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Thermal performance in the built environment — Determination of air permeance of building materials

Performance thermique en environnement bâti — Détermination de la perméance à l'air des matériaux de construction

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Foreword

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The committee responsible for this document is ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 1, *Test and measurement methods*.

Introduction

This International Standard contains the requirements for testing various building materials to determine their suitability to be used as an air barrier material.

Thermal performance in the built environment — Determination of air permeance of building materials

1 Scope

This International Standard specifies the equipment and procedures to determine the air permeance of building materials at various pressure differentials and then assigning an air permeance rate at a reference pressure differential rate (ΔP) of 75 Pa.

This method is intended for testing materials independent of a substrate using a 1 m × 1 m specimen size. The results of this test method can be used to determine whether a material qualifies to function as an air barrier material.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7345, *Thermal insulation — Physical quantities and definitions*

ISO 9229, *Thermal insulation — Vocabulary*

ISO 12576-1, *Thermal insulation — Insulating materials and products for buildings — Conformity control systems — Part 1: Factory-made products*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7345 and ISO 9229 and the following apply.

3.1
air permeance
rate of air flow (L/s), per unit area (m^2) and per unit static pressure differential (Pa)

4 Sampling and conformity control

The procedures described in ISO 12576-1 shall be applied for the purposes of sampling and conformity control.

5 Test specimens

5.1 Number

The number of test specimens shall be five.

5.2 Dimensions

The test specimens shall be 1,2 m × 1,2 m. Where the manufactured product is less than 1,2 wide, the length shall be increased to provide the same area.

5.3 Preparation

From the sample obtained in accordance with Clause 4, cut the material to 1,2 m × 1,2 m. For fluid-applied products, the material shall be installed on a release material or a substrate and then the materials shall be removed from the release material or substrate after curing.

5.4 Conditioning

The test specimens shall be conditioned for seven days at

(23 ± 2) °C and (50 ± 10) % relative humidity

or

(23 ± 5) °C and $\left(50^{+20}_{-10}\right)$ % relative humidity

or

(27 ± 5) °C and $\left(65^{+20}_{-10}\right)$ % relative humidity

unless other conditions are given in the relevant material standard.

6 Principle

A test specimen is subjected to various air pressure differentials and the air permeance is measured.

7 Apparatus

The schematic of the apparatus is shown in Figure 1.

7.1 Test chamber, shall be constructed with a 1 m × 1 m test opening in the top and which will accept a 1,2 m × 1,2 m specimen.

In some cases, the size could be modified for materials which are manufactured with a width less than 1,2 m. In all cases, the test opening shall be 1 m^2. The depth of the test chamber shall be 400 mm. A compression frame 0,1 m wide shall be installed around the outside of the test chamber at the top of the test chamber. The compression frame shall be stiff and fastened solidly to the test chamber to limit defection. Observation panels shall be installed on two sides of the test frame to allow observation of the material installed in the test chamber.

The test chamber shall be sealed with two parallel strips of medium-density gasket material at all sealing points of the test chamber so that the extraneous air leakage shall not be measurable at 700 Pa.

A second compression frame the same size and shape of the compression frame on the test chamber shall be constructed and the corners sealed.

7.2 Air flow measuring devices, shall be used which can measure of 1 × 10^{-7} m^3/s (0,000 1 L/s) up to 1 × 10^{-2} m^3/s (1,0 L/s) with an accuracy of ±3 %.

7.3 Static pressure differential measuring devices, shall be used which can measure up to 500 Pa with an accuracy of ±0,5 %.

7.4 Laboratory barometric pressure measuring device, shall be used which can measure pressure with ±3 % of the reading.

7.5 Piping, shall be used to connect the test chamber to the variable pressure differential equipment.

The piping shall be airtight. The pipe connection to the test chamber shall contain an air filter so that the air flow measuring device shall not be affected by dust or suspended particulates. The piping shall be designed so that the flow regime upstream and downstream of the air flow measuring device shall not affect the device's accuracy. The piping shall contain a flow control device to regulate the static pressure across the test specimen within ±0,5 % of the pressure reading. The piping shall contain a temperature measuring device with an accuracy of ±0,5 °C, to measure the temperature of the air flowing in the piping.

7.6 Variable pressure differential equipment, shall be an equipment with a variable control to produce a static pressure across the test specimen within ±0,5 % of the pressure reading.

The equipment shall be able to produce both positive and negative pressures.

7.7 Pressure limit device, shall be installed to control over-pressure and shall be set at 1 000 Pa.

7.6 Self-adhesive gasket material, strips of self-adhesive gasket material shall be installed on both compression frames (one constructed as part of the test chamber and the second on used to hold the specimen in place) and the corners shall be glued or fused.

7.7 Air impermeable material, non-permeable flexible material (such as 0,15-mm thick polyethylene film) is used to wrap the specimen to determine the air leakage of the test apparatus before conducting the air permeance test of the material.

7.8 Clamping devices, twelve clamping devices (such as C-clamps) used to clamp the two compression frames together after the specimen has been installed in the test chamber.

8 Procedures

8.1 Specimen installation

Cut the air impermeable material to 1,4 m × 1,4 m.

8.1.1 Self-supporting materials

Remove the protective paper from one side of the self-adhered, medium-density gasket strip and install onto the edges of the test specimen in a manner that the area inside the strips is 1 m × 1 m. Fuse or glue the corners. Install a second strip of medium-density gasket material outside the first strip and fuse or glue the corners.

Remove the protective paper on the top side of the self-adhered gasket material and install the test specimen with the gasket material side down onto the centre of a piece of flexible air impermeable material. Ensure that the gasket strip is adhered to the flexible air impermeable material.

On the top side of the specimen, remove the protective paper from self-adhered gasket material and install onto the edges of the test specimen in a manner that the area inside the strips is 1 m × 1 m and that the gasket is positioned over the gasket strip on the other side of the test specimen. Fuse or glue the corners. Install a second strip of self-adhesive gasket material outside the first strip and over gasket material on the other side of the test specimen. Fuse or glue the corners.

Cut the air impermeable material as shown in Figure 2.

Wrap the air impermeable material over the edges of the test specimen as shown in Figure 3 and press into the self-adhering, medium-density gasket strips. Tape the joints with construction tape.

Cut and remove all excess air impermeable material from inside the self-adhesive gasket material, leaving an opening to the test specimen of 1 m × 1 m.

Install the test specimen assembly onto the compression frame attached to the test chamber with the air impermeable material facing up as shown in Figure 4.

Install the second compression frame over the test specimen assembly and clamp into place using three clamping devices on each side of the test apparatus.

View the installed test specimen through the observation panels and confirm that it has been properly installed.

8.1.2 Non-self-supporting materials

The procedure for non-self-supporting material shall be the same as above with the addition of a rigid support. An open grill or wire mesh/screen with a square grid of a minimum of 25 mm × 25 mm opening (or equivalent means of support) shall be used. The wire mesh/screen shall be welded or otherwise mechanically supported to a solid metal frame.

Remove the protective paper from one side of the self-adhered, medium-density gasket strip and install onto the edges of the test specimen in a manner that the area inside the strips is 1 m × 1 m. Fuse or glue the corners. Install a second strip of medium-density gasket material outside the first strip and fuse or glue the corners.

Remove the protective paper on the top side of the self-adhered gasket material and install the test specimen with the gasket material side down onto the centre of the open grill or wire mesh/screen. Ensure that the gasket strip is adhered to the open grill or wire mesh/screen.

On the top side of the open grill or wire mesh/screen, remove the protective paper from self-adhered gasket material and install onto the edges of the open grill or wire mesh/screen in a manner that the area inside the strips is 1 m × 1 m and that the gasket is positioned over the gasket strip on the other side of the open grill or wire mesh/screen. Fuse or glue the corners. Install a second strip of self-adhesive gasket material outside the first strip and over gasket material on the other side of the open grill or wire mesh/screen. Fuse or glue the corners.

Cut the air impermeable material as shown in Figure 2.

Wrap the air impermeable material over the edges of the test specimen as shown in Figure 3 and press into the self-adhering, medium-density gasket strips. Tape the joints with construction tape.

Cut and remove all excess air impermeable material from inside the self-adhesive gasket material, leaving an opening to the test specimen of 1 m × 1 m.

Install the test specimen assembly onto the compression frame attached to the test chamber with the air impermeable material facing up as shown in Figure 5.

Install the second compression frame over the test specimen assembly and clamp into place using three clamping devices on each side of the test apparatus.

View the installed test specimen through the observation panels and confirm that it has been properly installed.

8.2 Test procedure

8.2.1 Calibration

Construct a calibration specimen using a 1,1 m × 1,1 m piece of (19 ± 3) mm thick of plywood with a 150 mm hole in the centre of the plywood.

Manufacture an orifice plate from 3 mm stainless steel 200 mm in diameter centred on the hole. The orifice plate shall have an interior square edge diameter of (25,4 ± 0,1) mm.

Install two rows of self-adhesive gasket material around the outside of the orifice plate. Fuse or glue where the ends of the self-adhesive gasket material meet. Centre the orifice plate on the plywood and secure the orifice plate to the plywood using wood screws. Install a sealant along the edge of the orifice plate where it meets the plywood.

Install a suitable adhesive tape over the hole in the orifice plate.

Install the calibration specimen into the test apparatus and determine the extraneous air leakage of the test assembly by conducting the test in accordance with 8.2.2.

Remove the adhesive tape from the hole in the orifice plate and determine the air flow rate at 75 Pa pressure difference (ΔP). The air flow rate shall be ±5 % of the predetermined flow rate of 3,47 L/s.

NOTE Other orifice plates with different diameters can be made to provide different flow rates.

8.2.2 Control tests

The air leakage of the open grill or wire mesh/screen shall not be measureable. This shall be confirmed by measuring the air flow rate of the test apparatus at a specific pressure difference without any test specimen being installed. The open grill or wire mesh/screen shall be installed and the flow rate of the test apparatus at the same pressure difference shall be measured. The flow rate shall be within 5 %.

8.2.3 Specimen tests

Install the specimens in accordance with 8.1.

Measure the extraneous air leakage (Q_{ei}) of the test apparatus with the specimen installed at 25 Pa, 50 Pa, 75 Pa, 100 Pa, 150 Pa, and 300 Pa static pressure differentials (ΔP).

Cut and remove the air impermeable material covering the test specimen which is inside the compression frame and the self-adhered gasket material. The opening shall be 1 m × 1 m.

Measure the total air leakage (Q_{ti}) at 25 Pa, 50 Pa, 75 Pa, 100 Pa, 150 Pa, and 300 Pa static pressure differentials (ΔP) in both a positive flow and a negative flow.

Determine if the measurement process has affected the air permeance of the material by re-measuring the total air leakage at 300 Pa, 150 Pa, 100 Pa, 75 Pa, 50 Pa, and 25 Pa static pressure differentials (ΔP) and compare to the original values. If the difference in the air leakage rate at the same pressure difference is greater than 10 %, the cause of the air leakage rate change shall be determined.

9 Calculation and expression of results

9.1 Standard temperature and pressure

Correct the air flow rate values to standard temperature and pressure (STP) using Formulae (1) and (2).

$$Q_{st} = Q\left(W/W_s\right)^{1/2} \tag{1}$$

where

Q is the airflow at non-standard conditions, in L/s;

Q_{st} is the airflow corrected to standard conditions, in L/s;

W_s is the density of air at reference standard conditions, 1 202 kg/m^3;

W is the density of air at the test site, in kg/m^3;

B is the barometric pressure at test site corrected for temperature, in Pa;

T is the temperature of air at flow meter, in °C.

At each of the pressure differences, the air flow rate through the test specimen (Q) shall be calculated by subtracting the extraneous air flow rate (Q_{ei}) from the total air flow rate (Q_{ti}).

The air flow rate formula $Q = CA$ (ΔP) shall be determined by fitting the data and the errors estimated.

Calculate the air permeance of the material at the pressure differences measured. The air permeance (P) of the test specimen at a given pressure differential *(ΔP)* is calculated by Formula (2);

$$P = \frac{Q}{(A)(\Delta P)} \tag{2}$$

where

Q is the air flow rate from the STP air flow rate formula;

A is the specimen cross sectional area (1 m^2);

ΔP is the pressure difference.

An error analysis shall be conducted which shall include an examination of the sources of the error, an evaluation of the systematic errors and propagation of error, and the resulting value of error on the air flow rate through the test specimen.

10 Precision

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

11 Test report

The report shall include the following:

a) the name and location of laboratory performing the tests and the accreditation agency for the laboratory;

b) the date the test was conducted;

c) the manufacturer's name, production facility identifier, and product designation;

d) the identification of the material tested, including type, name, and basis weight;

e) the material sampling procedure used;

f) the lot number and manufactured date;

g) the description of the specimen preparation;

h) the size of specimens used for each test (length, width, and thickness);

i) a statement either stating that the material was not attached to a substrate;

j) the tare of the test apparatus;

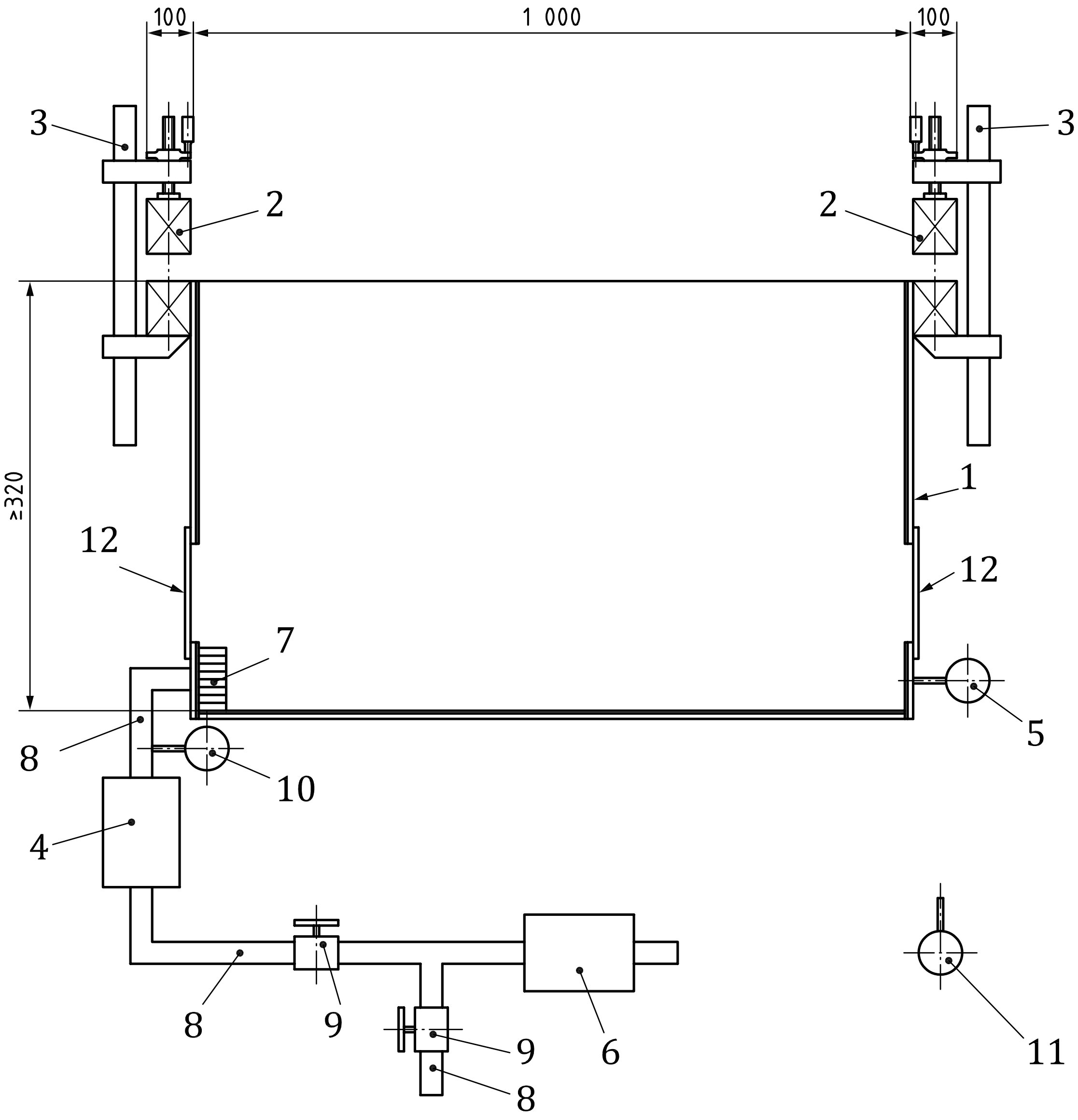
k) the measured air flow versus pressure difference data in graphic form (log/log graph) for the specimens (The air leakage rate at the reference pressure difference, ΔP, of 75 Pa shall be identified on the graph.);

l) flow rate equation, which shall be established through linear fitting of data by method of least squares for the pressure readings. The coefficient of determination (r^2) shall be calculated and presented. A regression line based on air leakage data that have an $r^2 < 0,99$ is not accepted unless proper explanations are given for the deviation. All air leakage rates shall be expressed in $L/(s/m^2)$;

m) the calculated air permeance versus the pressure difference in tabular form;

n) the error analysis as described in Clause 9;

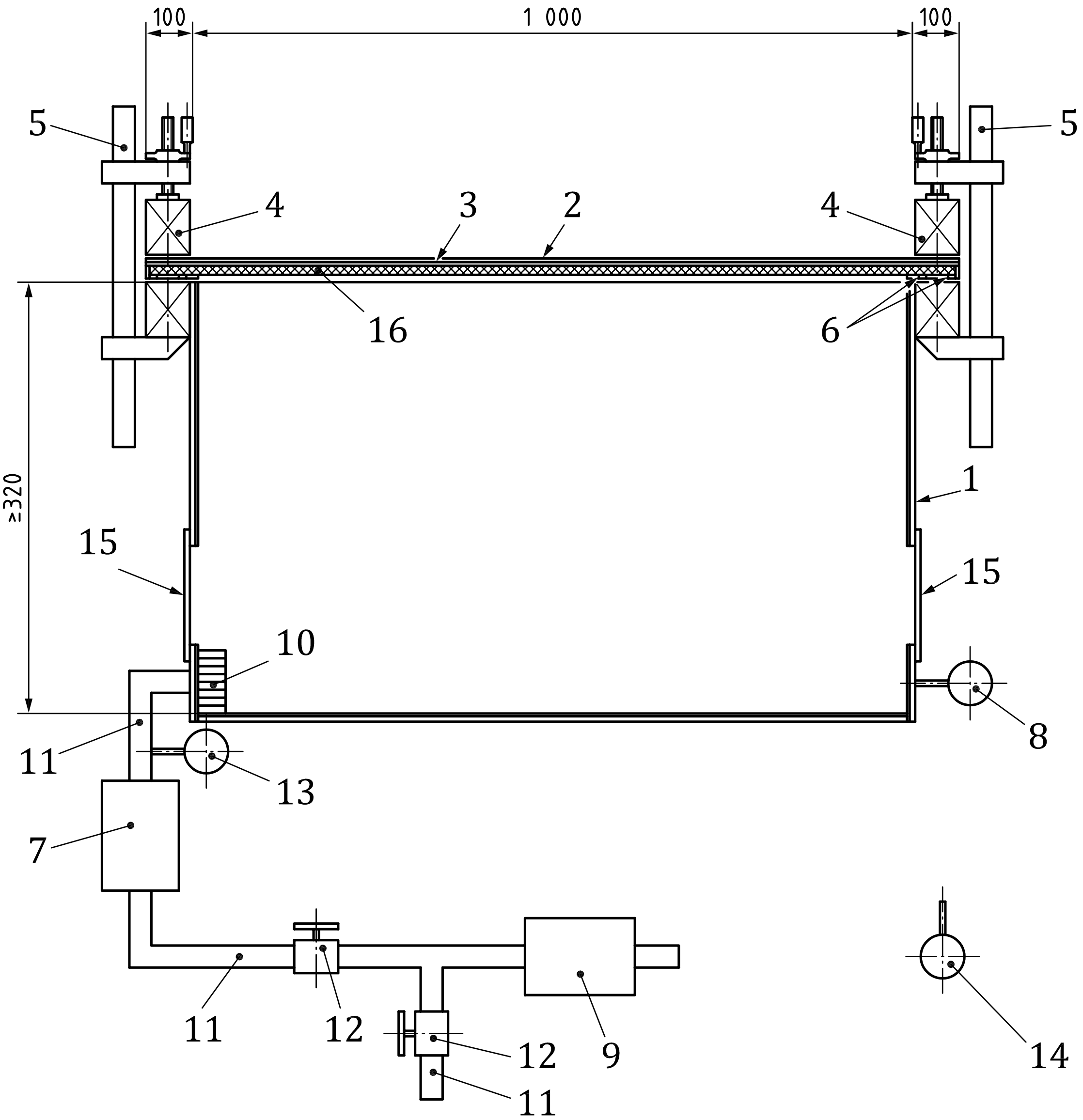
o) the declaration of conformity with the requirements of this test method or a detailed description of the modifications.



Key

1 chamber
2 compression frame
3 clamps
4 flow measuring device
5 pressure differential measuring device
6 blower unit
7 filter
8 piping
9 flow control devices
10 temperature measuring device
11 barometric pressure measuring device
12 window for viewing installed specimen

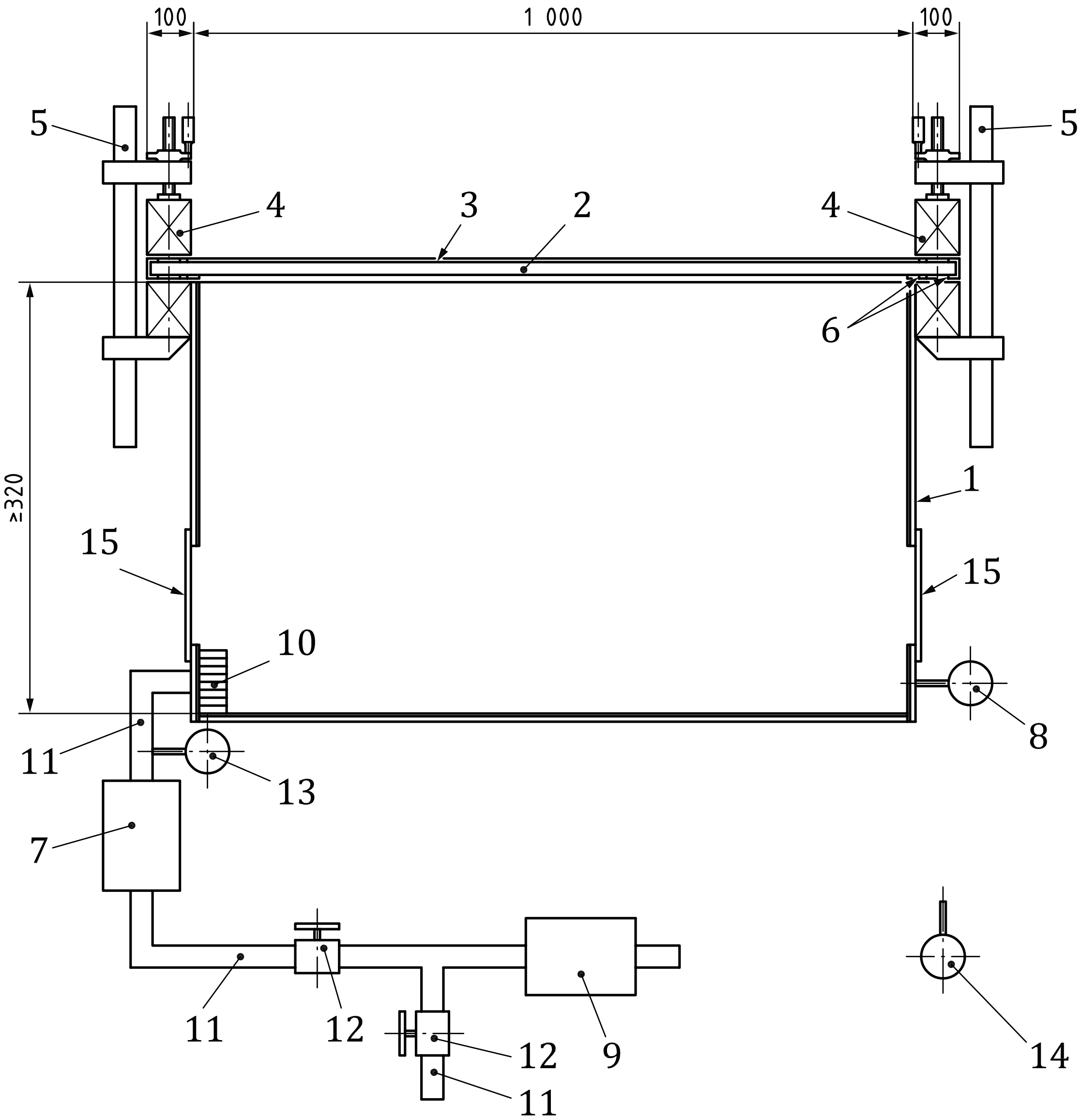
Figure 1 — General configuration of test apparatus



Key

1	chamber	9	blower unit
2	polyethylene sheet used to determine tare	10	filter
3	flexible specimen	11	piping
4	compression frame	12	flow control devices
5	clamps	13	temperature measuring device
6		14	barometric pressure measuring device
7	flow measuring device	15	window for viewing installed specimen
8	pressure differential measuring device	16	wire mesh to provide support to flexible specimen

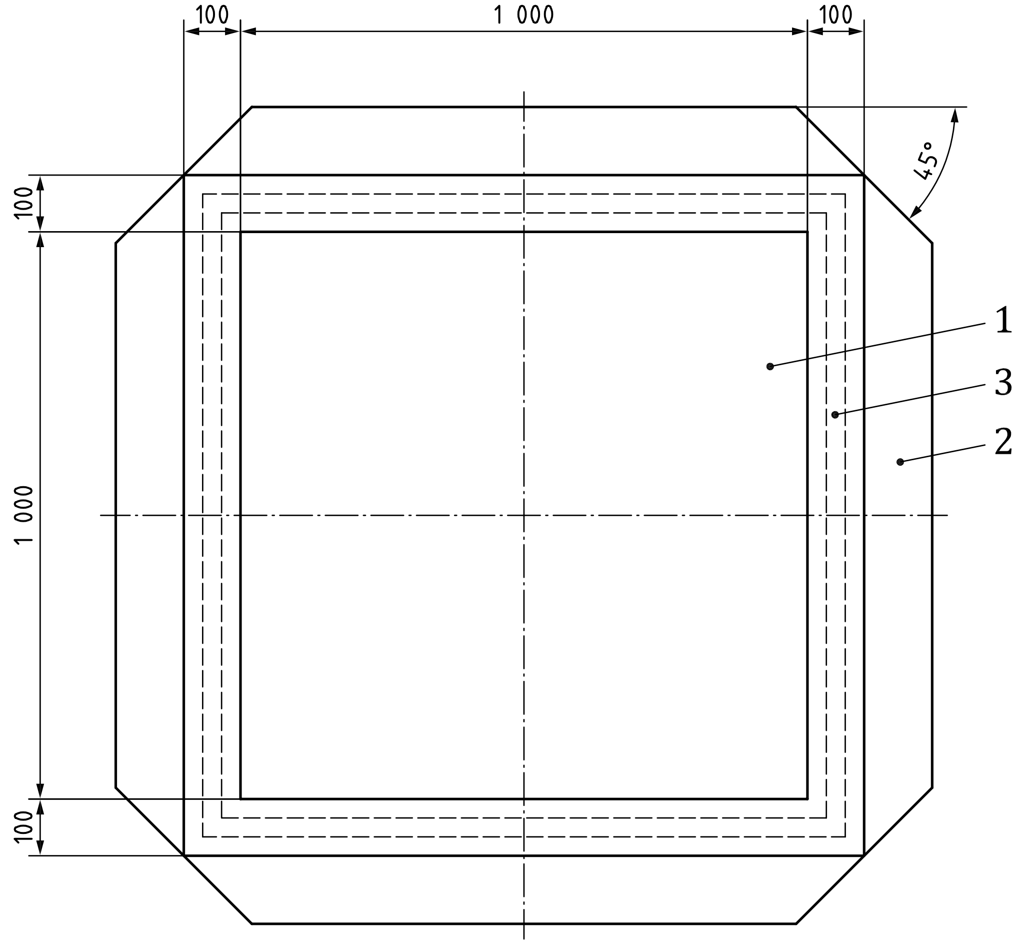
Figure 2 — Configuration of test apparatus with flexible specimen installed



Key

1	chamber	9	blower unit
2	polyethylene sheet used to determine tare	10	filter
3	flexible specimens	11	piping
4	compression frame	12	flow control devices
5	clamps	13	temperature measuring device
6		14	barometric pressure measuring device
7	flow measuring device	15	window for viewing installed specimen
8	pressure differential measuring device		

Figure 3 — Configuration of test apparatus with rigid specimen installed



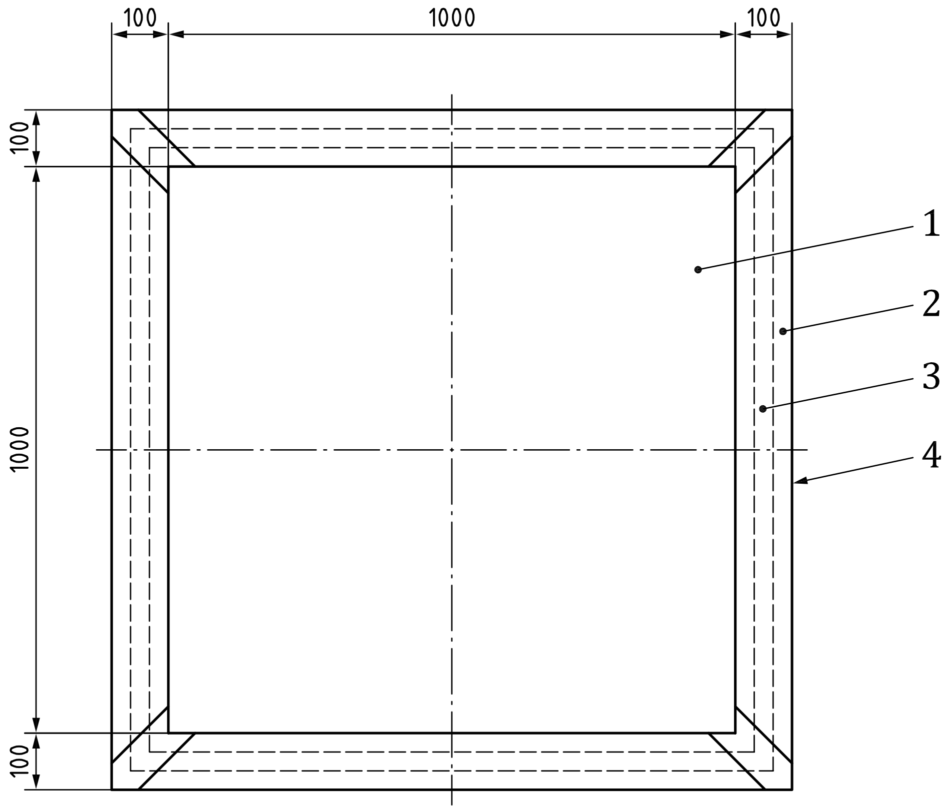
Key

1 specimen

2 polyethylene film

3 gaskets

Figure 4 — Top view – Polyethylene placed over specimen



Key

1 specimen

2 polyethylene film

3 gaskets

4 tape on corners to seal

Figure 5 — Rigid specimen test set-up

Annex A
(normative)

Procedure for estimating errors in derived quantities

This International Standard includes several derived quantities which are used to summarize the air permenace of building materials. An estimation of the error in these quantities is to be reported. All derived quantities are dependent on the air permenace coefficient C and the air pressure exponent n of Formula (A.1). Determine C and n by making a log transformation of the variables Q and dP for each reading.

$$x_i = l\pi\left(dP_i\right)$$

$$y_i = ln\left(Q_i\right) \qquad \text{(A.1)}$$

for $i = 1..N$

where

N is the total number of test readings.

Formula (A.1) then transforms into:

$$y = ln\left(C\right) + n \cdot x \qquad \text{(A.2)}$$

Compute the following quantities:

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{n} x_i \qquad \text{(A.3)}$$

$$\bar{y} = \frac{1}{N}\sum_{i=1}^{n} y_i \qquad \text{(A.4)}$$

$$S_x^2 = \frac{1}{N-1}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2 \qquad \text{(A.5)}$$

$$S_y^2 = \frac{1}{N-1}\sum_{i=1}^{n}\left(y_i - \bar{y}\right)^2 \qquad \text{(A.6)}$$

$$S_{xy} = \frac{1}{N-1}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)\left(y_i - \bar{y}\right) \qquad \text{(A.7)}$$

Then the best estimate n and $ln(C)$ is given by:

$$n = \frac{S_{xy}}{S_x^2} \qquad \text{(A.8)}$$

$$ln(C) = \bar{y} - n \cdot \bar{x} \tag{A.9}$$

$$C = \exp^{(\bar{y} - n \cdot x)} \tag{A.10}$$

The 95 % confidence limits for C and n can be determined as follows.

The variance of n is given by the estimate:

$$S_n = \frac{1}{S_x}\left(\frac{S_y^2 - n \cdot S_{xy}}{N-2}\right)^{\frac{1}{2}} \tag{A.11}$$

And the estimate of the variance on $ln(C)$ is given by

$$S_{ln(C)} = S_n\left(\frac{\sum_{i=1}^{N} x_i^2}{N}\right)^{\frac{1}{2}} \tag{A.12}$$

The confidence limits for $ln(C)$ and n are, respectively:

$$I_{ln(C)} = S_{ln(C)} T(95\,\%, N-2) \tag{A.13}$$

$$I_n = S_n T(95\,\%, N-2) \tag{A.14}$$

Where the values of the two-sided student distribution [T(95 %, N – 2)] is given in Table A.1. This means that the probability is 95 % that the pressure exponent n lies in the interval (n − I_n, n + I_n) and the air leakage coefficient C lies in the interval $\left[c \cdot \exp^{-I_{ln(C)}}, c \cdot \exp^{I_{ln(C)}}\right]$.

The estimate of the variance around the regression line [Formula (A.1)] at the value x is

$$S_y(x) = S_n\left[\frac{N-1}{N} S_x^2 + (x - \bar{x})^2\right]^{\frac{1}{2}} \tag{A.15}$$

and the confidence interval in the estimate of y using Formula (A.1) at any given x is

$$I_y(x) = S_y(x) T(95\,\%, N-2) \tag{A.16}$$

Therefore, the airflow rate Q predicted by Formula (A.1) at any pressure difference dP lies in the interval $\left\{Q \cdot \exp^{-1 y[ln(dP)]}, Q \cdot \exp^{1 y[ln(dP)]}\right\}$ with a probability of 95 %. It is this interval that shall be used to estimate the error in the leakage area or the airflow rate across the building material at a reference pressure (for example 75 Pa). In practice, the above error analysis can be carried out using standard statistical computer programs.

Table A.1 — Two-sided confidence limits *T* (95 %, *N* – 2) for a student distribution

N – 2	3	4	5	6	7	8	9	10
T(95 %, N – 2)	3,182	2,776	2,571	2,447	2,365	2,306	2,262	2,228

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