INTERNATIONAL STANDARD

ISO 15091

First edition
2012-12-01

Paints and varnishes — Determination of electrical conductivity and resistance

Peintures et vernis — Détermination de la conductivité et de la résistance électriques

Reference number
ISO 15091:2012(E)

Contents

Page

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15091 was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

Paints and varnishes — Determination of electrical conductivity and resistance

1 Scope

This International Standard specifies a method for determining the electrical conductivity and the electrical resistance of coating materials. The conductivity is usually measured for water-borne paints and varnishes, including electrodeposition coating materials, and the resistance is usually measured for solvent-borne paints and varnishes. If required, the resistivity of the coating material is calculated from either of these measurements. The method is applicable to products having a conductivity less than 5 µS/cm, corresponding to a resistivity greater than 200 kΩ·cm.

The conductivity of coating materials influences their processibility in the presence of an electric field. This is particularly important for electrodeposition paints and coating materials which are processed electrostatically.

2 Normative references

The following referenced documents are indispensable for the application 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.

ISO 1513, *Paints and varnishes — Examination and preparation of test samples*

ISO 3696, *Water for analytical laboratory use — Specification and test methods*

ISO 15528, *Paints, varnishes and raw materials for paints and varnishes — Sampling*

3 Terms and definitions

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

3.1
electrical resistance
R
ratio of the potential difference along a conductor and the current through the conductor

NOTE Resistance is given by Ohm's law:

$$R = \frac{U}{I} \tag{1}$$

where

U is the potential difference;

I is the current.

The unit of electrical resistance is the ohm (Ω), given by:

$$1\ \text{ohm} = \frac{1\ \text{volt}}{1\ \text{ampere}}$$

The electrical resistance depends on the material of the conductor, its dimensions (length and cross-section) and its temperature.

3.2
resistivity
ρ
resistance per unit length of a material of unit cross-sectional area

NOTE Resistivity is given by Equation (2):

$$\rho = R \times \frac{A}{l} \tag{2}$$

where

A is the cross-sectional area of the conductor;

l is the length of the conductor.

The unit of resistivity is the ohm metre (Ω·m).

3.3
conductance
G
reciprocal of the resistance

NOTE Conductance is given by Equation (3):

$$G = \frac{1}{R} = \frac{I}{U} \tag{3}$$

The unit of conductance is the siemens (S):

$$1\ \text{S} = \frac{1}{\text{ohm}} = \frac{1\ \text{ampere}}{1\ \text{volt}}$$

3.4
electrical conductivity
γ
reciprocal of the resistivity

NOTE Electrical conductivity is given by Equation (4):

$$\gamma = \frac{1}{\rho} = \frac{1}{R} \times \frac{l}{A} \tag{4}$$

The unit of electrical conductivity is the siemens reciprocal metre ($S \cdot m^{-1}$).

3.5
cell constant
c
quotient of the length and the cross-sectional area of a conductor

NOTE It is given by Equation (5):

$$c = \frac{l}{A} \tag{5}$$

From Equation (2), it can be seen that it corresponds to the ratio of the resistance to the resistivity of the conductor material.

For the determination of the resistivity by resistance measurement, this geometrical factor, i.e. the cell constant of the measurement assembly, will need to be known.

Cell constants are given in reciprocal centimetres (cm^{-1}).

4 General

4.1 Measurement of the resistance

The resistance may be determined by

— measurement of the current through a sample and the voltage acting on the sample;

or

— comparison of the measured resistance with a reference resistance.

For the current/voltage measurement, usually a constant pre-determined voltage is applied to the sample, and the current is measured with a suitable measuring instrument (e.g. a moving-coil instrument or a digital instrument). The resistance is then calculated from Equation (1). See Figures 1 to 3.

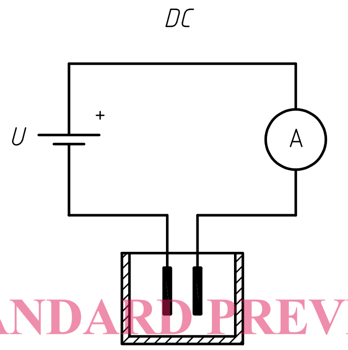


Figure 1 — Direct-current measurement

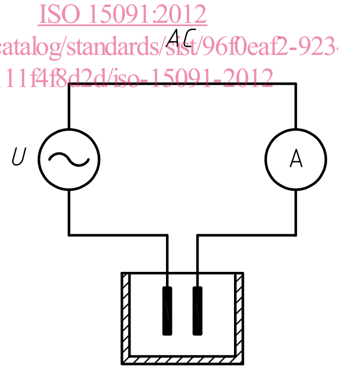


Figure 2 — Alternating-current measurement — Two-electrode cell

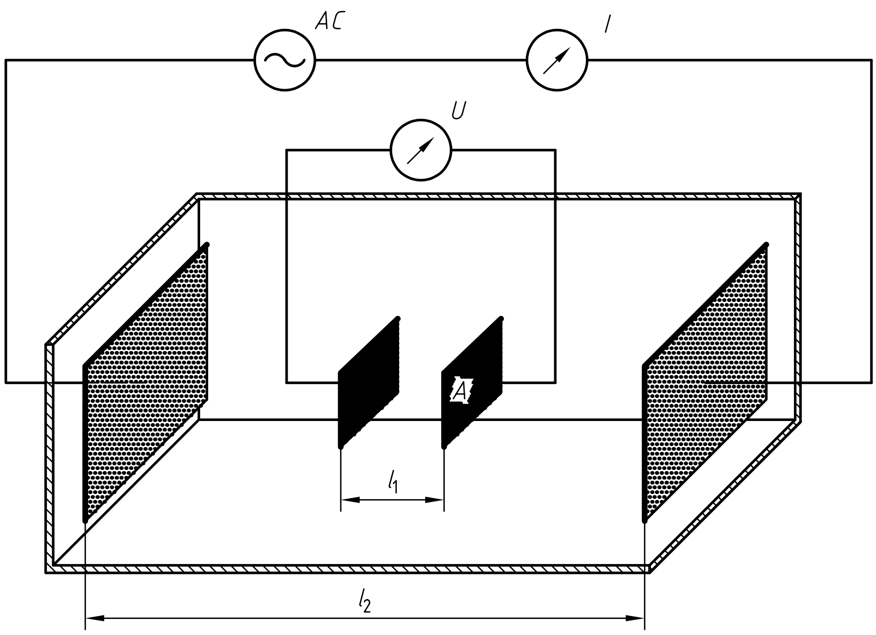
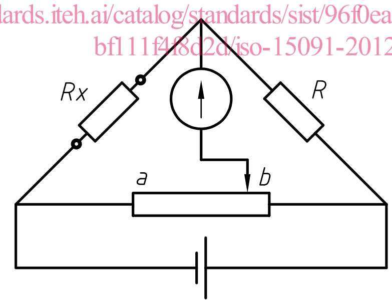


Figure 3 — Alternating-current measurement — Four-electrode cell

To compare the resistance of the sample with a reference resistance, a bridge circuit is used in which the resistances are balanced so that the bridge current becomes zero. The resistance of the sample is calculated from the ratio of the resistances of the bridge circuit. Because the bridge current is zero, errors which can result from the existence of a load on the voltage source when the voltage/current measurement method is used are avoided. The only contributions to the overall measurement error are any uncertainty in the reference resistance and any uncertainty in the adjustable resistance. See Figure 4.



$$R_x = R \times \frac{a}{b}$$

Figure 4 — Wheatstone bridge

4.2 Avoidance of electrolysis and polarization effects

In order to avoid electrolysis or polarization effects which would falsify the measurement, measurements of the resistance are usually carried out using alternating current. The frequency of the voltage applied to the measuring cell should, however, be as low as possible in order to minimize the contribution made by the reactance of the measuring cell, which acts as a capacitor.

5 Apparatus

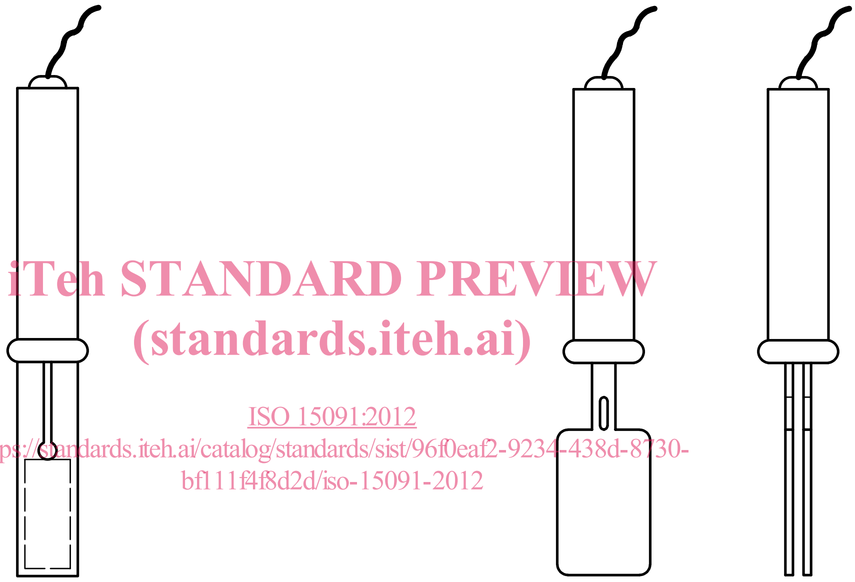
5.1 Measuring instrument

Use a resistance- or conductivity-measuring instrument calibrated as described in Annex A.

5.2 Measuring cell

The measuring cell consists of electrodes insulated from each other, with a known cell constant. The electrodes should preferably consist of a material that is easy to clean and inert (e.g. stainless steel, platinum, graphite, titanium) in order to make sure that the measurement will not be invalidated by changes in the electrodes. For examples of suitable electrodes, see Figure 5. It is important to ensure that the measuring cell is completely immersed in the liquid. The exact depth will depend on the type of electrode.

The cell geometry shall be chosen so that the possibility of contamination by dirt is minimized.



a) **Measuring cell with cylinder electrodes** b) **Measuring cell with plate electrodes**

Figure 5 — Examples of measuring cells

6 Sampling

Take a representative sample of the product to be tested, as described in ISO 15528.

Examine and prepare each sample for testing, as described in ISO 1513.

7 Procedure

7.1 Test conditions

Carry out the test at a temperature of (25 ± 1) °C, unless otherwise agreed. The deviation from any agreed temperature shall also be not more than ±1 °C.

The dependence of the conductivity on the measurement temperature is shown in Annex B.