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Thermal insulation products — Vacuum insulation panels (VIPs) — Specification

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Contents

Page

Foreword

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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 3, *Thermal insulation products, components and systems*.

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Thermal insulation products — Vacuum insulation panels (VIPs) — Specification

1 Scope

This document:

— defines requirements for vacuum insulation panels (VIPs) with silica or glass fibre core, which are used for thermal insulation of buildings;

— outlines required product properties, their performance, test methods and rules for conformity evaluations, identification and labelling;

— provides a test method to determine ageing factors and the influence of the linear thermal bridges at the edges.

This document is applicable to all types of silica and glass fibre core VIPs, independent of the type of envelope. In the case of a glass fibre core VIP, it is only applicable to VIPs with desiccants whose service life is ≥ 25 years.

This document is not applicable to:

— any specific installation and application requirements;

— products intended to be used for the insulation of building equipment and industrial installations.

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 1182, *Reaction to fire tests for products — Non-combustibility test*

ISO 1716, *Reaction to fire tests for products — Determination of the gross heat of combustion (calorific value)*

ISO 3529-1, *Vacuum technology — Vocabulary — Part 1: General terms*

ISO 3529-2, *Vacuum technology — Vocabulary — Part 2: Vacuum pumps and related terms*

ISO 3529-3, *Vacuum technology — Vocabulary — Part 3: Total and partial pressure vacuum gauges*

ISO 8301, *Thermal insulation — Determination of steady-state thermal resistance and related properties — Heat flow meter apparatus*

ISO 8302, *Thermal insulation — Determination of steady-state thermal resistance and related properties — Guarded hot plate apparatus*

ISO 8990, *Thermal insulation — Determination of steady-state thermal transmission properties — Calibrated and guarded hot box*

ISO 10211, *Thermal bridges in building construction — Heat flows and surface temperatures — Detailed calculations*

ISO 10456, *Building materials and products — Hygrothermal properties — Tabulated design values and procedures for determining declared and design thermal values*

ISO 11925-2, *Reaction to fire tests — Ignitability of products subjected to direct impingement of flame — Part 2: Single-flame source test*

ISO 12136, *Reaction to fire tests — Measurement of material properties using a fire propagation apparatus*

ISO 12567-1, *Thermal performance of windows and doors — Determination of thermal transmittance by the hot-box method — Part 1: Complete windows and doors*

ISO 12576-1:2001, *Thermal insulation — Insulating materials and products for buildings — Conformity control systems — Part 1: Factory-made products*

ISO 29465, *Thermal insulating products for building applications — Determination of length and width*

ISO 29466, *Thermal insulating products for building applications — Determination of thickness*

ISO 29467, *Thermal insulating products for building applications — Determination of squareness*

ISO 29468, *Thermal insulating products for building applications — Determination of flatness*

ISO 29472, *Thermal insulating products for building applications — Determination of dimensional stability under specified temperature and humidity conditions*

EN 13501-1, *Fire classification (Euroclasses) of construction products and building elements - Classification using test data from reaction to fire tests*

EN 13823, *Reaction to fire tests for building products - Building products excluding floorings exposed to the thermal attack by a single burning item*

3 Terms, definitions, symbols and units

For the purposes of this document, the following terms and definitions 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

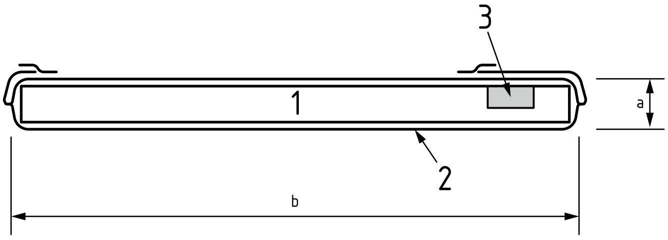
— IEC Electropedia: available at https://www.electropedia.org/

3.1 Terms and definitions

3.1.1
vacuum insulation panel
VIP
insulation element containing open porous *core material* (3.1.4) and an *adsorbent* (3.1.8) within an *envelope* (3.1.5), where the *inner pressure* (3.1.10) inside the envelope is significantly lower, close to the vacuum (i.e. zero pressure), than the ambient air pressure

Note 1 to entry: A schematic view of a VIP is shown in Figure 1.

Dimensions in millimetres



Key

1 core material

2 envelope

3 adsorbent

a Thickness, *d* (3.1.17).

b Working length, l_1.

Figure 1 — Schematic view of VIP

3.1.2
silica core VIP
vacuum insulation panel (VIP) (3.1.1) using fumed silica or other comparable silica powders as *core material* (3.1.4)

3.1.3
glass fibre core VIP
vacuum insulation panel (VIP) (3.1.1) using glass fibre as *core material* (3.1.4), and generally containing an *adsorbent* (3.1.8)

3.1.4
core material
open porous insulation material constituting the main component inside the *vacuum insulation panel (VIP)* (3.1.1) *envelope* (3.1.5)

3.1.5
envelope
barrier layer(s) of the *vacuum insulation panel (VIP)* (3.1.1) resisting gas or vapour permeation into and securing the vacuum inside the VIP

3.1.6
metallized film
MF
laminated film containing a high barrier performance metallic thin layer produced by chemical/physical deposition

3.1.7
aluminium foil laminated film
AF
laminated film containing aluminium foil as a gas barrier layer

3.1.8
adsorbent
material adsorbing either water vapour or dry air, or both, physically or chemically

3.1.9
desiccant
material added inside the *envelope* (3.1.5) for the purpose of adsorbing water vapour

EXAMPLE CaO.

3.1.10
inner pressure
total gas pressure within the *vacuum insulation panel (VIP)* (3.1.1)

3.1.11
working length
l_w
longer linear dimension of the major surface of the test specimen

Note 1 to entry: See Figure 2.

3.1.12
working width
w_w
shorter linear dimension of the major surface of the test specimen, measured at right angles to the *working length* (3.1.11)

Note 1 to entry: See Figure 2.

3.1.13
core length
l_c
longer linear dimension of the *core material* (3.1.4) of the test specimen

Note 1 to entry: See Figure 2.

3.1.14
core width
w_c
shorter linear dimension of the *core material* (3.1.4) of the test specimen, measured at right angles to the *core length* (3.1.13)

3.1.15
length of edge seal
l_2
longer linear dimension of the edge seal of the test specimen

Note 1 to entry: See Figure 2.

3.1.16
width of edge seal
w_2
shorter linear dimension of the edge seal of the test specimen, measured at right angles to the *edge seal length* (3.1.19)

Note 1 to entry: See Figure 2.

3.1.17
thickness
d
linear dimension measured perpendicularly to the length and width plane

3.1.18
surface area
A_{sur}
area of gas permeation plane of the test specimen

Note 1 to entry A_{sur} shall be determined by Formulae (1) and (2).

metallized film (MF) (3.1.6) on both sides:

$$A_{sur} = l_2 \times w_2 \times 2 \qquad (1)$$

MF on single side:

$$A_{sur} = l_2 \times w_2 \quad (2)$$

3.1.19
edge seal length
***l*_es_**

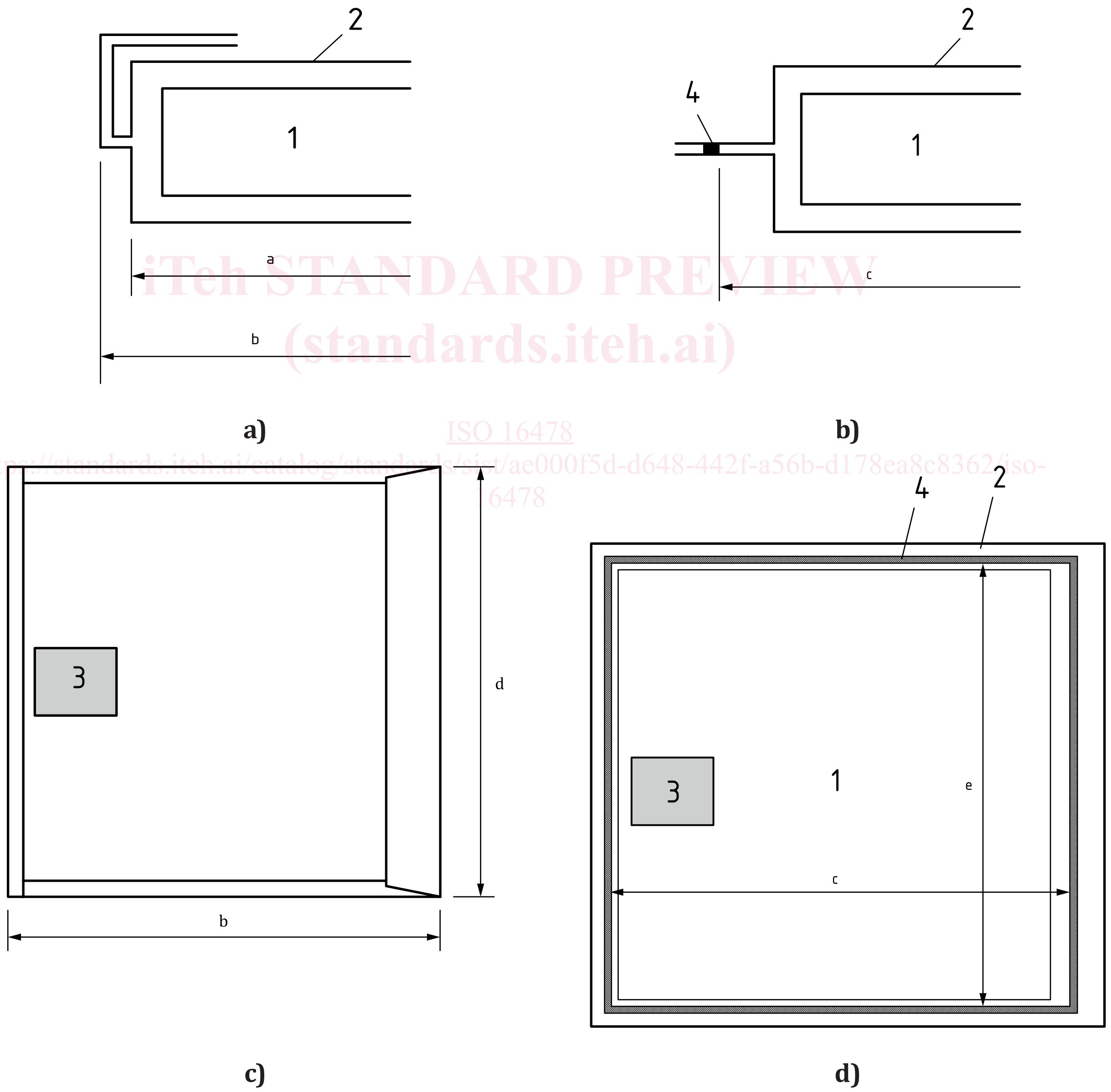
l_{es}

total length of the edge seal of the test specimen

Note 1 to entry: l_{es} shall be determined by Formula (3).

$$l_{es} = l_2 \times 2 + w_2 \times 2 \quad (3)$$

Dimensions in millimetres



Key

1 core material (3.1.4)

2 envelope (3.1.5)

3 adsorbent or desiccant

4 edge seal

a Core length, l_c,(3.1.13).

b Working length, l_w,(3.1.11).

c Length of edge seal, l_{es},(3.1.15).

d Working width, w_w, (3.1.12).

e Width of edge seal, w_{es}, (3.1.16).

Figure 2 — Dimensions of a VIP

3.1.20
centre of panel
COP
area of the *vacuum insulation panel (VIP)* (3.1.1) not affected by the *edge effect* (3.1.21)

3.1.21
edge effect
thermal bridging along the edge due to higher thermal conductivity of the outer *envelope* (3.1.5) compared to the *core material* (3.1.4)

3.1.22
aged value
expected mean thermal conductivity value at 25 years in specified laboratory conditions

3.2 Symbols and units

A	surface area of the VIP	m^2
A_m	metering area of the GHP or HFM apparatus used for measurement	m^2
A_N	nominal surface area of the VIP	m^2
A_{sp}	area of the specimen measured by hot box method	m^2
A_{sur}	surface area of gas permeation plane of the product	m^2
$A_{sur,sp}$	surface area of gas permeation plane of the specimen	m^2
C_{des}	capacity of the desiccant	g/g
$C_{des,20\ \%}$	capacity of the desiccant including a safety margin of 20 %	g/g
d	thickness	m
$d_{ambient}$	thickness of the ventilated VIP	m
d_N	nominal thickness of the product	m
d_{VIP}	thickness of the VIP	m
f_{air}	acceleration factor for dry air of the envelope	-

f_v	acceleration factor for water vapour of the VIP envelope	-
k	factor related to the number of test results available	-
l	length	m
l_c	core length	m
l_{es}	length of edge seal	m
l_w	working length	m
l_ψ	length of the joints within the metering area	m
m_1	initial water amount of core material	g
m_2	amount of adsorbed water vapour	g
m_{25a}	water vapour amount adsorbed over 25 years	g
m_{des}	mass of desiccant	g
$m_{des,1a}$	mass of the desiccant after test	g
$m_{des,1d}$	sufficient amount of desiccant	g
$m_{des,2a}$	mass of the desiccant before acceleration test	g
$m_{des,2c}$	mass of the desiccant after acceleration test	g
$m_{des,0}$	mass of the fully dried desiccant	g
$m_{des,sat}$	mass of the saturated desiccant	g
$m'_{t,air,\ 23/50}$	inner dry air mass increase rate at 23 °C, 50 % relative humidity (RH)	g/day
$m'_{t,v,\ 23/50}$	water vapour mass increase rate at 23 °C, 50 % RH	g/day
N	number of test results	-
P_{air}	air permeability of the VIP envelope	$m^3 \cdot Pa/(m^2 \cdot s)$
$P_{air,total,23/50}$	air permeability of the VIP envelope of the product at 23 °C, 50 % RH	g/(day·Pa)
$P_{air,total,sp,23/50}$	air permeability of the VIP envelope of the specimen at 23 °C, 50 % RH	g/(day·Pa)
$P_{air,A,23/50}$	air permeability of the film surface at 23 °C, 50 % RH	$g/(m^2 \cdot day \cdot Pa)$
$P_{air,l,23/50}$	air permeability of the edge seal at 23 °C, 50 % RH	g/(m·day·Pa)
P_v	water intake rate of the VIP envelope	$kg/(m^2 \cdot s)$
p_{air}	air pressure inside the VIP	Pa
$p_{air,atm}$	atmospheric pressure	Pa
p_{lim}	maximum value of the inner pressure measured at least 24 hours after production	Pa

p_v	water vapour pressure inside the VIP	Pa
$p_{v,out}$	atmospheric water vapour pressure	Pa
p_0	initial value of the inner pressure	Pa
$p_{1/2}$	inner pressure of VIP, where λ increases by 1/2 of the thermal conductivity of still air	Pa
$p'_{t,air,23/50}$	inner pressure increase rate at 23 °C, 50 % RH	Pa/day
$p'_{t,air,40}$	inner pressure increase rate at 40 °C	Pa/day
$p'_{t,air,60}$	inner pressure increase rate at 60 °C	Pa/day
$p'_{t,air,80}$	inner pressure increase rate at 80 °C	Pa/day
R_{aux}	thermal resistance of the auxiliary material	m²·K/W
R_D	declared thermal resistance	m²·K/W
R_{eq}	thermal resistance obtained by assuming the entire surface to be homogeneous calculated by the thermal transmittance	m²·K/W
$R_{s,t}$	total surface thermal resistance	m²·K/W
R_{mean}	mean thermal resistance	m²·K/W
R_{tot}	thermal resistance of VIP plus auxiliary material	m²·K/W
$R_{90/90}$	90 % fractile with a confidence level of 90 % for the thermal resistance	m²·K/W
S	top surface area (working length x working width) of the VIP	m²
S_b	deviation from squareness on width or length	mm/m
S_{MAX}	deviation from flatness	mm
S_N	nominal perimeter of the product	m
s_λ	estimate of the standard deviation of the thermal conductivity	W/(m·K)
T	temperature	K
t	time	s
t_{des}	lifetime of desiccant	a
U	thermal transmittance	W/(m²·K)
V	core volume of the product	m³
V_{sp}	core volume of the specimen	m³
V_{void}	void volume of core	m³
w	width	m
w_c	core width	m
w_{es}	width of edge seal	

w_{w}	working width	m
X	water content inside the VIP	mass-%
λ_{air}	thermal conductivity of still air	W/(m·K)
$\lambda_{ambient}$	thermal conductivity of a ventilated VIP at centre of the panel	W/(m·K)
λ_{cop}	thermal conductivity for centre of panel	W/(m·K)
$\lambda_{cop,mean}$(25 years)	average value of thermal conductivity over 25 years in use at centre of panel	W/(m·K)
$\lambda_{cop,90/90,aged}$	$\lambda_{90/90}$ at centre of panel plus ageing	W/(m·K)
λ_{D}	declared thermal conductivity	W/(m·K)
λ_{eq}	thermal conductivity including edge effect	W/(m·K)
$\lambda_{eq,ja}$	equivalent thermal conductivity including edge effect	W/(m·K)
λ_{mean}	mean value of thermal conductivity	W/(m·K)
λ_{i}	one test result of thermal conductivity	W/(m·K)
λ_{0}	thermal conductivity in the evacuated state	W/(m·K)
λ'_{p}	change of thermal conductivity with pressure	W/(m·K·Pa)
λ'_{t}	change of thermal conductivity with time	W/(m·K·s)
λ_{VIP}	thermal conductivity of the VIP	W/(m·K)
λ'_{X}	change of thermal conductivity with humidity	W/(m·K)/mass-%
$\lambda_{90/90}$	90 % fractile with a confidence level of 90 % of thermal conductivity	W/(m·K)
$\lambda'_{t,23/50}$	change of thermal conductivity with time at 23 °C 50 % RH	W/(m·K·s)
$\lambda'_{t,50/70}$	change of thermal conductivity with time at 50 °C 70 % RH	W/(m·K·s)
$\lambda_{cop}(t)$	time-dependent thermal conductivity value	W/(m·K)
$\lambda(t)_{,23/50}$	time dependent value of thermal conductivity at 23 °C 50 % RH	W/(m·K·s)
$\lambda(t)_{,50/70}$	time dependent value of thermal conductivity at 50 °C 70 % RH	W/(m·K·s)
$\lambda^{*}(t = 0)$	interpolated initial thermal conductivity	W/(m·K)
σ_{mt}	tensile strength perpendicular to faces	kPa
σ_{10}	compressive stress at 10 % deformation	kPa
φ	RH inside the VIP	%
φ'_{x}	change of RH inside the VIP as function of water content	(rel. humidity-%) /(mass-%)
Φ_{in}	quantity of heat generated in the hot box	W

Φ_l	quantity of heat loss from the hot box	W
Φ_{sur}	quantity of heat flow through the surround panel	W
ψ	linear thermal transmittance	W/(m·K)
ψ_m	linear thermal transmittance for the joints in the metering area	W/(m·K)
$\Delta\theta_n$	environmental temperature difference between both sides of the specimen	K

4 Requirements

4.1 General

Products shall be assessed in accordance with Clause 6 and meet the requirements as outlined in Clause 4.

All characteristics defined in Clause 4, if declared, shall be subject to product type determination (PTD) in accordance with Annex E. The minimum frequencies of tests in the factory production control (FPC) shall be in accordance with Annex E.

NOTE The manufacturer can choose to give information for additional properties (see Annex F).

4.2 Thermal resistance and thermal conductivity

4.2.1 General

Requirements of thermal resistance and thermal conductivity are given in Table 1.

Table 1 — Thermal resistance and thermal conductivity

Property	Thermal resistance R $m^{2+}K/W$	Thermal conductivity λ W/(m·K)
Initial value of centre of panel (COP) ($\lambda_{cop,90/90}$, $R_{cop,90/90}$)	> 1,6	< 0,005
Initial value including thermal bridging (λ_D)	—	Declare
Aged value of COP ($\lambda_{cop,90/90}$, $R_{cop,90/90}$)	> 0,8	< 0,010
Aged value including thermal bridging ($\lambda_{90/90,aged}$)	—	Declare

4.2.2 Initial COP thermal properties

The initial value of COP, $R_{cop,90/90}$ and $\lambda_{cop,90/90}$ shall be determined by using Formulae (4) and (5) and shall not exceed the limits given in Table 1.

$$\lambda_{cop,90/90} = \lambda_{mean} + k \times s_\lambda \quad (4)$$

$$R_{cop,90/90} = \frac{d_N}{\lambda_{cop,90/90}} \quad (5)$$

4.2.3 Size dependent value

4.2.3.1 General

Edge effect and ageing effect depends on the size of VIP.

The value, including thermal bridging and aged value, shall be declared according to Method A. In addition, for better comparison between different products, the thermal resistance and thermal conductivity shall be declared according to Method B for panels when at least one of their dimensions (length or width) is smaller than 250 mm.

Method A: Respective panel size of VIP as placed on the market;

Method B: Following a set of reference dimensions (length × width × thickness) of VIP:

a) 0,3 m × 0,3 m × 0,01 m;

b) 1,0 m × 0,5 m × 0,01 m;

c) 0,3 m × 0,3 m × 0,03 m;

d) 1,0 m × 0,5 m × 0,03 m.

More details regarding initial values including thermal bridging, aged value of COP and aged value including thermal bridging are provided in 4.2.3.2, 4.2.3.3 and 4.2.3.4, respectively.

4.2.3.2 Initial value including thermal bridging

Thermal conductivity, including thermal bridging along edges, λ_D, shall be determined by using Formulae (6) and (7) and shall be declared.

$$\lambda_D = \lambda_{cop,90/90} + \Delta\lambda_{edge} \tag{6}$$

$$\Delta\lambda_{edge} = \psi \times d_N \times \frac{S_N}{S} \tag{7}$$

4.2.3.3 Aged COP thermal properties

Aged value of COP, $\lambda_{90/90,\,aged}$ and $R_{cop,90/90,aged}$, shall be determined by using Formulae (8) and (9) and shall not exceed the limits provided in Table 1.

$$\lambda_{cop,90/90,aged} = \lambda_{cop,90/90} + \Delta\lambda_{cop,mean}\,(25\text{ years}) \tag{8}$$

$$R_{cop,90/90,aged} = \frac{d_N}{\lambda_{cop,90/90,aged}} \tag{9}$$

4.2.3.4 Aged value including thermal bridging

Aged value including thermal bridging, $\lambda_{90/90,aged}$, shall be determined by using Formula (10) and shall be declared.

$$\lambda_{90/90,aged} = \lambda_D + \Delta\lambda_{cop,mean}\,(25\text{ years}) \tag{10}$$

4.3 Length, width, squareness and flatness

The tolerance of core length, core width, squareness and flatness for silica core VIP and for glass fibre core VIP shall not exceed the limits given in Tables 2 and 3 respectively.