# IEC 62631-3-2

Edition 1.0 2015-12

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

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

**Propriétés diélectriques et résistives des matériaux isolants solides – Partie 3-2: Détermination des propriétés résistives (méthodes en courant continu) – Résistance superficielle et résistivité superficielle**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

This first edition cancels and replaces the second edition of IEC 60093, published in 1980, and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the second edition of IEC 60093:

a) IEC 60093 has been completely revised, both editorially and technically, and incorporated into the new IEC 62631 series;
b) test methods have been updated to current day state of the art;
c) volume and surface resistance and resistivity are now separated into IEC 62631-3-1 and IEC 62631-3-2, respectively.

The text of this standard is based on the following documents:

| FDIS | Report on voting |
|---|---|
| 112/340FDIS | 112/351/RVD |

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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 publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

# 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 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, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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.

**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 an adequate mechanical system applying the necessary contact force to the test specimen's surface.

**3.1.1**
**spring loaded electrodes**
line electrode system using two parallel lines of conducting spring tongues with sharp edges, separated by a gap

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

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[1] To be published.

**3.1.3**
**annular electrodes**
central circular planar electrode with a surrounding ring electrode separated by a gap

Note 1 to entry: Guarded electrode systems as described in IEC 62631-3-1 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.

**3.2**
**measured resistance**
ratio of 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 be used to exclude undesired volume currents from the determination of the measured resistance.

Note 2 to entry: A Wheatstone bridge may 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" is defined as "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" 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.

**3.3**
**surface resistance**
$R_S$
measured resistance between any electrode arrangement defined by this standard



Note 1 to entry: Dependent 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 by the unit Ω.



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

**3.4**
**surface resistance between spring loaded electrodes**
$R_{SA}$
measured resistance between spring loaded electrodes

**3.5**
**surface resistance between small line electrodes**
$R_{SB}$
measured resistance between small line electrodes

**3.6**
**surface resistance between annular electrodes**
$R_{SC}$
measured resistance between the inner circular area of an annular electrode system and the outer circular ring electrode.

**3.7**
**surface resistance between line electrodes**
$R_{SD}$
measured resistance between line electrodes

**3.8**
**surface resistance between line electrodes for small plates**
$R_{SE}$
measured resistance between line electrodes for small plates

**3.9**
**surface resistivity**
*σ*
surface resistance $R_{SA}$, $R_{SB}$, $R_{SC}$, $R_{SD}$ or $R_{SE}$ referred to a square, expressed as $\sigma_A$, $\sigma_B$, $\sigma_C$, $\sigma_D$ and $\sigma_E$ respectively

Note 1 to entry: Surface resistivity $\sigma_C$, $\sigma_D$ and $\sigma_E$ is expressed by the unit Ω.

Note 2 to entry: Surface resistivity is often also 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 3 to entry: It can be compared for materials only if identical dimensions of the electrodes are used. Recommended dimensions are given in 5.3.

# 4 Significance

Insulating materials are used in general to electrically isolate components of an electrical system from each other and from earth. Solid insulating materials can also provide mechanical support. For these purposes 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 the surface of materials and products. The surface resistance also permits monitoring of changes in the resistance by external effects. Surface resistance, however, for its major part is not a material property. Surface resistance depends mainly on processing parameters, environmental conditions, surface ageing phenomena and pollution, etc.

Dependent on the specific application, different electrode arrangements can be preferable.

# 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 standard, the specific method shall be used.

Different types of electrodes can be used, dependent 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 specimen are made from materials (e.g. soft rubber) changing their dimensions significantly when applying force by electrodes on them, 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 preferably be

10 V, 100 V, 500 V, 1 000 V and 10 000 V.

Other voltages may be applicable. If not otherwise stipulated, a voltage of 100 V shall be used.

NOTE 1 Partial discharges 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 $<5 \times 10^{-5}$ 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.



#### 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 below $10^{10}$ Ω,
- ±20 % for resistances between $10^{10}$ Ω and $10^{14}$ Ω,
- ±50 % for values higher than $10^{14}$ Ω.

#### 5.3.3 Voltage source

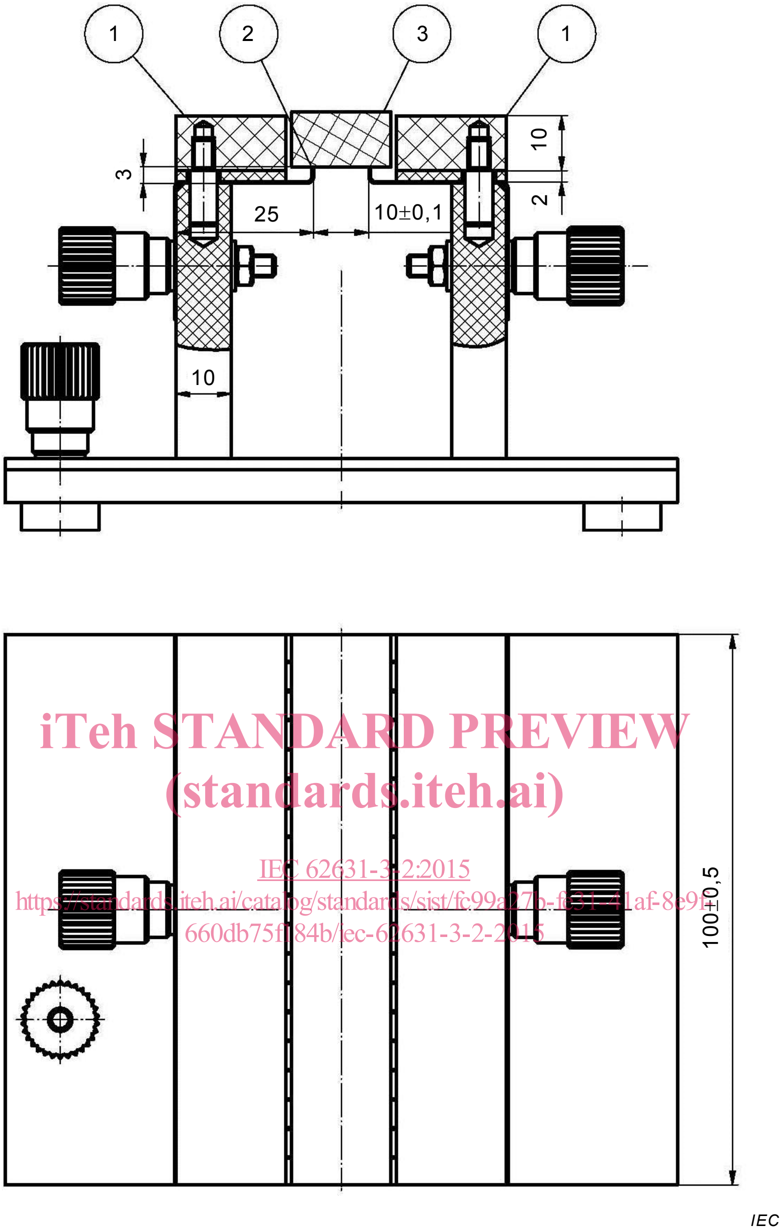
A source of very steady direct voltage is required. This can be provided either by batteries or by rectified and stabilized power supply. The degree of stability required is such that the change in current due to any change in voltage is negligible compared with the current to be measured.

#### 5.3.4 Electrode 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 apart 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 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 be applied with high-grade insulation where in contact with the specimen.






**Key**

1 guide bar (detachable)

2 metal knife-edges

3 specimen

**Figure 1 – Electrode arrangement A (example)**

### 5.3.5 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).

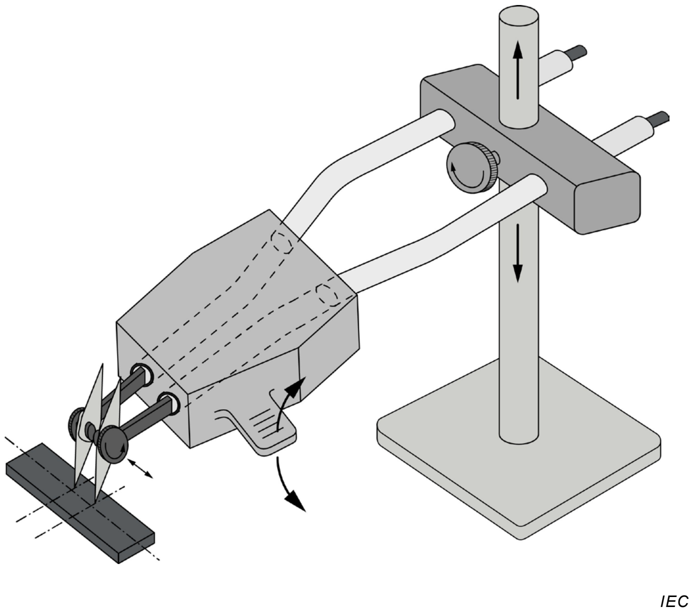


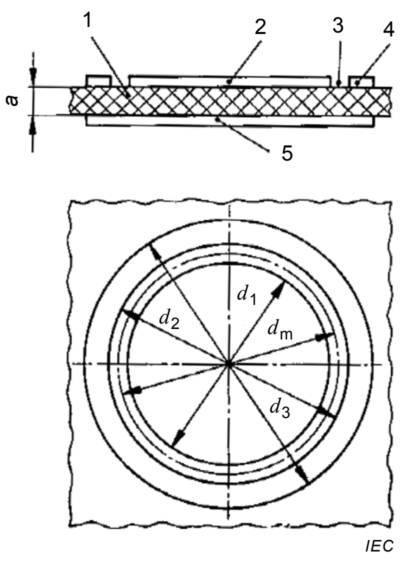

**Figure 2 – Collector electrode for electrode arrangement B**



### 5.3.6 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 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).






**Key**

1 specimen
2 electrode 1
3 measuring area
4 electrode 2
5 electrode 3 (guard electrode)

**Figure 3 – Electrode arrangement C**

Any electrode dimension can be used, unless otherwise stipulated. Typical electrode dimensions are given by Table 1. For comparison tests, electrode arrangement C1 is recommended.