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colour inside

Dielectric and resistive properties of solid insulating materials – Part 3-2: Determination of resistive properties (DC methods) – Surface resistance and surface resistivity

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DIELECTRIC AND RESISTIVE PROPERTIES OF SOLID INSULATING MATERIALS –

Part 3-2: Determination of resistive properties (DC methods) – Surface resistance and surface resistivity

FOREWORD

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This commented version (CMV) of the official standard IEC 62631-3-2:2023 edition 2.0 allows the user to identify the changes made to the previous IEC 62631-3-2:2015 edition 1.0. Furthermore, comments from IEC TC 112 experts are provided to explain the reasons of the most relevant changes, or to clarify any part of the content.

A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text. Experts' comments are identified by a blue-background number. Mouse over a number to display a pop-up note with the comment.

This publication contains the CMV and the official standard. The full list of comments is available at the end of the CMV.

IEC 62631-3-2 has been prepared by IEC technical committee 112: Evaluation and qualification of electrical insulating materials and systems. It is an International Standard.

This second edition cancels and replaces the first edition published in 2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) descriptions of the electrode arrangements have been clarified;
b) new descriptions of the conductive means have been added;
c) a new informative Annex B summarizing the results of the comparative verification study on surface resistivities using different electrode arrangements has been added.

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

Draft	Report on voting
112/612/FDIS	112/619/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 62631 series, published under the general title *Dielectric and resistive properties of solid insulating materials*, 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.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

DIELECTRIC AND RESISTIVE PROPERTIES OF SOLID INSULATING MATERIALS –

Part 3-2: Determination of resistive properties (DC methods) – Surface resistance and surface resistivity

1 Scope

This part of IEC 62631 ~~covers~~ describes 1 methods of test for the determination of surface resistance and surface resistivity of electrical insulation materials by applying DC voltage.

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 60212, *Standard conditions for use prior to and during the testing of solid electrical insulating materials*

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

IEC 62631-3-3, *Dielectric and resistive properties of solid insulating materials – Part 3-3: Determination of resistive properties (DC methods) – Insulation resistance*~~[1]~~

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 arrangement
electrical conductive bodies on the surface of a test specimen

Note 1 to entry: The arrangement of electrodes should include procedures to ascertain sufficient contact to the surface (e.g. by means of conducting paint) ~~and/~~or the use of adequate mechanical system applying the necessary contact force to the test specimen's surface or both.

~~[1] To be published.~~

3.1.1
annular electrode
central circular planar electrode with a surrounding ring electrode separated by a gap

SEE: Figure 3.

Note 1 to entry: Guard~~ed~~ electrode systems as described in ~~IEC 62631-3-1~~ IEC 62321-3-1 are of similar shape. In the case of surface resistance, the ring electrode does not have the function of a guard; guard functionality, however, is provided by the opposite electrode.

3.1.2
line electrode
electrode arrangement provided by two parallel lines, separated by a gap, applied to the test specimen's surface using a conductive material

SEE: Figure 2.

3.1.3
spring loaded electrode
line electrode system using two parallel lines of conducting spring tongues with sharp edges, separated by a gap

SEE: Figure 1.

3.2
measured resistance
ratio of a DC voltage applied to an electrode arrangement in contact with a test specimen to the current between them measured with sufficient precision

Note 1 to entry: A three-terminal electrode arrangement ~~may~~ can **2** be used to exclude undesired volume currents from the determination of the measured resistance.

Note 2 to entry: A Wheatstone bridge ~~may~~ can **3** also be used to compare the measured resistance with a standard resistor. However, Wheatstone bridges are not commonly used anymore.

Note 3 to entry: According to IEC 60050-121: Electromagnetism, "conductivity" (IEV 121-12-03) **4** is defined as "the scalar or tensor quantity, the product of which by the electric field strength in a medium is equal to the electric current density" and "resistivity" (IEV 121-12-04) as "the inverse of the conductivity when this inverse exists". ~~Measured in this way, the surface resistivity is an average of the resistivity over possible heterogeneities in the volume incorporated in the measurement; it includes the effect of possible polarization phenomena at the electrodes.~~ Measured in this way, the surface resistivity integrates different electrical conduction pathways at the surface of the material or in its nearby volume, with the possible presence of heterogeneities; it includes the effect of possible polarization phenomena at the electrodes. Therefore, it is considered as an averaged value. **5**

3.3
surface resistance
R_S
measured resistance between any electrode arrangement defined in IEC 62361-3-2

Note 1 to entry: Depending on the electrode arrangement used, it is designated as R_{SA}, R_{SB}, R_{SC}, R_{SD} or R_{SE} with surface resistance, R_S expressed in Ω.

Note 2 to entry: An indeterminable part of the resistance inside the material is also included in surface resistance during the measurement of this resistance.

3.4
R_{SC}
surface resistance between annular electrodes
measured resistance between the inner circular area of an annular electrode system and the outer circular ring electrode

3.5
R_{SD}
surface resistance between line electrodes
measured resistance between line electrodes

3.6
R_{SE}
surface resistance between line electrodes for small plates
measured resistance between line electrodes for small plates

3.7
R_{SB}
surface resistance between small line electrodes
measured resistance between small line electrodes

3.8
R_{SA}
surface resistance between spring load~~ed~~ electrodes
measured resistance between spring loaded electrodes

3.9
surface resistivity
σ/square
~~surface resistance R_{SA}, R_{SB}, R_{SC}, R_{SD} or R_{SE} referred to a square, expressed as σ_A, σ_B, σ_C, σ_D and σ_E respectively~~

~~Note 1 to entry: Surface resistivity σ_C, σ_D and σ_E is expressed by the unit Ω.~~

surface resistance reduced to a square

Note 1 to entry: The numerical value of surface resistivity is independent of the size of the square.

Note 2 to entry: Surface resistance R_{SA}, R_{SB}, R_{SC}, R_{SD} and R_{SE} referred to a square, are expressed as σ_A, σ_B, σ_C, σ_D and σ_E respectively.

Note 3~~2~~ to entry: Surface resistivity is often expressed by the non-standardized unit Ω per square, to show that the electrode dimension has been taken into account by calculating the specific value.

Note 4~~3~~ to entry: The surface resistivity is often used to compare one kind of surface characteristic of a sample material with those of other materials. It can be compared for materials only if identical standardized dimensions of the electrodes are used. Recommended dimensions are given in 5.3. 6

4 Significance

Insulating materials are used in general to electrically isolate components of an electrical system from each other and from the earth. Solid insulating materials can also provide mechanical support. For this purpose, it is generally desirable to have the insulation resistance as high as possible, consistent with acceptable mechanical, chemical and heat resistance properties.

Surface resistance is, as volume resistance, a part of the insulating resistance.

Insulating resistance shall be determined according to IEC 62631-3-3 and volume resistance according to IEC 62631-3-1.

Surface resistance supplies information on the electrical resistances ~~on~~ of 7 the surface of materials and products. ~~The surface resistance also permits monitoring of changes in the resistance by external effects.~~ 8 Surface resistance, however, for its major part is not a materials' property. Surface resistance depends mainly on processing parameters, environmental conditions, surface ageing phenomena and pollution, etc.

NOTE Depending on the specific application, different electrode arrangements can be preferable. 9

5 Method of test

5.1 General

This general method describes common values for general measurements. If a method for a specific type of material is described in this document, the specific method shall be used.

Different types of electrodes can be used, depending on the specific measurement or product demands. For instance, on surfaces with a curved shape, a small line electrode can be advantageous. Spring loaded electrodes provide measurements with low effort on products and are optimal for materials which have to be conditioned before the test. If not already stipulated by a product standard, the choice of the electrode arrangement shall be made considering the typical application.

If test specimens are made from materials (e.g. soft rubber) ~~changing their~~ whose dimensions will change significantly ~~when applying~~ as a result of the force applied by the electrodes on them 10, these electrodes are not applicable and an alternative arrangement shall be used.

If no information about the application is available, small line electrodes (R_{SB}) are recommended.

5.2 Voltage

The measuring voltage ~~shall~~ should 11 preferably be 10 V, 100 V, 500 V, 1 000 V, 10 000 V.

~~Other voltages may be applicable.~~ If not otherwise ~~stipulated~~ specified by the relevant product standard 12, a voltage of 100 V shall be used.

Technical committees shall specify the preferred test voltage when referring to this document. 13

NOTE 1 Partial discharge can lead to erroneous measurements when a specific inception voltage is exceeded. In air, below 340 V, no partial discharges will occur.

NOTE 2 The ripple of the voltage source is important. A typical value for 100 V is < 5×10^{-5} peak to peak.

5.3 Equipment

5.3.1 General

Care should be taken that the surface resistance is not negatively influenced by parasitic resistances parallel to the electrode arrangement, such as the resistance of test supports or cable isolation.

To prevent measuring errors for measured resistances higher than 10^{10} Ω, shielded cables and shielded measuring cabinets shall be used.

For the determination of surface resistance and surface resistivity, different electrode arrangements can be used. The evaluation of surface resistivity is dependent on the selected electrode arrangement.

NOTE Comparison between measurement results can be done only between measurements performed using the same electrode arrangements and conductive means. 14

5.3.2 Accuracy

Any suitable equipment can be used. The measuring device shall be capable of determining the unknown resistance with an overall accuracy of at least

- ±10 % for resistances less than 10^{10} Ω;
- ±20 % for resistances between 10^{10} Ω and 10^{14} Ω; and
- ±50 % for ~~values~~ resistances higher than 10^{14} Ω. 15

NOTE The provided accuracies have been confirmed through the round robin test results reported in Annex B. 16

5.3.3 Voltage source

A source of ~~very~~ steady direct voltage is required. This can be provided either by batteries or by rectified and stabilized power supply. The degree of stability required is such that the change in current due to any change in voltage is negligible compared with the current to be measured.

5.3.4 Electrode arrangements 17

5.3.4.1 General

Electrode arrangements consist of the combination of electrodes and conductive means. The conductive means shall be applied to the test specimen before performing the measurements. Electrodes are then placed in contact with the conductive means applied on the test specimen in order to perform measurements. 18

NOTE Annex B contains the results of the comparative verification study on surface resistivities using different electrode arrangements.

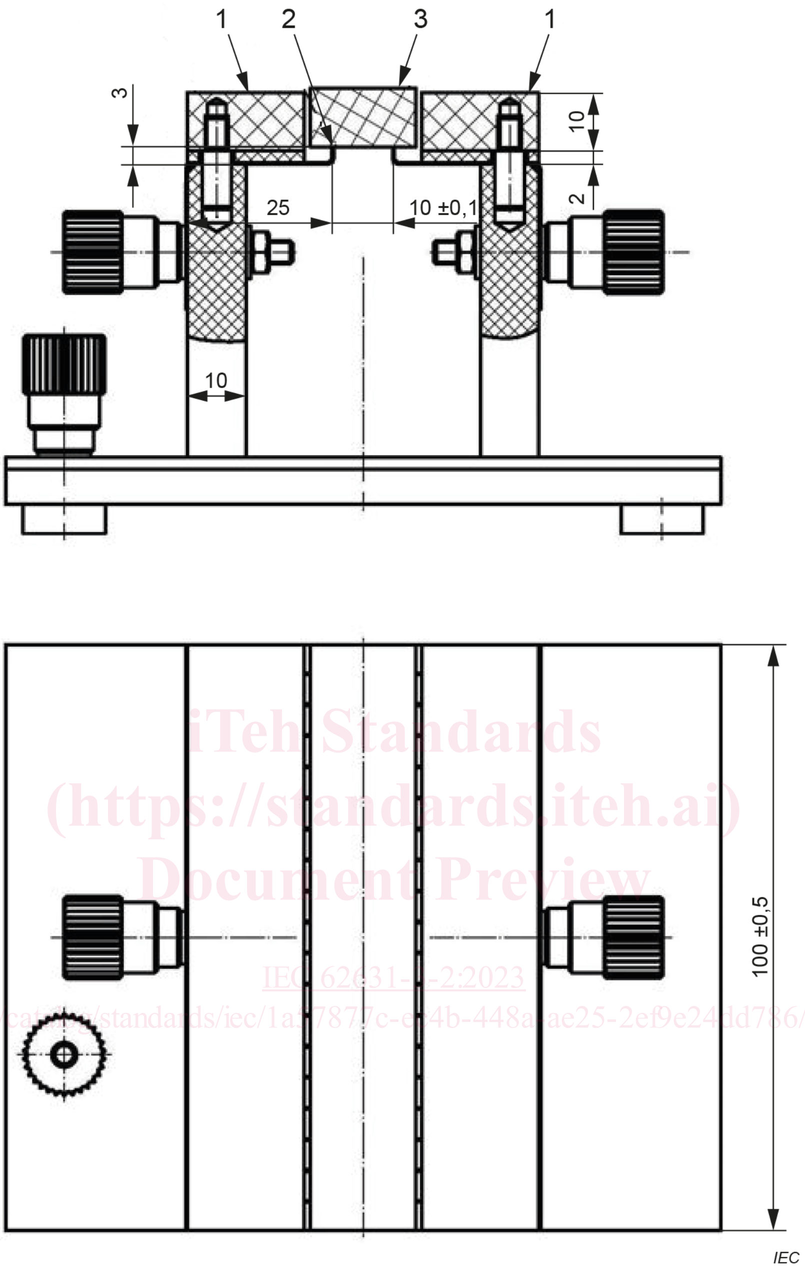
5.3.4.2 Electrode arrangement A – Spring loaded electrodes

The electrode arrangement A shall consist of two flexible metal knife-edges with a length of 100 mm and a gap distance of 10 mm as shown in Figure 1.

No guard electrode is used. The metal knife-edges shall consist of individual spring tongues arranged next to each other about 0,3 mm apart and each with a length not exceeding 5,0 mm and 0,3 mm thick. The contact force shall be high enough so that all tongues or segments rest against the surface of the test specimen, but without damaging the surface.

A piece of metal exerting the contact force ~~should~~ shall 19 be applied with high-grade insulation where in contact with the specimen.

Dimensions in millimetres



Key

1 guide bar (detachable)

2 metal knife-edges

3 specimen

Figure 1 – Electrode arrangement A (example)

5.3.4.3 Electrode arrangement B – Small line electrodes

~~Electrode arrangement B shall consist of two adhering line electrodes. No guard electrode is used. For this purpose, two 1,5 mm wide lines with a length of 25 mm and a gap distance of 2 mm apart shall be applied, e.g. with conductive silver. They shall be applied before the conditioning. The lines shall be contacted using a two terminal collector electrode arrangement with conductive blades in attach to them (see Figure 2).~~

Electrode arrangement B shall consist of a two-terminal collector with conductive blades being in contact with the conductive means on the test specimen, as shown in Figure 2. No guard electrode is used.

For the purpose of electrode arrangement B, conductive means shall be applied as two 1,5 mm wide lines with a length of 25,0 mm and a gap distance of 2,0 mm. Lines shall be applied before conditioning. **20**

Types of conductive means and the related applications are described in 5.6.4. **21**

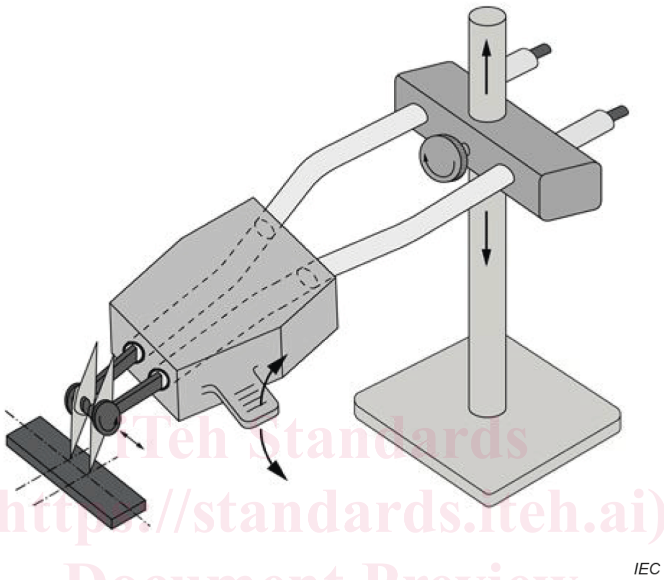


Figure 2 – ~~Collector electrode for electrode arrangement B~~ Electrode arrangement B (example)

5.3.4.4 Electrode arrangement C – Annular electrodes

Electrode arrangement C is a three-terminal electrode system, as shown in Figure 3. On one side of the test specimen, annular electrodes are applied. The opposite surface of the test specimen ~~is to~~ shall **22** be covered by a guard electrode, not smaller than the area covered by the corresponding electrodes. ~~Adhesive electrodes can be applied before the conditioning (see 5.6.3).~~