INTERNATIONAL STANDARD ISO 1853

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Conducting and antistatic rubbers — Measurement of resistivity

Élastomères conducteurs et anti-électrostatiques — Mesurage de la résistivité

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FOREWORD

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Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 1853 was drawn up by Technical Committee ISO/TC 45, *Rubber and rubber products,* and circulated to the Member Bodies in October 1972.

It has been approved by the Member Bodies of the following countries :

Australia	India	Sweden
Austria	Ireland	Switzerland
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No Member Body expressed disapproval of the document.

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Conducting and antistatic rubbers – Measurement of resistivity

0 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} Ω·m and 0,01 Ω·m 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 of nearby electrical equipment.

Products which, while conducting away static charges, are sufficiently insulating to fulfil the safety requirements above are termed antistatic 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. 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 an antistatic rubber product should be 5×10^4 Ω 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 material 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.

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the requirements for the laboratory testing of the volume resistivity of specially prepared test pieces of vulcanized rubber compounds rendered conducting or antistatic by the inclusion of carbon black. Antistatic properties may also be conferred on rubber materials by the incorporation into the rubber mix of ionizable materials. The test is suitable for materials with a resistivity of less than 10^6 Ω·m.

2 REFERENCE

ISO/R 471, *Standard atmospheres for the conditioning and testing of rubber test pieces.*

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} Ω 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 – Very small currents may be computed from measurement of the voltage drop across a known resistance using the electrometer (3.5).

3.3 Current electrodes, of clean metal approximately 5 mm long and across the full width of the test piece, together with suitable clamps or grips.

3.4 Potentiometric electrodes, constructed so that they exert a contacting force of approximately 65 N per metre width of test piece. (See figure 2.)

3.5 Electrometer, having an input resistance greater than 10^{11} Ω. An example of a suitable instrument is described in the annex and its circuit diagram is given in figure 3.

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

3.7 Oven, capable of being controlled at a temperature of 70 ± 3 °C.

4 TEST PIECE

The test piece is a strip, 10 to 150 mm wide, of vulcanized material 70 to 150 mm long and normally 2,4 or 6,3 mm thick with a tolerance on uniformity of thickness of ± 5 %. The test piece may be cut with a knife or die but care must be taken to minimize distortion 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.

Immediately prior to the commencement of the test, clamp the current electrodes to the ends of the test piece.

Place the test piece with the current electrodes on the sheet of insulating material and heat in the oven for 2 h at a temperature of 70 ± 3 °C.

Without removing it from the sheet of insulating material, condition the test piece for not less than 16 h at the standard laboratory temperature and humidity in accordance with ISO/R 471.

Place the two potentiometric electrodes in position with a distance of between 10 and 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 resistance between the potentiometric electrodes using the electrometer, after 1 min of electrification.

Repeat the measuring procedure twice more on the same test piece, moving the potentiometric electrodes each time to obtain measurements over lengths of 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 in ohm metres as follows.

$$\text{Resistivity } (\Omega.\text{m}) = \frac{\text{Average resistance in ohms} \times \text{cross-sectional area in square metres}}{\text{Distance between potentiometric contacts in metres}}$$

Report the median of the resistivities of the three test pieces.

8 TEST REPORT

The test report shall include the following particulars :

a) the median value of the resistivity of the three test pieces;

b) the temperature and humidity conditions during the test;

c) the dimensions of the test piece;

d) the current through the test piece;

e) the voltage applied to the current electrodes.

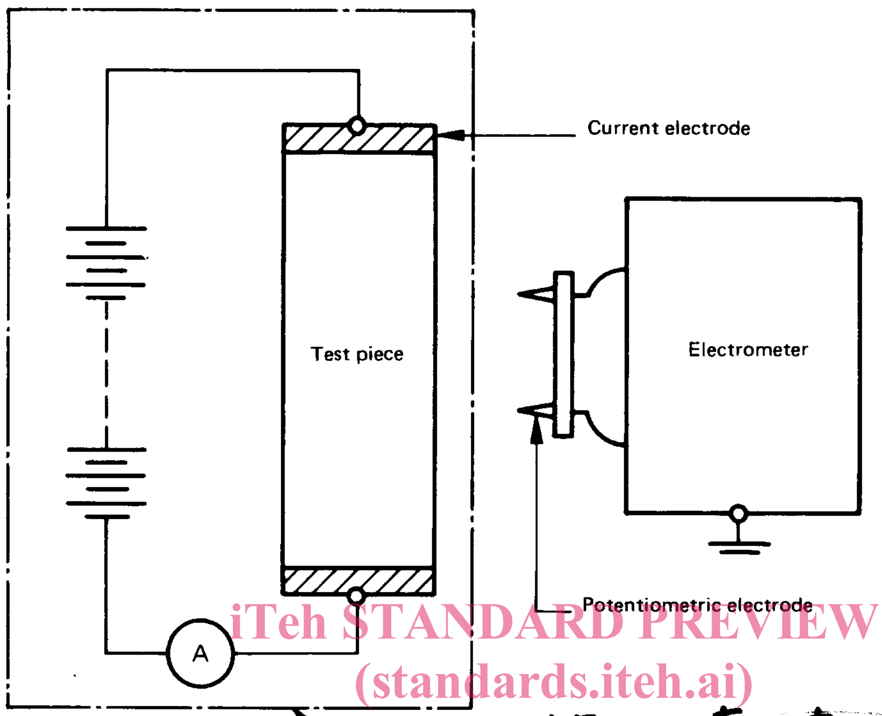

FIGURE 1 — **Schematic diagram of test circuit**

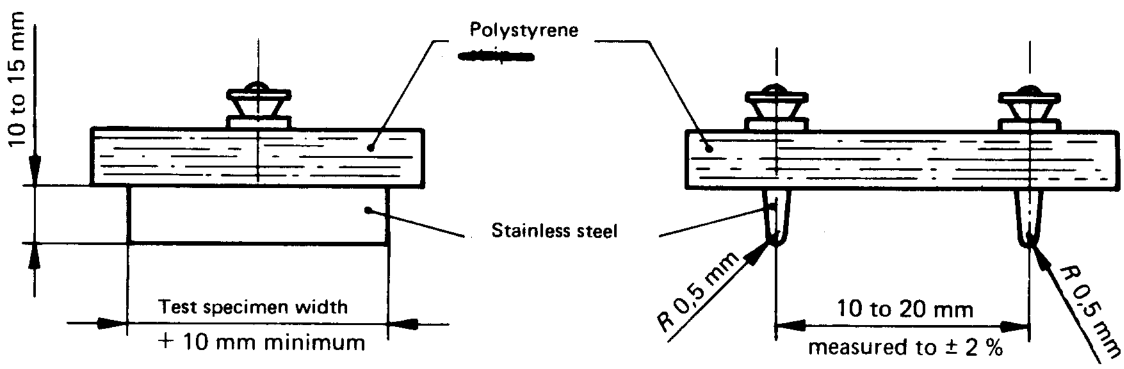

FIGURE 2 — **Potentiometric electrodes**

ANNEX

DESCRIPTION AND OPERATION OF A SUITABLE ELECTROMETER (VALVE VOLTMETER)

A.1 GENERAL CONSTRUCTION

The instrument (see figure 3) should be completely enclosed in a light-tight earthed metal case. The lead of the grid of the valve should be air-insulated and the terminal connected to it should have polystyrene or polyethylene insulation with fairly long surface leakage paths.

A.2 PRINCIPLE OF OPERATION

The voltage to be measured at the terminals T is opposed by a backing-off voltage so that the grid of the valve is returned to earth potential.

The voltage appearing across the backing-off circuit is then equal and opposed to that across the terminals T.

A.3 BATTERIES

The batteries used in the instrument should be of the mercury-zinc type which has a constant voltage output of approximately 1,3 V and a long shelf life. The batteries should be checked and replaced if normal functioning of the instrument cannot be obtained.

A.4 SETTING UP OF INSTRUMENT AND MEASUREMENT OF VOLTAGE

Before the instrument is switched on, the input terminals T should be short-circuited and the backing-off potentiometer set to the zero position. The zero-set potentiometer should then be adjusted until the anode current is 100 μA.

The short-circuit on the terminals T should then be removed and the terminals connected to the test piece potential electrodes, the grid terminal to the negative potential. The backing-off potentiometer should then be adjusted until the anode current again reads 100 μA and the input voltage read from the potentiometer voltmeter.

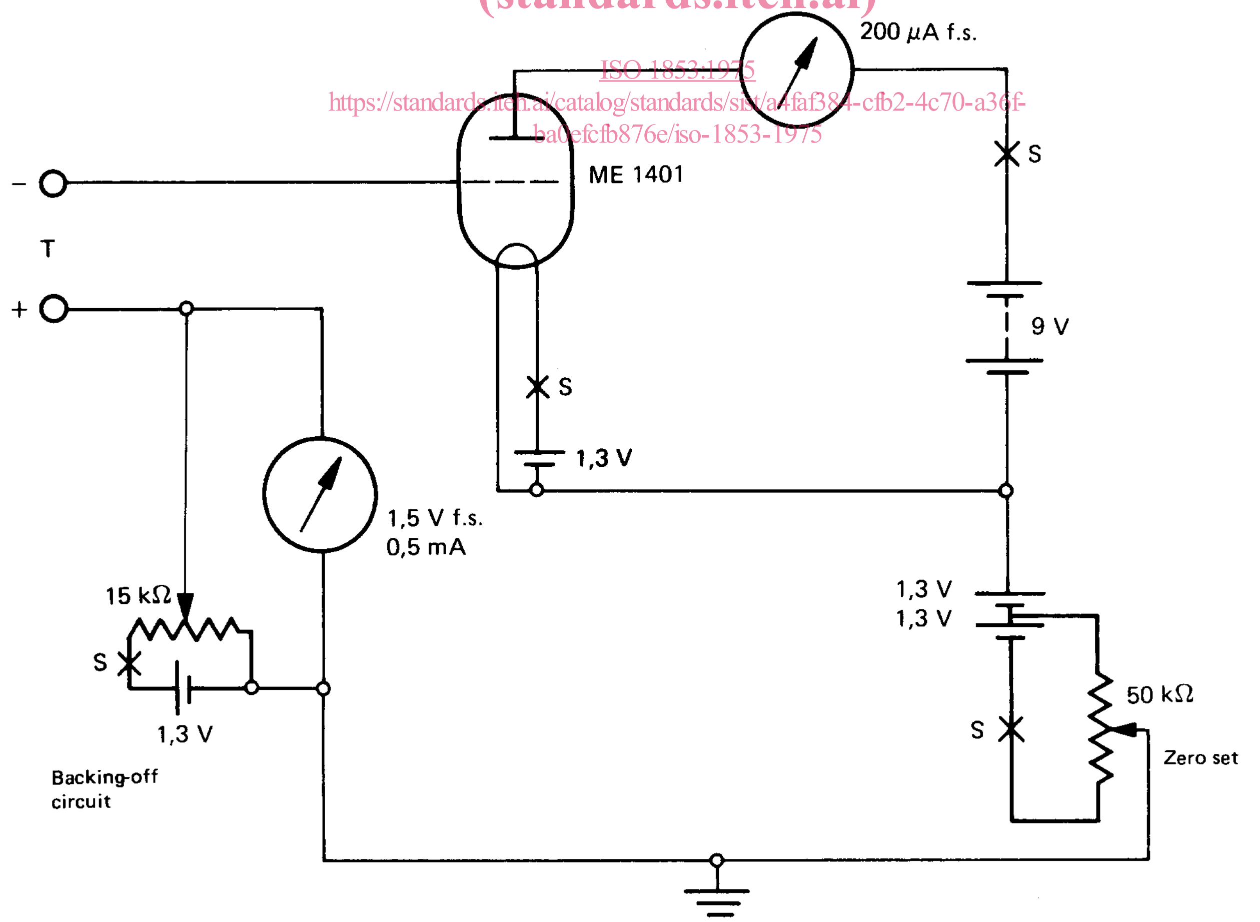

FIGURE 3 — **Sketch of circuit for high input resistance valve voltmeter in which valve is used as a null detector**

Circuit components specified are appropriate for use with an ME 1401 valve