
**Paints and varnishes — Electro-
deposition coatings —**

**Part 8:
Electric charge density**

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Contents

	Page
Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Principle	2
5 Apparatus and materials	2
6 Test panels	3
7 Number of determinations	3
8 Sample preparation	3
9 Procedure	4
10 Evaluation	5
10.1 Electric charge density per unit mass	5
10.2 Electric charge density per unit volume	5
11 Precision	6
12 Test report	6
Annex A (informative) Calculation of the electric charge density per unit mass using the practical or theoretical dry-film thickness in accordance with ISO 3233-2 or ISO 3233-3	8
Bibliography	10

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 electric charge density provides information about the efficiency of the deposition process during electro-deposition coating.

If measurement of the electrical wet-film resistance in accordance with ISO 22553-7 is necessary, this can be specified in the test assembly provided.

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Paints and varnishes — Electro-deposition coatings —

Part 8: Electric charge density

1 Scope

This document specifies a method for determining the electric charge density 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 2808, *Paints and varnishes — Determination of film thickness*

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 electric charge density

volume electric charge

ρ_A

quotient of electrical charge Q and volume V :

$$\rho_A = \frac{Q}{V}$$

Note 1 to entry: The electric charge density is expressed in coulombs per cubic metre ($\text{C}\cdot\text{m}^{-3}$).

Note 2 to entry: $1 \text{ C}\cdot\text{m}^{-3} = 1 \text{ A}\cdot\text{s}\cdot\text{m}^{-3}$.

3.2
practical dry-film density

practically determined density of a dried and cured coating

[SOURCE: ISO 3233-3:2015, 3.4, modified: a hyphen was added to the term, between "dry" and "film".]

3.3
theoretical dry-film density

coating density calculated from the densities of the solvents, coating materials and the non-volatile-matter content of the coating material

[SOURCE: ISO 3233-3:2015, 3.6, modified: a hyphen was added to the term, between "dry" and "film".]

4 **Principle**

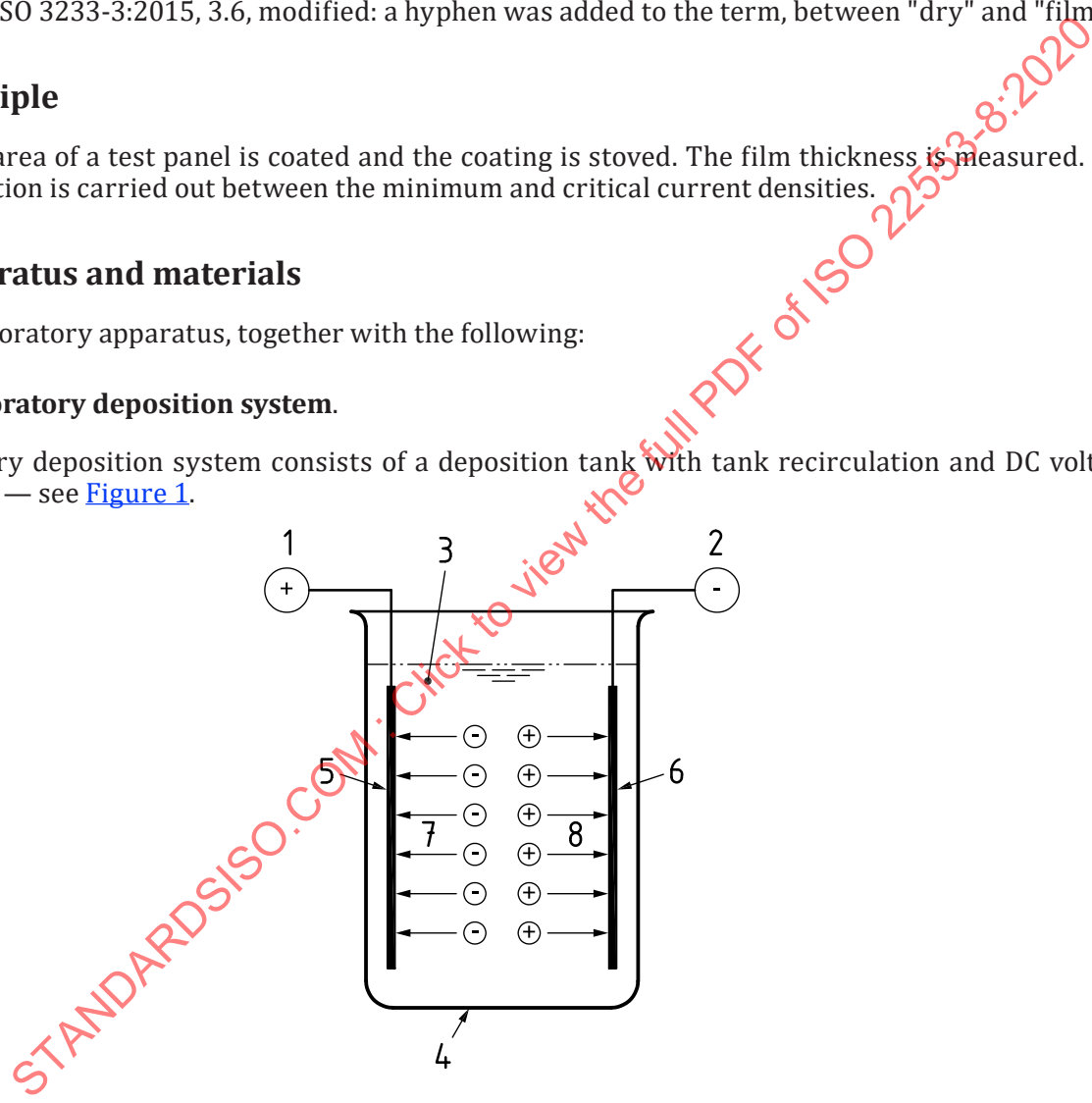
A defined area of a test panel is coated and the coating is stoved. The film thickness is measured. The determination is carried out between the minimum and critical current densities.

5 **Apparatus and materials**

Typical laboratory apparatus, together with the following:

5.1 **Laboratory deposition system.**

A laboratory deposition system consists of a deposition tank with tank recirculation and DC voltage equipment — see [Figure 1](#).



Key

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

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

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 is 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 Amperemeter.

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

5.4 Film thickness measuring device, with a measurement error of 0,1 µm.

5.5 Analytical balance, with a weighing accuracy of 0,000 1 g.

5.6 Oven, in which the test can be carried out reliably and in which the specified or agreed test temperature can be held to within ± 2 °C (for temperatures up to 150 °C) or $\pm 3,5$ °C (for temperatures between 150 °C and 200 °C).

6 Test panels

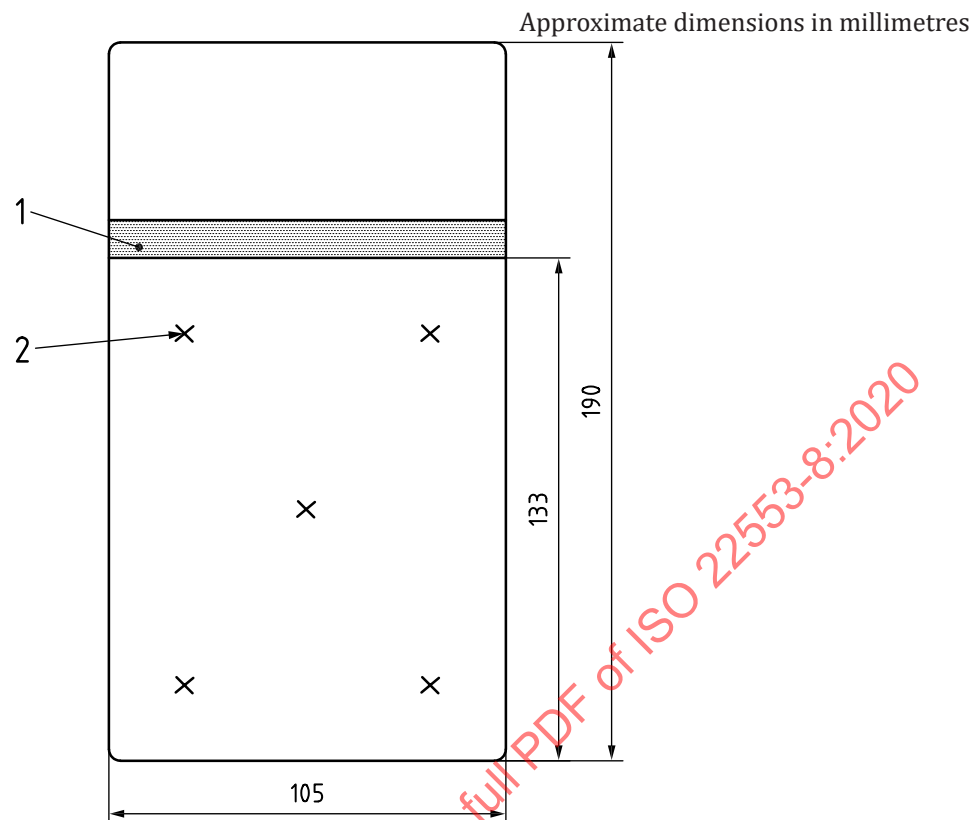
Use electrically conductive test panels with pre-treatment as specified in ISO 1514 with dimensions of approx. 190 mm × 105 mm × 0,75 mm.

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 cm² results (see [Figure 2](#)). Measure the exact area and state it in the test report.



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 homogenize 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.

Weigh each of the two test panels on an analytical balance (5.5) to within 1 mg (m_0).

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 bath temperature to the temperature as specifically required for the product, to $\pm 0,5 \text{ }^\circ\text{C}$.

NOTE 1 Usually the temperature is in the range of $25 \text{ }^\circ\text{C}$ to $35 \text{ }^\circ\text{C}$.

Select the deposition voltage and deposition time so that the film thickness of the electro-deposition coating on the test panel corresponds to the nominal dry-film thickness of the electro-deposition coating.

Increase the voltage to the selected coating voltage (if necessary, without series resistor). Maintain that voltage over the selected time.

Remove the test panel after coating and rinse with demineralized water.

Stove/cure the coated test panels in the oven as specifically required for the product.

The stoving temperature shall be the object temperature, not the displayed oven temperature.

NOTE 2 The stoving temperature is usually between 100 °C and 180 °C.

After the sample has cooled down, measure the dry-film thickness at five locations (see [Figure 2](#)) on both sides of the test panel in accordance with one of the methods described in ISO 2808 and calculate the mean value.

Then, weigh the test panels on an analytical balance ([5.5](#)) to within 1 mg (m_1).

10 Evaluation

10.1 Electric charge density per unit mass

The electric charge density per unit mass is the electric charge density that is required to create 1 g dry mass of electro-deposition coating material.

First calculate the mass of electro-deposition coating on the stoved test panel, m_t , in grams, from the weighings using [Formula \(1\)](#):

$$m_t = m_1 - m_0 \quad (1)$$

where

m_0 is the mass, in grams, of the uncoated test panel;

m_1 is the mass, in grams, of the coated, stoved test panel.

Repeat this procedure with the other test panel.

Calculate the mean value of the values for the two test panels.

Calculate the electric charge density, $\rho_{A,m}$, in coulombs per gram, using [Formula \(2\)](#):

$$\rho_{A,m} = \frac{Q}{m_t} \quad (2)$$

where

Q is the electrical charge, in coulombs;

m_t is the mass, in grams, of electro-deposition coating on the stoved test panel.

10.2 Electric charge density per unit volume

The electric charge density per unit volume is the electric charge density that is required to create 1 cm³ dry volume of electro-deposition coating material.

Calculate the electric charge density, ρ_A , (see 3.1) using Formula (3):

$$\rho_A = \frac{Q}{V} \quad (3)$$

The volume is the product of the total area of the coated test panel (front and back sides) and of the dry-film thickness using Formula (4):

$$V = A \cdot t_d \quad (4)$$

This results in the following for the electric charge density per unit volume, $\rho_{A,V}$, in coulombs per cubic centimetre, using Formula (5):

$$\rho_{A,V} = \frac{Q \cdot 10^{-4}}{A \cdot t_d} \quad (5)$$

where

Q is the electric charge, in coulombs;

V is the volume, in cubic metres;

A is the total area of the coated test panel (front and back sides), in square centimetres;

t_d is the dry-film thickness of the e-coat, in micrometres.

The electric charge density can also be calculated using the practical film thickness in accordance with ISO 3233-2 or the theoretical film thickness in accordance with ISO 3233-3. The calculation is given in Annex A.

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 (manufacturer, product labelling, batch number etc.);
- b) a reference to this document (i.e. ISO 22553-8:2020);
- c) the tank voltage;
- d) the tank temperature;
- e) the current;
- f) the charge;
- g) the application time: adjustment time and holding time, in seconds;
- h) the application period;
- i) the stoving temperature and time;
- j) the dry-film thickness, including measuring method, and, where applicable, the dry-film density;
- k) the coated area;

- l) the results of testing in accordance with [Clause 10](#);
- m) every agreed or other deviation from the specified test method;
- n) every unusual observation (anomaly) during the test;
- o) the date of the test.

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Annex A (informative)

Calculation of the electric charge density per unit mass using the practical or theoretical dry-film thickness in accordance with ISO 3233-2 or ISO 3233-3

Calculate the practical dry-film thickness, ρ_p , in grams per cubic centimetre, using [Formula \(A.1\)](#) with the measured values and the density of the coating medium:

$$\rho_p = \frac{m_3 - m_1}{m_2 + m_3 - m_1 - m_4} \cdot \rho_1 \quad (\text{A.1})$$

where

m_1 is the mass of the uncoated panel, weighed in air, in grams;

m_2 is the mass of the uncoated panel, weighed in coating medium, in grams;

m_3 is the mass of the coated panel, weighed in air, in grams;

m_4 is the mass of the coated panel, weighed in coating medium, in grams;

ρ_1 is the density of the coating medium, in grams per cubic centimetre.

Calculate the dry-film thickness, ρ_t , in grams per cubic centimetre, using [Formula \(A.2\)](#) and the determined content of non-volatile components (mass fraction in percent), the density of the coating material and the density of the solvent or of that solvent with the largest fraction in the coating material:

$$\rho_t = \frac{\rho_1 \cdot NV}{100 - \frac{\rho_1}{\rho_2} \cdot (100 - NV)} \quad (\text{A.2})$$

where

ρ_1 is the density of the coating material, in grams per cubic centimetre;

ρ_2 is the density of the solvents or of that solvent with the largest fraction, in grams per cubic centimetre;

NV is the content of non-volatile components in the coating material, expressed as a mass fraction in percent.

In the case of water-thinnable coating materials, the density of the solvents, ρ_2 , shall be the density of the solvent mixture including water or the density recommended in [Table A.1](#).

Table A.1 — Recommended density values of solvents in water-thinnable coating materials

Solvent mixture	Recommended values for ρ_2 if the density of solvents is not known g·cm ⁻³
predominantly aliphatic hydrocarbons	0,80
^a VOC: volatile organic compound.	