BRITISH STANDARD

BS EN 12429:1998

Thermal insulating products for building applications — Conditioning to moisture equilibrium under specified temperature and humidity conditions

The European Standard EN 12429:1998 has the status of a British Standard

ICS 91.100.99

National foreword

This British Standard is the English language version of EN 12429:1998. It is one of a large number of European test method standards which have been introduced for thermal insulating products. Guidance on the content and application of these new test methods is given in PD 6621.

The UK participation in its preparation was entrusted by Technical Committee B/540, Energy performance of materials, components and buildings, to Subcommittee B/540/1, European Standards for thermal insulation, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible 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.

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 9 and a back cover.

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Thermal insulating products for building applications — Conditioning to moisture equilibrium under specified temperature and humidity conditions

Produits isolants thermiques destinés aux applications du bâtiment — Conditionnement jusqu'à l'équilibre hygroscopique dans des conditions de température et d'humidité spécifiées

Wärmedämmstoffe für das Bauwesen — Einstellen der Ausgleichsfeuchte bei definierten Temperatur- und Feuchtebedingungen

This European Standard was approved by CEN on 25 June 1998.

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 Central Secretariat 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 Central Secretariat has the same status as the official versions.

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CEN
European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 88, Thermal insulating materials and products, the Secretariat of which is held by DIN.

This European Standard is one of a series of standards which specify test methods for determining dimensions and properties of thermal insulating materials and products. It supports a series of product standards for thermal insulating materials and products which derive from the Council Directive of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products (Directive 89/106/EEC) through the consideration of the essential requirements.

This European Standard contains the following normative annex:

annex A — Determination of limiting value of moisture content change and conditioning time factor by experiment;

and two informative annexes:

annex B — Computer calculations to determine the limiting value of moisture content change;

annex C — Calculations of conditioning time to reach equilibrium using the Fourier number.

This European Standard has been drafted for applications in buildings but it may also be used in other areas where it is relevant.

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 December 1998, and conflicting national standards shall be withdrawn at the latest by December 1998.

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, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Contents

1 Scope

This European Standard specifies equipment and procedures to condition a thermal insulating product to equilibrium moisture content at (23 ± 2) °C and (50 ± 5) % relative humidity.

The standard is also applicable to thermal insulating products with moulded skins but is not normally relevant for faced products or for products with other surface treatments.

NOTE 1 The normally specified moisture content is the result of the equilibrium between the atmosphere and the product at (23 ± 2) °C and (50 ± 5) % relative humidity. The standard may also be used if a product has to be conditioned to other relative humidities.

NOTE 2 The moisture equilibrium may – due to hysteresis effects – differ depending on whether the equilibrium has been reached by absorption or by desorption. In addition, perfect equilibrium may require a very long time to be reached. Therefore it is necessary to accept equilibrium within a certain accuracy.

NOTE 3 For products which do not absorb moisture, conditioning is not needed. It should nevertheless be ensured that there is no water on the surface before testing.

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 these publications apply to this draft European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 12085, *Thermal insulating products for building applications — Determination of linear dimensions of test specimens.*

prEN ISO 12571, *Building materials — Determination of hygroscopic sorption curves*
(ISO/DIS 12571:1996).

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this standard, the following definitions apply.

3.1.1

atmosphere 23/50

a controlled atmosphere at a temperature of (23 ± 2) °C and a relative humidity of (50 ± 5) %

3.1.2

hygroscopic range

moisture content in equilibrium with 98 % relative humidity or lower

3.1.3

equivalent time, Δt_e

d^2 hours, where d is the numerical value of the test specimen thickness in centimetres

3.1.4

limiting value of moisture content change, Δw_1

the change in moisture content during a specified period of equivalent time, Δt_e, at the upper limit of the hygroscopic range

3.1.5

conditioning time factor, γ

the factor by which the equivalent time, Δt_e, has to be multiplied to determine the required conditioning period in the hygroscopic range

3.2 Abbreviations

EPS	expanded polystyrene
ICB	insulation cork board
MW	mineral wool
PUR	polyurethane foam
XPS	extruded polystyrene foam

4 Principle

The conditioning is carried out using one or two steps, see Figure 1.

Step 1 is conditioning the test specimen to a moisture content within the hygroscopic range. This conditioning may take place in an atmosphere 23/50 or in a ventilated oven. The choice of condition depends on the type of material. Alternative I shows drying in atmosphere 23/50 and alternative II drying in a heated oven.

Step 2 is conditioning the test specimen to equilibrium with an atmosphere 23/50, after the moisture content has reached the hygroscopic range.

5 Apparatus

5.1 *Temperature and humidity controlled chamber*, capable of maintaining the atmosphere 23/50.

5.2 *Temperature controlled ventilated oven*, that takes the air from an environment of 23/50. The oven shall be capable of maintaining a temperature of (40 ± 5) °C or (70 ± 5) °C or (105 ± 5) °C as specified in the relevant product standard or any other European technical specification.

5.3 *Measuring instruments*, capable of measuring the linear dimensions of test specimens in accordance with EN 12085, to an accuracy of 1 %.

6 Test specimens

6.1 Dimensions of test specimens

The thickness of the test specimens shall be the original product thickness.

The test specimens shall be squarely cut and square, having sides of (200 ± 1) mm.

6.2 Number of test specimens

The number of test specimens shall be as specified in the relevant product standard. If the number is not specified, then at least three test specimens shall be conditioned.

NOTE In the absence of a product standard or any other European technical specification, the number of test specimens may be agreed between parties.

6.3 Preparation of test specimens

The test specimens shall be cut so that they are representative of the full size product. Any surface skins, facings and/or coatings shall be retained.

6.4 Preconditioning of test specimens

If the procedure shown in Figure 1a) is used ensure that the test specimens have a moisture content well above the hygroscopic range. If in this case the hygroscopic sorption curve for the product is not known, it shall be determined in accordance with prEN ISO 12571.

NOTE To increase the moisture content to above the hygroscopic range it may be necessary to immerse the test specimens in water, expose them to the exterior climate or expose them to water vapour in accordance with EN 12088: *Thermal insulating products for building applications — Determination of long-term water absorption by diffusion.*

7 Procedure

7.1 General

Determine the linear dimensions in accordance with EN 12085 to an accuracy of 1 %. Calculate the volume, *V*, of each test specimen.

The conditioning is carried out using either of the alternative procedures shown in Figure 1a) (steps 1 and 2) or the procedure shown in Figure 1b) (step 2 alone).

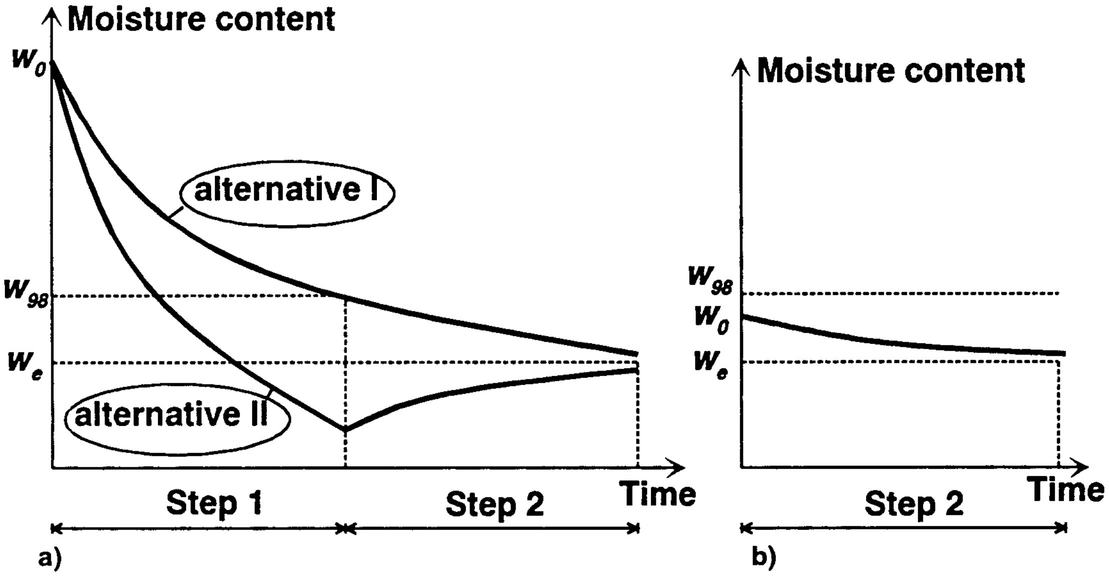
The test specimens shall be installed in the chamber or ventilated oven such that substantially free air circulation occurs around them.

In some cases, the moisture content will be within the hygroscopic range before the conditioning starts. In this case step 1 shall be omitted and only step 2 in accordance with Figure 1b) shall be followed.

7.2 Conditioning step 1

Place the test specimens in an atmosphere 23/50, or in a ventilated oven at an elevated temperature. The temperature shall be as specified in the relevant product standard.

NOTE 1 In the absence of a product standard or any other European technical specification the temperature may be agreed between parties.



a) b)

w_0 is the initial moisture content;
w_{98} is the moisture content at upper limit of hygroscopic range;
w_e is the moisture content in equilibrium with atmosphere 23/50.

Figure 1 — Moisture content versus time during step 1 and step 2

At preselected intervals of time, depending on the product tested and the atmosphere used, remove and weigh the test specimens to determine any mass changes. Continue until the change in moisture content is less than the limiting value, i.e.

$$\Delta w < \Delta w_1$$

where:

Δw	is the change in moisture content during a period of d^2 hours (d being the numerical value of the test specimen thickness in centimetres), in kilograms per cubic metre;
Δw_1	is the appropriate limiting value of moisture content change, determined in accordance with annex A, in kilograms per cubic metre.

NOTE 2 The limiting value of moisture content change may be determined following the procedures in annex B.

A suitable time interval is normally 24 h. Constant mass is considered to have been established when the change in the mass of the test specimen over a 24 h period is less than 0,05 % of the total mass.

NOTE 3 For products with a thickness greater than 10 cm, extra drying out time may be required. The acceptable rate of drying is inversely proportional to the square of the thickness, i.e. a 20 cm product would require a change in mass less than 0,013 % per 24 h.

NOTE 4 A temperature as high as possible is desirable because this will minimize the conditioning period, but the temperature should not be so high as to cause changes in the material properties.

NOTE 5 The effect of moulded skins should be taken into account by increasing the thickness, d, in the expression “d^2 hours”. The increase should be the thickness of a slice of homogeneous material with the same vapour resistance as the moulded skins, e.g. for XPS the thickness should be increased by one centimetre for each surface skin of the product.

7.3 Conditioning step 2

Place the test specimens in an atmosphere 23/50 until equilibrium is reached. Equilibrium is deemed to be reached if during the drying process, in two subsequent weighings using a 24 h interval, the change of mass between the two determinations is less than 0,05 % of the total mass.

NOTE 1 An approximation of the conditioning time can be estimated from $\gamma \times d^2$ hours, where γ is the conditioning time factor and d is the test specimen thickness, in centimetres. For values of γ, see annexes A and C.

NOTE 2 The effect of moulded skins should be taken into account by increasing the thickness, d, in the expression “d^2 hours”. The increase should be the thickness of a slice of homogeneous material with the same vapour resistance as the moulded skins, e.g. for XPS the thickness should be increased by one centimetre for each surface skin of the product.

NOTE 3 Products with a thickness greater than 10 cm and almost impermeable products require longer conditioning periods than specified by the equilibrium criterion and should be dealt with accordingly by the laboratory.

8 Calculation and expression of results

The limiting value of moisture content change and the conditioning time factor by experiment shall be calculated in accordance with annex A.

9 Accuracy

NOTE It has not been possible to include a statement on the accuracy of the measurements in this edition of the standard, but it is intended to include such a statement when the standard is next revised.

10 Test report

Information on the conditioning procedure shall be included in the relevant test report.

Annex A (normative)

Determination of limiting value of moisture content change and conditioning time factor by experiment

A.1 Calculation based on conditioning at atmosphere 23/50

Find the moisture content at equilibrium, w_{50}, from the hygroscopic sorption curve.

Calculate the moisture content at time t, w_t, in kilograms per cubic metre using equation (A.1):

$$w_t = \frac{m_t - m_e + w_{50} \times V}{V} \qquad \text{(A.1)}$$

where:

m_t is the mass of the moist test specimen at time t, in kilograms;

m_e is the mass of the test specimen in equilibrium with atmosphere 23/50, in kilograms;

w_{50} is the moisture content at equilibrium with atmosphere 23/50, in kilograms per cubic metre;

V is the test specimen volume, in cubic metres.

Plot the relationship between moisture content and time for each test specimen.

Find for each test specimen the slope of the drying curve, $\mathrm{d}w/\mathrm{d}t$, in kilograms per cubic metre per hour, at a moisture content corresponding to the upper limit of the hygroscopic range, 98 % relative humidity (w_{98}).

Calculate the limiting value of moisture content change, Δw_1, in kilograms per cubic metre using equation (A.2):

$$\Delta w_1 = \mathrm{d}w/\mathrm{d}t \times d^2 \qquad \text{(A.2)}$$

where:

d is the test specimen thickness, in centimetres;

d^2 is the equivalent time, Δt_e, in hours.

The limiting value of the moisture content change is the mean value of the individual results and shall be expressed to two significant figures.

Estimate the time period, t_{step2}, from the plot using moisture content w_{98} to w_{50}, in hours.

Calculate the conditioning time factor, γ, using equation (A.3):

$$\gamma = \frac{t_{\mathrm{step2}}}{d^2} \qquad \text{(A.3)}$$

where:

d is the test specimen thickness, in centimetres;

d^2 is the equivalent time, Δt_e, in hours.

A.2 Calculation based on conditioning in ventilated oven

Calculate the moisture content at time t, w_t, in kilograms per cubic metre using equation (A.4):

$$w_t = \frac{m_t - m_{\mathrm{dry}}}{V} \qquad \text{(A.4)}$$

where:

m_t is the mass of the moist test specimen at time t, in kilograms;

m_{dry} is the mass of the oven dried test specimen, in kilograms;

V is the test specimen volume, in cubic metres.

Plot the relationship between moisture content and time for each test specimen.

Find for each test specimen the slope of the drying curve, $\mathrm{d}w/\mathrm{d}t$, in kilograms per cubic metre per hour, at a moisture content corresponding to the upper limit of the hygroscopic range, 98 % relative humidity, w_{98}.

Calculate the limiting value of moisture content change, Δw_1, in kilograms per cubic metre using equation (A.5):

$$\Delta w_1 = \mathrm{d}w/\mathrm{d}t \times d^2 \qquad \text{(A.5)}$$

where:

d is the test specimen thickness, in centimetres;

d^2 is the equivalent time, Δt_e, in hours.

The limiting value of the moisture content change is the mean value of the individual results and shall be expressed to two significant figures.

Annex B (informative)

Computer calculations to determine the limiting value of moisture content change

Computer calculations, modelling the drying out process, have been carried out for five different products. The materials are: high density MW, EPS, XPS with moulded skins, ICB and PUR. Conditioning atmospheres are assumed to be either a controlled atmosphere 23/50 or a ventilated oven that takes the air from an environment at 23/50 at either 40 °C, 70 °C or 105 °C. Test specimen thickness is assumed to be 10 cm.

One-dimensional, isothermal conditions are assumed. Moisture flow is described by a diffusion equation (B.1) or (B.2):

$$g = \delta_v \times dv/dx \qquad (B.1) \qquad \text{or} \qquad g = \delta_p \times dp_v/dx \qquad (B.2)$$

where:

g is the density of moisture flow rate, in kilograms per square metre per second;

δ_v is the permeability with regard to humidity by volume, in square metres per second;

δ_p is the permeability with regard to partial vapour pressure, in kilograms per metre per second per pascal;

v is the humidity by volume, in kilograms per cubic metre;

p_v is the partial water vapour pressure, in pascals;

x is the co-ordinate in thickness direction, in metres.

δ_v and δ_p are assumed constant and are determined by a wet cup method in accordance with EN 12086, *Thermal insulating products for building applications — Determination of water vapour transmission properties.*

NOTE The assumption of one-dimensional conditions may give results on the safe side if the test specimen is allowed to dry out in all directions (no sealed surfaces).

The time (in days) needed to reach the hygroscopic range from an initial moisture content of 10 kg/m^3 (ICB: 50 kg/m^3) is given in Table B.1. If the initial amount of moisture is below 10 kg/m^3, the time needed can be estimated by proportion from the figures given in Table B.1.

Table B.1 — Time to reach the hygroscopic range for different materials at different temperatures

Material	Time in days at quoted temperature			
	23 °C	40 °C	70 °C	105 °C
MW, high density	2	<1	<1	—
EPS	18	5	1	—
XPS	>60	17	4	—
ICB	31	7	2	2
PUR	18	4	1	—

The criterion to check that the hygroscopic range is reached is that:

> the change in moisture content, Δw, during a specified period of equivalent time, Δt_e, is less than a limit value of Δw_1.

The assumption behind this type of criterion is that the rate of drying for a certain material of a certain thickness at a certain temperature is always the same at the upper limit of the hygroscopic range, regardless of the initial moisture content.

From the slope of the drying curves, the rate of drying at the upper limit of the hygroscopic range is determined. The limiting values Δw_1 are determined as the rate of drying multiplied by an interval of d^2 hours.

Table B.2 shows a summary of the results. This table can be used in the absence of experimental results determined according to annex A.

Table B.2 — Limiting value of moisture content change, Δw_1

Material	Moisture content change in kg/m^3 at quoted temperature			
	23 °C	40 °C	70 °C	105 °C
Fibrous and granular materials	10	—	—	—
Cellular plastics	0,4	1,5	4	—
Cork	1,2	5	25	50

NOTE The values in Table B.2 are calculated under the assumption that the products are homogeneous and that there are no moulded skins, facings or other surface treatment.

Annex C (informative)

Calculations of conditioning time to reach equilibrium using the Fourier number

The relationship between moisture content and time is described in the diagram below (w_0 and w_e are respectively, the initial and equilibrium moisture contents). The initial moisture content is assumed uniformly distributed.

Assuming, for example, that 90 % of the equalization has taken place, that is the moisture content will be in the range ±10 % from equilibrium with atmosphere 23/50, then:

$$\frac{w - w_e}{w_0 - w_e} = 0{,}10$$

and from the Figure C.1, *Fo* = 0,84. It is now possible to estimate the equalization time from the definition of the Fourier number:

$$Fo = 4 \times \frac{D_w}{d^2} \times t \quad \text{(C.1)} \qquad \text{or} \qquad t = \frac{Fo \times d^2}{4 \times D_w} \quad \text{(C.2)}$$

where

D_w is the moisture diffusivity, in square metres per second;

t is the equalization time, in seconds;

d is the test specimen thickness for two-sided drying, in metres.

The moisture diffusivity, D_w, in the hygroscopic range is a function of vapour permeability, temperature and slope of the sorption curve:

$$D_w = \frac{\delta_v \times v_{sat}}{\xi} \qquad \text{(C.3)}$$

where:

δ_v is the permeability with regard to humidity by volume, in square metres per second;

v_{sat} is the saturation humidity by volume, in kilograms per cubic metre (at 23 °C, v_{sat} = 0,021 kg/m^3);

ξ is the moisture differential capacity, in kilograms per cubic metre.

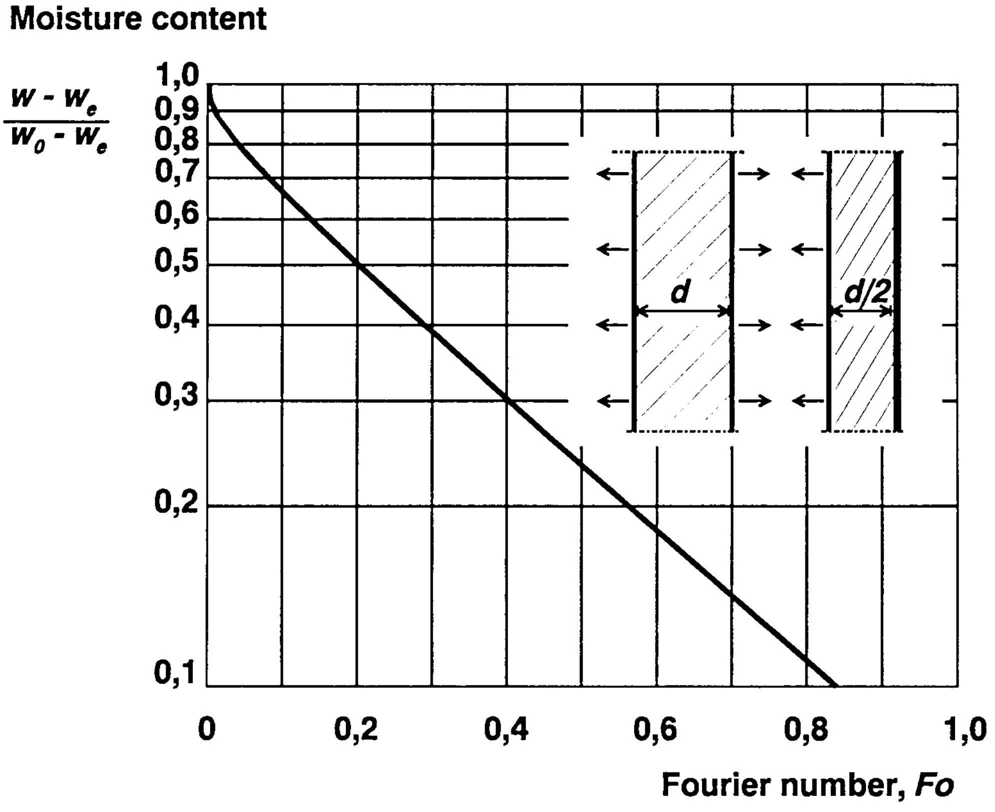


Figure C.1 — Mean moisture content, given as a dimensionless number between 0 and 1, shown as a function of the Fourier number, *Fo*, for a slab with the initial moisture content w_0 and equilibrium moisture content w_e

The moisture differential capacity, ξ, is the slope of the hygroscopic sorption curve as determined by prEN ISO 12571, and in the calculations the value in the range 50 % to 98 % relative humidity has been used:

$$\xi = \frac{\mathrm{d}w}{\mathrm{d}\varphi} \tag{C.4}$$

where:

w is the moisture content mass by volume, in kilograms per cubic metre;

φ is the relative humidity, in percentage.

Typical material properties for some products are given in Table C.1 below.

Table C.1 — Material properties

Material	δ_v m^2/s	ξ kg/m^3
MW, low density	20×10^{-6}	0,5
MW, high density	8×10^{-6}	2
EPS, 20 kg/m^3	$0,6 \times 10^{-6}$	2
XPS, 30 kg/m^3	$0,3 \times 10^{-6}$	1,5
ICB	$0,6 \times 10^{-6}$	30
PUR	$0,5 \times 10^{-6}$	3

Combining the equations (C.2) and (C.3) the equalization time can now be calculated as:

$$t = \frac{Fo \times d^2}{4 \times D_\mathrm{w}} = \frac{0,84 \times d^2 \times \xi}{4 \times \delta_\mathrm{v} \times 0,021} = \frac{10 \times d^2 \times \xi}{\delta_\mathrm{v}} \tag{C.5}$$

If t is expressed in hours and d in centimetres:

$$t = \frac{2,8 \times 10^{-7} \times d^2 \times \xi}{\delta_\mathrm{v}} \tag{C.6}$$

The assumption of 90 % equalization means roughly that the moisture content will be in the range ±10 % from equilibrium with atmosphere 23/50.

The theory requires the initial moisture content to be uniformly distributed. This is not quite true in the procedure suggested here, but the non-uniform moisture distribution at the beginning of step 2 in Figure 1 of this standard normally has no essential effect on the results.

Table C.2 shows a rough summary of the results. This table can be used in the absence of experimental results developed according to annex A.

Table C.2 — Required conditioning period expressed as $\gamma \times d^2$ where γ is the conditioning time factor and d is the thickness of the product in centimetres

Material category	Conditioning period h
Fibrous and granular materials	$0,2 \times d^2$
Cellular plastics	$2 \times d^2$
Cork	$20 \times d^2$

NOTE The same results would have been obtained with calculations using the vapour pressure (p_v) as a driving force for the diffusion and/or moisture content mass by mass (u).

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