INTERNATIONAL STANDARD

ISO 1853

Second edition
1998-03-01

Conducting and dissipative rubbers, vulcanized or thermoplastic — Measurement of resistivity

Caoutchoucs vulcanisés ou thermoplastiques conducteurs et dissipants — Mesurage de la résistivité

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 1853 was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Subcommittee SC 2, *Physical and degradation tests*.

This second edition cancels and replaces the first edition (ISO 1853:1975), which has been technically revised.

Annex A of this International Standard is for information only.

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Introduction

Rubber is normally regarded as a material of high electrical resistivity; consequently, it is widely used as an insulator. However, the incorporation of various materials, in particular certain forms of carbon black, greatly reduces the electrical resistance so that resistivities between 10^{13} Ωm and 0,01 Ωm are obtainable.

There are various technical and industrial purposes for which rubber with a reduced resistivity is a useful material, the most frequent application being for the dissipation of static charges. In certain circumstances, a lower limit of resistance must be imposed on a product with this latter application, as a safety precaution to prevent its ignition or to prevent severe shock to a person in contact with it, in the event of faulty insulation or nearby electrical equipment.

Products which, while conducting away static charges, are sufficiently insulating to fulfil the safety requirements above are termed dissipative rubbers. Products which do not fulfil the safety requirements are termed "conducting" rubbers. Since the dimensions of the product are involved it is not possible to define a suitable range of volume resistivities for either of these classes, but only a range of resistance values between defined points. However conductive materials are generally considered to have a resistivity below 10^6 Ωm and dissipative materials to have a resistivity between 10^5 Ωm and 10^{10} Ωm.

The principal hazard, apart from static electricity, in most buildings and with most electrical equipment is from leakage currents from normal voltage supply mains. To guard against these hazards, it is recommended that the lower limit of resistance for a dissipative rubber product should be $5 \cdot 10^4$ ohm for 250 V mains supplies, that is a maximum current of 5 mA. The limit can be proportionally less for lower voltages.

The maximum resistance which will permit the dissipation of static charges depends on the rate of generation of charge required to produce the minimum voltage which can be regarded as a hazard in a particular application.

Effect of temperature changes and strain on conducting and antistatic rubbers

The resistance of these materials is very sensitive to their strain and temperature history. The relationships are complex and arise from the kinetic energy and structural configuration of the carbon particles in the rubber.

Under normal conditions of service with varying temperature and strain history, the resistance of a sample of a given material can vary considerably, for example by a hundred or more times, between freshly strained materials at room temperatures and material which has remained unstrained for a short period at 100 °C.

In order that valid comparisons may be made on test pieces, a conditioning treatment is specified so that the measurements are made on test pieces brought to a condition of zero strain.

Electrode systems

Certain types of electrode, when applied to these rubbers, have a contact resistance which may be many thousands of times greater than the intrinsic resistance of the test piece. Dry contacts under light pressure or point contacts are particularly poor.

The definition of a suitable electrode system is therefore an important part of this method of test.

Conducting and dissipative rubbers, vulcanized or thermoplastic — Measurement of resistivity

WARNING - Persons using this International Standard should be familiar with normal laboratory practice. This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to ensure compliance with any national regulatory conditions.

1 Scope

This International Standard specifies the requirements for the laboratory testing of the volume resistivity of specially prepared test pieces of vulcanized or thermoplastic rubber compounds rendered conducting or dissipative by the inclusion of carbon black or ionizable materials. Antistatic properties may also be conferred on rubber materials by the incorporation of ionizable materials into the rubber mix. The test is suitable for materials with a resistivity of less than 10^{10} Ωm.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 471:1995, *Rubber -Temperatures, humidities and times for conditioning and testing*

3 Apparatus

(see figure 1 for schematic diagram of test circuit).

3.1 Current source. A source of direct current which has a minimum resistance to earth of 10^{12} ohm and which will not cause a dissipation of power greater than 1 W within the test piece.

3.2 Means of measuring the current to an accuracy of 5 %.

Note 1 - Very small currents may be computed from measurement of the voltage drop across a known resistance using the electrometer (3.5).

3.3 Test piece holder and current electrodes, comprising a polystyrene strip of about 10 mm thickness where the current electrodes are fixed (see figure 1). The current electrodes shall be of clean metal approximately 5 mm long and across the full width of the test piece, together with suitable clamps or grips.

The distance between the current electrodes shall be 50 mm ±1 mm or 100 mm ±1 mm, and the resistance between them shall be greater than 10^{12} Ω.

A minimum of three test piece holders shall be available.

3.4 Potentiometric electrodes, constructed so that they exert a contacting force of approximately 0,65 N for 10 mm wide test pieces or 1,3 N for 20 mm wide test pieces (see figure 2). The resistance between the potentiometric electrodes shall be greater than 10^{12} Ω.

3.5 Electrometer, having an input resistance greater than 10^{11} Ω. References for such instruments are given in annex A.

3.6 Sheet of insulating material, having a resistivity greater than 10^{13} Ωm.

3.7 Oven, capable of being controlled at a temperature of 70 °C ±1 °C.

4 Test piece

The test piece is a strip, 10 mm ±0,5 mm or 20 mm ±0,5 mm wide, of vulcanized or thermoplastic material minimum 70 mm long and normally 2 mm, 4 mm or 6,3 mm thick with a tolerance of uniformity of thickness of ± 5 %.

For comparison purposes test pieces of the same size shall be used.

The test piece may be cut with a knife or die but care shall be taken to minimize distorsion as this will affect the resistance values.

The surfaces of the test piece shall be clean; if necessary they may be cleaned by rubbing with Fuller's earth (aluminium magnesium silicate) and water, washing with distilled water and allowing to dry. The surfaces shall not be buffed or abraded.

5 Number of test pieces

Three test pieces of equal size shall be prepared and tested.

6 Procedure

Allow the test piece to rest for not less than 16 h after vulcanization or moulding, in accordance with ISO 471.

Immediately prior to the commencement of the test, place the test piece on the test piece holder and clamp the current electrodes to its ends.

Without removing it from the test piece holder, heat the test piece in the oven for 2 h at a temperature of 70 °C ±1 °C and then condition for not less than 16 h at the standard laboratory temperature and humidity in accordance with ISO 471. Place the two potentiometric electrodes in position with a distance of 10 mm to 20 mm between them, ensuring that the knife edges are at right angles to the current flow and that neither is nearer than 20 mm to a current electrode. Measure the distance between the potentiometric electrodes to an accuracy of ±2 %. Apply the current and determine the steady potential between the potentiometric electrodes, using the electrometer, after the current has been passing for 1 min.

Repeat the measuring procedure twice more on the same test piece, moving the potentiometric electrodes each time to obtain measurements over lengths of the test piece evenly distributed between the current electrodes.

Similarly, test the other two test pieces.

7 Expression of results

Average the three measurements of resistance for each test piece and calculate the resistivity, ρ, in ohm metres, as follows:

$$\rho = \frac{V.w.t}{l \cdot I}$$

where

V = measured potential in V

w = the width of the test piece in m

t = the thickness of the test piece in m

l = the distance between the potentiometer electrodes in m

I = measured current in A

Report the median value of the restivities of the three test pieces.

8 Test report

The test report shall include the following information:

a) a reference to this International Standard;

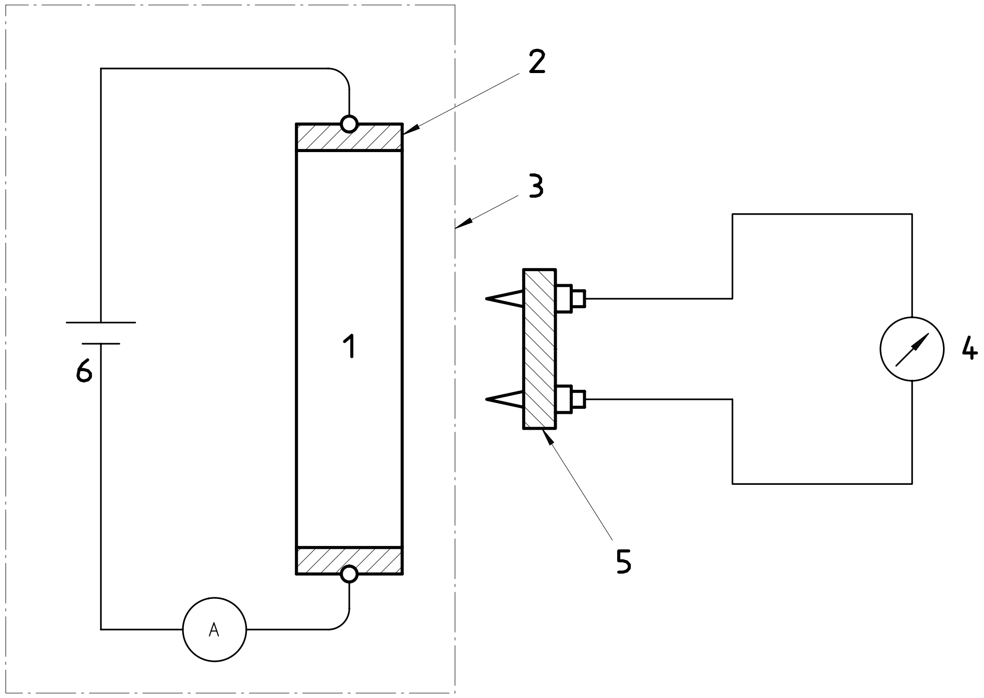
b) sample details:
   1) a full description of the sample and its origin;
   2) compund details and cure conditions, if known;
   3) the dimensions of the test pieces;

c) test details:
   1) the temperature and humidity conditions during the test;
   2) the voltage applied to the current electrodes;
   3) the current through the test piece;

d) test results:
   1) the median value of the resistivity of the three test pieces;
   2) the individual average resistivity value for each test piece, if required;

e) the date of test.

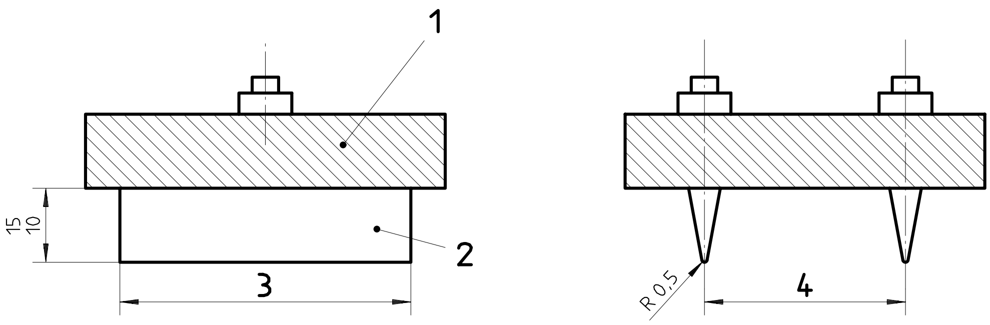
Dimensions in millimetres



Key

1 Test piece
2 Current electrode
3 Insulating mat — Resistance at least 10^{12} Ω
4 Electrometer
5 Potentiometric electrode
6 Adjustable direct-current voltage

Figure 1 — Schematic diagram of test circuit



Key

1 Polystyrene strip
2 Stainless steel
3 Test specimen width + at least 10 mm
4 10 mm to 20 mm measured to ± 2 %

Figure 2 — Potentiometric electrodes

ANNEX A

(Informative)

Solid state electrometer

Measurement of voltage and current in the ranges suitable for this International Standard can be performed also by means of a solid state electrometer having a sufficiently high input resistance.

An instrument of this type is the Model 602 solid state electrometer of Keithley Instruments. Used as a voltmeter the 602 Electrometer has an input resistance greater than 10^{14} ohm and a range from 0,001 V at full scale to 10 V; as an ammeter its range is from 10^{-14} A at full scale to 0,3 A.

This apparatus is manufactured by:

Keithley Instruments
28775 Aurora Road
Cleveland
Ohio 44139
USA

Their European Headquarter is:

Keithley Instruments GmbH
Landsberger Strasse 65
8034 Gemring
Germany.

An instrument measuring volume resistivity in compliance with this standard is the Elastocon EE 01 Volume Resistivity Tester. The EE 01 instrument has an integrated differential voltmeter and ammeter. The ammeter can measure currents down to 0,01 nA and the differential voltmeter which is integrated with the potentiometric electrode has an input resistance of > 0,1 TΩ.

This instrument is manufactured by:

Elastocon AB
Göteborgsvägen 99
S-504 60 GÖTEBORG
Sweden