the test pieces by rubbing with fuller's earth (hydrated magnesium-aluminium silicate), for example, using a clean cloth. After cleaning away all traces of the powder, wipe the surface with a clean cloth moistened with distilled water and then dry with a clean cloth.

5.1.4.5 Conditioning

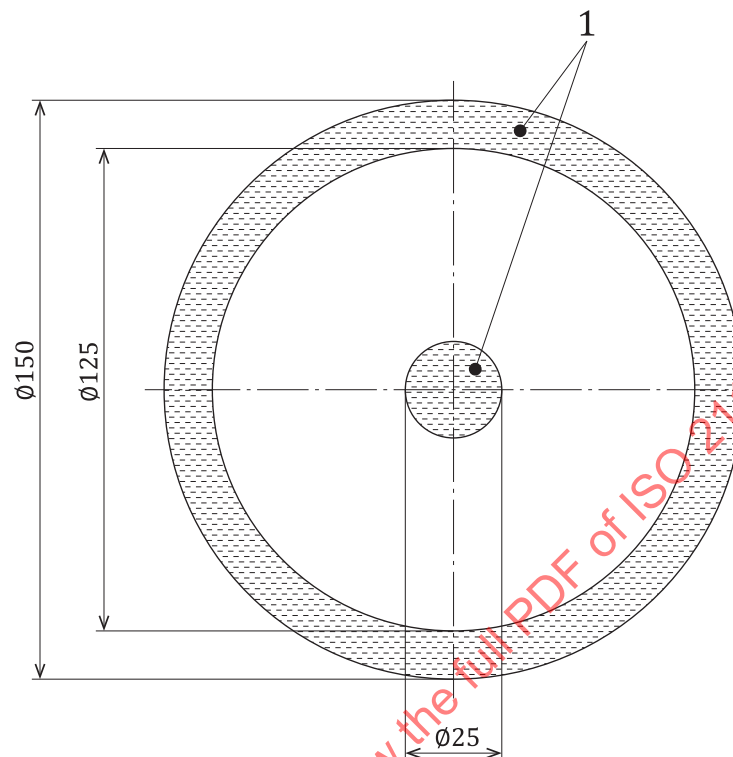
Before testing, condition the test pieces in accordance with ISO 18573, Atmosphere B, for 24 h, except that, if the light conveyor belt consists of materials with a high absorption of moisture, for example cotton or polyamide, condition the test piece for 48 h.

5.1.4.6 Preparation

To ensure good contact between electrodes and test piece a contact medium as described in [5.1.4.7](#) can be used if necessary.

If contact medium is used, paint two areas of the test piece as shown in [Figure 3](#). Take care to ensure the accuracy of the dimensions of the painted areas, although the symmetry of the centre is not critical.

Dimensions in millimetres



Key

1 contact medium

Figure 3 — Design to be painted on the test piece

5.1.4.7 Contact medium

The electrical surface resistivity of the contact medium shall not be higher than $10^4 \Omega$. For checking this value, use the same electrode arrangement as described in [Clause 6](#). Examples for suitable contact media are silver lacquer or a jelly.

NOTE A jelly having the following composition is suitable:

- Anhydrous polyethylene glycol of molecular mass 600: 800 parts by mass;
- Water: 200 parts by mass;
- Potassium chloride: 10 parts by mass;
- Soft soap (pharmaceutical quality): 1 part by mass.

5.1.5 Procedure

The temperature and relative humidity in the test room shall be in accordance with ISO 18573, Atmosphere B.

Measure the temperature and relative humidity in the test room.

Place the test piece on the sheet of insulating material, with the test surface upwards.

Apply the test voltage to the electrodes, starting with a low voltage to protect very fine antistatic layers against damage.

Read the value of the electrical resistance 1 min after applying the test voltage.

5.1.6 Expression of results

For each surface of the belt subjected to test, record the electrical resistance, in ohms, measured for each test piece, and calculate the mean of the values recorded for that surface for the three test pieces.

Record the electrical resistance for the two surfaces of the belt separately.

5.1.7 Test report

The test report shall include the following information:

- a) complete designation of the tested light conveyor belt material and the manufacturing date;
- b) reference to this document, i.e. ISO 21178;
- c) test room temperature and relative humidity;
- d) conditioning period;
- e) contact medium, if applied;
- f) voltage applied to the electrodes;
- g) results of the tests;
- h) date of test;
- i) any deviations from the standard test.

5.2 Method B: Measurement of surface resistance R_{OB} in longitudinal and transverse directions

5.2.1 Applicability

This method is applicable to belts which have electrically varying properties in the plane of the belt, especially those where fabrics have conducting threads in the longitudinal direction which can be exposed on the belt surface.

5.2.2 Principle

An electric current is passed via electrodes clamped in a suitable arrangement to the surface of a test piece of the belt material.

5.2.3 Apparatus (see [Figure 4](#))

5.2.3.1 Earthed screen plate

5.2.3.2 Bottom plate, made of insulating material, such as polymethylmethacrylate, polytetrafluoroethylene or similar, having dimensions 600 mm × 200 mm × 20 mm.

5.2.3.3 Electrodes (see [Figure 4](#)), with connection points for the ohmmeter connecting cables, as follows.

5.2.3.3.1 Contact area, 100 mm × 10 mm.

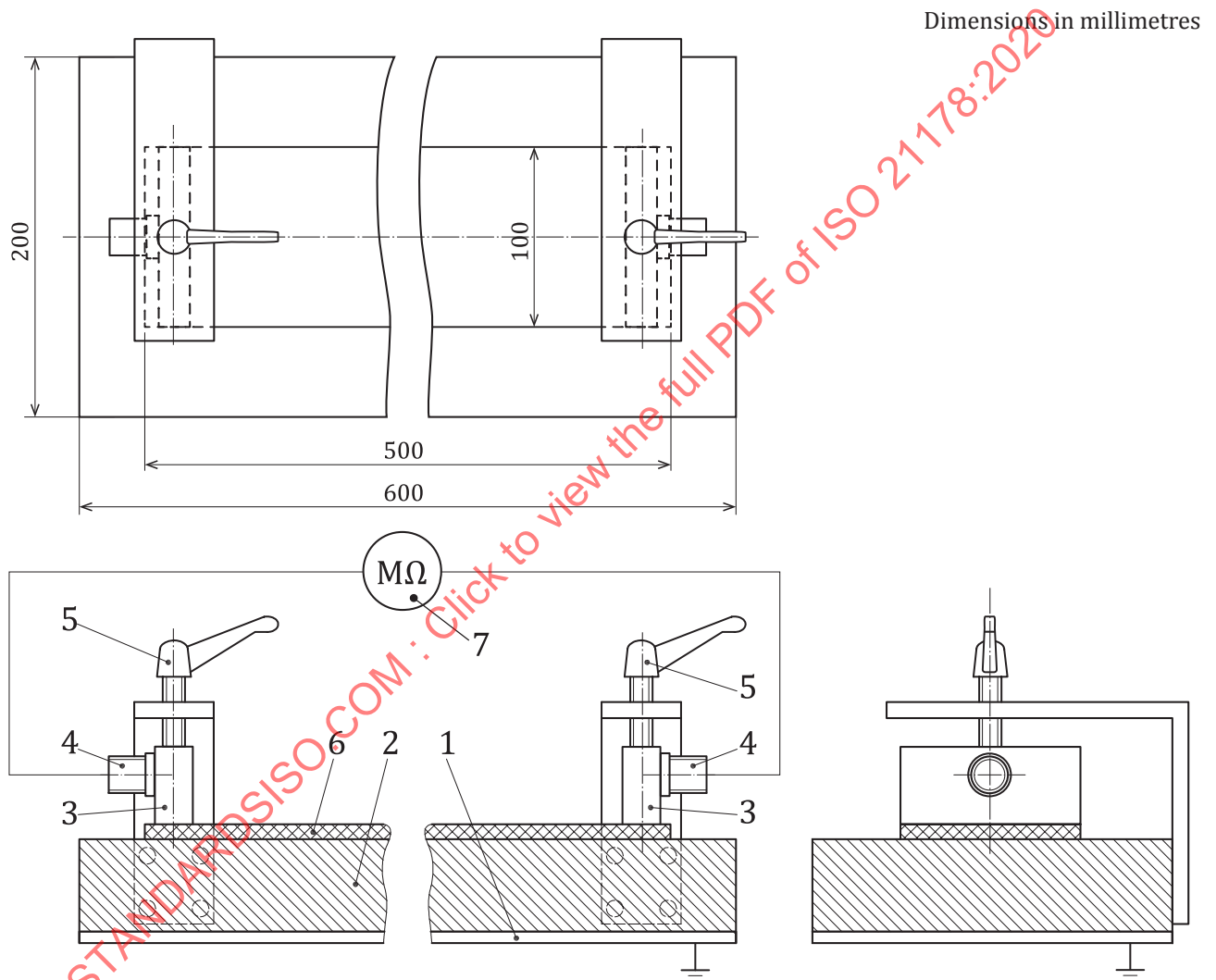
5.2.3.3.2 Material of electrodes, either brass or stainless steel.

5.2.3.4 Electrode holders

5.2.3.5 Ohmmeter, having a measuring range up to $10^{10} \Omega$ and accurate to within $\pm 5 \%$.

5.2.3.6 Source of direct current, adjustable up to 500 V, and not permitting a current greater than 10 mA.

NOTE The source current can be either an accumulator or a rectified, stabilized AC power supply.



Key

- 1 screen plate, earthed
- 2 bottom plate
- 3 electrodes
- 4 connection points
- 5 electrode holder
- 6 test piece
- 7 ohmmeter

Figure 4 — Test arrangement for measurement of electrical surface resistance R_{OB}

5.2.4 Test piece

5.2.4.1 Material

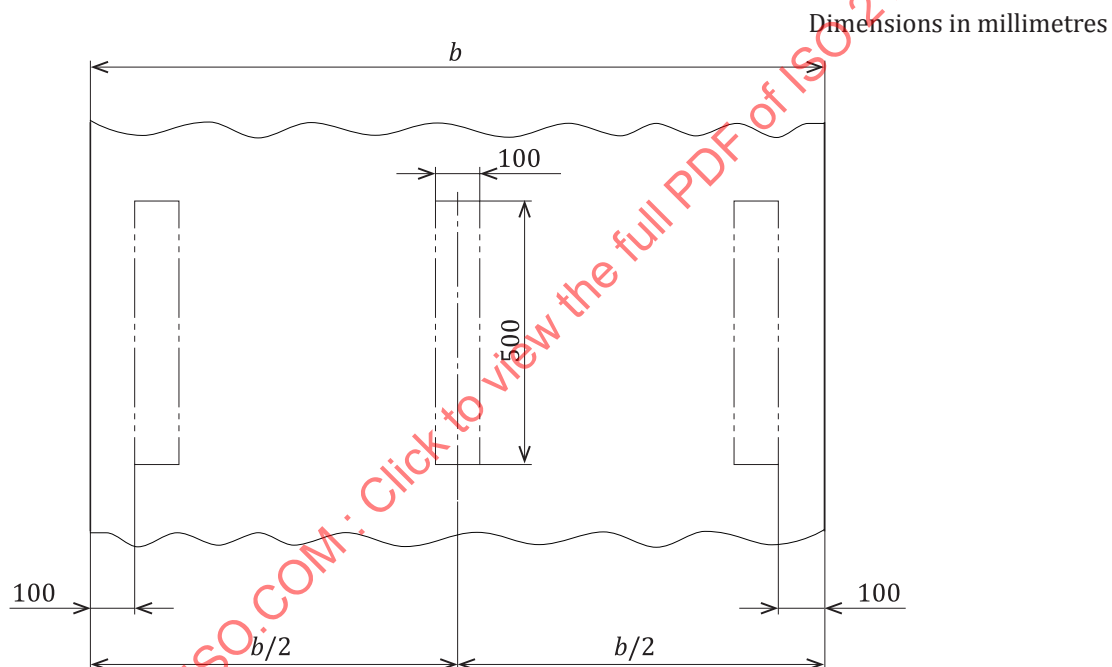
Test piece material in accordance with [5.1.4.1](#).

5.2.4.2 Dimensions

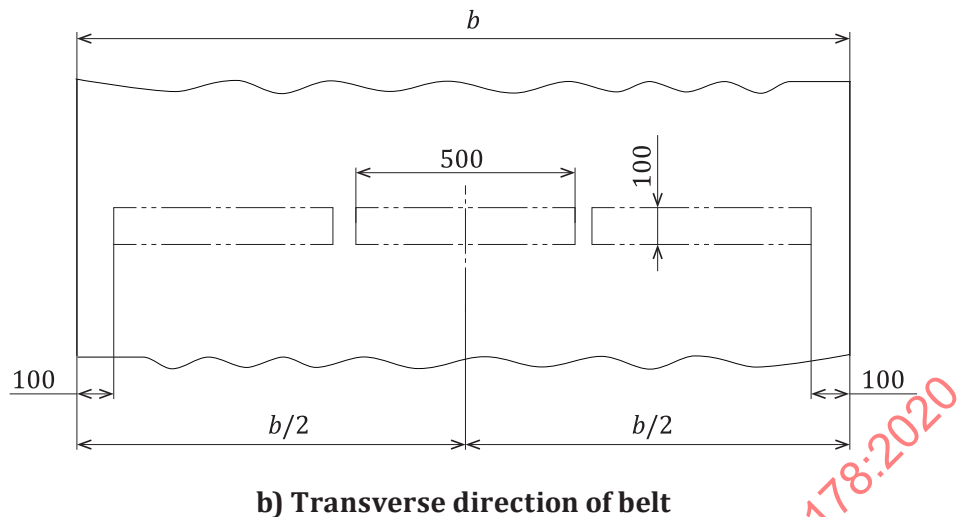
The test pieces, 500 mm long $\times$ 100 mm wide, shall be cut from the full thickness of the light conveyor belt in the longitudinal or transverse direction.

5.2.4.3 Number

Three test pieces shall be taken. One test piece shall be taken from the middle of the belt, the other two test pieces shall be taken 100 mm from each of the belt edges. The test pieces shall be selected in accordance with [Figure 5](#).



a) Longitudinal direction of belt

**Key** b belt width**Figure 5 — Distribution of test piece selection****5.2.4.4 Conditioning**

Condition the test pieces in accordance with [5.1.4.5](#).

5.2.4.5 Preparation

If the surface of the test piece is flat, contact medium as described in [5.1.4.7](#) is not required.

If the surface of the test piece is textured, a contact medium may be required to ensure good contact between electrodes and test piece. Paint the test piece or bottom surface of the cleaned electrodes with contact medium at contact area in accordance with [5.2.3.3.1](#).

5.2.5 Procedure

The temperature and relative humidity in the test room shall be in accordance with ISO 18573, Atmosphere B.

Measure the temperature and relative humidity in the test room.

Place the test piece on the insulating plate so that the warp is exactly at right angles to the long axes of the electrodes.

Place the electrodes on top of the test piece and clamp them in position.

Apply the test voltage to the electrodes starting with a low voltage to protect fine conducting layers against damage.

Read the value of the electrical resistance 1 min after applying the test voltage.

5.2.6 Expression of results

See [5.1.6](#).

5.2.7 Test report

See [5.1.7](#).

6 Electrical surface resistivity ρ_s

6.1 General

This electrical surface resistivity is calculated from the electrical surface resistance, R_{OG} , determined with a different electrode arrangement to that used in 5.1. This method is applicable to the same types of belt to which the method described in 5.1 applies.

NOTE 1 The values obtained using the methods described in [Clause 6](#) are comparable to those obtained using ASTM D 257.

NOTE 2 The unit is the ohm (Ω) but is also written Ω/sq (see [Clause 4](#), Note).

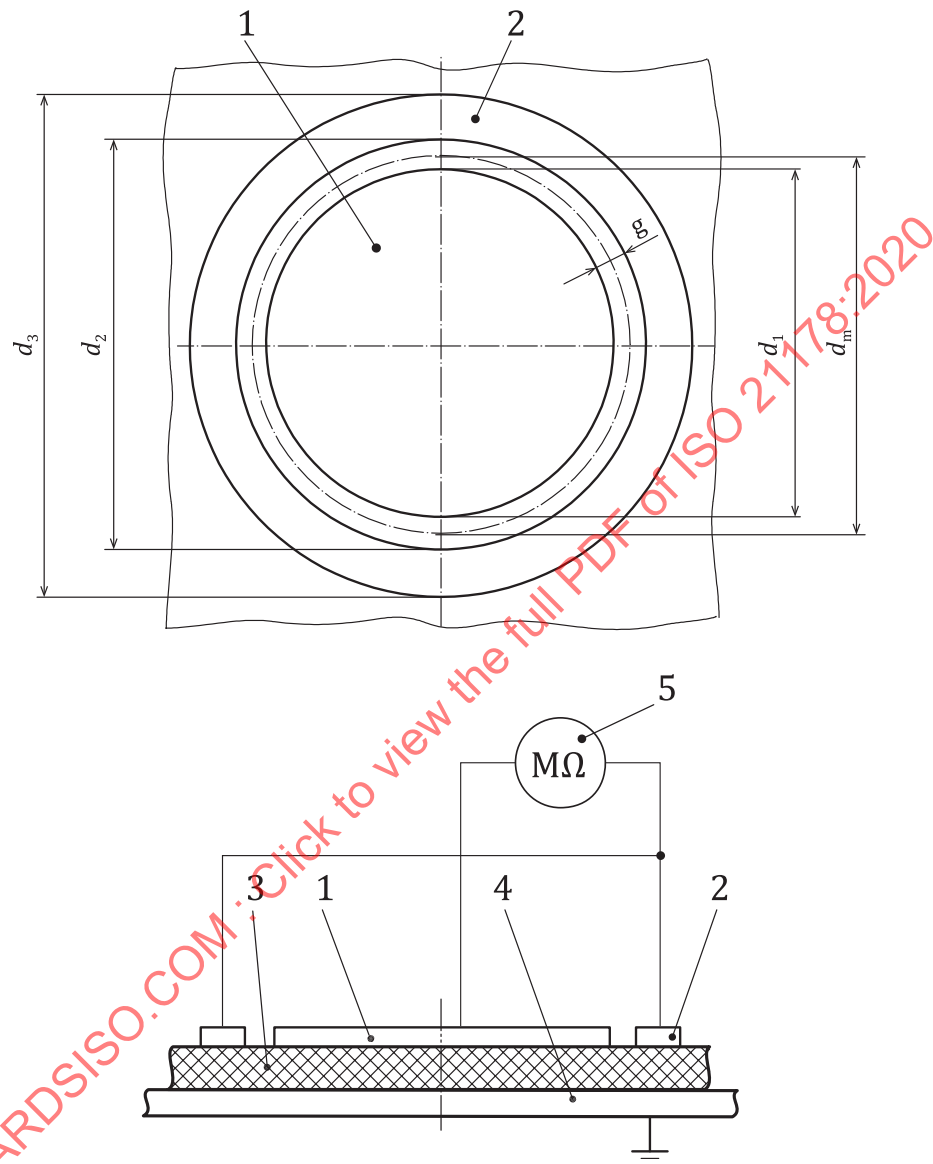
6.2 Principle

An electric current of specified voltage is passed via electrodes through a suitably prepared test piece taken from the belt.

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6.3 Apparatus

6.3.1 Three electrodes, having the following diameters: $d_1 = 50 \text{ mm}$, $d_2 = 60 \text{ mm}$, $d_3 = 80 \text{ mm}$, and $d_m = [(d_1 + d_2)/2]$ (see Figure 6).



Key

- 1 electrode 1
- 2 electrode 2
- 3 test piece
- 4 electrode 3
- 5 ohmmeter

Figure 6 — Test arrangement for measurement of electrical surface resistance R_{OG}

6.3.2 Ohmmeter, having a measuring range up to $10^{10} \Omega$ and accurate to within $\pm 5 \%$.

6.3.3 Source of direct current, adjustable up to 500 V, and not permitting a current greater than 10 mA.

NOTE The source current can be either an accumulator or a rectified, stabilized AC power supply.

6.4 Test piece

6.4.1 Material

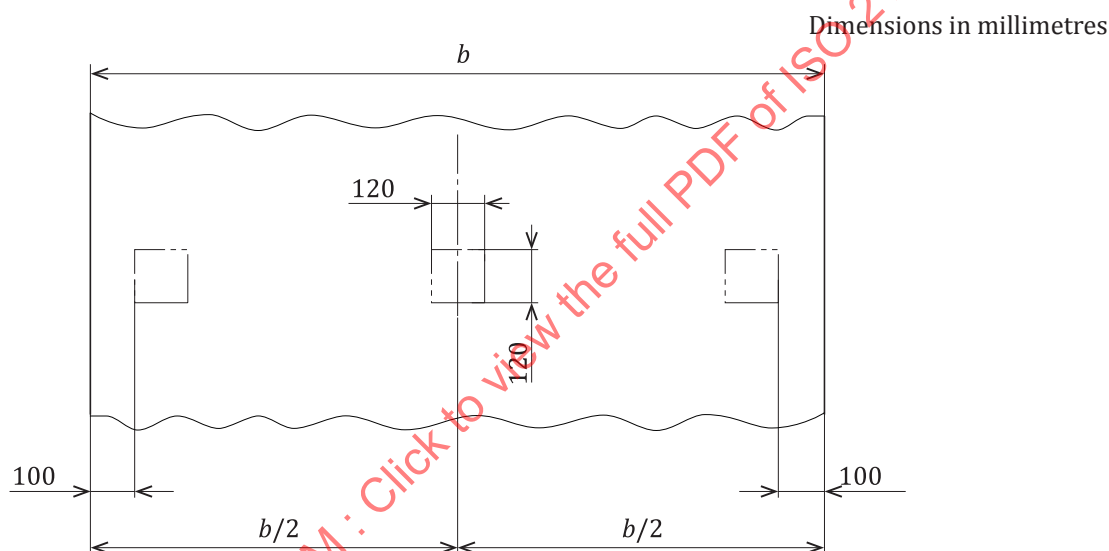
Test piece material in accordance with [5.1.4.1](#).

6.4.2 Dimensions

The test pieces shall be square, 120 mm × 120 mm minimum, and shall be cut from the full thickness of the belt.

6.4.3 Number

Three test pieces shall be taken. One test piece shall be taken from the middle of the belt, the other two test pieces shall be taken in the area between 100 mm to 220 mm from each of the belt edges. The test pieces shall be selected in accordance with [Figure 7](#).



Key

b belt width

Figure 7 — Distribution of test piece selection

6.4.4 Cleaning

Clean the test pieces in accordance with [5.1.4.4](#).

6.4.5 Conditioning

Condition the test pieces in accordance with [5.1.4.5](#).

6.4.6 Preparation

To ensure good contact between electrodes and test piece a contact medium as described in [5.1.4.7](#) can be used if necessary. Paint the test piece or contact surfaces of the cleaned electrodes with contact medium at contact area in accordance with [Figure 6](#).

6.5 Procedure

Carry out the procedure in accordance with [5.1.5](#).

6.6 Expression of results

For each surface of the belt tested, record the electrical resistance, R_{OG} , in ohms. Then, calculate the surface resistivity in ohms, as per [Formula \(1\)](#).

$$\rho_s = \frac{d_m \times \pi}{g} R_{OG} \quad (1)$$

where

$$d_m = \frac{d_1 + d_2}{2} = 55 \text{ (in mm);}$$

$$g = \frac{d_2 - d_1}{2} = 5 \text{ (in mm).}$$

For each surface of the belt tested, calculate the surface resistivity, in ohms, for each test piece, and calculate the arithmetic mean of the values for that surface for the three test pieces.

6.7 Test report

See [5.1.7](#).

7 Electrical volume resistances

7.1 Volume resistance, R_D , perpendicular to plane of belt

7.1.1 Principle

The top and bottom sides of a test piece, cut from the full thickness of the light conveyor belt, are connected to electrodes.

7.1.2 Apparatus

7.1.2.1 Three electrodes (see [Figure 8](#)), with contact surfaces machined flat and polished, as follows.

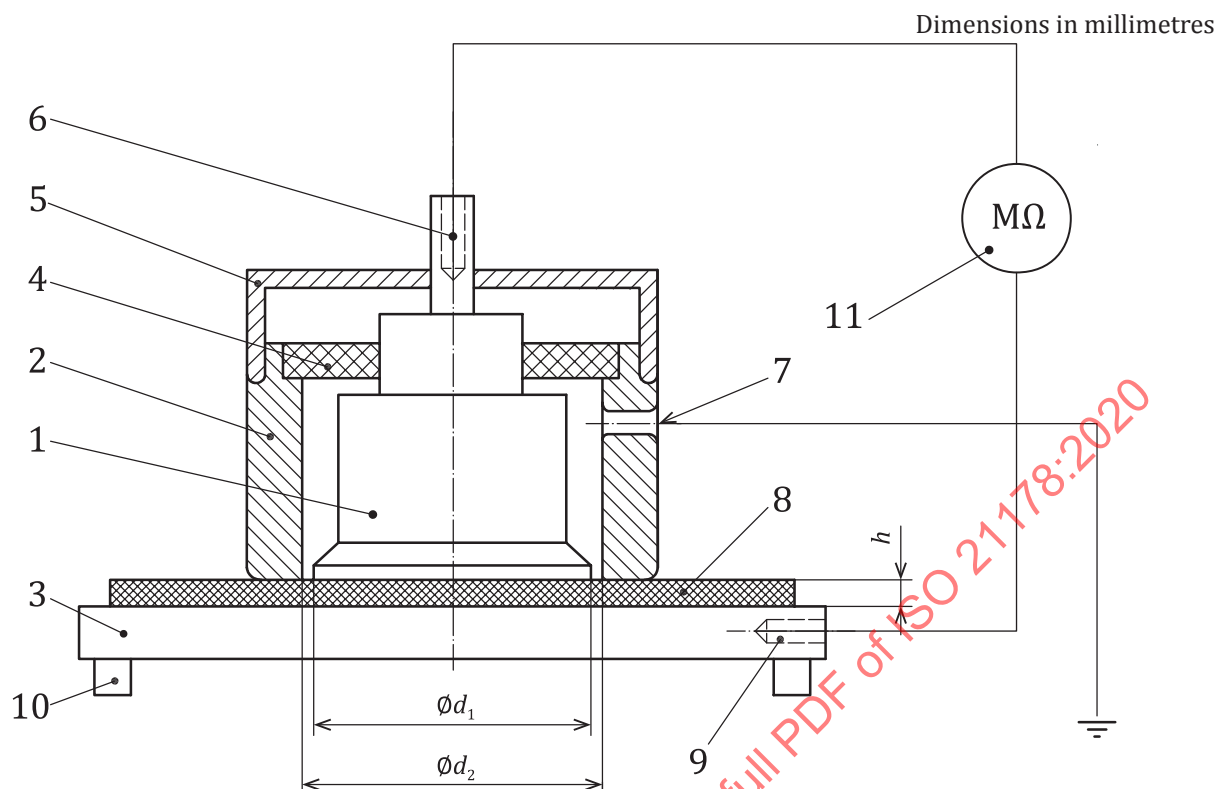
7.1.2.1.1 Electrode 1, circular (measuring electrode).

7.1.2.1.2 Electrode 2, annular (guarding electrode).

7.1.2.1.3 Electrode 3, of any shape provided that its area is greater than the test piece (counter electrode).

7.1.2.1.4 Material of electrodes, either brass or stainless steel.

7.1.2.2 Ohmmeter, having a measuring range up to $10^{10} \Omega$ and accurate to within $\pm 5 \%$. The instrument shall be calibrated in the range 100 V to 500 V DC, current $I_{\max} = 10 \text{ mA}$.



Key

$d_1 = 50$ mm

$d_2 = 60$ mm

- 1 electrode 1 (measuring electrode, guarded electrode)
- 2 electrode 2 (guard electrode, guard ring)
- 3 electrode 3 (counter electrode, unguarded electrode)
- 4 isolating and guide piece
- 5 shielding cap
- 6 positive pole connector for ohmmeter or ammeter
- 7 connector for earthing
- 8 test piece, thickness = h
- 9 negative pole connector for ohmmeter or ammeter
- 10 isolating stands
- 11 ohmmeter

Figure 8 — Circular disk electrode for measurement of electrical volume resistance R_D of light conveyor belts (design example)

7.1.3 Test piece

7.1.3.1 Material

Test piece material in accordance with [5.1.4.1](#).

7.1.3.2 Dimensions

Dimension of the test pieces in accordance with [6.4.2](#).

7.1.3.3 Number

The number of test pieces in accordance with [6.4.3](#).

7.1.3.4 Cleaning

Clean the test pieces in accordance with [5.1.4.4](#).

7.1.3.5 Conditioning

Condition the test pieces in accordance with [5.1.4.5](#).

7.1.3.6 Preparation

To ensure good contact between electrodes and test piece, a contact medium as described in [5.1.4.7](#) can be used if necessary. Paint the test piece or contact surfaces of the cleaned electrodes with contact medium at contact area in accordance with [Figure 8](#).

7.1.4 Procedure

The temperature and relative humidity in the test room shall be in accordance with ISO 18573, Atmosphere B.

Measure the temperature and relative humidity in the test room.

Bring the test piece into contact with the electrodes.

Connect cables as per the arrangement and method (see [Figure 8](#)).

Apply the test voltage for 60 s.

Measure and record the volume resistance, R_D .

If the resulting volume resistance, R_D , is $>10^8 \Omega$, repeat the measurement with the guard electrode fitted (illustrated as item 2 in [Figure 8](#)).

If the measured resistance, R_D , is $>10^{10} \Omega$, and a mains supply was used, remove it and repeat the measurement with an off-the-line DC source. Take the result of this measurement as final.

7.1.5 Expression of results

Express the results as the arithmetic mean value of the measurements on the three test pieces.

NOTE Normally, the range of values is $\pm 10\%$ to $\pm 20\%$.

7.1.6 Test report

The test report shall include the following information:

- complete designation of the tested light conveyor belt material and the manufacturing date;
- reference to document, i.e. ISO 21178;
- test room temperature and relative humidity;
- conditioning period;
- contact medium, if applied;
- voltage applied to the electrodes;

- g) thickness of each test piece
- h) time that voltage was applied;
- i) measured values of the appropriate resistances, in ohms;
- j) date of test;
- k) any deviations from the standard test.

7.2 Volume resistance, R_{Di} , in longitudinal and transverse directions parallel to plane of belt

7.2.1 Principle

An electric current is passed via electrodes through a suitably prepared test piece taken from the conveyor belt material.

7.2.2 Apparatus

7.2.2.1 Screen plate (counter plate), earthed.

7.2.2.2 Bottom plate, made of insulating material such as polymethylmethacrylate, polytetrafluoroethylene or similar, having dimensions 600 mm × 200 mm × 20 mm.

7.2.2.3 Electrodes (see [Figure 9](#)), with connection points for the ohmmeter connecting cables, as follows.

7.2.2.3.1 Contact area, 50 mm × 10 mm.

7.2.2.3.2 Material of electrodes, either brass or stainless steel.

7.2.2.4 Electrode holders.

7.2.2.5 Ohmmeter, having a measuring range up to $10^{10} \Omega$ and accurate to within $\pm 5 \%$.

7.2.2.6 Source of direct current, adjustable up to 500 V, and not permitting a current greater than 10 mA.