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Paints and varnishes — Determination of water-vapour transmission properties — Cup method

Peintures et vernis — Détermination des propriétés de transmission de la vapeur d'eau — Méthode de la coupelle

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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 7783 was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

This first edition of ISO 7783 cancels and replaces ISO 7783-1:1996 and ISO 7783-2:1999, which have been merged and technically revised. It also incorporates the Technical Corrigendum ISO 7783-1:1996/Cor.1:1998.

Introduction

ISO 7783 is one of a series of standards dealing with the sampling and testing of paints, varnishes and related products. It describes a method for determining the water-vapour transmission rate of self-supporting and non-self-supporting coatings.

The water-vapour transmission rate is not necessarily a linear function of film thickness, temperature or relative-humidity difference. A determination carried out under one set of conditions will not necessarily be comparable with one carried out under other conditions. Therefore, it is essential that the conditions of test are chosen to be as close as possible to the conditions of use.

Water-vapour transmission is of greatest interest under conditions of high humidity. For this reason, the wet-cup method has been adopted as the reference method. By agreement, other procedures and conditions, like the dry-cup method, may be used.

Paints and varnishes — Determination of water-vapour transmission properties — Cup method

1 Scope

This International Standard specifies a method for determining the water-vapour transmission properties of coatings of paints, varnishes and related products.

It supplements ISO 12572. As far as possible, the procedure, the definitions and the calculations have been taken over from ISO 12572. It is recommended that ISO 12572 be consulted, if necessary, to obtain a better understanding of the procedure specified in this International Standard.

Water-vapour transmission rates of more than 680 g/(m^2·d) (i.e. water-vapour diffusion-equivalent air layer thicknesses, s_d, of less than 0,03 m) will not be accurately quantified by the test method described in this International Standard.

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 2808, *Paints and varnishes — Determination of film thickness*

ISO 3233, *Paints and varnishes — Determination of percentage volume of non-volatile matter by measuring the density of a dried coating*

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
water-vapour transmission rate
V
mass of water vapour that is transmitted over a given period through a given surface area of a test piece under specified constant conditions of relative humidity at each face of the test piece

NOTE 1 It is measured in grams per square metre per day [g/(m^2·d)].

NOTE 2 A water-vapour transmission rate measured at atmospheric pressure, p, can be converted to the equivalent value at standard atmospheric pressure, p_0, by multiplying by p/p_0. This allows a linear correlation with the water-vapour diffusion-equivalent air layer thickness (s_d) value (see 3.3) by the factor 20,4.

NOTE 3 The term “water-vapour transmission” is often incorrectly used for water-vapour transmission rate.

3.2
rate of flow of water vapour through the test piece
G
mass of water vapour that is transmitted over a given period through a test piece under specified constant conditions of relative humidity at each face of the test piece

NOTE It is measured in grams per hour.

3.3
water-vapour diffusion-equivalent air layer thickness
$s_\mathbf{d}$
thickness of a static air layer that has, under the same conditions of measurement, the same water-vapour transmission rate as the coating tested

NOTE It is measured in metres.

3.4
water-vapour resistance factor
μ
factor that indicates how many times greater the water-vapour resistance of a material is compared with a layer of static air of the same thickness at the same temperature and pressure

NOTE 1 It is dimensionless.

NOTE 2 The calculation and use of a water-vapour resistance factor is meaningful only if the water-vapour transmission rate of a particular material is a constant, i.e. independent of the thickness, which, however, is normally not the case for coatings.

3.5
test piece
⟨non-self-supporting coatings⟩ supporting substrate with the coating applied to it or ⟨self-supporting coatings⟩ the coating alone

3.6
wet-cup method
method of measuring water-vapour permeability in which the test piece is sealed to the rim of a cup containing a saturated aqueous solution of ammonium dihydrogen phosphate

NOTE This is the most convenient manner of carrying out determinations of water-vapour permeability under conditions of high relative humidity (between 93 % and 50 %).

3.7
dry-cup method
method of measuring water-vapour permeability in which the test piece is sealed to the rim of a cup containing a desiccant

NOTE This is the most convenient manner of carrying out determinations of water-vapour permeability under conditions of low relative humidity (between 50 % and 3 %).

3.8
test assembly
assembly consisting of a test piece sealed to the rim of a test cup containing saturated ammonium dihydrogen phosphate solution in contact with undissolved ammonium dihydrogen phosphate crystals (wet-cup method) or containing desiccant (dry-cup method)

3.9
test area
area of the face of the test piece through which the water vapour flows during the test

NOTE It is measured in square metres.

4 Principle

A test assembly consisting of a self-supporting coating, or a non-self-supporting coating on porous substrate, sealed to the rim of a cup is placed in a test enclosure kept at a specified temperature (e.g. 23 °C) and relative humidity (e.g. 50 %). The relative humidity in the cup is maintained at a constant level — either at 93 % by means of a saturated salt solution (wet-cup method) or at 3 % by means of a desiccant (dry-cup method). Because of the difference between the partial pressure of the water vapour inside the test cup and the partial pressure of the water vapour in the test enclosure, water vapour diffuses through the coating under test. By weighing the test assembly at suitable time intervals, the change in mass of the test assembly is followed. From the change in mass and the test area, the water-vapour transmission rate and the water-vapour diffusion-equivalent air layer thickness are calculated.

5 Apparatus and materials

5.1 Substrate for non-self-supporting coatings

Any homogenous, porous material which has a water-vapour transmission rate above 240 g/(m^2·d) is suitable for use as the substrate for non-self-supporting coatings, for instance polyethylene frits, cellular-concrete discs, glass frits, unglazed ceramic tiles.

When using cellular-concrete substrates, the coating shall be applied on the smooth side.

If the coating system under test does not include a primer and it is necessary to use one before applying the coating system under test, do so, but the transmission rate of the primed substrate will have to be determined separately.

5.2 Test cup

Test cups are made of glass, plastic or metal. The test cup used shall be resistant to corrosion under the conditions of the test.

NOTE For aluminium test cups, a wall thickness of 1 mm has been found to be satisfactory.

The exact surface area of the test piece exposed is defined by the design of the cup. The area of the exposed surface shall be at least 50 cm^2 for non-self-supporting coatings and at least 10 cm^2 for self-supporting coatings.

The cup shall be so designed that an efficient seal is made between it and the test piece, using sealing material (see 5.5), if necessary.

When the saturated solution (5.3) or desiccant (5.4) has been placed in the cup, the area of the surface of the saturated solution or desiccant shall be similar to that of the exposed surface of the test piece. The air gap between the test piece and the surface of the solution or desiccant shall be between 10 mm and 30 mm.

5.3 Ammonium dihydrogen phosphate ($NH_4H_2PO_4$) solution for wet-cup method

Prepare a saturated solution of ammonium dihydrogen phosphate (analytical grade) in contact with undissolved crystals, using water of at least grade 3 purity as defined in ISO 3696.

In the wet-cup method, which is the reference method, the relative humidity in a cup containing this saturated solution will be 93 %. The resulting water vapour pressure difference relative to the test enclosure, in which the relative humidity is maintained at 50 %, is 1 207 Pa at standard temperature (23 °C) and pressure (101 325 Pa).

5.4 Desiccant for dry-cup method

The desiccant shall be either dried silica gel in the form of granules passing a 4 mm sieve but retained on a 1,6 mm sieve, or anhydrous calcium chloride which has been dried at 200 °C.

It shall be possible to complete the test before the efficiency of the desiccant is reduced appreciably.

In the dry-cup method, the relative humidity in the cup shall be 3 %. The resulting water-vapour pressure difference relative to the test enclosure, in which the relative humidity is maintained at 50 %, is 1 400 Pa at standard temperature (23 °C) and pressure (101 325 Pa).

5.5 Sealing material

It shall be ensured that the test assembly is fully sealed, with the exception of the test area. The sealing material shall be impermeable and free from cracks. For sealing, mechanical clamps, wax or two-component sealing materials have been found suitable. The use of molten wax for sealing the test assembly is described in Annex B.

The sealing material shall not contain solvents or other volatile constituents which could cause any change in the coating or lead to weighing errors caused by the evaporation of solvent.

NOTE The most usual way of sealing the cup is to fit the cup with a mechanical clamp or screw device which can incorporate a sealing ring made of a suitable polymeric material. Mechanical sealing might not be suitable if the test piece has a rough surface or if it is very fragile. In such cases, the use of molten wax is more satisfactory.

5.6 Test enclosure

The test enclosure shall be of a design such that both the temperature and the relative humidity in the enclosure can be controlled at the levels required for the test. Thus, for the reference method, the enclosure shall be capable of maintaining the temperature at (23 ± 2) °C and the relative humidity at (50 ± 5) % (standard conditions as defined in ISO 3270). To ensure uniform conditions during the test, the air shall be caused to flow over the outer surface of the test piece at a speed between 0,02 m/s and 0,3 m/s. The ambient air pressure shall be corrected to standard pressure (1 013,25 hPa) as described in 8.1.

NOTE Maintaining the air speed at the correct level is the second most important source of error after preparation of the test pieces.

When cups have to be removed from the test enclosure for weighing, the specified conditions shall be re-established not more than 15 min after the door of the enclosure has been closed. The door shall remain open for the shortest possible time. This is especially important with materials having a high permeability.

5.7 Balance

The balance used shall be suitable for determining the change in mass of the test assembly with an accuracy of 1 mg or better for cups giving a test area of 50 cm^2 or less, or 10 mg for cups giving a test area greater than 50 cm^2.

The most suitable arrangement is to have the balance located in the test enclosure. If this is not possible, care shall be taken that no loss in mass occurs during the transport of the test assembly to the balance.

6 Preparation for the test

6.1 Sampling of coating material

Take a representative sample of the product to be tested (or of each product in the case of a multi-coat system), as described in ISO 15528.

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

6.2 Preparation of test pieces

6.2.1 Preparation of non-self-supporting coatings on a porous substrate

The substrate shall be clean and dry.

Apply the coating material to be tested to the substrate in accordance with the manufacturer's application instructions. Do not apply less than the amount indicated by the manufacturer and not more than 50 % more, e.g. by applying a larger number of coats or by applying the first coat as a primer coat after dilution. It is essential that the coating be complete, continuous, homogeneous and free from visible imperfections. If the amount necessary to produce such a coating is more than 50 % greater than the amount indicated by the manufacturer, use another substrate or another test method.

Dry the test pieces for 7 days in freely circulating air at (23 ± 2) °C and (50 ± 5) % relative humidity.

6.2.2 Preparation of self-supporting coatings

Use a substrate from which the coating can be easily detached when dry/hard. The most suitable substrates are glass plates coated with high-density polyethylene or polytetrafluoroethylene which is free from surface defects. Other techniques may be used, for example precoating a substrate with a soluble material such as poly(vinyl alcohol) which will permit the coating to be removed easily by soaking in water. This method should be used with caution, however, since water-soluble material can affect the water-vapour permeability of the coating.

Coat the substrate by the method specified by the manufacturer and dry it for 7 days in freely circulating air at (23 ± 2) °C and (50 ± 5) % relative humidity (if stoving is required, care shall be taken to ensure that the substrate chosen is not affected at the relevant temperature).

Remove the coating carefully from the substrate.

Use a cutting template (see Figure B.1) to cut out specimens of a size suitable for the cup. Examine the test pieces visually and discard any which appear to have pinholes.

6.2.3 Conditioning

Method A

For coatings which, in use, will not be exposed to rain, e.g. coatings for interior use or for arid places, condition the test pieces at (23 ± 2) °C and (50 ± 5) % relative humidity for 28 days or until the difference in mass between two consecutive weighings, carried out at 24 h intervals, is less than 1 %.

Method B

Since, in use, the volatile and/or water-soluble constituents of a coating can be removed by the influence of the weather (in particular, water-soluble constituents can be leached out by rainwater), coatings which are affected by rain shall be conditioned prior to the determination of the water-vapour transmission rate by subjecting the test pieces to 3 cycles under the following conditions:

— 24 h in water (tap water) at (23 ± 2) °C;

— 24 h drying at (50 ± 2) °C.

During the weekend or any interruption of the conditioning for other reasons, store the test pieces at (23 ± 2) °C and (50 ± 5) % relative humidity.

After the last cycle, continue to dry the test pieces at (50 ± 2) °C for at least another 24 h. Then condition the test pieces at (23 ± 2) °C and (50 ± 5) % relative humidity for at least 24 h before carrying out the test.

6.3 Determination of the thickness of the coating

6.3.1 General

The thickness, d, of the coating is required for the calculation of the water-vapour resistance factor, μ. It may be determined by calculation or by optical, mechanical or other suitable methods.

NOTE Optical determination of the thickness of the coating can also be used to check the test piece for pores, holes, etc., and to determine the depth of penetration of the coating material into the substrate.