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Thermal insulating products for building equipment and industrial installations — Determination of water vapour transmission properties of preformed pipe insulation

Produits isolants thermiques pour les équipements de bâtiments et les installations industrielles — Détermination des propriétés de transmission de la vapeur d'eau des coquilles isolantes préformées

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Foreword

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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).

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This document was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 1, *Test and measurement methods*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 88, *Thermal insulating materials and products*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 12629:2011), which has been technically revised.

The main changes are as follows:

— EN 13469:2012 and ISO 12629:2011 have been merged into one document;

— technical revision of Clause 3, Terms, definitions, symbols and subscripts, 6.3, Number of test specimens, Clause 7, Procedure and Clause 8, Calculation and expression of results;

— Annex A has been deleted;

— editorial revisions.

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.

Thermal insulating products for building equipment and industrial installations — Determination of water vapour transmission properties of preformed pipe insulation

1 Scope

This document specifies the equipment and procedure for determining the water vapour transmission properties in the steady state under specified test conditions for test specimens of preformed pipe insulation. It is applicable to thermal insulating products.

It is intended to be used for homogeneous materials (see NOTE below) and for products which can have integral skins or adhered facings of some different material.

NOTE   A material is considered to be homogeneous in terms of mass distribution if its density is approximately the same throughout, i.e. if the measured density values are close to its mean density.

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 9346, *Hygrothermal performance of buildings and building materials — Physical quantities for mass transfer — Vocabulary*

ISO 12628, *Thermal insulating products for building equipment and industrial installations — Determination of dimensions, squareness and linearity of preformed pipe insulation*

ISO 29768, *Thermal insulating products for building applications — Determination of linear dimensions of test specimens*

3 Terms, definitions, symbols, units and subscripts

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9346 and the following apply.

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

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

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

3.1.1
water vapour flow rate
G
quantity of water vapour transmitted through the surface of the test specimen in mass divided by time

3.1.2
density of water vapour flow rate
g
mass of water vapour transferred through the specimen per area and per time under specified conditions of temperature, humidity and thickness

3.1.3
water vapour permeance
W
quotient of water vapour transmission rate of the test specimen and the water vapour pressure difference per area between the test specimen faces during the test

3.1.4
water vapour resistance
Z
inverse of *water vapour permeance* (3.1.3) ($1/W$)

3.1.5
water vapour permeability
δ
product of the permeance and the thickness of the test specimen ($\delta = W \cdot d$)

Note 1 to entry: The water vapour permeability of a homogeneous product is a property of the material. It is the quantity of water vapour transmitted per unit of time through a unit area of the product per unit of vapour pressure difference between its faces for a unit thickness.

3.1.6
water vapour resistance factor
μ
quotient of the *water vapour permeability* (3.1.5) of air and the water vapour permeability of the material or the homogeneous product concerned

Note 1 to entry: It indicates the relative magnitude of the *water vapour resistance* (3.1.4) of the product and that of an equally thick layer of stationary air at the same temperature.

3.2   Symbols and units

The symbols and units are given in Table 1.

Table 1 — Symbols and units

Symbol	Quantity	Unit
A	area of specimen	m^2
G	water vapour flow rate through specimen	kg/s
R_v	gas constant for water vapour = 462	$N \cdot m/(kg \cdot K)$
T	thermodynamic temperature	K
W	water vapour permeance with respect to partial vapour pressure	$kg/(m^2 \cdot s \cdot Pa)$
Z	water vapour resistance with respect to partial vapour pressure	$m^2 \cdot s \cdot Pa/kg$
d	mean thickness of specimen	m
g	density of water vapour flow rate	$kg/(m^2 \cdot s)$
l	length of the test specimen	m
m	mass of specimen	kg
p	barometric pressure	hPa
p_0	standard barometric pressure = 1 013,25	hPa
p_s	water vapour saturation pressure	hPa
t	time	s
Δp	water vapour pressure difference across specimen	Pa
δ	water vapour permeability of the specimen	$kg/(m \cdot s \cdot Pa)$
δ_a	water vapour permeability of air	$kg/(m \cdot s \cdot Pa)$

Table 1 *(continued)*

Symbol	Quantity	Unit
μ	water vapour resistance factor	—
ϑ	celsius temperature	°C
φ	relative humidity (RH)	—

NOTE   The above units are in accordance with ISO 9346; a conversion table to other units commonly used in permeability measurements is given in ISO 12572:2016, Annex J.

3.3 Subscripts

The subscripts are given in Table 2.

Table 2 — Subscripts

Subscript	Denoting
1, 2	time steps, index
a	air
i	inside
o	outside

4 Principle

A desiccant filled "dry cup" made from a preformed pipe insulation test specimen is placed in a test atmosphere whose temperature and humidity are controlled. Because of the difference between the partial water vapour pressures in the test assembly and in the test atmosphere water vapour flows through the test specimen, periodic weighings of the assembly are made to determine the rate of water vapour transmission when the steady state is reached.

The water vapour transmission rate and permeance values are specific to the test specimen (i.e. the product) thickness tested. For homogeneous products, the water vapour permeability is a property of the material.

If the pipe insulation is cut from a flat product, then the water vapour transmission properties can be obtained from tests carried out on the flat product with similar properties according to ISO 12572.

5 Apparatus

5.1 Chamber, capable of being maintained within a temperature of (23 ± 1) °C and a relative humidity (RH) of (50 ± 3) %.

NOTE   In order to maintain the required conditions throughout the chamber, it can be necessary to use air circulation with an air speed between 0,02 m/s to 0,3 m/s.

5.2 Desiccant, anhydrous calcium chloride ($CaCl_2$) with particle size 2 mm to 15 mm (RH 0 %) or any other desiccant that gives the same results.

5.3 Analytical balance, capable of weighing the test assembly to an accuracy of ±1 mg or better. If larger test assemblies are used, the weighing accuracy may be determined with respect to the total weight and the required accuracy of the test results.

5.4 Measuring instruments, capable of determining linear dimensions and thicknesses in accordance with the requirements of ISO 29768 or ISO 12628, whichever is relevant.

5.5   **Aluminium foil**, water vapour diffusion tight (at least 50 μm thick) protected with a polymer film on the face in contact with the calcium chloride ($CaCl_2$).

5.6   **Adhesive**, suitable to make a water-vapour-tight joint between the aluminium foil and the test specimen (see relevant product standard).

NOTE   Any combination of foil or sealant and adhesive which provides comparable results can be used.

6   Test specimens

6.1   General

The test specimens shall be representative of the product and shall include any natural surface skins or adhered facings of different materials.

Pipe insulation pieces (half sections or segments) shall be placed together using an appropriate sealant or adhesive to form a full-size pipe insulation test specimen.

NOTE   For faced or coated products with a water vapour diffusion resistance factor $\mu \leq 3$, for the core material, the permeability can be determined from measurements made on the facing/coating itself, after separation from the product. For pipe insulations with large dimensions, test specimen of the facing or coating can be cut out and tested according to ISO 12572.

6.2   Dimensions of the test specimen

Cut the test specimens to a minimum length of (100 ± 1) mm; for outside diameters greater than 100 mm the length shall be at least 150 mm. The cut surfaces shall be as flat as possible, equally formed and perpendicular to the vertical axis of the test specimen.

The thickness of the test specimen shall be the thickness of the product.

6.3   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 five test specimens shall be used.

In addition to the specified test specimens, one test specimen, "dummy", identical to the others but not filled with desiccant shall be prepared. This "dummy" shall be included in the test procedure. Its weight changes during the test procedure are not caused by water vapour diffusion, but by, e.g. gas or humidity evaporation/absorption or air pressure variations.

NOTE 1   In the absence of a product standard or any other technical specification, the method of selection of the test specimens can be agreed between parties.

The weight changes of the test specimens shall be corrected by the weight changes of the dummy.

NOTE 2   Information on the use of a "dummy" test specimen can be found in Reference [4].

6.4   Conditioning of test specimens

The test specimens shall be stored for at least 6 h at (23 ± 5) °C. In case of dispute, they shall be stored at (23 ± 2) °C and (50 ± 5) % RH for the time stated in the relevant product standard.

In tropical climates, different conditioning and testing conditions can be relevant. In this case, the conditions shall be (27 ± 5) °C and (65 ± 5) % RH and shall be stated clearly in the test report.

7 Procedure

7.1 Test conditions

Select the desired test environment from the conditions given in Table 3.

Table 3 — Test conditions

Set	Condition °C - % relative humidity (RH)	Tolerances				
		Temperature °C	Relative humidity (RH)[a] %			
			Dry state		Wet state	
			Set point	Tolerance	Set point	Tolerance
A	23 – 0/50	23 ± 1	0	+5	50	±5
B	23 – 0/85	23 ± 1	0	+5	85	±5
C	23 – 50/93	23 ± 1	50	±5	93	±5
D	38 – 0/93	38 ± 1	0	+5	93	±3
E	23 – 50/100	23 ± 1	50	±5	100	
NOTE 1 "Dry" tests (condition A) give information about the performance of materials at low humidities when moisture transfer is dominated by vapour diffusion. "Wet" tests (condition C) give guidance about the performance of materials under high humidity conditions. At higher humidities, the material pores start to fill with water; this increases the transport of liquid water and reduces vapour transport. Tests in this area therefore give some information about liquid water transport within materials. This is discussed further in ISO 15148.						
NOTE 2 Condition E is used for low resistance specimens.						
[a] Saturated salt solutions, which regulate the RH in the specimens at some value less than 100 %, are used because, with many materials, there is a danger of condensation occurring on the underside of the sample, which disrupts the vapour flow. In the case of very low resistance, the vapour flow rates are so high that a) condensation is unlikely and b) the saturated salt solution will possibly not remain in equilibrium for the duration of the test. In this case, that distilled water should be used.						

Other sets of temperature and RH may be agreed between the parties when needed for special application conditions.

EXAMPLE 1   This is an example of desiccants which produce the specified air relative humidities at 23 °C.

Desiccants

Calcium chloride, $CaCl_2$ - particle size < 3 mm	0 %
Magnesium perchlorate, $Mg(ClO_4)_2$	0 %
Phosphorus pentoxide, P_2O_5	0 %
Silicagel	0 %

EXAMPLE 2   This is an example of saturated aqueous solutions which produce the specified air relative humidities at 23 °C.

Aqueous solutions

Sodium dichromate, $Na_2Cr_2O_7 \cdot 2H_2O$	52 %
Magnesium nitrate, $Mg(NO_3)_2$	53 %
Potassium chloride, KCl	85 %

Ammonium dihydrogen phosphate, $NH_4H_2PO_4$ 93 %

Potassium nitrate, KNO_3 94 %

Further details of suitable solutions can be found in ISO 12571:2013[1]), Annexes A and B.

Regular checks shall be made, especially during long tests, to ensure that saturated solutions remain as a mixture of liquid with a large amount of undissolved substance.

It is presupposed that all chemical substances are handled with care and in accordance with relevant safety regulations.

7.2   Preparation of specimen and test assembly

Bond the test specimen to the aluminium foil (see 5.5), at one end, to achieve a water-vapour-tight joint.

Place sufficient desiccant within the test specimen.

The quantity of desiccant shall not be greater than 2/3 of the enclosed volume.

Close the open end of the test specimen as in the first paragraph.

Bubbles under the foil should be avoided, and the bond between the foil and the test specimen should be such that any attempt to separate the foil from the test specimen breaks the test specimen rather than the bond.

In case of products with a low water vapour transmission rate the borderline between the foil and the test specimen may be sealed in addition with a sealant (e.g. wax) in such a way that the reduction in free surface is not significant.

Immerse the test specimens in the test chamber (see Figure 1) under the specified test conditions. Avoid contact between the test specimens.

Condition the test specimens in the test chamber for a period between 1 h and 24 h.

7.3   Test procedure

Weigh the test specimens at regular intervals. The weighing shall be carried out under the same conditions that exist in the test chamber. If the weighing is made outside of the chamber, care shall be taken that the duration of time outside of the chamber does not affect the result. The weight changes of the test specimens shall be corrected by the weight changes of the dummy.

In order to avoid contamination of the test specimen, gloves should be used while handling the test specimen.

Repeat the weighings until five successive determinations of "change in mass per unit time" are constant to within ±5 % of the mean value for the test specimen (see 8.1). Repeat the procedure for the remaining test specimens.

Plot a curve of change in mass against time to help recognize the condition of constant change (steady state).

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1)   Cancelled and replaced by ISO 12571:2021.
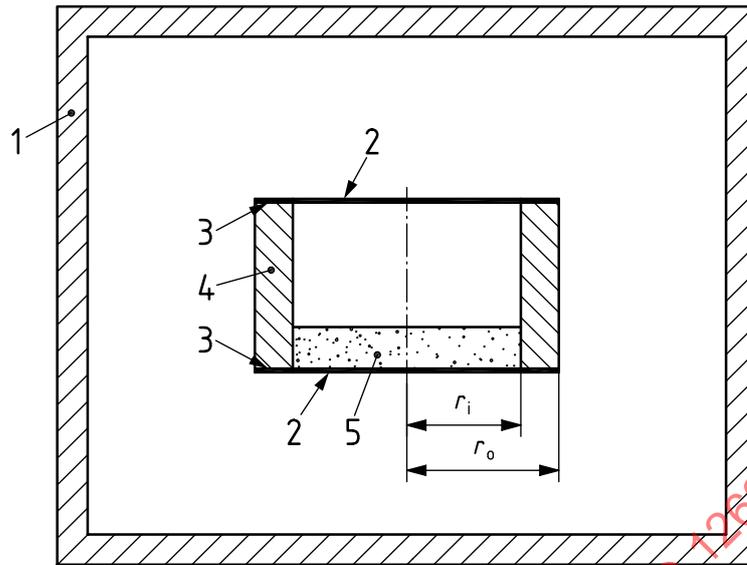
Key

1   test chamber
2   aluminium foil
3   adhesive
4   test specimen
5   desiccant

r_i inside radius
r_o outside radius

Figure 1 — Example of test assembly

8   Calculation and expression of results

8.1   Water vapour flow rate

Calculate for each test specimen for the selected time interval, the water vapour flow rate, $\Delta \dot{m}_{12}$, using Formula (1):

$$\Delta \dot{m}_{12} = \frac{m_2 - m_1}{t_2 - t_1} \tag{1}$$

where

$\Delta \dot{m}_{12}$ is the change of mass per time for a single determination, in kg/s;

m_1 is the mass of the test assembly at time t_1, in milligrams;

m_2 is the mass of the test assembly at time t_2, in milligrams;

t_1 and t_2 are successive times of weighings, in seconds.

G is the mean of five successive determinations of $\Delta \dot{m}_{12}$ for each test specimen.

The final value of G is obtained when each of the last five successive determinations of $\Delta \dot{m}_{12}$ is within ±5 % of G.

8.2 Density of water vapour flow rate

Calculate the water vapour transmission rate, g, as given by Formula (2).

$$g = \frac{G}{A} \tag{2}$$

where A is the calculated exposed area of the test specimen, in m², using Formula (3).

$$A = \frac{2 \cdot \pi \cdot l \cdot (r_o - r_i)}{ln\dfrac{r_o}{r_i}} \tag{3}$$

where

l is the length of the test specimen, in m;

r_o is the outside radius, in m;

r_i is the inside radius, in m.

8.3 Water vapour permeance

The water vapour permeance, W, is given by Formula (4).

$$W = \frac{G}{A \cdot \Delta p} \tag{4}$$

where Δp is the water vapour pressure difference, in Pa, calculated from the means of the measured temperatures and relative humidities over the course of the test, using Formula (5).

$$p = \varphi \cdot 610{,}5 \cdot e^{\frac{17{,}269 \cdot \vartheta}{237{,}3 + \vartheta}} \tag{5}$$

Table 4 summarizes the values of Δp for the five test conditions specified in Table 3.

Table 4 — Δp values for each test condition

Set	Condition °C - % relative humidity (RH)	Δp Pa
A	23 - 0/50	1 404
B	23 - 0/85	2 387
C	23 - 50/93	1 207
D	38 - 0/93	6 157
E	23 - 50/100	1 404

8.4 Water vapour resistance

The water vapour resistance, Z, is the reciprocal of the water vapour permeance, see Formula (6).

$$Z = \frac{1}{W} \tag{6}$$

8.5 Water vapour permeability

The water vapour permeability, δ, is given by Formula (7).

$$\delta = W \cdot d \tag{7}$$

where d is the test specimen thickness $(r_o - r_i)$, in m.

8.6 Water vapour diffusion resistance factor

8.6.1 General

The water vapour diffusion resistance factor, μ, is defined by Formula (8).

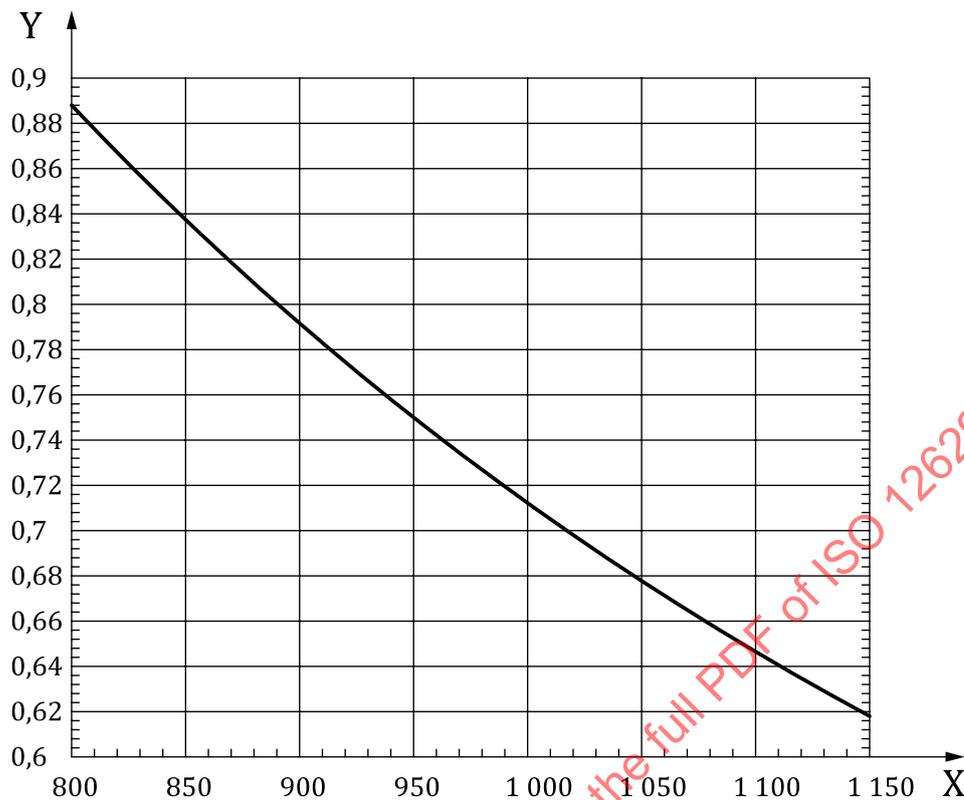$$\mu = \frac{\delta_a}{\delta} \tag{8}$$

where

δ is the water vapour permeability of the test specimen;

δ_a is the water vapour permeability of air (depending on the mean barometric pressure during the test; see Figure 2 at 23 °C).

NOTE Since the water vapour permeability of air and the material are assumed to depend equally on the barometric pressure, their quotient, the factor μ, can be considered independent from the barometric pressure. When calculating water vapour transmission rate at different locations, the actual barometric pressure can be taken into account using Formula (9).

$$g = \frac{\Delta p}{(\mu \cdot d)} \cdot \delta_a \tag{9}$$

8.6.2   Calculation of δ_a

Key

X   barometric pressure in hPa

Y δ_a in mg/(m·h·Pa)

Figure 2 — Water vapour permeability in air at 23 °C

The calculation can also be made by using the Schirmer formula:

$$\delta_a = \frac{D}{R_v \cdot T} \tag{10}$$

$$\delta_a = \frac{0{,}083}{R_v \cdot T} \cdot \frac{p_o}{p} \cdot \left(\frac{T}{273{,}15}\right)^{1{,}81} \tag{11}$$

where

D is the water vapour diffusion coefficient, in m^2/h;

R_v is the gas constant of water vapour: 462 N·m/(kg·K);

T is the test temperature, in K;

p is the mean barometric pressure during the test, in hPa;

p_o is the standard barometric pressure: 1 013,25 hPa.

8.6.3 Calculation of δ

$$\delta = d \cdot \frac{G}{\Delta p \cdot A} \tag{12}$$

where

d is the thickness of the test specimen ($r_o - r_i$), in m;

G is the water vapour flow rate, in mg/h;

A is the area, in m^2;

Δp is the water vapour pressure difference between inside and outside of the test specimen, in Pa.

a) Water vapour flow rate

$$G = \frac{\Delta m}{\Delta t} \tag{13}$$

where

Δm is the weight difference in mg between two readings;

Δt is the measuring time, in h.

b) Water vapour pressure difference

$$\Delta p = (p_{s1} \cdot \varphi_1) - (p_{s2} \cdot \varphi_2) \tag{14}$$

where

p_{s1} is the water vapour saturation pressure in the test chamber, in Pa;

φ_1 is the RH in the test chamber, expressed as a decimal;

p_{s2} is the water vapour saturation pressure in the test assembly — above the desiccant, in Pa;

φ_2 is the RH in the test assembly — above the desiccant, expressed as a decimal.

If calcium chloride is used as desiccant, an RH of 0 % is assumed, in which case, φ_2 is equal to zero.

Therefore $\Delta p = p_{s1} \cdot \varphi_1$

A good approximation for p_s is:

$$p_s = a \cdot \left(b + \frac{T - 273,15}{100} \right)^n \tag{15}$$

where

a is 288,68 Pa;

b is 1,098;

n is 8,02;

T is the temperature, in K.

8.6.4 Calculation of μ

Calculate the μ value from Formula (16):

$$\mu = \frac{1}{(r_o - r_i)} \cdot \frac{0,083}{R_D \cdot T} \cdot \frac{p_o}{p} \cdot \left(\frac{T}{273,15}\right)^{1,81} \cdot \frac{\Delta t}{\Delta m} \cdot$$
$$\frac{2 \cdot \pi \cdot l \cdot (r_o - r_i)}{ln \dfrac{r_o}{r_i}} \cdot 288,68 \cdot \left(1,098 + \frac{(T - 273,15)}{100}\right)^{8,02} \cdot \varphi_1 \tag{16}$$

9 Accuracy of measurement

NOTE   It has not been possible to include a statement on the accuracy of the method in this version of this document, but it is intended to include such a statement when this document is next revised. ISO 12572 gives some general guidance on the accuracy of testing.

10 Test report

The test report shall include the following information:

a) reference to this document, i.e. ISO 12629:2022;

b) product identification:

   1) product name, factory, manufacturer or supplier;

   2) production code number;

   3) type of product;

   4) packaging;

   5) the form in which the product arrived at the laboratory;

   6) other information as appropriate, e.g. nominal thickness, nominal density;

c) test procedure:

   1) pre-test history and sampling, e.g. who sampled and where;

   2) conditioning;

   3) deviation from Clauses 6 and 7 if applicable, including, for example, testing of the facing alone;

   4) date of testing;

   5) conditioning and testing conditions in tropical climates, if applicable;

   6) dimensions and number of test specimens;

   7) general information relating to the test;

   8) events which can have affected the results;

Information about the apparatus and identity of the technician should be available in the laboratory but it need not be recorded in the report.

d) results:

   1) the water vapour transmission property (water vapour diffusion factor, permeance or permeability) including the direction of the water vapour flow relative to the facings, if the