INTERNATIONAL STANDARD

ISO 22553-7

First edition
2020-05

Paints and varnishes — Electro-deposition coatings —

Part 7:
Electrical wet-film resistance

Peintures et vernis — Peintures d'électrodéposition —

Partie 7: Résistance électrique du film frais

Reference number
ISO 22553-7:2020(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

A list of all parts in the ISO 22553 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The electrical wet-film resistivity provides information about the deposition behaviour of electro-deposition coatings, i.e. about film thickness and changes in film thickness, throwing power and possibly also the deposition performance under defined conditions.

Paints and varnishes — Electro-deposition coatings —

Part 7:
Electrical wet-film resistance

1 Scope

This document specifies a method for determining the wet-film resistivity of an electro-deposition coating (e-coat) for automotive industries and other general industrial applications, e.g. chiller units, consumer products, radiators, aerospace, agriculture.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 1514, *Paints and varnishes — Standard panels for testing*

ISO 4618, *Paints and varnishes — Terms and definitions*

ISO 22553-1, *Paints and varnishes — Electro-deposition coatings — Part 1: Vocabulary*

ISO 23321, *Solvents for paints and varnishes — Demineralized water for industrial applications — Specification and test methods*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4618, ISO 22553-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

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

Note 1 to entry: Resistance is given by Ohm's law shown in Formula (1):

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

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.

[SOURCE: ISO 15091:2019, 3.1]

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

Note 1 to entry: Resistivity is given by Formula (2):

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

where

A is the cross-sectional area of the conductor;

l is the length of the conductor.

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

[SOURCE: ISO 15091:2019, 3.2]

3.3
electrical wet-film resistance
R_w
measured total *electrical resistance* (3.1) of the electro-deposition coating including substrate, pre-treatment and other coats

Note 1 to entry: When the electrical resistance is being measured, the technical measurement conditions also have an influence, e.g. membrane, measurement electrode.

Note 2 to entry: The unit of electrical wet-film resistance is the ohm (Ω).

3.4
dynamic electrical wet-film resistance
$R_{w,\,dyn}\,(t)$
measured total *electrical resistance* (3.1) of the electro-deposition coating including substrate, pre-treatment and other coats as a function of the deposition time

Note 1 to entry: The unit of *electrical wet-film resistance* (3.3) is the ohm (Ω).

3.5
static electrical wet-film resistance
$R_{w,\,sta}\,(t_{end})$
measured total *electrical resistance* (3.1) of the electro-deposition coating including substrate, pre-treatment and other coats as read off at the end of the deposition time

Note 1 to entry: The unit of *electrical wet-film resistance* (3.3) is the ohm (Ω).

3.6
electrical wet-film resistivity
ρ_w
electrical wet-film resistance (3.3) multiplied by the area of the electrodes related to the distance between the electrodes

Note 1 to entry: Electrical wet-film resistivity is given by Formula (3):

$$\rho_w = R_w \cdot \frac{A}{l} \tag{3}$$

where

R_w is the electrical wet-film resistance;

A is the area of the electrodes;

l is the length of the conductor.

The unit of electrical wet-film resistivity is the ohm · metre (Ω·m).

3.7
electrical conductivity
γ
reciprocal of the *resistivity* (3.2)

Note 1 to entry: Electrical conductivity is given by Formula (4):

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

The unit of electrical conductivity is the siemens · metre^{-1} (S·m^{-1}).

[SOURCE: ISO 15091:2019, 3.4]

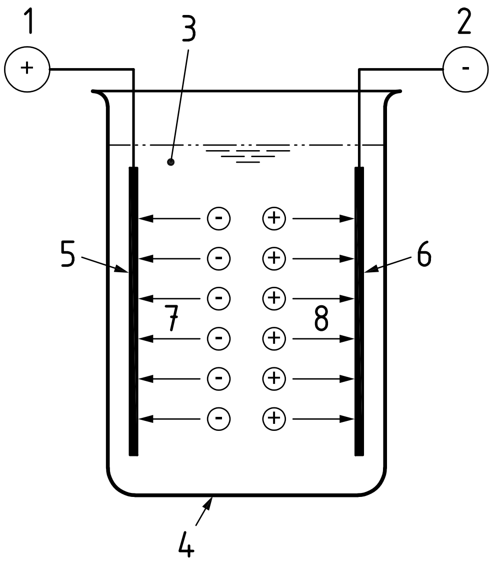
4 Principle

The test panel is entered into the deposition system and a constant current is set. The resulting voltage is read off at time intervals during the entire deposition time (method A). Alternatively, a constant voltage can be set and the resulting current can be read off at time intervals during the entire deposition time (method B). This data is used to calculate the electrical wet-film resistance, which differs depending on the method used. Both the dynamic and static electrical wet-film resistances can be measured with either method.

5 Apparatus and materials

Typical laboratory apparatus, together with the following:

5.1 Laboratory deposition system, consisting of a deposition tank with tank recirculation and DC voltage equipment – see Figure 1.



Key

1 anode
2 cathode
3 electro-deposition coating material
4 deposition tank
5 anode (counter electrode for cathodic e-coat)
6 cathode (test panel for cathodic e-coat)
7 acid
8 electro-deposition coating material

Figure 1 — Schematic diagram of a laboratory deposition system with cathodic e-coat material

The container of the deposition system shall be filled with the electro-deposition coating material and the tank circulation (stirrer or pump) initiated. Subsequently, the test panels shall be immersed in the container. The deposition conditions shall be adjusted according to the specification and the deposition process initiated. Upon completion of the deposition process, the test panels shall be removed from the container and thoroughly rinsed using demineralized water specified in ISO 23321, so that any excess of the electro-deposition coating material (cream coat) is removed.

5.2 Voltmeter (for method A) or **amperemeter** (for method B).

5.3 Thermometer, with a reading accuracy of 0,1 °C.

5.4 Timer, with a reading accuracy of 1 s.

6 Test panels

Use electrically conductive test panels with pre-treatment as specified in ISO 1514 with dimensions of approx. 190 mm × 105 mm × 0,75 mm.

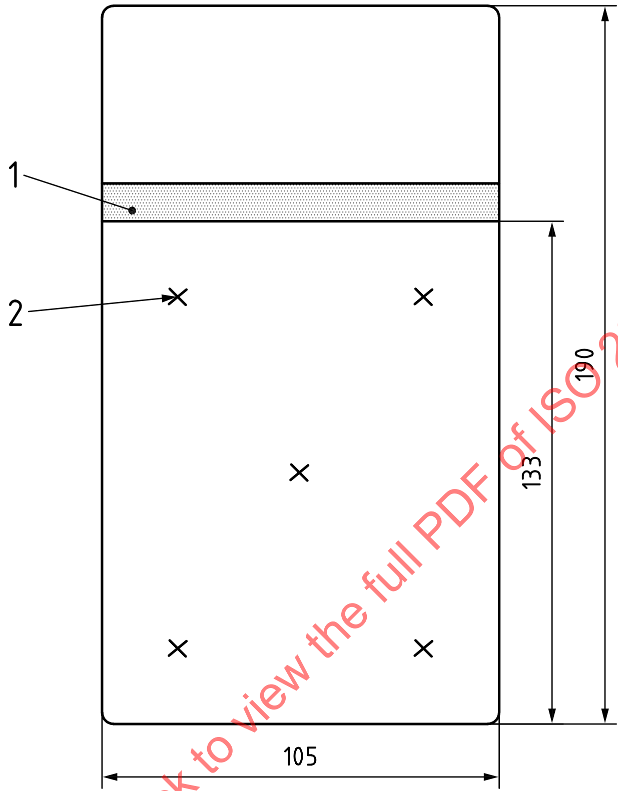
7 Number of determinations

Carry out each determination in duplicate.

8 Sample preparation

Mask the test panels using a temperature-resistant tape in such a way that an area to be coated (sum of the front and back sides of the test panel) of approx. 280 cm^2 results (see Figure 2). Measure the exact area and state it in the test report.

Approximate dimensions in millimetres



Key

1 tape

2 measuring point for film thickness

Figure 2 — Masked test panel

9 Procedure

Fill the tank with the electro-deposition coating material up to about 1 cm below the edge and homogenise the coating material, e.g. using a stirring machine with paddle stirrer (diameter min. 50 mm) at 500 min^{-1}, so that sufficient tank circulation is visually detectable.

Put the test panel in the laboratory deposition system and connect the anode and cathode to the current source. Maintain stirring the electro-deposition coating material with a stirring machine or a magnet stirrer.

Set the tank temperature to the temperature as specifically required for the product, to ±0,5 °C.

NOTE Usually the temperature is in the range of 25 °C to 35 °C.

Method A: Set the current to the required value. Maintain the current for a time which is to be agreed between the interested parties. Measure the resulting voltage at time intervals, e.g. every second, over the entire deposition period.

Method B: Set the voltage to the specified value. Maintain the voltage for a time which is to be agreed between the interested parties. Measure the resulting current at time intervals, e.g. every second, over the entire deposition time.

10 Evaluation

10.1 Dynamic electrical wet-film resistance

Compare the curve measured over the deposition time with the specified or agreed curve. The curves depend on the substrate, the pre-treatment and the electro-deposition coating material.

NOTE The measured dry-film thickness can be included with the curve profile as additional information.

10.2 Static electrical wet-film resistance

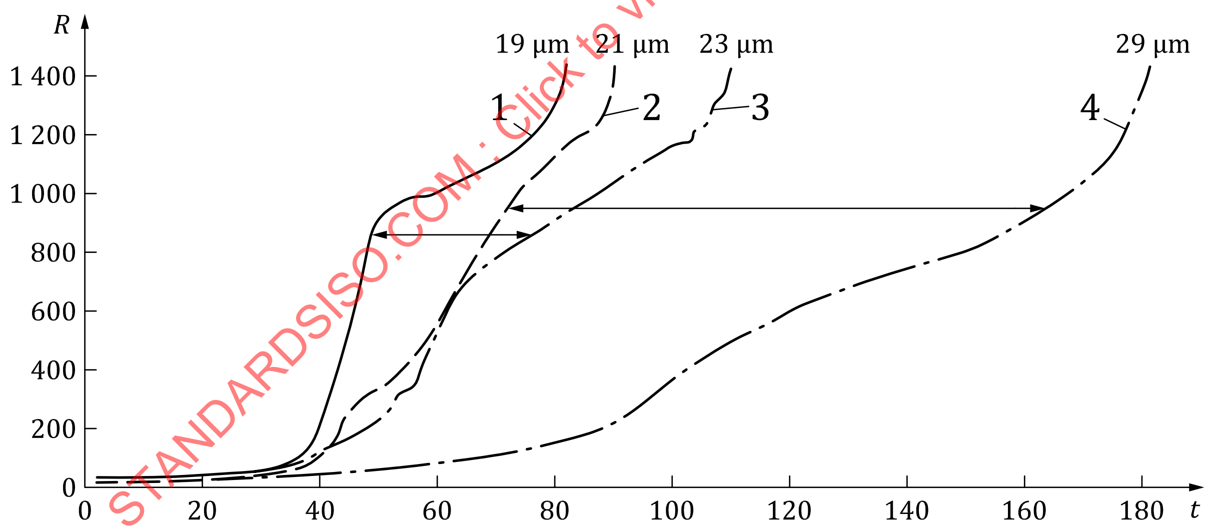
Determine the static electrical wet-film resistance at below critical deposition conditions, e.g. current density or voltage, at the end of a defined deposition time.

NOTE The measured dry-film thickness can be included with the final value as additional information.

10.3 Electrical wet-film resistivity

The electrical wet-film resistivity can be calculated from the static electrical wet-film resistance, the coated area and the dry-film thickness. See Annex A for details. Annex B provides a sample calculation of the electrical wet-film resistivity.

Figure 3 shows sample curves for the change in the electrical resistance of two cathodic electro-deposition coatings on various substrates over time.



Key

t time

R electrical resistance

1 cathodic e-coat 1 substrate 1

2 cathodic e-coat 2 substrate 1

3 cathodic e-coat 1 substrate 2

4 cathodic e-coat 2 substrate 2

Figure 3 — Sample curves for the change in the electrical resistance of cathodic electro-deposition coatings on various substrates over time

A constant bath temperature and a constant current density ($mA \cdot cm^{-2}$) are specified for the deposition. A voltage results and deposition is stopped at a maximum voltage of 340 V.

The electrical resistance profiles are compared for cathodic e-coat 1 substrate 1 and cathodic e-coat 1 substrate 2 (curves 1 and 3) and for cathodic e-coat 2 substrate 1 and cathodic e-coat 2 substrate 2 (curves 2 and 4). A good cathodic e-coat is characterized by relatively parallel profiles and a resistance profile that is almost identical. This is the case for cathodic e-coat 1, for example. This cathodic e-coat is able to provide insulation on two different substrates in almost similar form. This results in similar film thicknesses (this is why the resulting film thickness is included at the top of the curves).

However, cathodic e-coat 2 (substrate 1 and substrate 2) is characterized by very poor deposition characteristics, as cathodic e-coat 2 provides very poor insulation on substrate 2 (different electrical conductivity).

NOTE This is problematic with multi-metal vehicle bodies, for example.

11 Precision

No precision data is currently available.

12 Test report

The test report shall contain at least the following information:

a) all details necessary for the identification of the tested coating material (e.g. manufacturer, product labelling, batch number);

b) a reference to this document (i.e. ISO 22553-7:2020);

c) the deposition voltage or the current (depending on the method);

d) the bath temperature;

e) the deposition time: adjustment time and holding time, in seconds;

f) the stoving temperature and time;

g) where applicable, the dry-film thickness, including measuring method;

h) the results of the test in accordance with Clause 10;

i) every agreed or other deviation from the specified test method;

j) every unusual observation (anomaly) during the test;

k) the date of the test.

Annex A
(informative)

Theoretical derivation of the wet-film resistivity

The electrical wet-film resistivity can be calculated for a defined coating time, t, for example, at the end of the deposition time, t_{end}.

The total electrical resistance, $R_{w,sum}$, in ohms is given in Formula (A.1):

$$R_{w,sum} = R_{w,bath} + R_w \tag{A.1}$$

where

$R_{w,bath}$ is the electrical bath resistance, in ohms;

R_w is the electrical wet-film resistance, in ohms.

As the total electrical resistance and the electrical bath resistance can be determined by measurement before coating, the electrical wet-film resistance, in ohms, can be calculated from Formula (A.2):

$$R_w = R_{w,sum} - R_{w,bath} \tag{A.2}$$

In accordance with Ohm's law, it holds that, see Formula (A.3):

$$R_{w,sum} = \frac{U_t}{I_t} \tag{A.3}$$

As a result, Formula (4) holds for the electrical wet-film resistance after inserting Formula (A.3) into Formula (A.2):

$$R_w = \frac{U_t}{I_t} - R_{w,bath} \tag{A.4}$$

where

U_t is the electrical bath voltage read off at time t, in volts;

I_t is the electrical bath current read off at time t, in amperes.

The electrical bath resistance ($R_{w,bath}$) can either be measured between the anode and cathode directly before coating or else the bath conductivity ($\gamma_{w,bath}$) is measured at a defined bath temperature and the electrical bath resistance, in ohms, is calculated from Formula (A.5):

$$R_{w,bath} = \frac{1}{\gamma_{w,bath}} \cdot \frac{l_d}{A} \tag{A.5}$$