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REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Electrostatics –
Part 2-3: Methods of test for determining the resistance and resistivity of solid ~~planar~~ materials used to avoid electrostatic charge accumulation

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROSTATICS –

Part 2-3: Methods of test for determining the resistance and resistivity of solid ~~planar~~ materials used to avoid electrostatic charge accumulation

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 61340-2-3 has been prepared by IEC technical committee 101: Electrostatics.

This second edition cancels and replaces the first edition published in 2000. This edition constitutes a technical revision.

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

a) a distinction has been introduced between instrumentation used for laboratory evaluations, instrumentation used for acceptance testing and instrumentation used for compliance verification (periodic testing);
b) an alternative electrode assembly is described, which can be used on non-planar products or when the dimensions of the product under test are too small to allow the larger electrode assembly to be used;
c) the formulae for calculating surface and volume resistivity have been modified to correspond with common industry practice in the main areas of application for the IEC 61340 series.

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

CDV	Report on voting
101/470/CDV	101/494/RVC

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 the parts in the IEC 61340 series, published under the general title *Electrostatics*, 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.

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

The contents of the corrigendum 1 (2023-07) have been included in this copy.

INTRODUCTION

Measurements of resistances and related calculations of resistivities belong to the fundamental objectives of electrical measuring techniques along with measurements of voltage and current.

Resistivity is the electrical characteristic having the widest range, extending over some thirty orders of magnitude from the most conductive metal to almost perfect insulators.

The basis is Ohm's law and is valid for DC current and instantaneous values of AC current in electron conductors (metals, carbon, etc.). Values of resistance measurements using AC current can be influenced by capacitive/inductive reactance, depending on the frequency. Thus, existing national and international standards dealing with resistance measurements of solid materials normally require the application of DC current.

Most non-metal materials such as plastics are classified as polymers and ion conductors. The transport of charges can be dependent upon the applied electrical field strength during the measurement. Beside the measuring current, there exists a charging current that polarizes and/or electrostatically charges the material, indicated by an asymptotic decay of the measuring current with time and causing an apparent change in resistance. If this effect is observed, it will be advisable to repeat the measurement immediately after a definite electrification time has elapsed using the reverse polarity for the measuring current and averaging both obtained values.

ELECTROSTATICS –

Part 2-3: Methods of test for determining the resistance and resistivity of solid ~~planar~~ materials used to avoid electrostatic charge accumulation

1 Scope

This part of IEC 61340 describes test methods for the determination of the electrical resistance and resistivity of solid materials used to avoid electrostatic charge accumulation, in which the measured resistance is in the range 10^4 Ω to 10^{12} Ω.

It takes account of existing IEC/ISO standards and other published information, and gives recommendations and guidelines on the appropriate method.

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 60093:1980, *Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials*~~

~~IEC 60167:1964, *Methods of test for the determination of the insulation resistance of solid insulating materials*~~

~~IEC 60212:1971, *Standard conditions for use prior to and during the testing of solid electrical insulating materials*~~

~~IEC 60260:1968, *Test enclosures of non-injection type for constant relative humidity*~~

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*

IEC 62631-3-2, *Dielectric and resistive properties of solid insulating materials – Part 3-2: Determination of resistive properties (DC Methods) – Surface resistance and surface resistivity*

IEC 62631-3-3, *Dielectric and resistive properties of solid insulating materials – Part 3-3: Determination of resistive properties (DC Methods) – Insulation resistance*

ISO 1853~~:1998~~, *Conducting and ~~antistatic~~ dissipative rubbers, vulcanized or thermoplastic – Measurement of resistivity*

ISO 2951~~:1974~~, *Rubber, vulcanized or thermoplastic – Determination of insulation resistance*

ISO 3915~~:1981~~, *Plastics – Measurement of resistivity of conductive plastics*

ISO 7619-1, *Rubber, vulcanized or thermoplastic – Determination of indentation hardness – Part 1: Durometer method (Shore hardness)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply:

3.1
electrode
conductor of defined shape, size and configuration being in contact with the specimen to be measured

3.2
resistance
R
ratio of a DC voltage (V) applied between two points and the steady-state current (A) between the two points

Note 1 to entry: Resistance is expressed in ohms.

3.3
resistance to ground
R_g
resistance measured between an electrode placed on the surface of a test specimen and a local ground

Note 1 to entry: Resistance to ground is expressed in ohms.

3.4
resistance to groundable point
R_{gp}
resistance measured between an electrode placed on the surface of a test specimen and a groundable point fitted to the test specimen

Note 1 to entry: Resistance to groundable point is expressed in ohms.

3.5
point-to-point resistance
R_{pp}
resistance measured between two electrodes placed a specified distance apart on the same surface of a test specimen

Note 1 to entry: Point-to-point resistance is expressed in ohms.

3.6
surface resistance
R_s
~~the ratio of a d.c. voltage (V) applied between two electrodes on a surface of a specimen and the current (A) between the electrodes~~
resistance measured between a central disc electrode and a surrounding concentric ring electrode placed on the surface of a test specimen

Note 1 to entry: Surface resistance is expressed in ohms.

3.7
surface resistivity
ρ_s
resistivity equivalent to the surface resistance of a square area, having the electrodes at two opposite sides

Note 1 to entry: The SI unit of surface resistivity (Ω) is sometimes referred to as Ω/sq (ohms per square), to distinguish resistivity values from resistance values. However, the use of Ω/sq is deprecated because it may imply a resistance per unit area, which is not correct.

3.8
volume resistance
R_v
~~the ratio of a d.c. voltage (V) applied between two electrodes placed on two (opposite) surfaces of a specimen and the steady-state current (A) between the electrodes~~
resistance measured between two electrodes placed on opposite surfaces of a test specimen

Note 1 to entry: Volume resistance is expressed in ohms.

3.9
volume resistivity
ρ_v
ratio of a DC field strength (V/m) and the steady-state current density (A/m^2) within the material

Note 1 to entry: In practice, it is equivalent to the volume resistance of a cube with unit length, having the electrodes at two opposite surfaces.

Note 2 to entry: Volume resistivity is not an appropriate characteristic for materials that are electrically inhomogeneous.

Note 3 to entry: Volume resistivity is expressed in ohm meters.

~~**3.5**~~
~~**measuring electrode**~~
~~a conductor of defined shape, size and configuration being in contact with the specimen to be measured~~

4 Conditioning and test environment

The electrostatic behaviour of materials is influenced by environmental conditions, such as relative humidity and temperature.

For this reason, measurements shall be performed under controlled conditions. The selection of the appropriate conditions for testing shall be decided according to the type of material (product specification) and the intended application, based on the most severe conditions expected to occur during usage (e.g. lowest humidity and highest humidity).

Unless otherwise agreed, the atmosphere for conditioning and testing shall be (23 ± 2) °C and (12 ± 3) % relative humidity, and the conditioning time prior to testing shall be at least 24 h.

If it is required to test that the measured resistance is not below a minimum limit, additional testing at high humidity is required. Unless otherwise agreed, the atmosphere for conditioning and testing at high humidity shall be (23 ± 2) °C and (60 ± 10) % relative humidity, and the conditioning time prior to testing shall be at least 24 h.

Specimens shall normally be conditioned and measured in the same climate, if not specified differently. However, preconditioning ~~can~~ may be necessary in order to eliminate the effects of stress appearing after the moulding process of some plastic materials or as a drying treatment before the test procedure starts. Preconditioning ~~shall~~ is normally ~~handled~~ done in a different environment.

Adequate devices are a desiccator in an oven or a climate chamber preferably equipped with forced circulation and interchange of air. ~~Additional guidance may be taken from IEC 60212 and IEC 60260.~~

5 Selection of test method

For planar materials, the following procedure shall be used to select the test method:

a) if the range of electrical resistance of a material to be tested is known, then use the relevant clause (Clause 6, 7, 8 or 10) where appropriate standards are listed or methods described;

b) for a material of initially unknown resistivity, start the measurements by using methods for conductive materials according to Clause 6.

If the measurement is not possible or the obtained result exceeds the given range for the application of the test method, it shall be regarded as being inadequate and the result shall not be taken into account. The measurement shall be repeated according to Clause 8 or Clause 10 for electrostatic dissipative materials. If the situation described above occurs again, the measurement shall be repeated according to Clause 7 for insulating materials.

For non-planar materials and for products with structures that are too small to allow the use of the electrode assemblies specified in 8.2, the method described in Clause 10 shall be used.

If the measurement result using the method described in Clause 10 is less than 10^4 Ω or greater than 10^{12} Ω, and the shape or dimensions of the material under test do not allow measurements according to Clause 6 or Clause 7, the test result shall be reported as either "$<10^4$ Ω" or "$>10^{12}$ Ω".

6 Resistance measurements ~~of~~ for solid conductive materials

The resistance of solid conductive materials (non-metals) shall be measured in accordance with ISO 3915 for plastics or ISO 1853 for rubbers. If the measured resistance is greater than or equal to 10^4 Ω, use the methods described in Clause 7, 8 or 10.

~~For highly conductive materials, the contact resistances necessitate the method of a quadrupole measurement in order to avoid a non-linear potential distribution over the specimen. The most important parameter is the current injected through the specimen or, even more precisely, the dissipated power in order to avoid significantly heating the material.~~

7 Resistance measurements ~~of~~ for solid insulating materials

The resistance of solid insulating materials shall be measured in accordance with ~~IEC 60093, IEC 60167~~ IEC 62631-3-1, IEC 62631-3-2 or IEC 62631-3-3 for plastics, or ISO 2951 for rubbers.

~~For highly insulating materials, the resistance along the surface can be much lower compared to the resistance through the material due to the effect of adsorbed contaminants such as water. Furthermore, there can exist a non-linear functional correlation between the applied voltage and the conducted current. Thus, the surface and volume resistance of solid insulating materials are conventionally measured under specified conditions (generally 500 V and 1 min time of electrification) with guarded electrodes.~~

~~Liquid, painted or sprayed contact electrodes could modify the behaviour of the specimen under test and shall not be applied. The use of conductive rubber as contact material is strongly recommended instead.~~

8 Resistance measurements ~~of~~ for planar electrostatic dissipative materials (used to avoid electrostatic charge accumulation)

~~The resistance of materials used to avoid electrostatic charge accumulation shall be measured according to the instructions given in the subclauses below.~~

8.1 Instrumentation

8.1.1 General

The instrumentation may consist of either a DC power supply and an ammeter, or an integrated instrument (ohmmeter). National safety regulations shall be followed.

~~If an ohmmeter without current reading facility is used for volume resistance measurements, a separate ammeter is required capable of reading at least from 10 pA to 10 mA with an accuracy of ±5 %.~~

8.1.2 Instrumentation for laboratory evaluation

The ~~open circuit~~ output voltage under load shall be (100 ± 5) V for measurements of 1×10^6 Ω and higher, and (10,0 ± 0,5) V for less than 1×10^6 Ω.

If an ohmmeter is used, readings shall be possible at least from 1×10^3 Ω to 1×10^{13} Ω, with an accuracy of ±10 %.

If a DC power supply and ammeter are used, readings shall be possible at least from 10 pA to 10 mA. The combined accuracy of the DC power supply and ammeter shall be ±10 %.

8.1.3 Instrumentation for acceptance testing

Instrumentation for laboratory evaluation or instrumentation meeting the following requirements shall be used for acceptance testing.

The open circuit voltage shall be (100 ± 5) V for measurements of 1×10^6 Ω and higher, and (10,0 ± 0,5) V for less than 1×10^6 Ω.

If an ohmmeter is used, readings shall be possible at least from 1×10^3 Ω to 1×10^{13} Ω, with an accuracy of ±20 %.

If a DC power supply and ammeter are used, readings shall be possible at least from 10 pA to 10 mA with an accuracy of ±20 %.

In case of dispute, instrumentation for laboratory evaluations shall be used.

8.1.4 Instrumentation for compliance verification (periodic testing)

Instrumentation meeting the requirements for laboratory evaluations or acceptance testing, or instrumentation meeting the following requirements shall be used.

Compliance verification instrumentation shall be capable of making measurements one order of magnitude above and below the intended measurement range. The output voltage of compliance verification instrumentation may vary from laboratory evaluation or acceptance testing instrumentation, and may be rated under load or open circuit. Compliance verification instrumentation shall be checked against laboratory evaluation or acceptance testing instrumentation to ensure there is correlation between measurement results.

In case of dispute, instrumentation for acceptance testing or laboratory evaluation shall be used.

8.2 Electrode assemblies

8.2.1 General

The electrodes shall consist of a material that allows intimate contact with the specimen surface and introduces no appreciable error because of electrode resistance or contamination of the specimen. The electrode material shall be corrosion resistant under test conditions and shall not cause a chemical reaction with the material being tested.

The assemblies described in the subclauses below are recommended to be suitable, but other configurations complying with national or international standards may also be used, if appropriate. Especially for volume resistance measurements of electrostatic dissipative materials, it is important that applied probes of the guarded ring type have sufficient space between the centre (measuring) and ring (guard) contact electrode in order to minimize stray currents falsifying the readings. It is recommended, that the gap g shall be at least 10 mm. In cases of dispute, the assemblies described in this standard shall be applied.

8.2.2 Assembly for the measurement of surface resistance

The electrode assembly (probe 1) contains a central disc surrounded by a concentric ring made of conductive materials which make contact with the material under test (see Figure 1). The total mass of the electrode assembly shall be (2,5 ± 0,25) kg.

The contact surface material shall have a volume resistance of less than 10^3 Ω when tested on a stainless, non-corrosive metal plate (not aluminium) as the counter electrode by applying (10,0 ± 0,5) V, and shall have a Shore A hardness of 50 to 70 when tested according to ISO 7619-1.

Insulating materials used in the electrode assembly shall have volume and/or surface resistance greater than 10^{13} Ω when tested according to IEC 62631-3-1 and/or IEC 62631-3-2 respectively.

The material under test ~~should~~ shall be placed on an insulating support as described in 8.2.5.