BS EN 1062-6:2002

Paints and varnishes — Coating materials and coating systems for exterior masonry and concrete —

Part 6: Determination of carbon dioxide permeability

The European Standard EN 1062-6:2002 has the status of a British Standard

ICS 87.040

National foreword

This British Standard is the official English language version of EN 1062-6:2002.

The UK participation in its preparation was entrusted by Technical Committee STI/28, Paint systems for non-metallic substrates, to Subcommittee STI/28/1, Masonry and emulsion paints, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

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Paints and varnishes - Coating materials and coating systems for exterior masonry and concrete - Part 6: Determination of carbon dioxide permeability

Peintures et vernis - Produits de peinture et systèmes de revêtement pour maçonnerie et béton extérieur - Partie 6: Détermination de la perméabilité au dioxyde de carbone

Beschichtungsstoffe - Beschichtungsstoffe und Beschichtungssysteme für mineralische Untergründe und Beton im Außenbereich - Teil 6: Bestimmung der Kohlenstoffdioxid-Diffusionsstromdichte (Permeabilität)

This European Standard was approved by CEN on 26 March 2002.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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Foreword

This document EN 1062-6:2002 has been prepared by Technical Committee CEN/TC 139 "Paints and varnishes", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2003, and conflicting national standards shall be withdrawn at the latest by January 2003.

This European Standard was prepared jointly by CEN/TC 139, Paints and varnishes (Secretariat: DIN Deutsches Institut für Normung e. V.) and CEN/TC 104/SC 8, Protection and repairs of concrete structures (Secretariat: DIN Deutsches Institut für Normung e. V.), after considerable preparatory work by CEN/TC 139/WG 1 "Coating systems for masonry" (Convenor: R. Michel, France) which had formed a Joint Group with CEN/TC 104/SC 8/WG 1 "Surface protection" (Convenor: Dr. R. Stenner, Germany).

EN 1062 consists of the following parts under the general title *Paints and varnishes – Coating materials and coating systems for exterior masonry and concrete:*

Part 1: Classification
Part 2: Determination and classification of water-vapour transmission rate (permeability)[1)]
Part 3: Determination and classification of liquid-water transmission rate (permeability)
Part 6: Determination of carbon dioxide permeability
Part 7: Determination of crack-bridging properties – Test methods and classification
Part 11: Methods of conditioning before testing

The annex A, B and C of this European Standard are normative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This is one of a number of Parts of EN 1062 dealing with test methods for coating materials and coating systems for exterior masonry and concrete. It should be read in conjunction with EN 1062-1.

1 Scope

This European Standard specifies two methods for determining the carbon dioxide permeability of coatings, coating systems and related products, intended for exterior masonry and concrete.

The methods are applicable to coatings and coating systems on porous substrates such as plaster, concrete etc.

2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 1062-1:1996, *Paints and varnishes – Coating materials and coating systems for exterior masonry - Part 1: Classification*.

EN 1062-11, *Paints and varnishes – Coating materials and coating systems for exterior masonry and concrete – Part 11: Methods of conditioning before testing*.

EN ISO 15528, *Paints and varnishes and raw materials for paints and varnishes – Sampling (ISO 15528:2000).*

EN 23270:1991, *Paints and varnishes and their raw materials – Temperatures and humidities for conditioning and testing (ISO 3270:1984)*.

EN ISO 1513, *Paints and varnishes – Examination and preparation of samples for testing (ISO 1513:1992)*.

EN ISO 2808:1999, *Paints and varnishes – Determination of film thickness (ISO 2808:1997)*.

[1)] Published as EN ISO 7783-2.

EN ISO 7783-1:1999, *Paints and varnishes – Determination of water-vapour transmission rate – Part 1: Dish method for free films (ISO 7783-1:1996, including Technical Corrigendum 1:1998).*

3 Terms and definitions

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

3.1
carbon dioxide permeability i
amount of carbon dioxide in grams (g) that will diffuse in one day (d) through one square metre of the coating under the action of a defined partial pressure or difference in concentration. It is expressed in $g/(m^2 \cdot d)$

3.2
diffusion-equivalent air layer thickness s_D
thickness of a static air layer that possesses, under the same conditions, the same carbon dioxide permeability as the coating. It is expressed in m

3.3
diffusion resistance number μ
number indicating how many times more a coating is impermeable to carbon dioxide than a static air layer of the same thickness under the same conditions

4 Principle

4.1 Method A: Gravimetric method

The coated side of a test piece is exposed to the measuring gas, and the diffused carbon dioxide is determined quantitatively. The test piece seals a test cell containing an absorbant for carbon dioxide so that the cell is gas-tight to the surroundings. The test cell is kept in a dry carbon dioxide/air atmosphere at (23 ± 2) °C and weighed at regular intervals. The carbon dioxide permeability is calculated from the increase of mass. The determination is completed when a steady state is reached, i.e. when the increase of mass no longer changes with time.

For control purposes, a reference film (standard) of known carbon dioxide permeability is measured in each series of determinations.

4.2 Method B: Carrier gas method

A coated test piece is clamped between two halves of a permeation cell and the two halves are made gas-tight to each other and to the surroundings. Through one half of the permeation cell the measuring gas passes, whilst through the other half a carrier gas stream (preferably nitrogen or air, free from carbon dioxide) passes. This carrier gas stream transports the diffused carbon dioxide to a detection system, based on infrared spectrometry or gas chromatography. The determination is carried out at (23 ± 2) °C and is completed when a steady state is reached, i.e. when the carbon dioxide permeability no longer changes with time.

Both gases (measuring gas and carrier gas) can be humidified as required.

For control purposes, a reference film (standard) of known carbon dioxide permeability is measured in each series of determinations.

Both methods are carried out isostatically, i.e. the test piece is not subjected to a difference in absolute pressure but to a difference in partial pressure.

NOTE When using method A, only a dry carbon dioxide/air mixture can be used because the absorbent would react with humidity from the measuring gas. Therefore, if the carbon dioxide permeability is to be known at a different humidity level, for example at 50 % relative humidity, only method B is suitable.

5 Apparatus and materials

5.1 For methods A and B

5.1.1 Carbon dioxide gas analyzer, for measuring the carbon dioxide concentration of the measuring and carrier gases in the range 0 % to 20 % (*V/V*) carbon dioxide.

5.1.2 Device for measuring film thickness, suitable for measurements to a limit deviation of at least 3 % of the thickness of the substrate.

5.1.3 Barometer, for measuring the atmospheric pressure to a limit deviation of ± 400 Pa.

5.1.4 Measuring gas, containing (10 ± 0,5) % (*V/V*) carbon dioxide, prepared by mixing 1 part by volume of carbon dioxide and 9 parts by volume of dry air.

5.1.5 Reference film (standard), of thickness (50 ± 5) µm, for use as a calibration film for the measurement device.

NOTE For the diffusion resistance number of the reference film which is commercially available by Polymer-Institut, Quellenstraße 3, D-65439 Flörsheim-Wicker, a value of $\mu = 1{,}75 \cdot 10^6$ has been found, as a result of a comparative testing programme.

5.1.6 Sealing material. A wax material complying with the requirements of EN ISO 7783-1:1999, D.1.3 (see annex A) or two-component adhesives have been found suitable.

5.1.7 Substrate. For coatings not requiring a reaction with the substrate, any substrate is suitable which has a water-vapour transmission rate of not more than 240 g/($m^2 \cdot d$), for instance glass frites, unglazed ceramic tiles. The area shall be at least 60 cm^2 for one side.

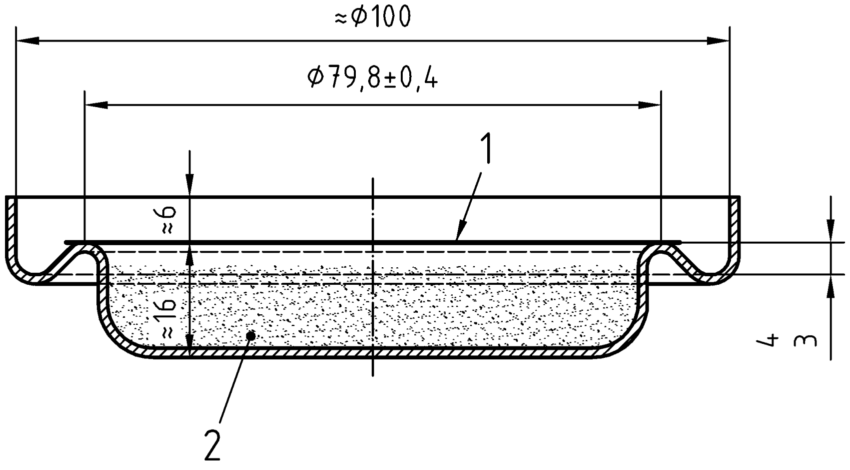
5.2 For method A only

5.2.1 Test chamber, consisting of a gas-tight vessel, equipped with a suitable device for circulating the measuring gas. A desiccator of volume about 20 l or a gas-tight oven is suitable.

5.2.2 Test cells

Dishes complying with the requirements of EN ISO 7783-1:1999, 7.1, are suitable. The dishes shall be resistant under the test conditions. A suitable test cell is shown in Figure 1.

Dimensions in millimetres



Key
1 Test piece
2 Absorbent

Figure 1 – Example of test cell

5.2.3 Balance, capable of weighing up to 400 g to 1 mg.

5.2.4 Absorbents

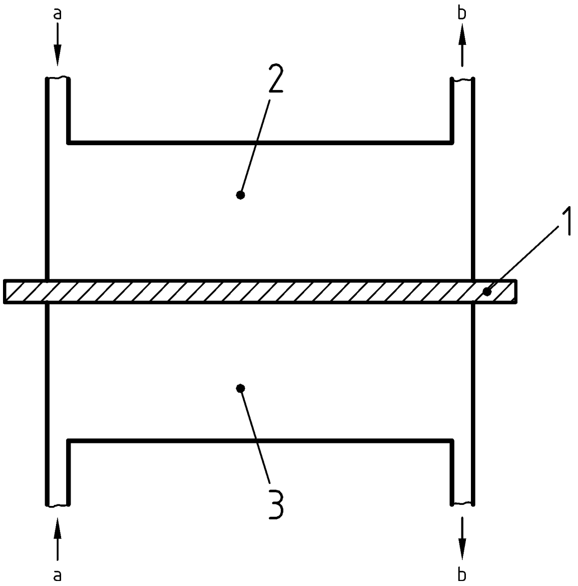
a) Desiccant: Phophorus pentoxide with moisture indicator or a molecular sieve with indicator are suitable.

b) Carbon dioxide absorbent: Sodium hydroxide on a support, granulated for elemental analysis, is suitable.

5.3 For method B only

5.3.1 Metal templates, for holding the test pieces, fitting to the permeation cell (5.3.2). Templates made of stainless steel sheet of thickness 1 mm, having a circular opening of diameter 90,5 mm, have been found suitable.

5.3.2 Permeation cell, made of impermeable material, preferably of metal or glass, and consisting of two halves (schematic diagram see Figure 2). The two halves are each provided with an inlet and an outlet for the measuring gas and the carrier gas respectively. Permeation cells with a volume of 150 cm^3 of each of the two halves are suitable.



Key

1 Test specimen on template

2 Measuring gas: 10 % (*V/V*) CO_2/90 % (*V/V*) N_2

3 Carrier gas: N_2 or air

a) Gas input

b) Gas output

Figure 2 – Schematic diagram of permeation cell

5.3.3 System for gas analysis. Any measurement method that quantitatively determines carbon dioxide in nitrogen or air is suitable. Recognized methods comprise infrared detection or gas-chromatographic methods.

5.3.4 Carrier gas. Nitrogen or air, dry and free from carbon dioxide, are suitable.

6 Sampling

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 EN ISO 15528.

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

7 Test pieces

7.1 Substrate

If not otherwise agreed, use the substrate specified in 5.1.7.

7.2 Number and dimensions

Prepare three test pieces for each determination. The diameter of the test piece shall be at least four times the thickness of the test piece. The surface area of the coating to be exposed shall be circular and shall be at least 60 cm^2.

7.3 Preparation

Coat the substrate and dry the coating in accordance with the manufacturer's instructions.

Condition the test pieces in accordance with EN 1062-11 prior to testing. The conditioning method shall be agreed between the interested parties and stated in the test report. Afterwards, either

- dry over desiccant (5.2.4) to constant mass, or
- condition at the humidity level agreed between the interested parties (method B).

7.4 Dry film thickness

a) Free films

Measure the thickness either prior to testing, using a thickness gauge with mechanical or electronic reading (e.g. surface calipers) or, after testing, using a microscope method in accordance with EN ISO 2808:1999, method 5A.

b) Coatings on substrate (see 5.1.7)

Break the test pieces after testing and measure the coating thickness at the cross section, using a microscope method in accordance with EN ISO 2808:1999, method 5A.

8 Procedure

8.1 Method A – Gravimetric method

Carry out the determination in triplicate.

Fill the test cell (5.2.2) with a sufficient quantity of the carbon dioxide absorbent (5.2.4 b)) to ensure absorption of carbon dioxide during the whole duration of the determination. Maintain a space of 10 mm between the surface of the absorbent and the level of the test piece (this makes it possible to rearrange the absorbent by shaking). Close the filled test cell with the test piece so that the coated side is facing upwards and the cell is gas-tight to the surroundings. Place the cell with the test piece in the test chamber (5.2.1), pass measuring gas (5.1.4) through the chamber and expose the coated side of the test piece, at a temperature of (23 ± 2) °C, to the measuring gas.

Weigh the test cell at time intervals of 24 h. If the mass increase between two measurements is less than 5 mg, prolong the intervals. The determination is completed when the mass increase of the test cell remains constant during two subsequent intervals.

Determine the carbon dioxide permeability of the reference film (5.1.5), using the same procedure.

8.2 Method B – Carrier gas method

Carry out the determination in triplicate.

Install the test piece between the two halves of the permeation cell (5.3.2) so that a gas-tight connection is achieved (see the note). When the template (5.3.1) is used, glue the test piece onto it, apply sealing grease (vacuum grease) to the carrier gas side of the template and press the two halves of the permeation cell together so that they are aligned.

NOTE Because of the porous nature of the substrate materials and the rough surface of the test piece, direct installation of the test piece in the permeation cell is not possible since lateral diffusion introduces errors. Using the template, good sealing between the two halves of the permeation cell will be achieved.Pass measuring gas (5.1.4) and carrier gas (5.3.4) through the appropriate halves of the permeation cell, and expose the coated side of the test piece, at a temperature of (23 ± 2) °C, to the measuring gas.

The determination is completed when a steady state is reached, i.e. when the concentration in the measuring gas no longer changes with time.

Determine the carbon dioxide permeability of the reference film (5.1.5), using the same procedure.

9 Expression of results

In both methods, the permeability is based on a partial pressure difference of 10 kPa (100 mbar). For this purpose, the difference in carbon dioxide concentration prevailing during the determination on the two sides of the test piece, expressed in % (*V/V*), has to be converted into a difference in partial pressure. This conversion takes into account the prevailing air pressure and the elevation of the laboratory carrying out the test. The equations given in 9.1 and 9.2 make allowance for this conversion.For both methods, calculate the mean of the three determinations and report the result to three significant figures.

9.1 Method A

9.1.1 Carbon dioxide permeability

Calculate the carbon dioxide permeability i, expressed in g/(m^2 · d), using equation (1a) or (1b).

where

d_m is the mass difference, in grams, of two successive weighings at constant change of mass;

$$i = \frac{d_m \times \mathrm{K}_1 \times \mathrm{K}_2 \times \mathrm{p}}{t \times A \times c \times p_{\mathrm{amb}}} \tag{1a}$$

K_1	is a factor for the conversion of hours to days; $\mathrm{K}_1 = 24$;
K_2	is a factor for the conversion of c to 10 % (*V/V*); $\mathrm{K}_2 = 10$;
t	is the duration of the determination, in hours, at constant permeation rate;
A	is the test area, in square metres;
c	is the carbon dioxide concentration, in % (*V/V*), in the measuring gas;
p_{amb}	is the ambiant atmospheric pressure, in kilopascals;
p	is a factor for the conversion of p_{amb} in kilopascals to the reference pressure 1 bar; p = 100.

Equation (1a) can be simplified, as indicated in equation (1b).

$$i = \frac{d_m \times 24 \times 10^3}{t \times A \times c \times p_{\mathrm{amb}}} \tag{1b}$$

9.1.2 Diffusion equivalent air layer thickness

Calculate the diffusion equivalent air layer thickness s_{D}, expressed in metres, using equations (2) and (3).

$$s_{\mathrm{D}} = s_{\mathrm{D\ COATING}} + s_{\mathrm{D\ SUBSTRATE}} \tag{2}$$

$$s_{\mathrm{D}} = \frac{D_{\mathrm{CO_2}} \times |\Delta c|}{i} \tag{3}$$

where

D_{CO2}	is the diffusion coefficient for carbon dioxide in air, in square metres per day ($D_{\mathrm{CO2}} = 1{,}38\ \mathrm{m^2/d}$ in air at 23 °C);
$\lvert\Delta c\rvert$	is the difference, in grams per cubic metres, in carbon dioxide concentration of the carbon dioxide-free air and the carbon dioxide-containing air ($\Delta c = 180\ \mathrm{g/m^3}$ for 10 % (V/V) at 23 °C);

NOTE For a difference in carbon dioxide concentration $|\Delta c|$ from 0 % (*V/V*) against 10 % (*V/V*) carbon dioxide, a test temperature of 23 °C and an air pressure of 100 kPa, the product $D_{\mathrm{CO2}} \cdot |\Delta c| = 248$. Then s_{D} is, for a difference in concentration of 10 % (*V/V*) as given in equation (4).

$$s_{\mathrm{D}} = \frac{248}{i} \tag{4}$$

9.1.3 Diffusion resistance number

Calculate the diffusion resistance number μ, using equation (5).

$$\mu = \frac{s_{\mathrm{D}}}{s} \tag{5}$$

where

s_{D}	is the diffusion-equivalent air layer thickness, in metres, calculated in accordance with equations (2) and (3);
s	is the thickness, in metres, of the coating to be tested, as obtained from film thickness measurement.

If the diffusion resistance number measured for the reference film (5.1.5) differs from $1{,}75 \cdot 10^6$ by more than 30 %, repeat the procedure.

NOTE When testing coatings on substrates, the diffusion resistance number can be calculated on the basis of the total resistance of the coating plus the substrate provided that the diffusion resistance of the substrate compared to that of the coating is so low that it can be neglected. In all other cases, the diffusion resistance of the coating is to be calculated by subtraction in accordance with equation (2) and is to be inserted in equation (5).

9.2 Method B

NOTE From the many possible procedures for carrying out the carrier gas method, the following calculations are given as representative examples for the continuous procedure using a gas chromatograph with input loop and for the gas collection procedure using infrared detection.

9.2.1 Continuous procedure, using a gas chromatograph with input loop

9.2.1.1 Carbon dioxide permeability

Calculate the carbon dioxide permeability i, expressed in $\mathrm{g/(m^2 \cdot d)}$, using equation (6a) or (6b).

$$i = \frac{A_\mathrm{m} \times V_\mathrm{c} \times S \times \mathrm{K}_4 \times T_0 \times p_\mathrm{amb1} \times \mathrm{K}_2 \times M_{\mathrm{CO_2}} \times \mathrm{p}}{A_\mathrm{c} \times V_\mathrm{m} \times A \times T_\mathrm{m} \times \Delta c \times p_\mathrm{amb2} \times P_0 \times V_{\mathrm{CO_2}}} \qquad \text{(6a)}$$

where

A_m	is the peak area for the measurement (input loop);
A_c	is the peak area for the calibration volume;
V_c	is the calibration volume, in cubic centimetres;
V_m	is the measurement volume (loop volume), in cubic centimetres;
A	is the effective area, in square metres, of the test piece;
S	is the volume flow, in cubic centimetres per minute, of the carrier gas;
K_2	is a factor for the conversion of Δc to 10 % (V/V); $\mathrm{K}_2 = 10$;
K_4	is a factor for the conversion of minutes to days; $\mathrm{K}_4 = 1440$;
M_CO2	is the molar mass of carbon dioxide in grams per mole; $M_\mathrm{CO2} = 44{,}01$ g/mol;
V_CO2	is the molar volume of carbon dioxide under standard conditions (273,15 K and 101,3 kPa) in cubic centimetres per mole; V_CO2 22250 $\mathrm{cm^3/mol}$;
p_amb1	is the ambient atmospheric pressure, in kilopascals, during calibration;
p_amb2	is the ambient atmospheric pressure, in kilopascals, during measurement;
T_m	is the measurement temperature, in Kelvin;
Δc	is the difference, in % (V/V), in the carbon dioxide concentration;
p_0	is the standard pressure, in kilopascals; $p_0 = 101{,}3$ kPa;
T_0	is the standard temperature, in Kelvin; $T_0 = 273{,}15$ K;
p	is a factor for the conversion of p_amb, in kilopascals, to the reference pressure 1 bar; p = 100;
Index c	= calibration;
Index m	= measurement.

Equation (6a) can be simplified, as indicated in equation (6b).

$$i = \frac{A_m \times V_c \times S \times 7{,}68 \times 10^3 \times p_{amb1}}{A_c \times V_m \times A \times T_m \times \Delta c \times p_{amb2}} \quad (6b)$$

9.2.1.2 Diffusion-equivalent air layer thickness

See 9.1.2.

9.2.1.3 Diffusion resistance number

See 9.1.3.

If the diffusion resistance number measured for the reference film (5.1.5) differs from $1{,}75 \cdot 10^6$ by more than 30 %, repeat the procedure.

9.2.2 Gas collection procedure, using infrared detection, gas cell and metal bellows pump

9.2.2.1 Carbon dioxide permeability

Calculate the carbon dioxide permeability i, expressed in g/(m$^2 \cdot$ d), using equation (7a) or (7b).

$$i = \frac{V_c \times K_4 \times p_{amb1} \times T_0 \times K_2 \times M_{CO_2} \times p}{A \times t \times \Delta c \times p_{amb2} \times p_0 \times T_m \times V_{CO_2}} \quad (7a)$$

where

t is the time, in minutes, to reach the calibration mark.

As to the meaning of the other symbols see 9.2.1.1.

Equation (7a) can be simplified, as indicated in equation (7b).

$$i = \frac{V_c \times 7{,}68 \times 10^3 \times p_{amb1}}{A \times t \times \Delta c \times T_m \times p_{amb2}} \quad (7b)$$

9.2.2.2 Diffusion equivalent air layer thickness

See 9.1.2.

9.2.2.3 Diffusion resistance number

See 9.1.3.

If the diffusion resistance number measured for the reference film (5.1.5) differs from $1{,}75 \cdot 10^6$ by more than 30 %, repeat the procedure.

10 Precision

NOTE The precision data given in 10.1 and 10.2 respectively are based on the results of a comparative testing programme in Germany with three laboratories participating. They refer to the gravimetric method (method A).

No sufficient precision data are currently available for the carrier gas method (method B).

10.1 Repeatability (*r*)

The value below which the absolute difference between two single test results, each the mean of triplicates, obtained on identical material by one operator in one laboratory within a short interval of time using the standardized test method, may be expected to lie with a 95 % probability, is 30 %.

10.2 Reproducibility (*R*)

The value below which the absolute difference between two test results, each the mean of triplicates, obtained on identical material by operators in different laboratories using the standardized test method, may be expected to lie with a 95 % probability, is 33 %.

11 Test report

The test report shall contain at least the following information:

a) all details necessary to identify the product tested;

b) a reference to this part of EN 1062 (EN 1062-6);

c) the method of conditioning in accordance with EN 1062-11;

d) the results of the test, as indicated in clause 9;

e) the method used (method A or method B), in case of the carrier gas method (method B) together with details of the procedure and the relative humidity of the air during the determination;

f) the dry film thickness, in micrometres, of the coating or coating system;

g) the nature and the thickness of the substrate;

h) any deviation from the test methods specified;

i) the date of the test.

Annex A
(normative)

Wax for sealing test cells
(abstracted from EN ISO 7783-1:1999)

A suitable material is a wax material that adheres strongly to both the dish used as the test cell, and the test piece, and is not brittle at the test temperature, not hygroscopic and not susceptible to oxidation. A surface of 50 cm^2 of freshly melted wax, when exposed for 24 h at 38 °C and 90 % relative humidity, shall not give a variation in mass of more than 1 mg. Wax mixtures that attack the test piece shall not be used.

Suitable wax compositions are:

a) 60 % (*m/m*) microcrystalline wax and 40 % (*m/m*) refined crystalline paraffin wax;

b) 80 % (*m/m*) paraffin wax with a melting point of 50 °C to 52 °C and 20 % (*m/m*) viscous-consistency polyisobutene (relative low degree of polymerization);

c) mixture of waxes melting over the range 60 °C to 75 °C and with an oil content of 1,5 % (*m/m*) to 3 % (*m/m*).

If the wax contains traces of water, these can be eliminated by heating (with caution) to 105 °C to 110 °C and stirring.

It is advisable to use new wax to seal each test piece. However, if wax is reused, then care shall be taken to remove foreign bodies and impurities before use.

Annex B
(normative)

Notes on method A: Gravimetric method

B.1 Notes on procedure

During the procedure, the following conditions should particularly be observed:

B.1.1 The specified concentration of carbon dioxide in the test chamber, i.e. 10 % (*V/V*), is to be maintained constant. When coatings with normal carbon dioxide diffusion are to be tested, this can be ensured by ten times flooding the test chamber with the measuring gas. In the case of coatings of particularly high permeability, the flux of the measuring gas is to be increased. Independently from the flux, the measuring gas should be circulated within the test chamber.

B.1.2 As the absorbent for carbon dioxide also absorbs water which will be detected gravimetrically, the water content in the test chamber between the first and the final weighing is to be reduced to a minimum. Besides the use of desiccant in the test chamber, the measuring gas is therefore to be subjected to previous drying.

Access to the test chamber during the determination should be restricted to an absolutely necessary minimum. From experience it is known that the adjustment of the stationary diffusion stream can be recognized by a further weighing at half-time between the first and final weighings.

Reference test cells containing calcium chloride as an absorbent for water can indicate the need of correction. However, the accuracy of this auxiliary method is restricted by the different absorption ability of sodium hydroxide on support and calcium chloride as absorbents for water. It is more recommended to temporarily increase the flux of the previously dried measuring gas after an access to the test chamber.

B.2 Bibliography

B.2.1 Explanations regarding the development of the gravimetric method for the determination of the carbon dioxide permeability are given in [1].

B.2.2 A definition of the barrier for carbonation on the basis of a diffusion-equivalent air layer thickness $s_D \geq$ 50 m is given in [2].

[1] Engelfried, R.: Carbonisation von Beton, ihre Bedeutung und ihre Beeinflussung durch Beschichtungen, defazet 31/No. 9/1977, p. 353-359.

[2] Klopfer, H.: Bauphysikalische Aspekte der Betonsanierung, B + B, No 4/1980, p.128-131

Annex C
(normative)

Notes on method B: Carrier gas method

The volume of the two halves of the permeation cell should be as small as possible. For a permeation area of 50 cm^2, volumes of about 150 cm^3 are appropriate and lead to rapid gas exchange in the permeation cell.

The flows of the measuring gas and the carrier gas must be sufficiently large for the difference in carbon dioxide concentration between the two halves of the cell. It must not be changed by more than 0,3 % (*V/V*) due to the permeation. A flow which is too low on the measuring gas side leads to a carbon dioxide concentration being too low, and on the carrier gas side to one being too high. This leads to a reduction in the partial pressure difference and, thus, to a result which is too low.

Table C.1 gives the flow of measuring and carrier gases required for different coating permeabilities and test (permeation) areas.

Table C.1 – Required flows of measuring and carrier gases

Permeability of coating g/($m^2 \cdot d$)	Permeation area cm^2	Flow cm^3/min		Reduction of the concentration difference % (*V/V*)
		Measuring gas	Carrier gas	
2	20	20	5	0,035
	50	20	5	0,087
	100	20	5	0,174
	200	20	10	0,083
20	20	30	10	0,185
	50	30	20	0,290
	100	60	40	0,290
	200	120	80	0,290
200	20	300	100	0,290
	50	300	200	0,290
	100	600	400	0,290
	200	1200	800	0,290

Alternatively, the difference in concentration can be obtained by measuring the carbon dioxide concentration of the measuring and carrier gases, upstream and downstream of the permeation cell, and adjusting the flows if the difference in concentration is reduced to a value smaller than 0,3 % (*V/V*).

When using gas collection procedures in which the carrier gas is circulated, it is to be ensured that the carbon dioxide concentration in the gas collection circuit does not rise by more than 0,3 % (*V/V*).

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