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Thermal performance of windows and doors — Determination of thermal transmittance by hot box method —

Part 2: Roof windows and other projecting windows

Isolation thermique des fenêtres et portes — Détermination de la transmission thermique par la méthode à la boîte chaude —

Partie 2: Fenêtres de toit et autres fenêtres en saillie

Reference number
ISO 12567-2:2005(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 12567-2 was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 1, *Test and measurement methods*.

ISO 12567 consists of the following parts, under the general title *Thermal performance of windows and doors — Determination of thermal transmittance by hot box method*:

— *Part 1: Complete windows and doors*

— *Part 2: Roof windows and other projecting windows.*

Introduction

This part of ISO 12567 should be read together with ISO 12567-1:2000 *Thermal performance of windows and doors — Determination of thermal transmittance by hot box method — Part 1: Complete windows and doors*. These two parts were jointly developed by ISO and CEN. They are designed to provide standardised thermal transmittance test values, to enable product comparisons to be made. ISO 12567-1:2000 specifies standardised specimen sizes and applied test criteria.

It is recognised that the thermal performance of products will vary with heat flow direction and so it is preferable to test these products at the orientation in which they will be installed. However, as there are only a few hot boxes capable of carrying out such measurements, this measurement procedure specifies that it is acceptable to measure the thermal transmittance of roof windows mounted vertically to facilitate the fair comparison of products.

It should be noted that measurements with the specimen mounted vertically will generally produce U-values lower than those measured at other orientations with heat flow up. An alternative to measuring at the actual orientation that will be used in practice is to carry out calculations of convective and radiant heat transfer using the procedures specified in ISO 15099, ISO 10077-1, ISO 10077-2 and EN 673.

Thermal performance of windows and doors — Determination of thermal transmittance by hot box method —

Part 2: Roof windows and other projecting windows

1 Scope

This part of ISO 12567 specifies a method to measure the thermal transmittance of roof windows and projecting windows.

It does not include:

— edge effects occurring outside the perimeter of the specimen;

— energy transfer due to solar radiation on the specimen;

— effects of air leakage through the specimen.

2 Normative references

The following referenced documents are indispensable for the application 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 7345:1987, *Thermal insulation — Physical quantities and definitions*

ISO 8990:1994, *Thermal insulation — Determination of steady-state thermal transmission properties — Calibrated and guarded hot box*

ISO 12567-1:2000, *Thermal performance of windows and doors — Determination of thermal transmittance by hot box method — Part 1: Complete windows and doors*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7345 and ISO 12567-1 and the following apply.

3.1
projecting windows
product, where any glazing layer projects beyond the outside surface of the building envelope

3.2
roof windows
any framed glazed product installed in a sloped or horizontal building envelope

NOTE 1 Roof windows are treated as projecting windows.

NOTE 2 See also Reference [1] in Bibliography.

4 Principle

This part of ISO 12567 is based on a measurement procedure for roof windows and other projecting windows, in accordance with the procedure specified in ISO 12567-1:2000, except for the deviations specified below:

— the window is installed in the surround panel flush to the cold side (insert- or kerb-mounted as shown in Figure 1), to reflect the installation in practice;

— the calibration procedure and the specimen tests shall be carried out at the same orientation;

— for practical reasons, vertical mounting of the specimen is acceptable for product declaration purpose.

Although the evaluation of the thermal performance of these types of products will be made for a variety of reasons, it is important that when measurements are made for purposes of product comparison, they are carried out at the same orientation.

NOTE For building load or energy calculations, the value may be corrected for the effect of the sloped glazing position using suitable national procedures.

5 Requirements for test specimens and apparatus

5.1 General

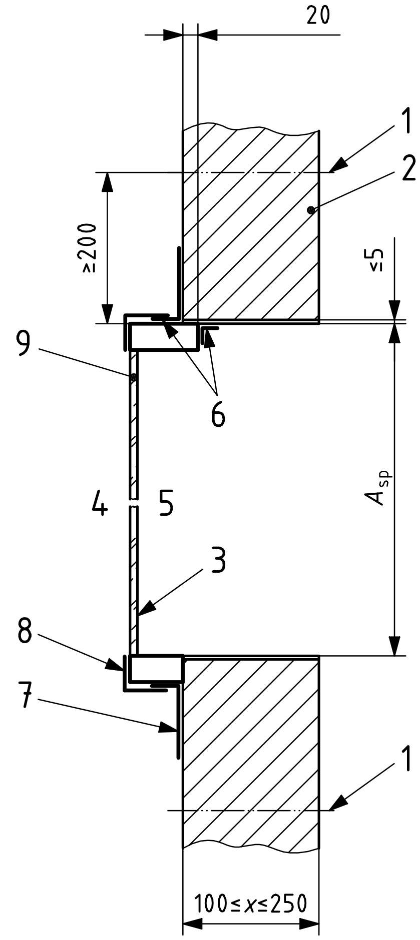
The construction and operation of the apparatus shall comply with the requirements specified in ISO 8990:1994 except where modified by ISO 12567-1:2000 and this document.

5.2 Test specimen location

The test specimen shall be mounted in the surround panel aperture according to the manufacturer's instructions. If the method of installation of the roof window in the hot box cannot be unambiguously determined from the manufacturer's installation instructions, the window shall be installed as shown in Figure 1. Flashings and/or kerb (curb) shall be included as the windows are normally installed (see Figure 1).

NOTE Kerb and curb are synonymous.

Dimensions in millimetres



Key

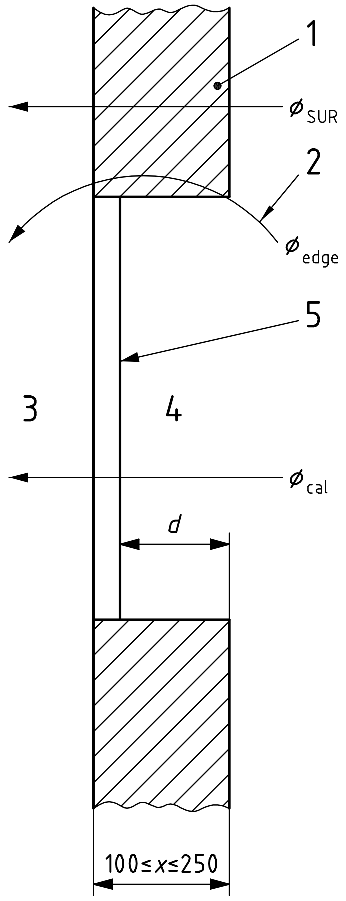
1 border of metering area
2 surround panel, $\lambda \leqslant 0.04$ W/(m·K)
3 glazing
4 cold side
5 warm side
6 to be sealed with non-metallic tape or mastic material
7 flashing
8 kerb-mounted roof window
9 insert-mounted roof window

Figure 1 — Roof window in surround panel (top part: insert-mounted; bottom part: kerb-mounted)

5.3 Calibration panels

The calibration panels or CTS (calibration transfer standard) shall be mounted in the surround panel aperture flush with the cold face as shown in Figure 2.

Dimensions in millimetres



Key

1 surround panel

2 boundary effects

3 cold side

4 warm side

5 calibration panel

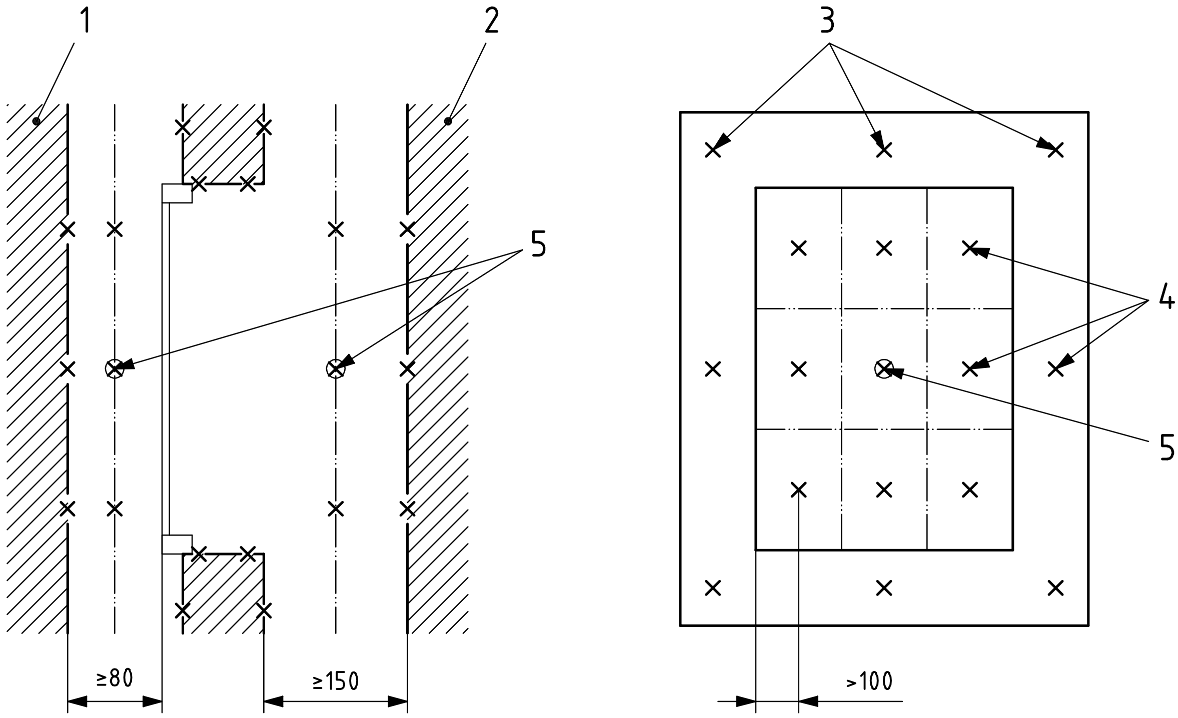
Figure 2 — Mounting of calibration panel in aperture

5.4 Baffle position

The distance between the baffle on the cold side and the glazing of the test specimen shall not be less than 80 mm, see Figure 3.

For air speeds greater than 2 m/s, the distance between baffle and specimen shall be greater than 80 mm in order to ensure free stream conditions.

Dimensions in millimetres



a) Vertical section

b) Face elevation

Key

1 cold side baffle

2 warm side baffle

3 all surround panel thermocouples located centrally

4 air temperature sensors

5 recommended position of air speed sensor aligned in the centre

Figure 3 — Location of temperature sensors and air speed sensor

6 Procedure

6.1 General

The measurement shall be carried out under the conditions specified in ISO 12567-1:2000, except for the deviations indicated in 6.2, 6.3 and 6.4.

6.2 Calibration measurements

Calibration measurements shall be made according to ISO 12567-1:2000, 6.2.

If calibration data for the surround panel thermal resistance R_{sur} have been already measured according to ISO 12567-1:2000, the calibration results may be used.

The notation for determination of the environmental temperature for roof or projecting windows according to the procedure indicated in ISO 12567-1:2000 is given in Figure A.1. For the determination of the heat flow rate through the edge zone, Φ_{edge}, between calibration panel and surround panel [ISO 12567-1:2000, Equation (10)], values for the linear thermal transmittance of the edge zone, ψ_{edge}, are given in Table B.1.

6.3 Specimen measurements

After installation of the test specimen, the air velocity on the cold side shall be adjusted to give the same air velocity (within ± 10 %) as found with the calibration panel, when setting the total surface thermal resistance, $R_{s,t}$. For the determination of Φ_{edge}, the heat flow rate through the edge zone between test specimen and surround panel [Equation (10)], values for the linear thermal transmittance of the edge zone, ψ_{edge}, are given in Table B.2 (insert mounting) and in Table B.3 (kerb mounting).

The specimen area A_{sp} is the area of the aperture in the surround panel.

6.4 Expression of results

The result is expressed as given in ISO 12567-1:2000, 6.3. For projecting products, no correction is made for the effect of the density of heat flow rate, q, on the total surface resistance, $R_{s,t}$, as specified in ISO 12567-1:2000, 6.3.

An example of a calibration measurement and roof window test is given in Annex C.

7 Test report

The test report shall contain the information specified in ISO 12567-1:2000. In addition, the following shall be stated:

a) inclination of the tested window;

b) all details (see Annex C) of how the specimen was installed in the surround panel, including the area of the specimen A_{sp}, used to calculate the thermal transmittance.

NOTE The thermal transmittance, as measured with the window in the vertical position, may be used for the purposes of product comparisons. For building load or energy calculations, the value may be corrected using suitable national procedures.

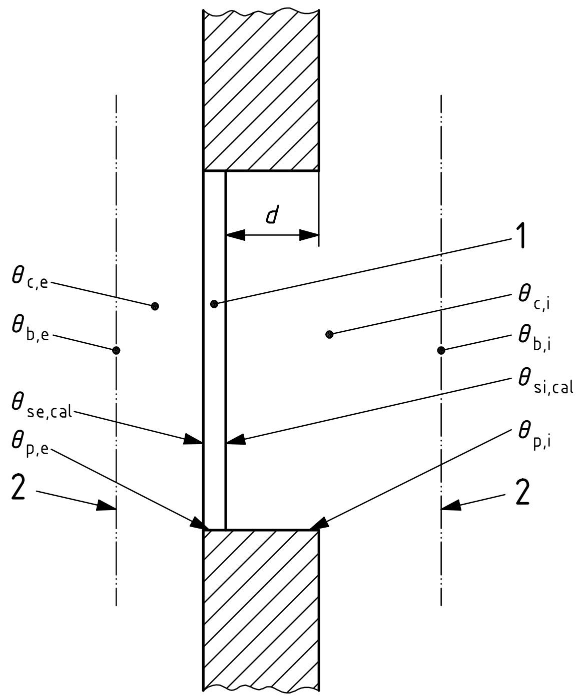
Annex A
(normative)

Environmental temperature

The concept of environmental temperatures as laid down in ISO 12567-1:2000, Annex A, is used.

A.1 General

In this Annex, the notations shown in Figure A.1 are used.



Key

1 calibration panel or test specimen

2 baffle

$\theta_{s,cal}$ average surface temperature of the calibration panel, in °C

θ_p average surface temperature of the reveal of surround panel (top, side, bottom), in °C

θ_b average surface temperature of the baffle, in °C

θ_c average air temperature, in °C

d depth of reveal, expressed in millimetres

Figure A.1 — Notation used for environmental temperature θ_n in relation to the calibration panel

A.2 Environmental temperature

The environmental temperature, θ_n, is the weighting of the radiant temperature θ_r and the air temperature, θ_c. Calculate the environmental temperature θ_n, in °C, on both sides using Equation (A.1):

$$\theta_n = \frac{h_c \cdot \theta_c + h_r \cdot \theta_r}{h_c + h_r} = F_c \cdot \theta_c + (1 - F_c) \cdot \theta_r \quad \text{(A.1)}$$

where

h is the surface heat transfer coefficients, in W/(m²·K);

θ is the temperature in °C;

c is an index referring to mean air temperature;

r is an index referring to mean radiant temperature.

The convective fraction, F_c, on the warm side and the cold side, shall be derived from the calibration measurements as a function of the density of heat flow rate, q_{cal} (see example given in Figure C.2).

A.3 Mean radiant temperature

The mean radiant temperature, θ_r, in °C, of the surfaces «seen» by the surface of the test specimen (calibration panel or window) shall be calculated using one of the following equations.

The mean radiant temperature on the cold side is calculated as an area weighted mean temperature of all surfaces «seen» by the specimen. If there is a baffle parallel to the surround panel, then the baffle temperature may be used as the mean radiant temperature.

For the warm side of the calibration panel or test specimen, an idealised plane area for radiation heat exchange is assumed (see Figure A.2). The heat exchange is calculated according to ISO 12567-1:2000, Annex A.

a) If $|\theta_b - \theta_p| \leqslant 5$ K then Equation (A.2) is used:

$$\theta_r = \frac{\alpha_{cb}\theta_b + \alpha_{cp}\theta_p}{\alpha_{cb} + \alpha_{cp}} \quad \text{(A.2)}$$

b) Otherwise Equation (A.3) is used:

$$\theta_r = \frac{\alpha_{cb} h_{cb} \theta_b + \alpha_{cp} h_{cp} \theta_p}{\alpha_{cb} h_{cb} + \alpha_{cp} h_{cp}} \quad \text{(A.3)}$$

The radiant heat transfer coefficient, h_r, in W/(m²·K), is calculated using Equation (A.4):

$$h_r = \alpha_{cb} h_{cb} + \alpha_{cp} h_{cp} \quad \text{(A.4)}$$

where h_{cb}, h_{cp} are the black body radiant heat transfer coefficients calculated using Equations (A.5) and (A.6):

$$h_{cb} = \sigma (T_{cal}^2 + T_b^2)(T_{cal} + T_b) \quad \text{(A.5)}$$

$$h_{cp} = \sigma (T_{cal}^2 + T_p^2)(T_{cal} + T_p) \quad \text{(A.6)}$$

where

σ is the Stefan-Boltzmann constant, $\sigma = 5{,}67 \times 10^{-8}$ in $W/(m^2 \cdot K^4)$;

α_{cb}, α_{cp} are radiation factors from the baffle to the calibration panel or window and the surround panel reveals to the calibration panel or window calculated using ISO 12567-1:2000, Equations (A.8) and (A.9).

The values of h_{cb} and h_{cp} are calculated from the data set of the calibration panel and can be used for all specimens with the appropriate cold side temperatures.

View factors depending on the depth of surround panel reveal, d, for the standardised test aperture are given in ISO 12567-1:2000, Tables A.1 and A.2.

For an aperture size of 1 140 mm × 1 400 mm (width × height), the view factors are given in Table A1.

Table A.1 — w factors for a 1 140 mm × 1 400 mm (width × height) aperture

Type of view factor [a]	Value for the reveal depth, d mm				
	50	**100**	**150**	**200**	**250**
f_{cb}	0,926	0,859	0,798	0,742	0,691
f_{pp}	0,065	0,113	0,155	0,191	0,225
$f_{cp} = f_{bp} = 1 - f_{cb}$ [a]	0,074	0,141	0,202	0,258	0.,309
$f_{pb} = (1 - f_{pp}) / 2$ [a]	0,467	0,443	0,423	0,404	0,387

[a] In accordance with ISO 12567-1:2000.

Alternatively, the following approximating formulae can be used:

$$f_{cb} = 1 - 1{,}4 \times d \quad ; \quad f_{pp} = 1{,}1 \times d \tag{A.7}$$

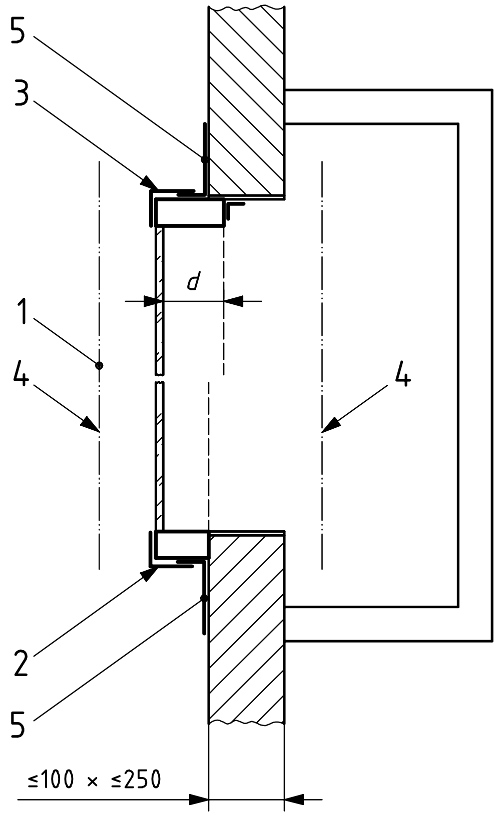
A.4 Convective surface heat transfer coefficient

The convective surface heat transfer coefficient, h_c, shall be calculated for the warm and cold side using Equation (A.8):

$$h_c = \frac{q_{cal} - h_r \left|\theta_r - \theta_{cal}\right|}{\left|\theta_c - \theta_{cal}\right|} \tag{A.8}$$

where q_{cal} is the density of heat flow rate through the calibration panel, in W/m^2.

Dimensions in millimetres



Key

1 location of temperature sensors on the cold side that can exchange radiation with the test specimen
2 kerb-mounted roof window
3 insert-mounted roof window
4 baffle
5 flashing

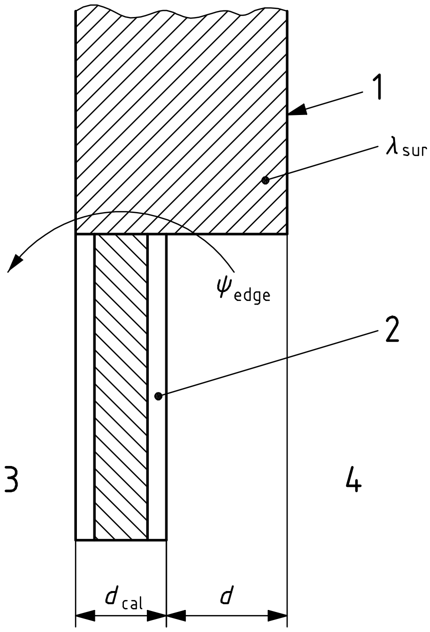
Figure A.2 — Notation used for environmental temperatures in relation to the window specimen

Annex B
(normative)

Linear thermal transmittance of the edge zone

Figures B.1, B.2 and B.3 show the notation used in Tables B.1, B.2 and B.3, respectively, to calculate the thermal transmittance.

Dimensions in millimetres



Key

1 surround panel

2 calibration panel

3 cold side

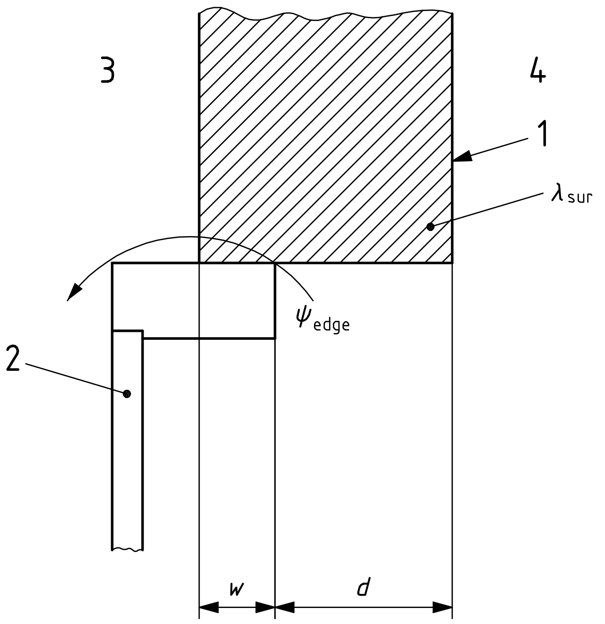
4 warm side

Figure B.1 — Glazed calibration panel with thickness d_{cal}

Table B.1 — Linear thermal transmittance, Ψ, for thick glazed calibration panel

d mm	Ψ_{edge} for d_{cal} = 60 mm W/(m·K)			Ψ_{edge} for d_{cal} = 100 mm W/(m·K)		
	λ_{sur} = 0,030 W/(m·K)	λ_{sur} = 0,035 W/(m·K)	λ_{sur} = 0,040 W/(m·K)	λ_{sur} = 0,030 W/(m·K)	λ_{sur} = 0,035 W/(m·K)	λ_{sur} = 0,040 W/(m·K)
0	na	na	na	0,000 1	0,000 2	0.000 2
20	na	na	na	0,001 3	0,001 5	0,001 7
40	0,004 6	0,005 3	0,006 0	0,003 0	0,003 4	0,003 9
60	0,007 2	0,008 3	0,009 4	0,004 6	0,005 3	0,005 9
80	0,009 5	0,011 0	0,012 4	0,006 0	0,007 1	0,007 9
100	0,011 7	0,013 5	0,015 2	0,007 4	0,008 8	0,009 8
120	0,013 7	0,015 8	0,017 7	0,008 8	0,010 4	0,011 6
140	0,015 6	0,018 0	0,019 9	0,010 0	0,012 0	0,013 3
160	0,017 3	0,019 9	0,021 9	na	na	na
180	0,019 0	0,021 7	0,023 7	na	na	na
NOTE The Ψ- values for intermediate λ_{sur}, d_{cal} and d values are obtained by linear interpolation.						

Dimensions in millimetres



Key

1 surround panel

2 test specimen

3 cold side

4 warm side

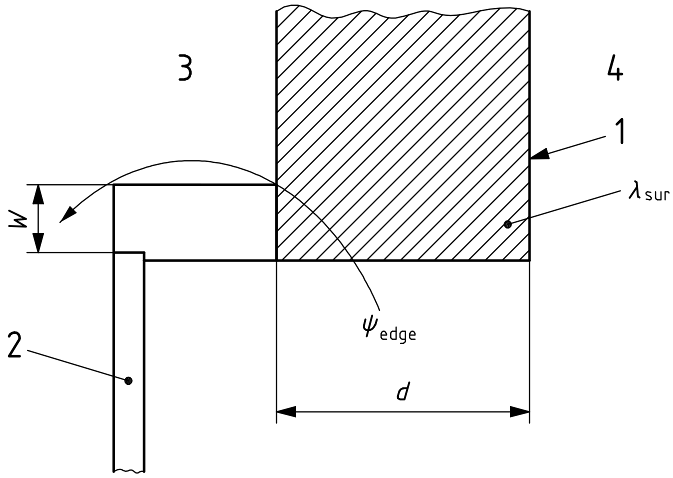
Figure B.2 — Insert-mounted test specimen with depth of frame insertion w

Table B.2 — Linear thermal transmittance, Ψ, for insert-mounted test specimens

w mm	d mm	Ψ_{edge} W/(m·K) λ_{sur} = 0,030 W/(m·K)	λ_{sur} = 0,035 W/(m·K)	λ_{sur} = 0,040 W/(m·K)
0	100	0,035 9	0,040 0	0,044 1
	150	0,042 8	0,047 6	0,052 5
	200	0,047 4	0,053 3	0,058 9
	250	0,051 4	0,057 8	0,064 0
10	90	0,026 7	0,030 1	0,033 2
	140	0,033 4	0,037 7	0,041 9
	190	0,038 3	0,043 4	0,048 2
	240	0,042 2	0,047 9	0,053 3
20	80	0,021 6	0,024 8	0,027 3
	130	0,028 1	0,031 8	0,035 4
	180	0,033 0	0,037 5	0,041 8
	230	0,037 0	0,042 0	0,046 9
30	70	0,019 0	0,021 3	0,023 5
	120	0,025 5	0,028 7	0,031 9
	170	0,030 3	0,034 4	0,038 2
	220	0.,034 2	0.,038 8	0,043 3
40	60	0,017 1	0,019 1	0,020 9
	110	0,023 6	0,026 5	0,029 3
	160	0,028 4	0,032 0	0,035 6
	210	0,032 3	0,036 5	0,040 7
50	50	0,016 2	0,018 0	0,019 7
	100	0,022 5	0,025 2	0,027 9
	150	0,027 3	0,030 8	0,034 1
	200	0,031 3	0,035 3	0,039 2
60	40	0,014 6	0,016 3	0,017 8
	90	0,020 9	0,023 4	0,025 8
	140	0,025 6	0,028 8	0,032 0
	190	0,029 6	0,033 4	0,037 1

NOTE The Ψ-values for intermediate λ_{sur}, d_{cal} and d values can be obtained by linear interpolation.

Dimensions in millimetres



Key

1 surround panel

2 test specimen

3 cold side

4 warm side

Figure B.3 — Kerb-mounted test specimen with kerb width w

Table B.3 — Linear thermal transmittance for kerb-mounted test specimens

w mm	d mm	Ψ_{edge} in W/(m·K) λ_{sur} = 0,030 W/(m·K)	 λ_{sur} = 0,035 W/(m·K)	 λ_{sur} = 0,040 W/(m·K)
10	100	0,029 0	0,032 4	0,035 7
	150	0,035 3	0,039 8	0,044 0
	200	0,040 4	0,045 6	0,050 7
	250	0,044 4	0,050 3	0,055 9
20	100	0,020 5	0,022 9	0,025 1
	150	0,026 1	0,030 9	0,034 8
	200	0,031 1	0,036 9	0,041 8
	250	0,035 6	0,041 5	0,046 8
30	100	0,014 0	0,015 7	0,017 4
	150	0,021 8	0,024 3	0,027 0
	200	0,027 1	0,030 4	0,033 9
	250	0,030 7	0,034 7	0,038 9
40	100	0,008 9	0,010 1	0,011 1
	150	0,015 6	0,018 3	0,020 4
	200	0,021 0	0,024 5	0,027 4
	250	0,025 3	0,029 2	0,032 7
50	100	0,003 6	0,004 1	0,005 1
	150	0,011 2	0,012 9	0,014 5
	200	0,016 9	0,019 4	0,021 8
60	100	0,000 7	0,000 7	0,000 7
	150	0,008 6	0,009 7	0,010 9
	200	0,014 3	0,016 3	0,018 3

Annex C
(informative)

Example of calibration test and measurement of a roof window specimen

C.1 Calibration test with panel size 1,23 m × 1,48 m (width × height)

Two calibration panels with total thermal resistance of approximately 0,3 $(m^2 \cdot K)/W$ and 1,5 $(m^2 \cdot K)/W$, and total thickness of 17 mm and 58 mm, respectively, were used. The panels were built with an insulating core covered on both sides with 4 mm hardened glass. The calibration panels were installed in a surround panel made of polystyrene, with a thickness of 240 mm. The measured data are summarized in Table C.1.

The basic data for the calibration panel have been measured in a hot plate apparatus according to ISO 8302. The measured data are:

Panel 1(d = 17 mm): $R_{cal} = 0,317\,8 - 0,000\,2 \cdot \theta_{me}$
Panel 2 (d = 58 mm): $R_{cal} = 1,471\,9 - 0,000\,8 \cdot \theta_{me}$

where θ_{me} is the mean core temperature in degrees Celsius.

Table C.1 — Calibration panel — measured data

Calibration panel (measured values)			Panel 1			Panel 2		
d_{cal}	Overall thickness	m	0,017			0,058		
A_{cal}	Area of panel (1,23 m × 1,48 m)	m^2	1,82			1,82		
A_{sur}	Area of surround panel	m^2	1,24			1,24		
A_{tot}	Hot box metering area (1,63 m × 1,88 m)	m^2	3,06			3,06		
L	Perimeter length	m	5,42			5,42		
Test number			2	1	3	5	4	6
Cold temperatures, measured								
θ_{ce}	Air	°C	7,98	2,06	–7,75	8,03	0,08	–7,71
$\theta_{se,\,b}$	Surface baffle	°C	8,03	2,14	–7,62	8,05	0,12	–7,65
$\theta_{se,\,cal}$	Surface calibration panel	°C	9,14	3,66	–5,47	8,42	0,64	–6,99
$\theta_{se,\,sur}$	Surface surround panel	°C	8,27	2,54	–6,92	8,10	0,15	–7,41
Warm temperatures, measured								
θ_{ci}	Air	°C	22,35	22,23	22,04	22,55	22,49	22,43
$\theta_{si,\,b}$	Surface baffle	°C	23,17	23,36	23,65	22,91	23,01	23,12
$\theta_{si,\,cal}$	Surface calibration panel	°C	18,33	16,79	14,31	21,16	20,51	19,92
$\theta_{si,\,p}$	Surface reveal panel	°C	21,16	20,71	20,03	21,81	21,54	21,27
$\theta_{si,\,sur}$	Surface surround panel	°C	22,23	22,17	22,02	21,97	21,78	21,60
Φ_{in}	Input power to hot box	W	57,6	82,0	123,1	19,6	30,4	40,8
v_i	Air flow warm side, down	m/s	0,1	0,1	0,1	0,1	0,1	0,1
v_e	Air flow cold side, up	m/s	1,7	1,7	1,7	1,7	1,7	1,7
Test number 1 was used to fix the fan setting on the cold side during calibrations.								

Table C.2 — Linear thermal transmittance and view factors of the calibration panel

Values resulting from mounting instructions				Remarks	Panel 1	Panel 2
Total thickness of the calibration panel			mm	—	17	58
Total thickness of the surround panel			mm	—	240	240
Surround panel reveal depth - warm side			mm	—	223	182
Surround panel reveal depth - cold side			mm	—	0	0
ψ_{edge} for λ_{sur} = 0,030 W/(m·K)			W/(m·K)	Table B.1	—	0,019 2
– Warm side	view factors f		cb_i	ISO 12567-1:2000, Table A.1	0,726	0,775
			pp_i		0,199	0,164
			cp_i	ISO 12567-1:2000, Equation (A.11)	0,274	0,225
			bp_i	ISO 12567-1:2000, Equation (A.11)	0,274	0,225
			pb_i	ISO 12567-1:2000, Equation (A.12)	0,401	0,418
	radiant factors α		cb_i	ISO 12567-1:2000, Equation (A.8)	0,586	0,624
			cp_i	ISO 12567-1:2000, Equation (A.9)	0,223	0,183
– Cold side	view factors f		cb_e	ISO 12567-1:2000, Table A.1	1,000	1,000
			pp_e		0,000	0,000
			cp_e	ISO 12567-1:2000, Equation (A.11)	0,000	0,000
			bp_e		0,000	0,000
			pb_e	ISO 12567-1:2000, Equation (A.12)	0,500	0,500
	radiant factors α		cb_e	ISO 12567-1:2000, Equation (A.8)	0,798	0,798
			cp_e	ISO 12567-1:2000, Equation (A.9)	0,000 0	0,000 0
NOTE Radiant factors were calculated with ε_{cal} = 0,84, ε_p = 0,92, ε_b = 0,95.						

Table C.3 — Calculation of surround panel thermal resistance, R_{sur}

Data element		Remarks	Panel 2 (58 mm)		
$\Delta\theta_c$	K	—	14,52	22,41	30,14
$\Delta\theta_{s,sur}$	K	—	13,87	21,63	29,01
$\theta_{me,sur}$	°C	—	15,04	10,97	7,10
Φ_{in}	W	—	19,6	30,4	40,8
Φ_{cal}	W	ISO 12567-1:2000, Equation (9)	15,88	24,69	33,40
Φ_{edge}	W	ISO 12567-1:2000, Equation (10)	1,51	2,33	3,14
$\Phi_{in} - \Phi_{cal} - \Phi_{edge}$	W	—	2,21	3,38	4,26
R_{sur}	m²·K/W	ISO 12567-1:2000, Equation (8)	7,79	7,94	8,44

Table C.4 — Calculation of surface resistances and convective fractions, F_c

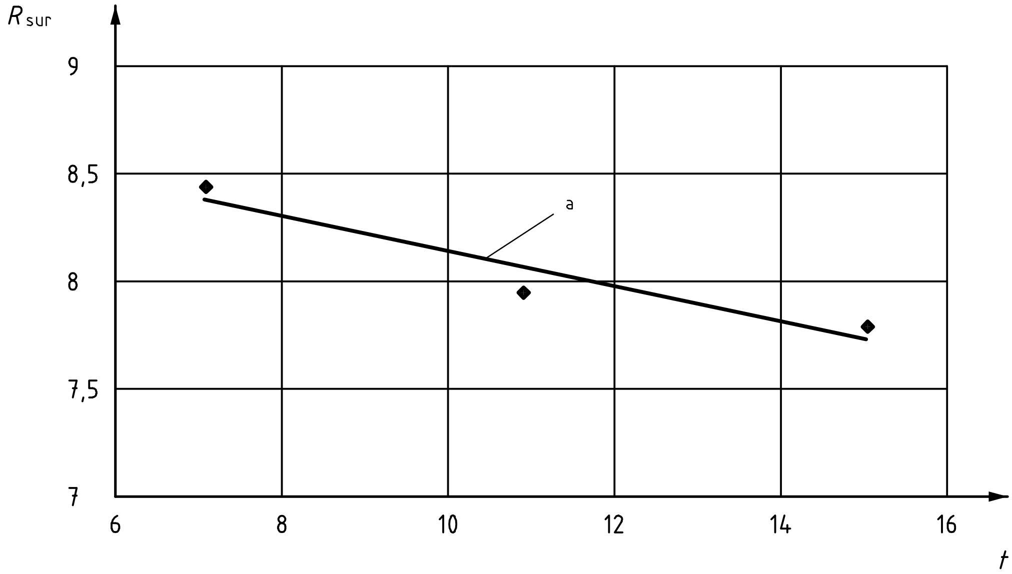
Data element		Equation (ISO 12567-1:2000)	Panel 1 (17 mm)			Panel 2 (58 mm)		
$\theta_{me,cal}$	°C	—	13,74	10,23	4,42	14,79	10,58	6,47
$\Delta\theta_{s,cal}$	K	—	9,19	13,13	19,78	12,74	19,87	26,91
R_{cal}	$m^2 \cdot K/W$	(3)	0,315 5	0,316 5	0,317 0	1,460 0	1,464 7	1,466 4
q_{cal}	W/m^2	(2)	29,13	41,48	62,40	8,73	13,57	18,35
$h_{cb,i}$	$W/(m^2 \cdot K)$	(A.6)	5,76	5,72	5,66	5,83	5,82	5,80
$h_{cb,e}$	$W/(m^2 \cdot K)$	(A.6)	5,07	4,77	4,30	5,05	4,64	4,26
$h_{cp,i}$	$W/(m^2 \cdot K)$	(A.7)	5,70	5,64	5,55	5,80	5,77	5,75
$h_{r,i}$	$W/(m^2 \cdot K)$	(A.5)	4,65	4,61	4,55	4,70	4,69	4,68
$h_{r,e}$	$W/(m^2 \cdot K)$	(A.5)	4,05	3,81	3,43	4,03	3,70	3,40
$\theta_{r,i}$	°C	(A.3)	22,62	22,63	22,65	22,66	22,68	22,70
$\theta_{r,e}$	°C	(A.3)	8,03	2,14	–7,62	8,05	0,12	–7,65
$h_{c,i}$	$W/(m^2 \cdot K)$	(A.10)	2,29	2,68	3,16	1,20	1,72	2,13
$h_{c,e}$	$W/(m^2 \cdot K)$	(A.10)	21,24	22,31	24,13	18,55	20,79	22,37
$F_{c,i}$	—	(6)	0,330	0,367	0,409	0,203	0,268	0,313
$F_{c,e}$	—	(6)	0,840	0,854	0,876	0,821	0,849	0,868
$\theta_{ni,cal}$	°C	(7)	22,53	22,48	22,40	22,64	22,63	22,62
$\theta_{ne,cal}$	°C	(7)	7,99	2,07	–7,73	8,03	0,09	–7,70
$\Delta\theta_{n,cal}$	K	—	14,54	20,41	30,14	14,60	22,54	30,32
R_{si}	$m^2 \cdot K/W$	(4)	0,144	0,137	0,130	0,169	0,156	0,147
R_{se}	$m^2 \cdot K/W$	(5)	0,040	0,038	0,036	0,044	0,041	0,039
$R_{s,tot}$	$m^2 \cdot K/W$	(1)	0,184	0,176	0,166	0,214	0,197	0,186

The results from the calibration measurements are plotted in Figures C.1 and C.2, The following regression curves have been derived by least-square fits from the data set:

thermal resistance of the surround panel: $R_{sur} = 8{,}946\,6 - 0{,}080\,8 \cdot \theta_{me,sur}$

convective fraction: $F_{c,i} = 0{,}218\,2 + 0{,}003\,4 \cdot q_{sp}$

$F_{c,e} = 0{,}832\,6 + 0{,}000\,6 \cdot q_{sp}$



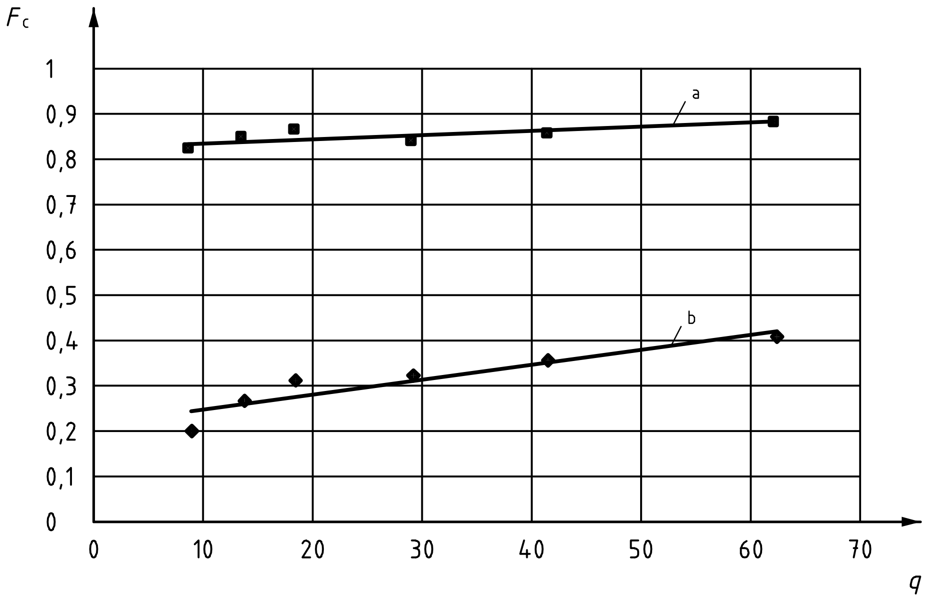
Key

R_{sur} thermal resistance, in m²·K/W

t surround panel mean temperature, in °C

[a] $R_{sur} = -0{,}080\,8\,t + 8{,}946\,6$

Figure C.1 — Thermal resistance of surround panel



Key

F_c convective fraction

q density of heat flow rate q in W/m²

1 cold side

2 warm side

[a] $F_c = 0{,}000\,6\,q + 0{,}832\,6$

[b] $F_c = 0{,}003\,4\,q + 0{,}218\,2$

Figure C.2 — Convective fractions

NOTE The curves have been derived by least-square fits.

C.2 Window specimen measurement

General data of the tested window.

a) Type

Wooden roof window.

b) Frame

Wood, with aluminium cladding.

c) Glazing

Insulating glass unit (4-16-4 mm) with low-e-coating on surface number 3[1] ($\varepsilon_n \cong 0{,}04$) and stainless steel spacer, argon gas filling, U_g = 1,2 W/(m^2·K) declared by the manufacturer.

d) Dimensions

Window height	1,400 m
Window width	1,140 m
Projected window area (1,40 m × 1,14 m)	1,596 m^2
Glass area (1,15 m × 0,96 m)	1,104 m^2
Projected frame area	0,492 m^2

The window was installed in a vertical position.

1) Surfaces are numbered from outside to inside.

Dimensions in millimetres

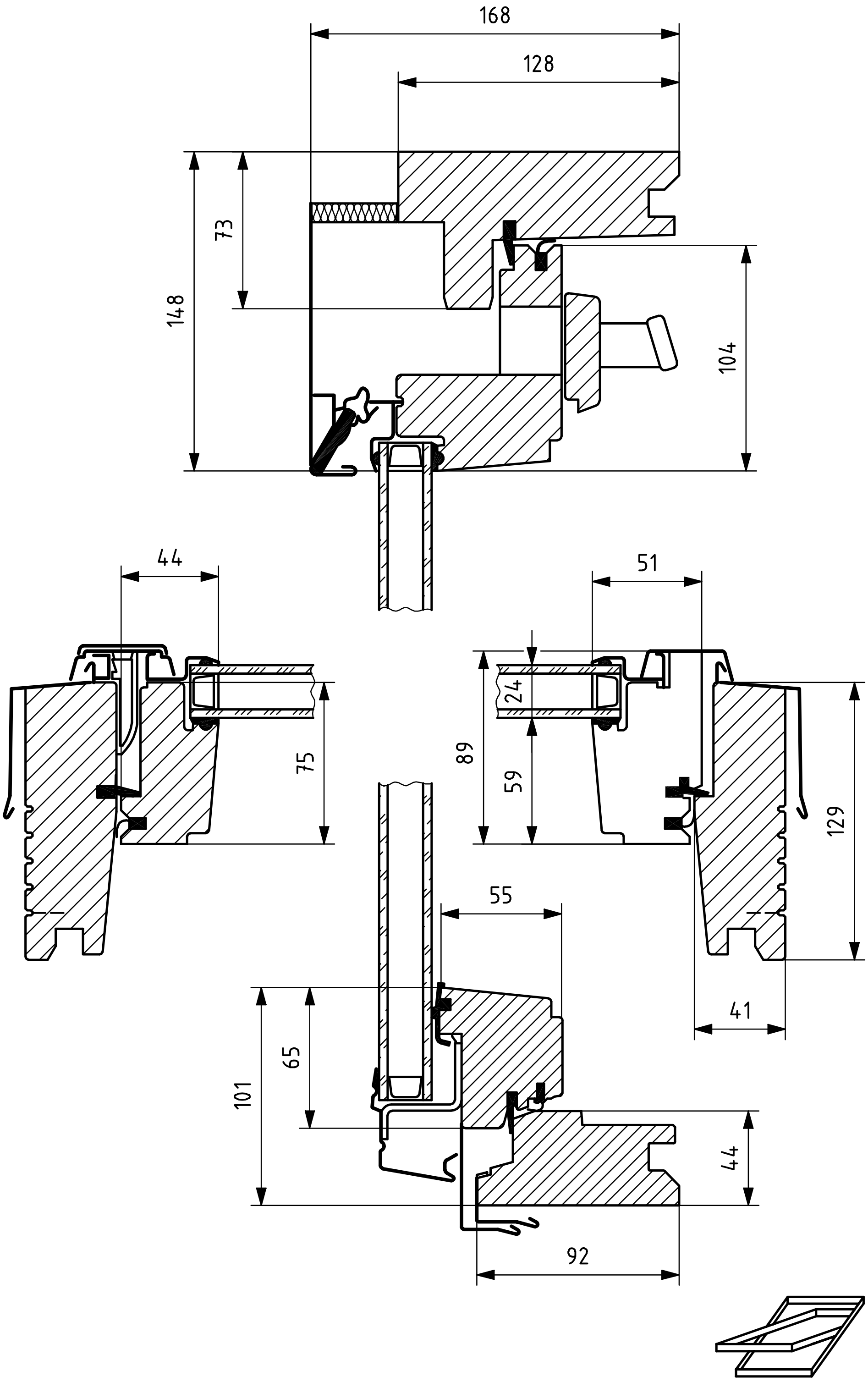
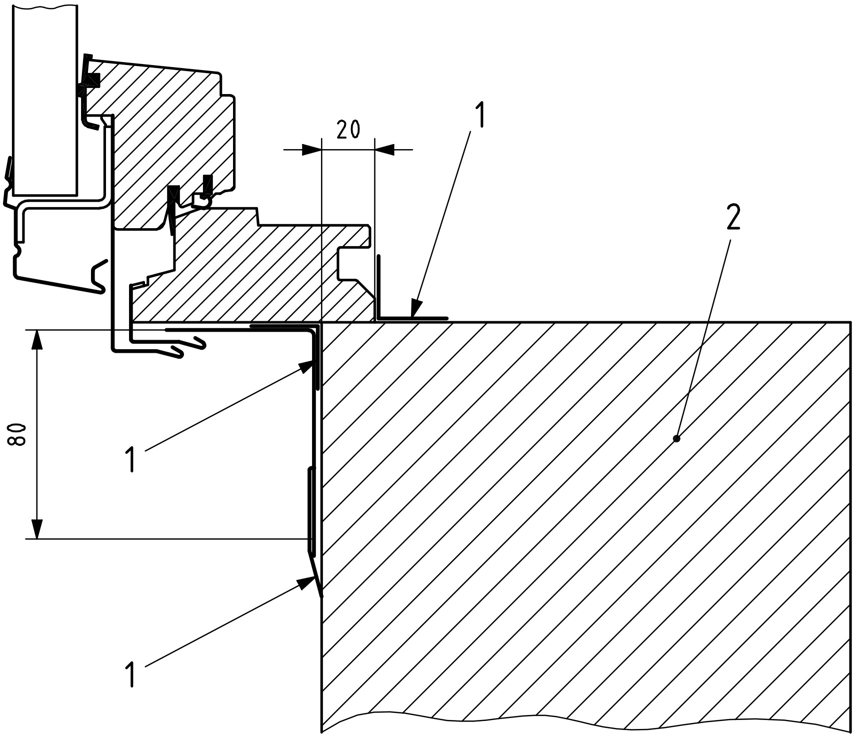


Figure C.3 — Section drawings of the roof window

Dimensions in millimetres



Key

1 tape

2 surround panel (thickness 150 mm, polystyrene, λ = 0,03 W/(m·K)

Figure C.4 — Section of the roof window installed in the surround panel

Table C.5 — Window data and measurement results

Data element			Remarks	Value
w	Frame insertion in surround panel	m	—	0,020
d	Depth of reveal	m	—	0,220
A_{sp}	Area of window	m^2	—	1,596
A_{sur}	Area of surround panel	m^2	—	1,464
L	Perimeter length	m	—	5,080
f_{cb}	Warm-side view factor	—	Table A.1	0,722
f_{pp}	Warm-side view factor	—	Table A.1	0,205
f_{cp}	Warm-side view factor	—	Table A.1	0,278
f_{bp}	Warm-side view factor	—	Table A.1	0,278
f_{pb}	Warm-side view factor	—	Table A.1	0,398
α_{cb}	Warm-side radiant factor	—	ISO 12567-1:2000, Equation A.8	0,583
α_{cp}	Warm-side radiant factor	—	ISO 12567-1:2000, Equation A.9	0,226

Table C.6 — Window measurement results

Data element			Value
Cold temperatures, measured			
θ_{ce}	Air	°C	0,82
$\theta_{se,b}$	Baffle	°C	0,84
$\theta_{se,sur}$	Surround panel temperature	°C	0,95
Warm temperatures, measured			
θ_{ci}	Air	°C	20,88
$\theta_{si,b}$	Baffle	°C	22,70
$\theta_{si,p}$	Reveal temperature	°C	19,40
$\theta_{si,sur}$	Surround panel temperature	°C	20,57
Φ_{in}	Input power in hot box	W	57,61
v_i	Air flow warm, down	m/s	0,1
v_e	Air flow cold, up	m/s	1,7

NOTE In accordance with 6.3, the air velocity on the cold side has been adjusted to the air velocity given during the calibration procedure.

The effective emissivities were assumed to be:

— ε = 0,84 for the glass surface;

— ε = 0,95 for the baffle surface;

— ε = 0,92 for the surround panel surface.

Table C.7 — Calculation of the thermal transmittance of the window

Data element			Value	Remarks
$\theta_{me,sur}$	Mean temperature of surround panel	°C	10,76	—
R_{sur}	Surround panel thermal resistance	$m^2 \cdot K/W$	8,08	Figure C.1
λ_{sur}	Conductivity of surround panel	W/(m·K)	0,030	—
ψ_{edge}	For w = 20 mm / d = 220 mm	W/(m·K)	0,036 2	Table B.2
$\Delta\theta_{s,sur}$	Temperature difference of surround panel	K	19,62	—
$\Delta\theta_c$	Air temperature difference	K	20,06	—
Φ_{in}	Input power to hot box	W	57,61	—
Φ_{sur}	Surround panel heat flow	W	3,56	ISO 12567-1:2000, Equation (12)
Φ_{edge}	Edge zone heat flow	W	3,69	ISO 12567-1:2000, Equation (10)
q_{sp}	Heat flow density of specimen	W/m^2	31,56	ISO 12567-1:2000, Equation (11)
F_{ci}	Convective fraction, warm side	—	0,325	Figure C.2
F_{ce}	Convective fraction, cold side	—	0,852	Figure C.2
θ_{ri}	Radiant temperature, warm side	°C	21,78	ISO 12567-1:2000, Equation (A.3)
θ_{re}	Radiant temperature, cold side	°C	0,84	ISO 12567-1:2000, Equation (A.2)
θ_{ni}	Environmental temperature, warm side	°C	21,48	ISO 12567-1:2000, Equation (7)
θ_{ne}	Environmental temperature, cold side	°C	0,82	ISO 12567-1:2000, Equation (7)
$\Delta\theta_n$	Environmental temperature difference	K	20,66	—
U_m	Measured thermal transmittance	$W/(m^2 \cdot K)$	1,53	ISO 12567-1:2000, Equation (13)
ΔU_m	Estimated uncertainty of the measurement	$W/(m^2 \cdot K)$	± 0,08	—

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