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



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

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 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

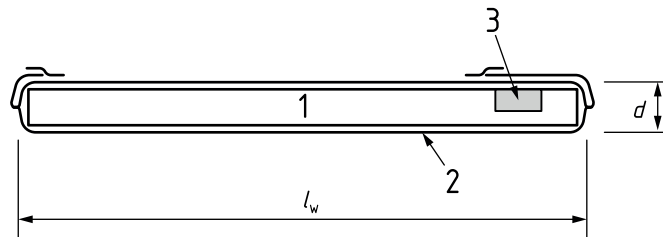
3.1.1

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](#).

**Key**

- 1 core material
- 2 envelope
- 3 adsorbent
- d thickness (3.1.17)
- l_w working length (3.1.11)

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 \(1\)](#) or [\(2\)](#).

metallized film (MF) ([3.1.6](#)) on both sides:

$$A_{\text{sur}} = l_2 \times w_2 \times 2$$

MF on single side:

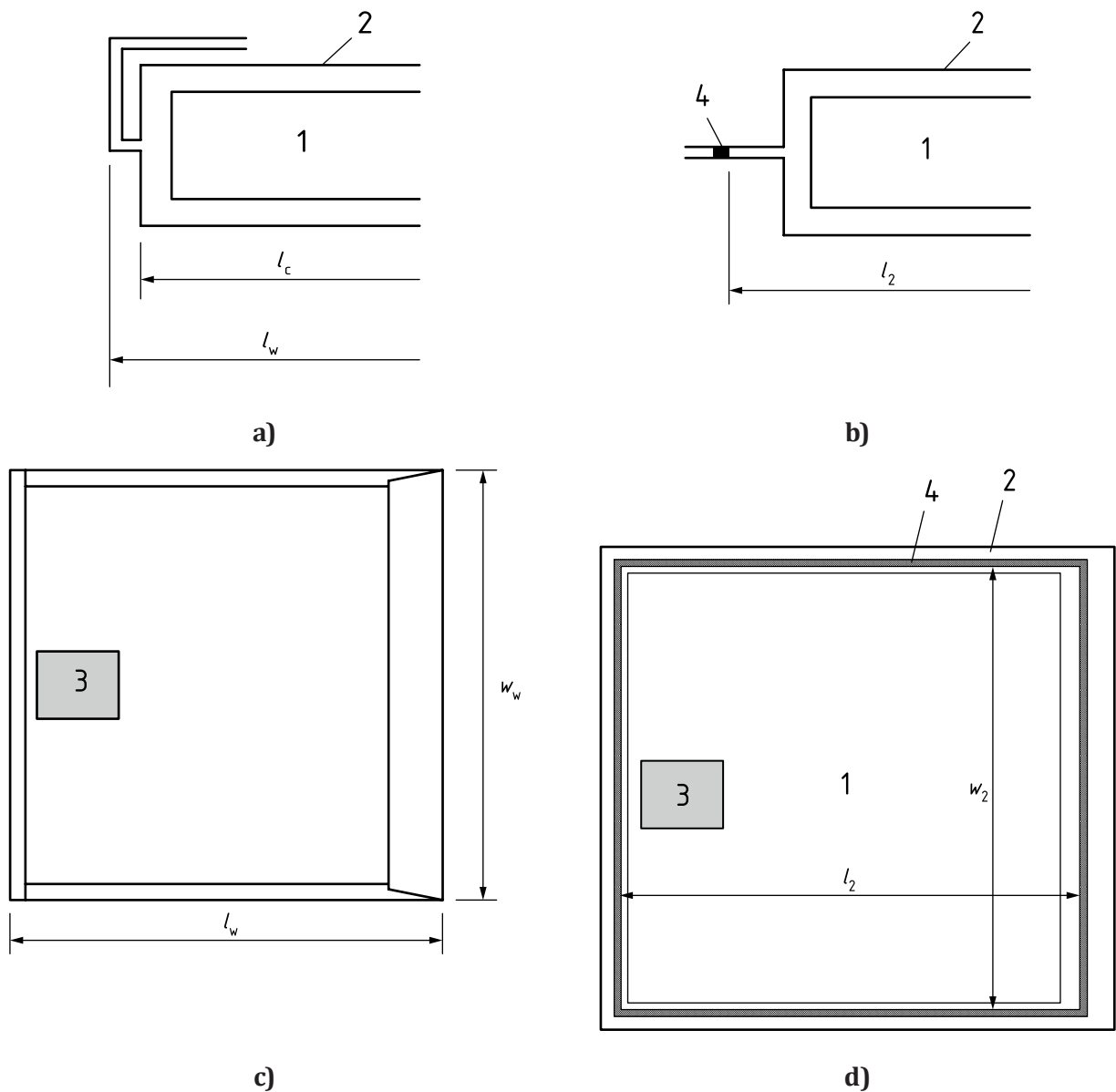
$$A_{\text{sur}} = l_2 \times w_2 \quad (2)$$

3.1.19 edge seal length

l_{es}
total length of the edge seal of the test specimen

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

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



Key

- 1 core material ([3.1.4](#))
- 2 envelope ([3.1.5](#))
- 3 adsorbent or desiccant
- 4 edge seal
- l_c core length ([3.1.13](#))
- l_w working length ([3.1.11](#))
- l_2 length of edge seal ([3.1.15](#))
- w_w working width ([3.1.12](#))
- w_2 width of edge seal ([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_2	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/($m \cdot day \cdot Pa$)
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	m ² ·K/W
R_D	declared thermal resistance	m ² ·K/W
R_{eq}	thermal resistance obtained by assuming the entire surface to be homogeneous calculated by the thermal transmittance	m ² ·K/W
$R_{s,t}$	total surface thermal resistance	m ² ·K/W
R_{mean}	mean thermal resistance	m ² ·K/W
R_{tot}	thermal resistance of VIP plus auxiliary material	m ² ·K/W
$R_{90/90}$	90 % fractile with a confidence level of 90 % for the thermal resistance	m ² ·K/W
S	top surface area (working length x working width) of the VIP	m ²
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/(m ² ·K)
V	core volume of the product	m ³
V_{sp}	core volume of the specimen	m ³
V_{void}	void volume of core	m ³
w	width	m
w_c	core width	m
w_2	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)
λ_{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)
$\lambda_{\text{cop,mean}}(25 \text{ years})$	average value of thermal conductivity over 25 years in use at centre of panel	W/(m·K)
$\lambda_{\text{cop,90/90,aged}}$	$\lambda_{90/90}$ 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)
$\lambda_{\text{eq,ja}}$	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)
$\lambda_{\text{cop}}(t)$	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	Thermal conductivity
	R m ² ·K/W	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 ($\lambda_{cop,90/90,aged}$, $R_{cop,90/90,aged}$)	> 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](#).

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

(4)

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

(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.

$$\lambda_D = \lambda_{\text{cop},90/90} + \Delta\lambda_{\text{edge}} \quad (6)$$

$$\Delta\lambda_{\text{edge}} = \psi \times d_N \times \frac{S_N}{S} \quad (7)$$

4.2.3.3 Aged COP thermal properties

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

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

$$R_{\text{cop},90/90, \text{aged}} = \frac{d_N}{\lambda_{\text{cop},90/90, \text{aged}}} \quad (9)$$

4.2.3.4 Aged value including thermal bridging

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

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

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.

Table 2 — Tolerances of length, width, squareness and flatness for silica core VIP

Tolerance				
Core length and core width			Squareness on length and width	Flatness
$(l_c, w_c) < 500$ mm	$500 \text{ mm} \leq (l_c, w_c) \leq 1\,000$ mm	$(l_c, w_c) > 1\,000$ mm	S_b	$S_{\max}$
mm			mm/m	mm
± 4	± 5	± 6	5	6

Table 3 — Tolerances of length, width, squareness and flatness for glass fibre core VIP

Tolerance				
Core length and core width			Squareness on length and width	Flatness
$(l_c, w_c) < 500$ mm	$500 \text{ mm} \leq (l_c, w_c) \leq 1\,000$ mm	$(l_c, w_c) > 1\,000$ mm	S_b	$S_{\max}$
mm			mm/m	mm
± 5	± 5	± 6	10	6

4.4 Thickness

The tolerance of thickness shall not exceed the limits given in [Table 4](#).

Table 4 — Tolerances of thickness

Thickness mm	Tolerance mm	
	Silica core VIP	Glass fibre core VIP
≤ 10	$\pm 0,5$	± 1
$10 < d_N \leq 20$	± 1	± 2
$20 < d_N \leq 30$	$\pm 1,5$	± 3
> 30	± 2	± 4

4.5 Dimensional stability

The relative changes in length and width shall not exceed 1 %, and the relative change in thickness shall not exceed 3 %.

5 Sampling

The laboratory conducting the testing shall be responsible for random sampling of VIP.

6 Test methods

6.1 General

One test result for a product property is the average of the measured values on the number of test specimens mentioned in [Table 5](#).

Unlike other insulating materials, VIPs cannot be cut to the size required by the test standards. They shall be produced in the sizes stated in [Table 5](#).

Table 5 — Test methods and test specimens

Clause number in ISO 16478 (this document)	Test method	Test specimen length and width ^a	Minimum number of measurements to get one test result
6.2.1	ISO 8301 or ISO 8302	≥ 300	10
6.2.2	Annex A	≥ 300	1
6.2.3	Annex B	≥ 300	2 per condition
	Annex C	≥ 300	3 per condition
6.3	6.3.1	Full-size	3
6.3	6.3.2	Full-size	3
6.3	6.3.3	Full-size	3
6.4	6.4	Full-size	3
6.5	ISO 29472	≥ 200	3
^a Full-size product thickness when the limits of the test methods are exceeded.			

6.2 Thermal resistance and thermal conductivity

6.2.1 General

The thermal conductivity and the thermal resistance shall be rounded upwards in steps of 0,000 5 W/(m·K) and downwards to the nearest 0,05 m²·K/W, respectively.

6.2.2 Initial COP thermal properties

Thermal resistance and thermal conductivity within 2 d to 30 d after production shall be determined in accordance with ISO 8301 or ISO 8302 under the following conditions:

- at a mean reference temperature of 10 °C or 23 °C;
- after conditioning the test specimen at (23 ± 2) °C and (50 ± 5) % relative humidity (RH) for at least 24 h.

$\lambda_{\text{cop},90/90}$ shall represent at least 90 % of the production, determined with a confidence level of 90 % in accordance with ISO 10456.

The measurement shall be carried out directly on the VIP, or, for uneven surfaces, to avoid air gaps. The measurement shall be carried out with the VIP positioned between two flexible contact sheets of another insulation material of known thermal conductivity (“auxiliary material”). The thermal conductivity λ_{VIP} can be calculated from the total thermal resistance R_{tot} of the composites, the thermal resistance of the auxiliary material R_{aux} and the measured thickness of VIP using [Formula \(11\)](#).

$$\lambda_{\text{VIP}} = \frac{d_{\text{N}}}{R_{\text{tot}} - R_{\text{aux}}} \quad (11)$$

6.2.3 Linear thermal transmittance

Linear thermal transmittance, ψ , shall be determined in accordance with [Annex A](#).

6.2.4 Aged thermal properties (25 years)

Aged $\Delta\lambda_{\text{cop,mean}}$ (25 years) for silica core VIP and for glass fibre core VIP shall be determined in accordance with [Annexes B](#) and [C](#), respectively.

6.3 Length, width, squareness and flatness

6.3.1 General

Length, l , and width, w , shall be determined in accordance with ISO 29465. The seams and folded edges or ends shall not be included in the measurement. The deviation from squareness on length and width, S_b , shall be determined in accordance with ISO 29467. The deviation from flatness, S_{max} , shall be determined in accordance with ISO 29468.

6.3.2 Length and width

ISO 29465 applies with the following recommendation:

- Considering the welding or folding of the envelope of the product, it is recommended to pinch the panel with a flat bar and measure the distance between them.

6.3.3 Squareness on length and width

- ISO 29467 is normally applicable to products with straight edges. ISO 29467 stipulates that it can be adapted accordingly for products of other shapes such as profiles edges.
- The determination of the squareness for length and width shall be done by measuring the deviation on all sides of the test specimen, the test specimen laying on a flat surface. Therefore, there are four points to be measured, one for each side. The 4 values of linearity deviation for each side shall be recorded.
- If the squareness concerns a field having a welding or folding of the envelope, the measurements shall be carried out twice by turning the test specimen upside down on the flat side. In this case, the number of measurements rises from four values to eight values.
- The test report shall include all individual values measured for deviation from squareness for length and width and from linearity, specifying if the measurements are made on the short or the long edge.
- If the summit to be measured has an angle greater than 90° , the measurement cannot be done (it will be obtained by turning the panel over on the other side), the indication "angle > 90° " shall be mentioned in the test report (different from 0).
- All of the measurements shall be recorded in the test report.

6.3.4 Flatness

ISO 29468 applies with the following recommendations:

- The panel shall be laid down on the opposite side of any welding or folding of the envelope of the products.
- The measuring points as stated in the standard shall exclude the welding or folding areas of the envelopes of the products.

6.4 Thickness

If there is neither folding nor welding of the envelope on both measured sides, ISO 29466 applies, with a load plate of 250 Pa.

If the products show welding or folding of the envelope on at least one of the areas being measured, these shall be measured while applying different load plates.