EUROLUX

GUIDELINE 01

Determination of thermal transmittance of rooflights

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EUROLUX

Determination of thermal transmittance of rooflights of plastics in accordance with EN 1873 and EN 14963

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1 Foreword

Energy consumption in building currently accounts for over 40% of all the energy consumed in Europe. This is the greatest share of total energy consumption, ahead of transport and industrial production.

According to the EU Commission, the energy efficiency of European building has to increase by 50%.

To increase the efficiency of the building envelope (barrier between conditioned and unconditioned space), better insulation has to be made for all parts of walls and roofs.

Kyoto protocol and European directive on the energy performance of buildings give objectives to improve energy efficiency.

All countries in Europe have national regulations published regarding thermal performances products and rules for calculation of heat loss of buildings.

For the European market manufacturers have to use European standards to determine and declare performances of the products using common rules and procedures which allow to compare directly declared performances (classes or values).

It is therefore necessary to avoid that erroneous application or interpretation of the standard lead to different values of the declared performance.

Eurolux prepared this guideline to introduce all relevant issues in determination of the thermal transmittance of rooflights in accordance to physics.

The contents clarified the application of the actual EN 1873 and EN 14 963 and would be included in the future updated revised standards.

This document is prepared by the main European experts involved more than 20 years in the writing process of the above mentioned standards.

2 Scope

This document specifies requirements and detailed rules to determine U value of rooflights in accordance with EN 1873 or EN 14963.

3 Document's references

Standards :

EN 673, Glass in building - Determination of thermal transmittance (U value) - Calculation method

EN 674, Glass in building - Determination of thermal transmittance (U value) – Guarded hot plate method

EN 1873, Prefabricated accessories for roofing - Individual rooflights of plastics - Product specification and test methods

EN 12412-2, Thermal performance of windows, doors and shutters - Determination of thermal transmittance by hot box method - Part 2: Frames

EN 14963, Roof coverings - Continuous rooflights of plastics with or without upstands - Classification, requirements and test methods

EN ISO 6946, Building components and building elements - Thermal resistance and thermal transmittance - Calculation method

EN ISO 10077-2, Thermal performance of windows, doors and shutters - Calculation of thermal transmittance - Part 2: Numerical method for frames (ISO 10077-2:2003)

EN ISO 10211, Thermal bridges in building construction - Heat flows and surface temperatures - Detailed calculations

EN ISO 12567-2, Thermal performance of windows and doors - Determination of thermal transmittance by hot box method. Roof windows and other projecting windows

National regulations:

(This aera is reserved to amend any specific national regulations.)

4 Components and definitions

4.1 Plastic rooflight

Building element used for lighting by mean of daylight which consists of a translucent part and eventual additional edge profiles and junction parts.

4.2 Translucent part

Consists in at least an outside plastic skin and several additional translucent skins below optionally. The additional skins can follow or be integrate the outer skin or be an additional flat skin.

NOTE: Additional flat skin may not be in plastic.

4.3 Upstand

Element which is single- or multi-walled or composite with vertical and/or pitched walls; with or without thermal insulation and having the two-fold purpose of providing an area for the fixture of plastic roof lights and for connection to the substructure, the roof covering or the roof sealing. The upstand transmits into the substructure the loads acting upon the plastic rooflights.

NOTE: Upstands may include ventilation devices. These are not taken into account while determining the U-values according to this guideline.

4.4 Accessories

Connections, opening and locking devices and seals for the assembly of the elements according to 4.1, 4.2 and 4.3.

4.5 Edge profile

Any additional frame and/or profile necessary to fix and/or open the translucent part of the rooflight.

NOTE: Edge profiles can be made out of plastic materials. Edge profiles are typically located on the perimeter of the rooflight

4.6 Junction part

Any additional element (e. g. frame and/or profile) used with the edge profile to compound the individual or continuous rooflight, when made by more than one translucent part.

NOTE: Junction part can be made out of plastic materials.

4.7 Panel

untransparent building element consisting of preferably two metal layers and rigid insulation material between these layers.

NOTE: For certain reasons panels can replace translucent parts or gable ends.

4.8 Plastic rooflight with upstand

Building element which consists of at least the separate elements in accordance with 4.1, 4.2, 4.3 and 4.4.

4.9 Family of rooflights

Rooflights for which performances of all dimensions can be determined from the same test report. Families may be different for different characteristic.

For the purpose of determination of thermal transmittance, the family is defined by the same design concept: same materials and construction details e. g. the type of the edge profiles and junction parts (if existing), and the same translucent part.

4.10 Starting point of calculation

Point or horizontal surface where adiabatic conditions are to be taken into account for calculation.

5 Symbols

A_e	Area of the outer exposed surface of the edge profile, in m²
A_{ge}	Area of the outer exposed surface of the gable end, in m²
A_j	the outer exposed surface of the junction part, in m²
$A_{j,b}$	total area of bearing profiles (junction parts), in m²
$A_{j,r}$	area of junction parts at gable ends, in m²
a_p	width of translucent part, measured between bearing profiles (standard sheet), in m
A_P	Area of the outer exposed surface of the panels, in m²
$A_{p.b}$	area of panels measured between bearing profiles (standard sheet), in m²
$A_{p,ge}$	area of panels of gable end, in m²
$A_{p.r}$	area of panels measured between gable end and next bearing profiles (marginal sheet), in m²
a_r	the width of translucent part between gable end (junction part) and next bearing profile (marginal sheet), in m
A_r	the surface of the rooflight without upstand, in m²
A_{rc}	the surface of the rooflight with upstand, in m²
A_t	Area of the outer exposed surface of the translucent part bordered with the perimeter of the translucent part, in m²
$A_{t.b}$	area of translucent parts measured between bearing profiles (standard sheet), in m²
$A_{t,flat}$	area of the horizontal projection of the clear opening of the translucent part, of individual rooflight, in m²
$A_{t,ge}$	area of the translucent part of the gable end, in m²
$A_{t.r}$	area of translucent parts measured between limit of the rooflight in longitudinal direction and next bearing profile (marginal sheet), in m²
A_{up}	Area of the outer exposed surface of the rooflight upstand, in m²
b_a	width of bearing profile, in m
$b_{r,h}$	horizontal width of junction part at the gable end, in m
$b_{r,v}$	vertical width of junction part at the gable end, in m
e_e	the width of the edge profile, in m
$e_{e,c}$	virtual width of the edge profile in longitudinal direction, in m

$e_{e,g}$ virtual height of the edge profile in longitudinal direction, in m

$e_{e,h}$ horizontal distance between the upper outside border of the insulation and the clear opening of the translucent part, in m

$e_{e,v}$ vertical distance between the upper level of the translucent part and the upper level of the upstand, in m

e_{es} the width of the edge profile in transversal direction, in m

$e_{es,h}$ virtual width of the edge profile in transversal direction, in m

$e_{es,v}$ virtual height of the edge profile in transversal direction, in m

$e_{j.h}$ the width of the junction part, in m

e_l the width of the edge profile, in longitudinal direction, in m

e_{up} the height of the upstand, in m

h horizontal envelope boundary

k factor to take into account the shape of the translucent part

k_t coefficient of covering the part of upstand by insulating part of the roof, in W/(m·K)

l_c arc length of bearing profiles, in m

L_c arc length of the translucent part, in m

l_e length of the sealing of the edge profile, in m

L_e the upper outer length of the edge profiles, in m

l_{es} the upper outer width of the edge profiles, in m

l_j length of the transition zone between translucent part and junction part, in m

l_o length of the clear rooflight opening, in m

l_t length of the transition zone between translucent part and edge profile, in m

$n_{b.p}$ number of bearing profiles

P_e perimeter of the edge profile, in m

P_t perimeter of the translucent part, equal to the perimeter of the clear opening of the translucent part, in m

P_{up} the reference perimeter of the upstand, in m

$P_{up,u}$ upper outer perimeter of the upstand, in m

$P_{up,l}$ lower outer perimeter of the upstand, in m

r bending radius of the system, in m

t_c width of the upstand, in m

t_i width of the insulation material of the upstand, in m

$t_{i,ge}$ width of the insulation material of the upstand at the gable end, in m

U_e thermal transmittance of the edge profile, in W/(m²·K)

U_{ge} thermal transmittance of the gable end, in W/(m²·K)

U_j thermal transmittance of the junction part, in W/(m²·K)

U_p the thermal transmittance of the panels, in W/(m²·K)

U_r total thermal transmittance of rooflights including the edge profile, if so, in W/(m²·K)

$U_{r,ref}$ total thermal transmittance of a rooflight without upstand (reference model), in W/(m²·K)

U_{rc} total thermal transmittance of rooflights including the edge profile, if so, and upstand, in W/(m²·K)

$U_{rc,ref300}$ total thermal transmittance of a rooflight with upstand (300 mm height, reference model), in W/(m²·K)

$U_{rc,inst}$ thermal transmittance of the rooflight, installed on the roof, in W/(m²·K)

U_t thermal transmittance of the translucent part, in W/(m²·K)

U_{up} thermal transmittance of the upstand, in W/(m²·K)

$U_{up,e}$ thermal transmittance of the upstand and the edge profile, if so, in W/(m²·K)

v vertical envelope boundary

w_o width of the clear rooflight opening, in m

α slope angle at the upstand, in degree

β central angle (= 2α), in degree

Ψ_e linear thermal transmittance in the transition zone of edge profile and upstand, in W/(m·K)

Ψ_j linear thermal transmittance in the transition zone of the translucent part or panels and junction part, in W/(m·K)

Ψ_t linear thermal transmittance in the transition zone of the translucent part or panels and edge profile, in W/(m·K)

6 Determination of thermal transmittance U of individual rooflights according to EN 1873

The thermal transmittance U-value, in W/(m²·K), determines the thermal flow through exchange surface, in m², between inside and outside of all components of the individual rooflight, as defined in clause 4 (translucent part, upstand, etc).
The thermal transmittance U-value is determined in reference to the external surface.

6.1 Determination of thermal transmittance of rooflight components

6.1.1. Determination by measurement

U-value shall be measured in accordance with the test method of EN ISO 12567-2 fixing the test specimen on the test rig in horizontal position.

6.1.2 Determination by calculation

6.1.2.1 Thermal transmittance of the upstand U_{up} and $U_{up,e}$

The U_{up}-value as nominal value of an upstand is either measured according to EN 12412-2 or calculated according to EN ISO 6946 for thermal homogenous design or according to EN ISO 10077-2 and EN ISO 10211 in other case.
The $U_{up,e}$-value as nominal value of the combination of an upstand and an edge profile is calculated according to EN ISO 10077-2 and EN ISO 10211.

6.1.2.2 Thermal transmittance of the edge profile U_e

The U_e-value as nominal value of the edge profile is either measured according to EN 12412-2 or calculated according to EN ISO 10077-2.

6.1.2.3 Thermal transmittance of the junction part U_j

The U_j-value as nominal value of the junction part is either measured according to EN 12412-2 or calculated according to EN ISO 10077-2.

6.1.2.4 Thermal transmittance of the translucent parts U_t

In general the U_t-value as nominal value of the translucent parts can be either calculated or measured in accordance with table 1. In the process one has to consider that the sheets are built in horizontally or nearly horizontally. In this respect the orientation especially of the multiwall sheets (vertical or horizontal) has to be recorded during the measuring.

Table 1: Normative references for calculation and measurement of translucent parts

Element	Calculation	Measurement
Single, double, triple etc skins of solid sheets	EN 673	EN 674
Multiwall sheets	Methods described in EN ISO 10077-2 and EN ISO 10211	EN 674
Non parallel translucent parts	EN 673 Methods described in EN ISO 10077-2 and EN ISO 10211	EN 674
Additional layer - mineral glass	EN 673	EN 674

Note:
The U_t-value of translucent part thermo-formed from multiwall sheet is declared by the manufacturer and deviates from the U_t-value measured on the raw material (flat sheet). If no tested value is available conservative justified value may be used.

6.1.2.5 Linear thermal transmittances Ψ_e,Ψ_j, Ψ_t

Ψ_e is to be calculated according to EN ISO 10211.

Ψ_j , Ψ_t are to be calculated according to EN ISO 10077-2.

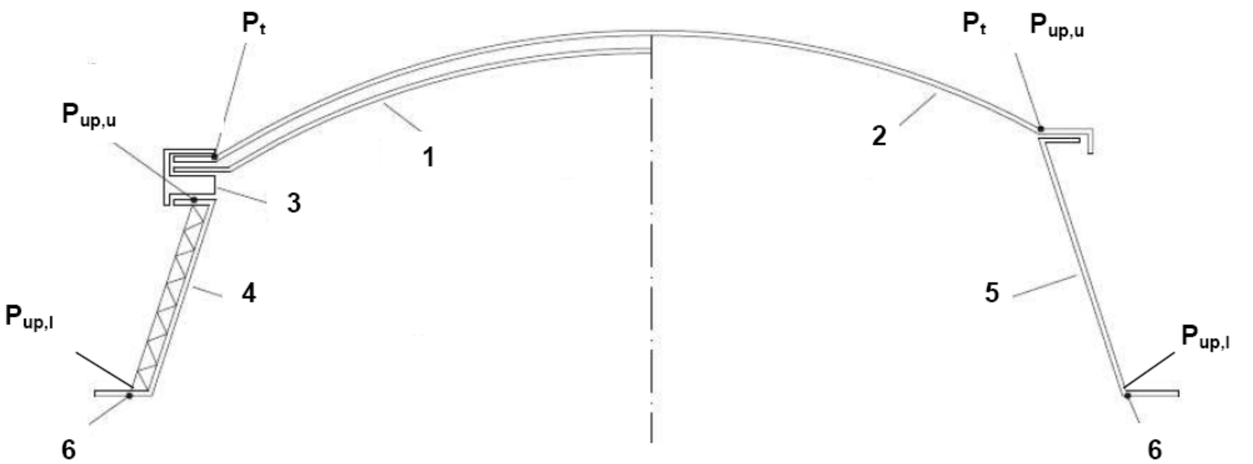
Ψ_e-, Ψ_j-,Ψ_t-values have to be indicated using two significant digits.

0,35 W/(m·K) is a conservative value for Ψ_e, Ψ_j and Ψ_t.

NOTE:
The linear thermal transmittance Ψ_i regards the higher heat transfer in the border area for example at rooflights caused by the sheet spacer and enclosing area of the edge profile.
It depends on the border area construction as well as the level of isolation of the used framing or of the glazing bars.

6.2 Determination of areas of a rooflight

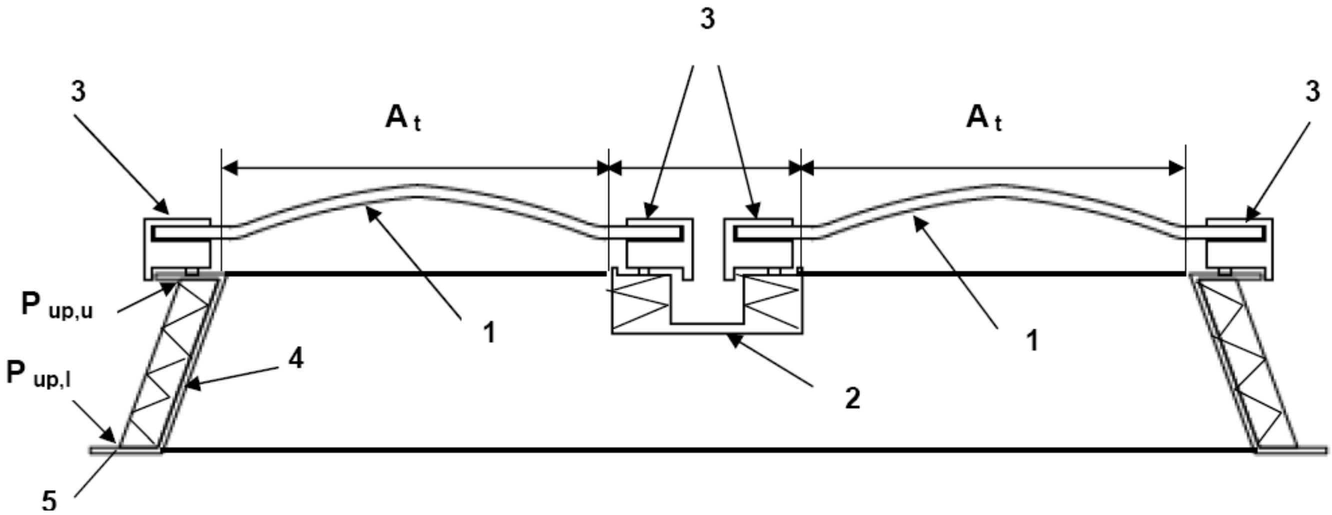
6.2.1 Components



Key:

1	translucent part
2	translucent part, single skin
3	edge profile
4	insulated upstand
5	non insulated upstand
6	starting point of calculation
P_t	perimeter of the translucent part
$P_{up,u}$	upper outer perimeter of the upstand
$P_{up,l}$	lower outer perimeter of the upstand

Figure 1: Exemplary overview of the components of a individual rooflight



Key:

1	translucent part
2	junction part
3	edge profile
4	insulated upstand
5	starting point of calculation
A_t	Area of the outer exposed surface of the translucent part bordered with the perimeter of the translucent part, in m²
$P_{up,u}$	upper outer perimeter of the upstand
$P_{up,l}$	lower outer perimeter of the upstand

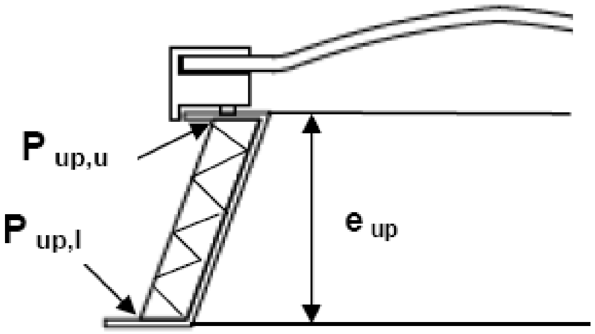
Figure 2: Exemplary overview of the components of a rooflight with a junction

6.2.2 Area of the rooflight upstand

The area of the rooflight upstand A_{up} is the outer exposed surface.
In this guideline the outer exposed surface of the rooflight upstand is defined as:

$$A_{up} = P_{up} \cdot e_{up} \ [m^2] \qquad (1)$$

Where
P_{up} the reference perimeter of the upstand (calculated as average of upper outer perimeter $P_{up,u}$ and lower outer perimeter $P_{up,l}$)
e_{up} the height of the upstand equates to the distance of $P_{up,u}$ and $P_{up,l}$



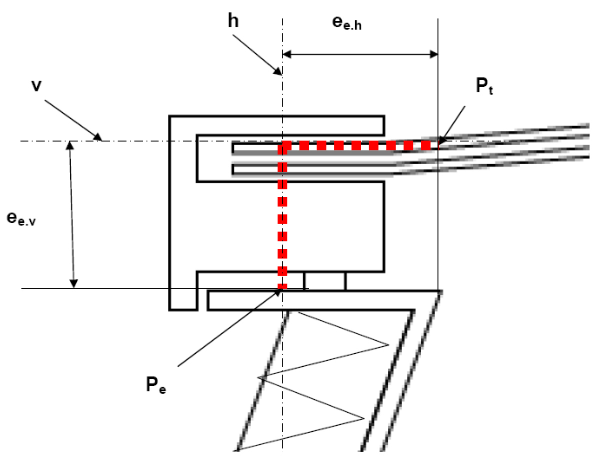
Key:
e_{up} the height of the upstand
$P_{up,u}$ upper outer perimeter of the upstand
$P_{up,l}$ lower outer perimeter of the upstand

Figure 3: Exemplary overview showing the perimeter and the height of the upstand

6.2.3 Area of the edge profile

Instead of the real geometry of the edge profiles a virtual simplified geometry as shown in figure 4 and figure 5 is used for calculation. The dimensions of $e_{e,h}$ and $e_{e,v}$ depend on the specific design of the construction of the manufacturer and must determine individually. Decisively for the location of the virtual lines is the envelope boundary.

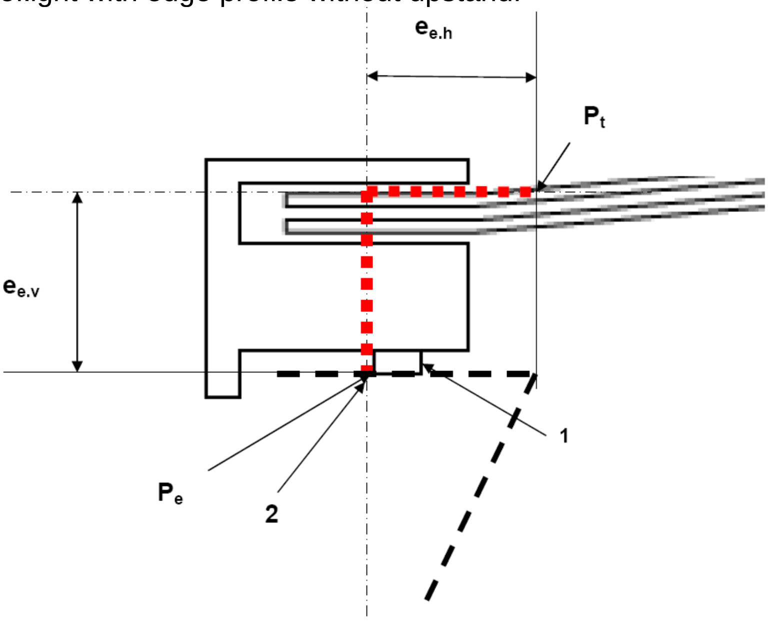
Rooflight with edge profile and upstand:



Key:
$e_{e,h}$ horizontal distance between the upper outside border of the insulation and the clear opening of the translucent part
$e_{e,v}$ vertical distance between the upper level of the translucent part and the upper level of the upstand
P_e perimeter of the edge profile (= $P_{up,u}$)
P_t perimeter of the translucent part
h horizontal envelope boundary
v vertical envelope boundary

Figure 4: Exemplary overview of the aera with edge profile and upstand

Rooflight with edge profile without upstand:



Key:

1	joint sealing
2	starting point of calculation
$e_{e,h}$	horizontal distance between the upper outside border of the insulation and the clear opening of the translucent part
$e_{e,v}$	vertical distance between the upper level of the translucent part and the upper level of the fixing plane
P_e	perimeter of the edge profile (= $P_{up,u}$)
P_t	perimeter of the translucent part

Figure 5: Exemplary overview of the aera with edge profile and without upstand

The area of the edge profile is defined as:

$$A_e = P_e \cdot e_e \qquad [m^2] \tag{2}$$

Where

P_e the virtual outer perimeter of the edge profiles

e_e the width of the edge profile

The width of the edge profile is defined as:

$$e_e = e_{e,h} + e_{e,v} \tag{3}$$

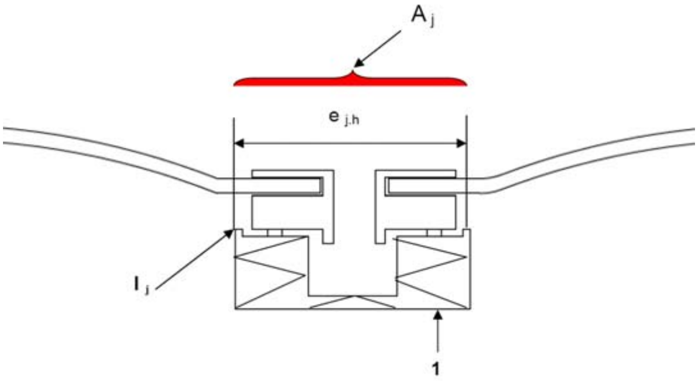
Where

$e_{e,h}$ horizontal distance between the upper outside border of the insulation in case of an upstand or the upper outside border of the joint sealing, if there is no upstand, and the clear opening of the translucent part

$e_{e,v}$ vertical distance between the upper level of the translucent part and the upper level of the upstand

For rooflights with upstand the perimeter of the edge profile equates to the upper outer perimeter of the upstand $P_{up,u}$. For rooflights without upstand it is defined with the outside edge of the joint sealing according to figure 5.

6.2.4 Area of the junction part



Key:
1 junction part
A_j area of the junction part
$e_{j,h}$ the width of the junction part
l_j the length of the junction part

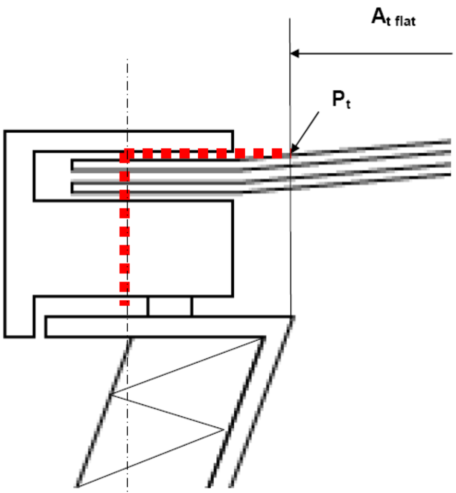
Figure 6: Exemplary overview of the aera of junction part

The area of the junction part is defined as:

$$A_j = l_j \cdot e_{j.h} \quad [m^2] \tag{4}$$

Where
l_j the length of the junction part, in m
$e_{j.h}$ the width of the junction part (see figure 6), in m

6.2.5 Area of the translucent part A_t



Key:
P_t perimeter of the translucent part
$A_{t,flat}$ area of the horizontal projection of the clear opening of the translucent part of an individual rooflight

Figure 7: Exemplary overview of the aera of translucent part

The area of the translucent part A_t is the outer exposed surface bordered with the perimeter of the translucent part P_t. Within the scope of this guideline the translucent part is to be calculated simply as followed:

$A_t = A_{t,flat} \cdot k$ [m²] (5)

Where
$A_{t,flat}$ area of the horizontal projection of the clear opening of the translucent part
k factor to take into account the shape of the translucent part

k = 1,12 for normal dome curve – for height/length relation between 1/6 and 1/4
k = 1,0 for slightly curve rooflight – for height/length relation 1/40 < and < 1/6

Without calculation of the outer surface it is allowed to use factor k.

As an alternative for determination of the surfaces it is allowed to use the exact outer surface areas of the translucent part.

6.2.6 Surface of the rooflight

The surface of the rooflight without upstand A_r with a single translucent part is defined as

$A_r = A_e + A_t$ [m²] (6)

Where
A_e area of the edge profile, in m²
A_t area of the translucent part, in m²

The surface of the rooflight with upstand A_{rc} with a single translucent part is defined as:

$A_{rc} = A_{up} + A_e + A_t$ [m²] (7)

Where
A_e area of the edge profile, in m²
A_t area of the translucent part, in m²
A_{up} area of the upstand, in m²

The surface of the rooflight with upstand A_{rc} with more than one translucent part is defined as:

$A_{rc} = A_{up} + A_e + \Sigma A_j + \Sigma A_t$ [m²] (8)

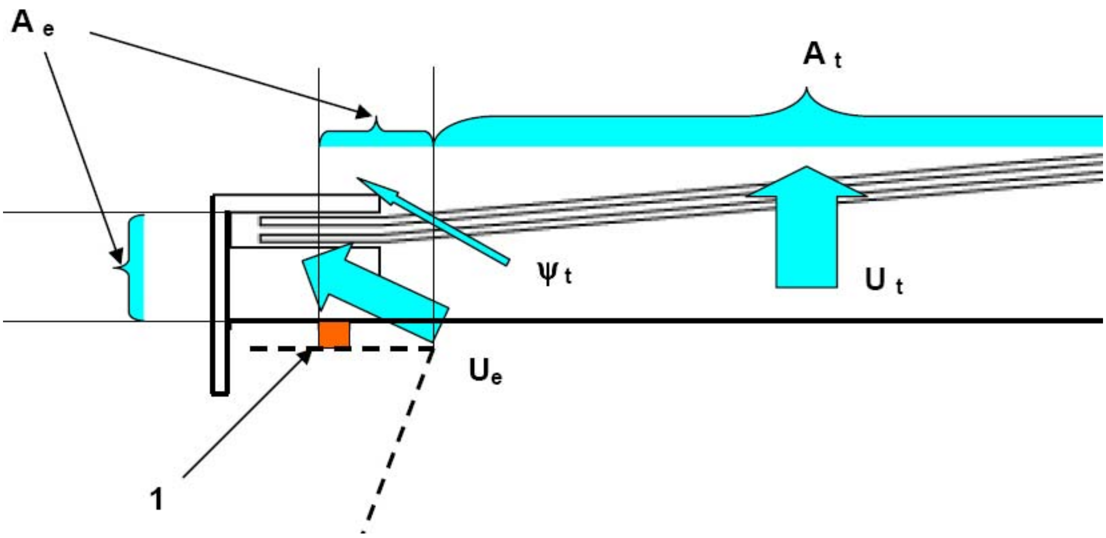
Where
A_e area of the edge profile, in m²
ΣA_j total area of the junction parts, in m²
ΣA_t total area of the translucent parts, in m²
A_{up} area of the upstand, in m²

6.3 Total thermal transmittance of individual rooflights U_r

The total U-value of an individual rooflight shall be evaluated taking into account characteristics of translucent part, edge profiles, junction part and upstand:

- Surface of the rooflight without upstand A_r as defined in 6.2.6
- Surface of the rooflight with upstand A_{rc} as defined in 6.2.6
- Surface of the upstand A_{up} as defined in 6.2.2
- Surface of the edge profile part A_e as defined in 6.2.3
- Surface of the junction part A_j as defined in 6.2.4
- Surface of the translucent part A_t as defined in 6.2.5
- Thermal transmittance of upstand U_{up} as defined in 6.1.2.1
- Thermal transmittance of upstand and edge profile $U_{up,e}$ as defined in 6.1.2.1
- Thermal transmittance of edge profile U_e as defined in 6.1.2.2
- Thermal transmittance of the junction part U_j as defined in 6.1.2.3
- Thermal transmittance of translucent part U_t as defined in 6.1.2.4
- the linear thermal transmittance coefficient in the transition zone of edge profile and upstand Ψ_e as defined in 6.1.2.5
- the linear thermal transmittance coefficient in the transition zone of the translucent part and junction part Ψ_j as defined in 6.1.2.5
- the linear thermal transmittance coefficient in the transition zone of the translucent part and edge profile Ψ_t as defined in 6.1.2.5

6.3.1 Total thermal transmittance U_r of individual rooflights including the edge profile



Key:

1	starting point of calculation
A_e	the outer exposed surface of the edge profiles
A_t	the outer exposed surface of the translucent part
U_e	the thermal transmittance of the edge profiles
U_t	the thermal transmittance of the translucent part
Ψ_t	the linear heat transfer coefficient in the transition zone of the translucent part and the edge profile

Figure 8: Explanation of the factors of the calculation of individual rooflights including edge profiles

The U-value of the rooflight U_r including the edge profile is calculated as followed:

$$U_r = \frac{A_e \times U_e + A_t \times U_t + l_t \times \Psi_t}{A_e + A_t} \qquad [\mathrm{W/(m^2 \cdot K)}] \qquad (9)$$

Where

A_e the outer exposed surface of the edge profiles, in m²

A_t the outer exposed surface of the translucent part, in m²

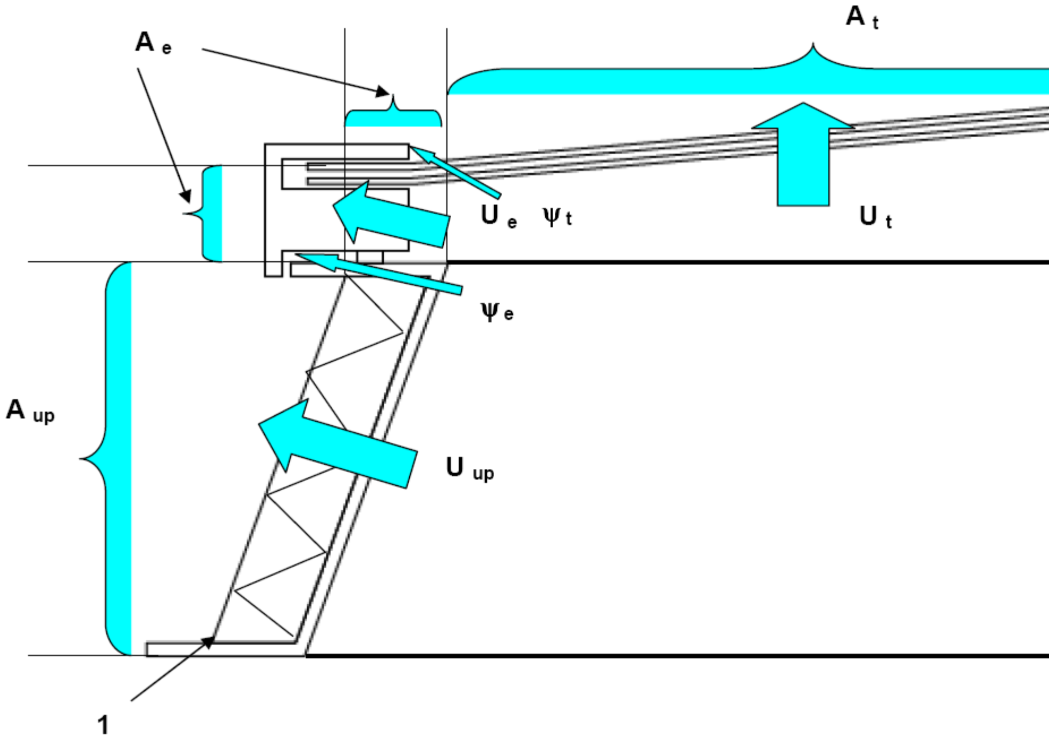
l_t length of the transition zone between translucent part and edge profiles (= P_t), in m

U_e the thermal transmittance of the edge profiles, in W/(m²·K)

U_t the thermal transmittance of the translucent part, in W/(m²·K)

Ψ_t the linear heat transfer coefficient in the transition zone of the translucent part and the edge profile, in W/(m·K)

6.3.2 Total thermal transmittance U_{rc} of individual rooflights including the edge profile and upstand



Key:

1 starting point of calculation

A_e the outer exposed surface of the edge profiles

A_t the outer exposed surface of the translucent part

A_{up} the outer exposed surface of the upstand

U_e the thermal transmittance of the edge profiles

U_t the thermal transmittance of the translucent part

U_{up} the thermal transmittance of the upstand

Ψ_e the linear heat transfer coefficient in the transition zone of edge profile and upstand

Ψ_t the linear heat transfer coefficient in the transition zone of the translucent part and the edge profile

Figure 9: Explanation of the factors of the calculation of individual rooflights including the edge profile and upstand

The U-value of the complete individual rooflight U_{rc} consisting of rooflight with edge profile and upstand is calculated as followed:

$$U_{rc} = \frac{A_{up} \times U_{up} + A_e \times U_e + A_t \times U_t + l_e \times \Psi_e + l_t \times \Psi_t}{A_{up} + A_e + A_t} \text{ [W / (m}^2 \cdot \text{K)]} \qquad (10)$$

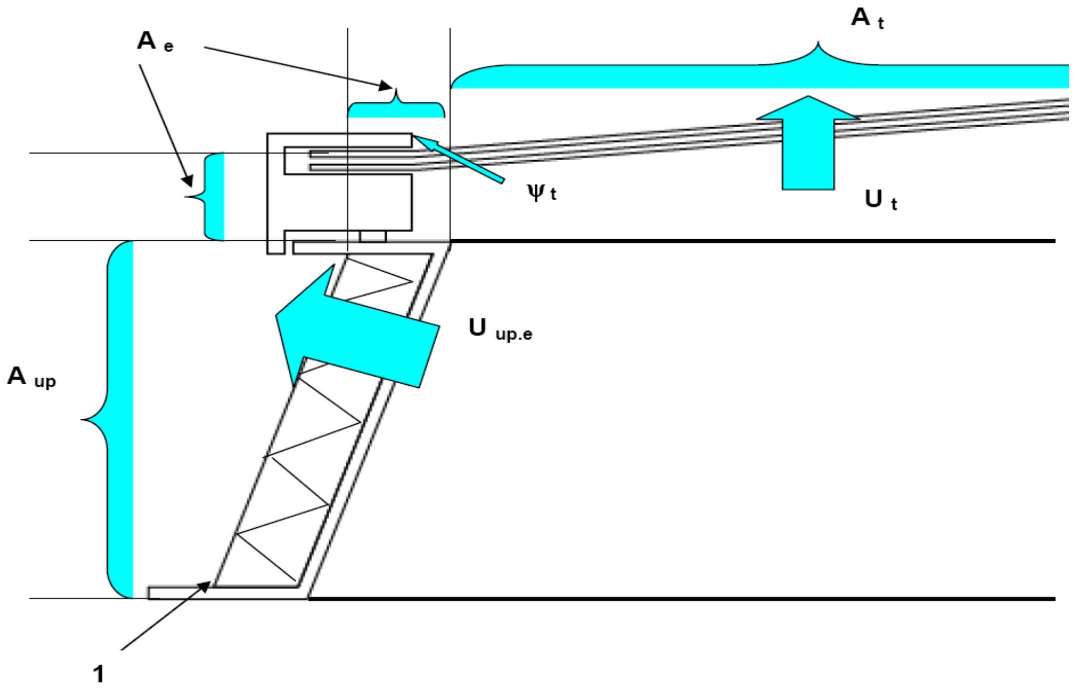
Where

A_e the outer exposed surface of the edge profile, in m²

A_t the outer exposed surface of the translucent part, in m²

A_{up} the outer exposed surface of the upstand, in m²
l_e length of the sealing of the edge profile, in m
l_t length of the transition zone between translucent part and edge profiles (= P_t), in m
U_e the thermal transmittance of the edge profile, in W/(m²·K)
U_t the thermal transmittance of the translucent part, in W/(m²·K)
U_{up} the thermal transmittance of the upstand, in W/(m²·K)
Ψ_e the linear heat transfer coefficient in the transition zone of edge profile and upstand, in W/(m·K)
Ψ_t the linear heat transfer coefficient in the transition zone of the translucent part and edge profile, in W/(m·K)

6.3.3 Total thermal transmittance U_{rc} of individual rooflights including the edge profile and upstand (other possibility)



Key:
1 starting point of calculation
A_e the outer exposed surface of the edge profiles
A_t the outer exposed surface of the translucent part
A_{up} the outer exposed surface of the upstand
U_t the thermal transmittance of the translucent part
$U_{up,e}$ the thermal transmittance of the upstand including edge profile
Ψ_t the linear heat transfer coefficient in the transition zone of the translucent part and the edge profile

Figure 10: Explanation of the factors of the calculation of individual rooflights including the edge profile and upstand (other possibility)

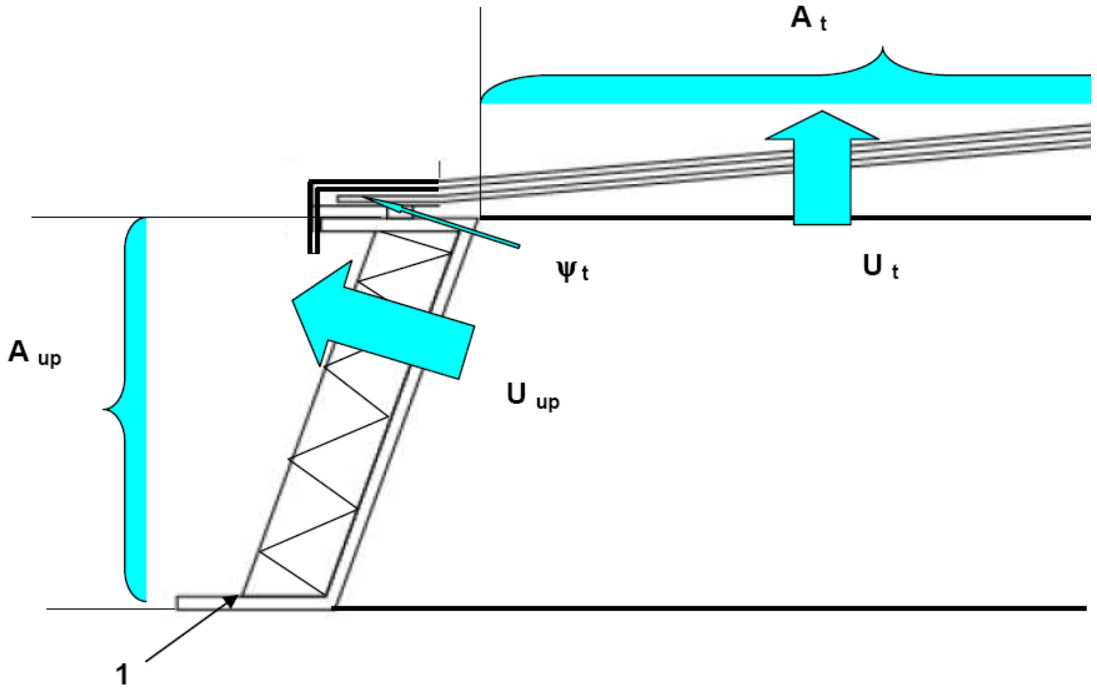
The U-value of the complete individual rooflight U_{rc} consisting of rooflight with edge profile and upstand is calculated as followed:

$$U_{rc} = \frac{(A_{up} + A_e) \times U_{up,e} + A_t \times U_t + l_t \times \Psi_t}{A_{up} + A_e + A_t} \quad \text{[W/(m²·K)]} \qquad (11)$$

Where
A_e the outer exposed surface of the edge profile, in m²
A_{up} the outer exposed surface of the upstand, in m²
A_t the outer exposed surface of the translucent part, in m²

l_t length of the transition zone between translucent part and edge profiles (= P_t), in m
$U_{up,e}$ the thermal transmittance of the upstand and edge profile, in W/(m²·K)
U_t the thermal transmittance of the translucent part, in W/(m²·K)
Ψ_t the linear heat transfer coefficient in the transition zone of the translucent part and edge profile, in W/(m·K)

6.3.4 Total thermal transmittance U_{rc} of individual rooflights including the upstand without edge profile



Key:
1 starting point of calculation
A_t the outer exposed surface of the translucent part
A_{up} the outer exposed surface of the upstand
U_t the thermal transmittance of the translucent part
U_{up} the thermal transmittance of the upstand
Ψ_t the linear heat transfer coefficient in the transition zone of the translucent part and the upstand

Figure 11: Explanation of the factors of the calculation of individual rooflights with upstand but without edge profile

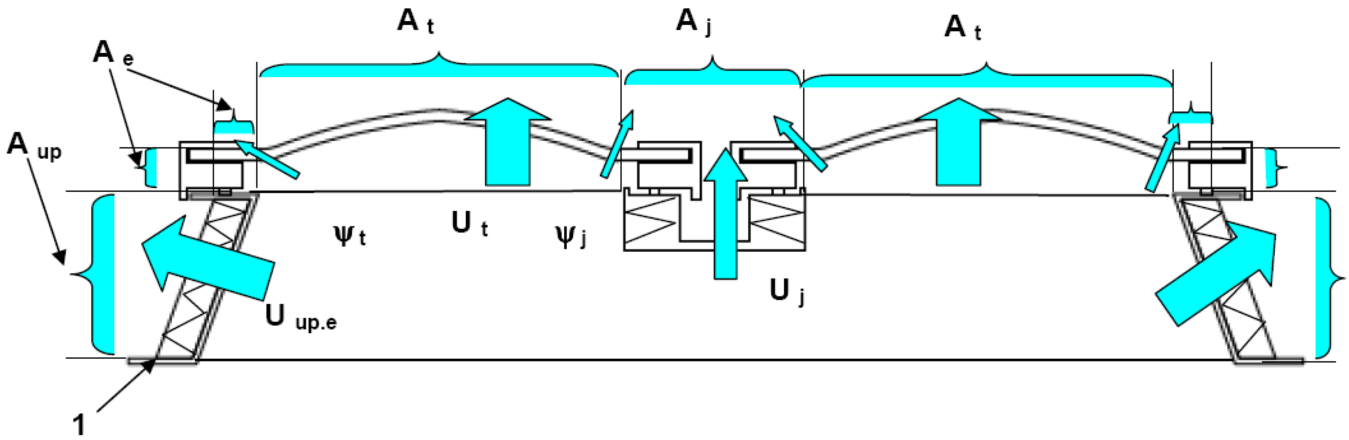
The U-value of the complete individual rooflight U_{rc} consisting of rooflight with upstand but without edge profile is calculated as followed:

$$U_{rc} = \frac{A_{up} \times U_{up} + A_t \times U_t + l_t \times \Psi_t}{A_{up} + A_t} \quad [\mathrm{W/(m^2 \cdot K)}] \qquad (12)$$

Where
A_t the outer exposed surface of the translucent part, in m²
A_{up} the outer exposed surface of the upstand, in m²
l_t length of the transition zone between translucent part and edge profiles (= P_t), in m
U_t the thermal transmittance of the translucent part, in W/(m²·K)
U_{up} the thermal transmittance of the upstand, in W/(m²·K)

Ψ_t the linear heat transfer coefficient in the transition zone of the translucent part and upstand, in W/(m·K)

6.3.5 Total thermal transmittance U_{rc} of individual rooflights including the edge profile and upstand with more than one translucent part



Key:

1 starting point of calculation
A_e the outer exposed surface of the edge profiles
A_j outer exposed surface of the junction part
A_t the outer exposed surface of the translucent part
A_{up} the outer exposed surface of the upstand
U_j thermal transmittance of the junction part
U_t the thermal transmittance of the translucent part
$U_{up,e}$ the thermal transmittance of the upstand
Ψ_j the linear thermal transmittance in the transition zone of the translucent part and junction part
Ψ_t the linear heat transfer coefficient in the transition zone of the translucent part and the edge profile

Figure 12: Explanation of the factors of the calculation of individual rooflights with edge profile, upstand and more than one translucent part (as example shown here as two flaps)

The U-value of the complete individual rooflight U_{rc} consisting of rooflight with edge profile and upstand is calculated as followed:

$$U_{rc} = \frac{(A_{up} + A_e) \times U_{up,e} + \Sigma A_t \times U_t + \Sigma A_j \times U_j + \Sigma l_t \times \Psi_t + \Sigma l_j \times \Psi_j}{A_{up} + A_e + \Sigma A_t + \Sigma A_j} \quad [\mathrm{W/(m^2 \cdot K)}] \qquad (13)$$

Where

A_e the outer exposed surface of the edge profile, in m²
ΣA_j the sum of the outer exposed surfaces of the junction parts, in m²
ΣA_t the sum of the outer exposed surfaces of the translucent parts, in m²
A_{up} the outer exposed surface of the upstand, in m²
U_j the thermal transmittance of the junction parts, in W/(m²·K)
U_t the thermal transmittance of the translucent part, in W/(m²·K)
$U_{up,e}$ the thermal transmittance of the upstand and edge profile, in W/(m²·K)
Σl_t sum of the length of the transition zone between translucent part and edge profile, in m
Σl_j sum of the length of the transition zone between translucent part and junction part, in m
Ψ_j the linear thermal transmittance in the transition zone of the translucent part and junction part, in W/(m·K)

Ψ_t the linear thermal transmittance in the transition zone of the translucent part and edge profile, in W/(m·K)

6.3.6 Rounding to be used for thermal transmittance in calculation and classification

For the calculation of the thermal transmittance values of U_e, U_{up} and Ψ and the values of the surfaces as input have to be indicated using 3 significant digits.
For the ouput (result for classification), values have to be indicated using 2 significant digits.

For example:
Calculation = 1,41 becomes 1,4 W/(m²·K)
Calculation = 1,45 becomes 1,5 W/(m²·K)
Calculation = 0,741 becomes 0,74 W/(m²·K)
Calculation = 0,745 becomes 0,75 W/(m²·K)

7 Determination of thermal transmittance U of continuous rooflights according EN 14963

The thermal transmittance U-value, in W/(m²·K), is the determination of the transmittance through exchange surface, in m², between inside and outside of all components of the continuous rooflight, as defined in clause 4 (translucent part, upstand, etc).
The thermal transmittance U-value is determined in reference to the external surface.

7.1 Determination of thermal transmittance of continuous rooflight components

7.1.1 Determination by measurement

U-value shall be measured in accordance with the test method of EN ISO 12567-2 fixing the test specimen on the test rig in horizontal position.

7.1.2 Determination by calculation

7.1.2.1 Thermal transmittance of the upstand U_{up} and $U_{up,e}$

The U_{up}-value as nominal value of an upstand is either measured according to EN 12412-2 or calculated according to EN ISO 6946 for thermal homogenous design or according to EN ISO 10077-2 and EN ISO 10211 in other case.
The $U_{up,e}$-value as nominal value of the combination of an upstand and an edge profile is calculated according to EN ISO 10077-2 and EN ISO 10211.

7.1.2.2 Thermal transmittance of the edge profile U_e

The U_e-value as nominal value of the edge profile is either measured according to EN 12412-2 or calculated according to EN ISO 10077-2.

7.1.2.3 Thermal transmittance of the junction part U_j

The U_j-value as nominal value of the junction part is either measured according to EN 12412-2 or calculated according to EN ISO 10077-2.

7.1.2.4 Thermal transmittance of the translucent parts U_t

In general the U_t-value as nominal value of the translucent parts can be either calculated or measured in accordance with table 1. In the process one has to consider that the sheets are built in horizontally or nearly horizontally. In this respect the orientation especially of the multiwall sheets (vertical or horizontal) has to be recorded during the measuring.

7.1.2.5 Thermal transmittance of panels U_p

The U_p-value as nominal value of a untransparent panel is calculated according to EN ISO 6946. Bases of calculation are the thickness of the layers in m and the heat conductivity of the separate materials in W/(m·K).

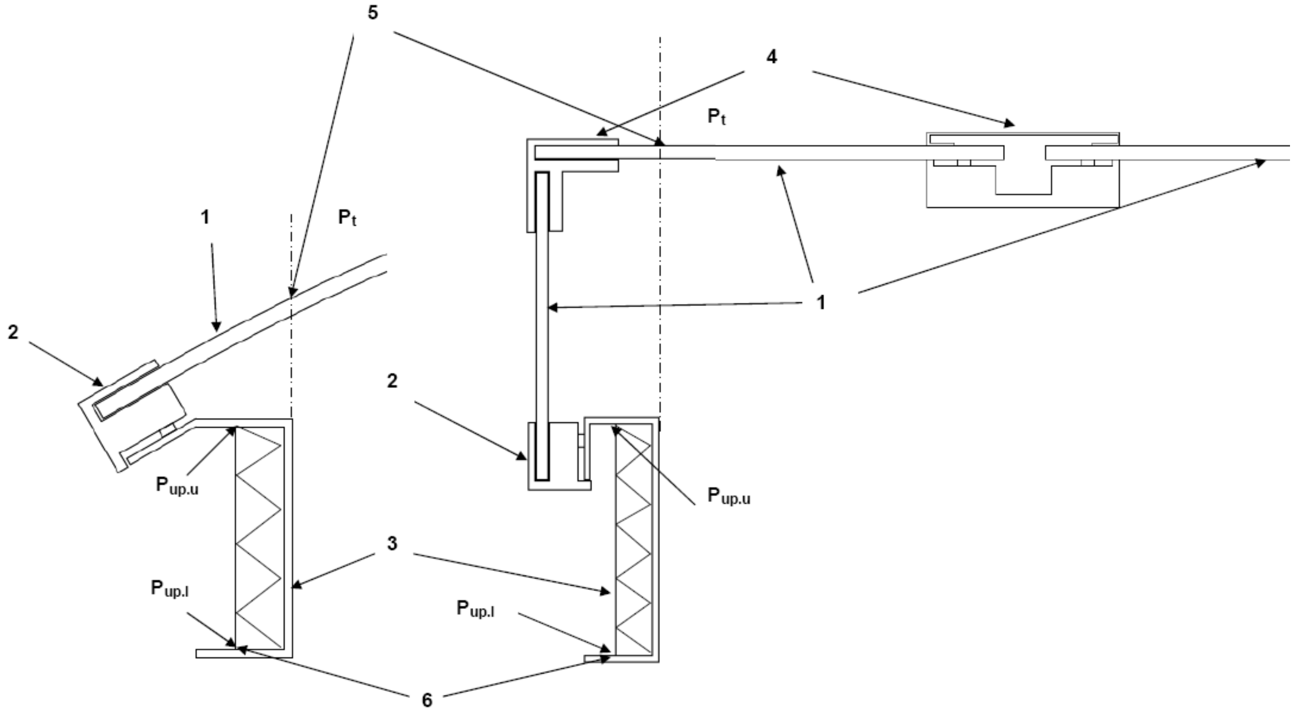
7.1.2.6 Linear thermal transmittance Ψ_e Ψ_j, Ψ_t

Ψ_e is to be calculated according to EN ISO 10211.
Ψ_j and Ψ_t are to be calculated according to EN ISO 10077-2.
Ψ_e-, Ψ_j-, Ψ_t-values have to be indicated using two significant figures.
Ψ_e, Ψ_j, Ψ_t = 0,35 W/(m·K) are conservative values.

NOTE:
The linear thermal transmittance Ψ_i regards the higher heat transfer in the border area for example at rooflights caused by the sheet spacer respectively at continuous rooflights between multiwall sheets and bearing profile.

It depends on the border area construction as well as the level of insulation of the used framing or of the bearing profiles.

7.2 Determination of areas of continuous rooflight
7.2.1 Components

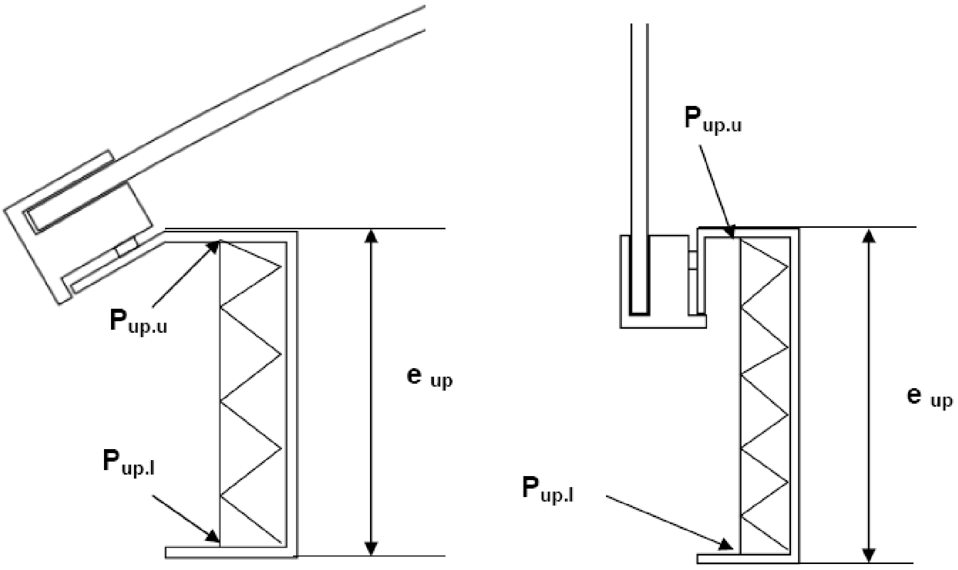


Key:
1 translucent part
2 edge profile
3 insulated upstand
4 junction part
5 limit of clear opening
6 starting point of calculation

P_t perimeter of the translucent part, equal to the clear opening of the translucent part
$P_{up,u}$ upper outer perimeter of the upstand
$P_{up,l}$ lower outer perimeter of the upstand

Figure 13: Exemplary overview of the components of a continuous rooflight

7.2.2 Area of the continuous rooflight upstand



Key:
e_{up} height of the upstand
$P_{up,l}$ lower outer perimeter of the upstand
$P_{up,u}$ upper outer perimeter of the upstand

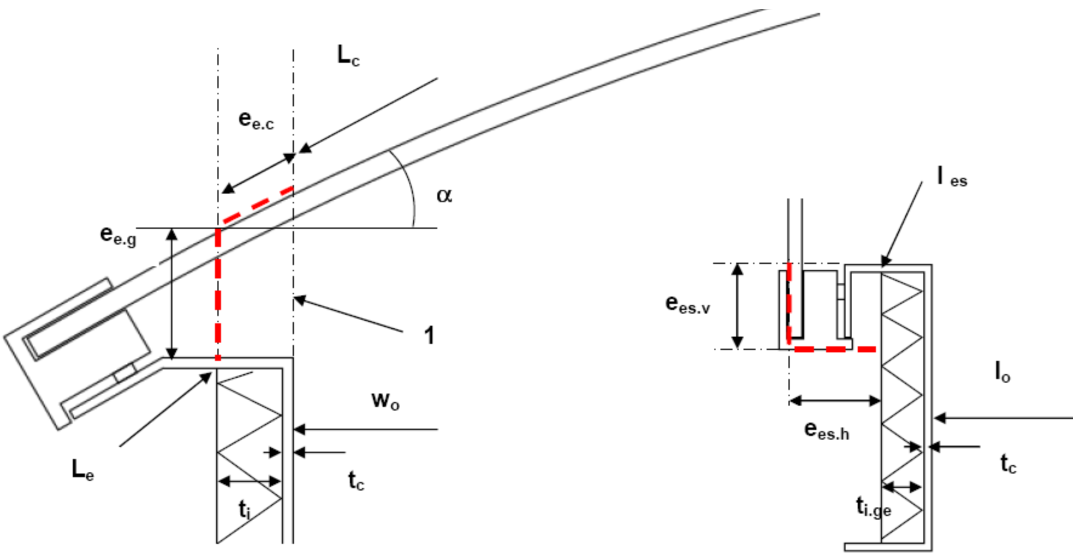
Figure 14: Exemplary overview showing the perimeter and the height of the upstand

The area of the rooflight upstand A_{up} is the outer exposed surface.
In this guideline the outer exposed surface of the rooflight upstand is defined according equation (1).
In alternative it is allowed to use the exact surface area.

7.2.3 Area of the edge profile

Instead of the real geometry of the edge profiles a virtual simplified geometry as shown in figure 15 and figure 16 is used for calculation. The dimensions of $e_{e,c}$, $e_{e,v}$, $e_{es,h}$ and $e_{es,v}$ depend on the specific design of the construction of the manufacturer and must determine individually. Decisively for the location of the virtual lines is the envelope boundary.

Continuous rooflight with edge profile and upstand:



Key:
1 limit of clear opening

α slope angle at the upstand
$e_{e,c}$ virtual width of the edge profile in longitudinal direction
$e_{e,g}$ virtual height of the edge profile in longitudinal direction
$e_{es,h}$ virtual width of the edge profile in transversal direction
$e_{es,v}$ virtual height of the edge profile in transversal direction
L_e the upper outer length of the edge profiles
L_c arc length of the translucent part
l_{es} the upper outer width of the edge profiles
l_o length of the clear rooflight opening
t_c width of the upstand
t_i width of the insulation material of the upstand
$t_{i,ge}$ width of the insulation material of the upstand at the gable end
w_o width of the clear rooflight opening

Figure 15: Exemplary overview of the aera with edge profile and upstand for continuous rooflights

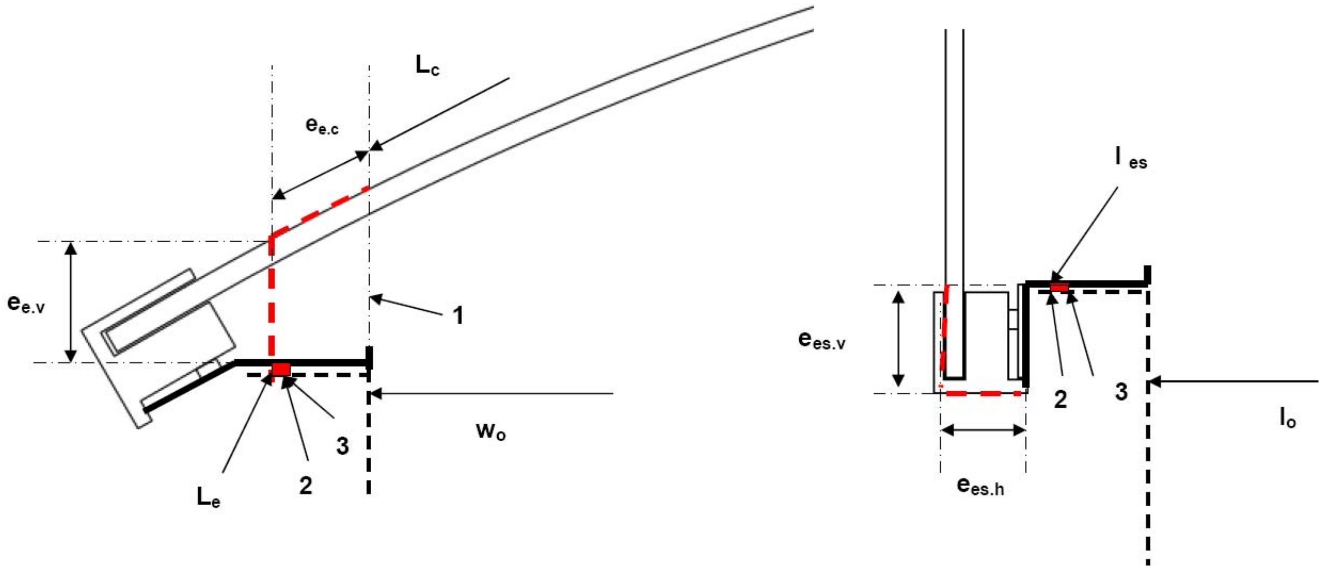
For rooflights with upstand the perimeter of the edge profile equates to the upper outer perimeter of the upstand $P_{up,u}$.

For the situation shown above the virtual width of the edge profile $e_{e,c}$ is defined as:

$$e_{e,c} = \frac{t_c + t_i}{\cos \alpha} \quad [\mathrm{m}] \qquad (14)$$

Where
α slope angle at the upstand (inclination from horizontal), in degree
t_c thickness of the upstand, in m
t_i thickness of the insulation of the upstand, in m

Continuous rooflight with edge profile but without upstand:



Key:
1 limit of clear opening
2 joint sealing
3 starting point of calculation

$e_{e,c}$ virtual width of the edge profile in longitudinal direction

$e_{e,g}$ virtual height of the edge profile in longitudinal direction
$e_{es,h}$ virtual width of the edge profile in transversal direction
$e_{es,v}$ virtual height of the edge profile in transversal direction
L_e the upper outer length of the edge profiles
L_c arc length of the translucent part
l_{es} the upper outer width of the edge profiles
l_o length of the clear rooflight opening
w_o width of the clear rooflight opening

Figure 16: Exemplary overview of the aera with edge profile but without upstand for continuous rooflights

For rooflights without upstand the vertical envelope boundary is normally defined as the outside edge of the joint sealing (see figure 16).

The total area of the edge profile is defined as:

$$A_e = 2 \cdot L_e \cdot e_l + 2 \cdot l_{es} \cdot e_{es} \quad [m^2] \qquad (15)$$

Where (according to figures 15 and 16)
L_e the upper outer length of the edge profiles
e_l the width of the edge profile in longitudinal direction
l_{es} the upper outer width of the edge profiles
e_{es} the width of the edge profile in transversal direction

e_l is defined as:

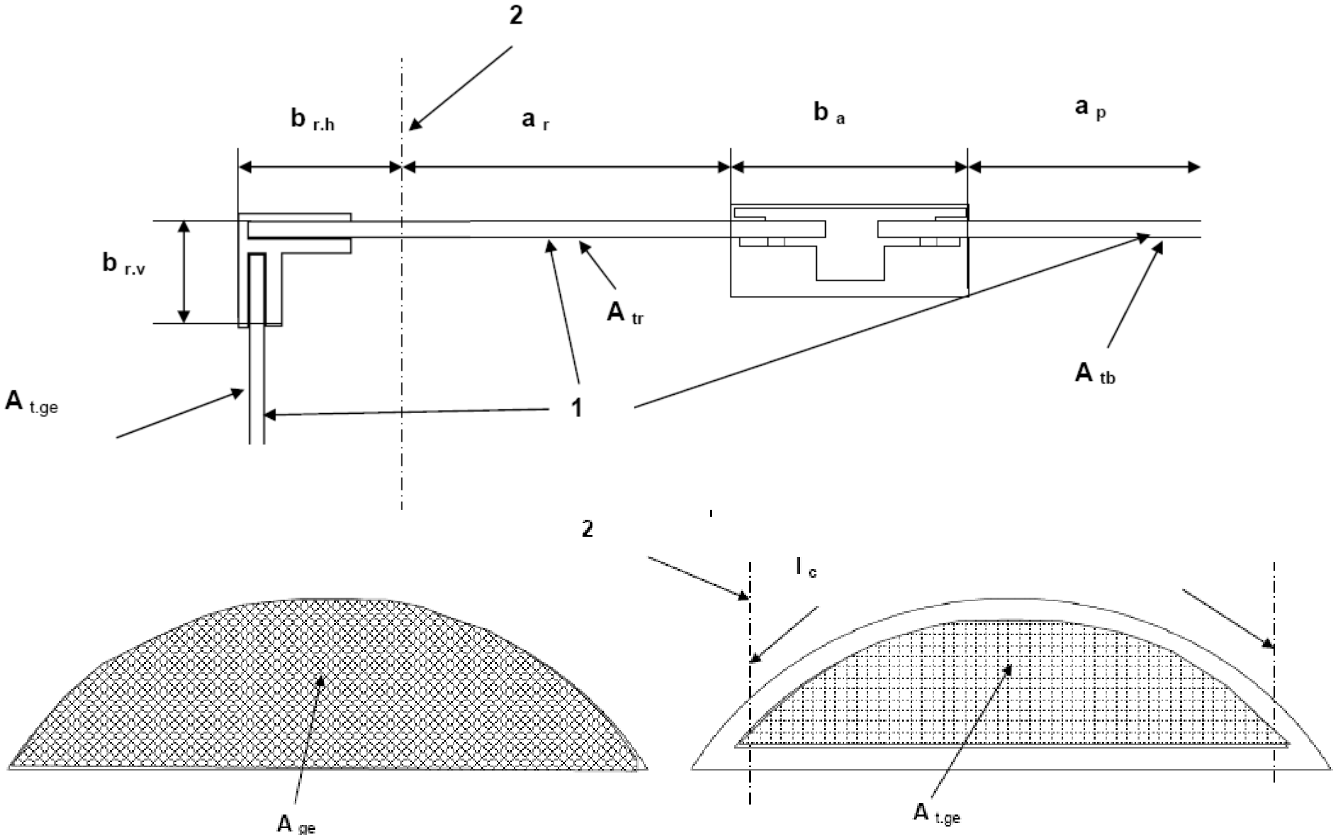
$$e_l = e_{e,c} + e_{e,g} \quad [m] \qquad (16)$$

Where
$e_{e,c}$ virtual width of the edge profile in longitudinal direction, in m
$e_{e,g}$ virtual height of the edge profile in longitudinal direction, in m
e_{es} is defined as:

$$e_{es} = e_{es,h} + e_{es,v} \quad [m] \qquad (17)$$

Where
$e_{es,h}$ virtual width of the edge profile in transversal direction, in m
$e_{es,v}$ virtual height of the edge profile in transversal direction, in m

7.2.4 Area of the junction part



Key:

1 translucent part
2 limit of clear opening

a_p width of translucent part, measured between bearing profiles (standard sheet)
a_r width of translucent part between gable end (junction part) and next bearing profile (marginal sheet)
A_{tb} area of translucent parts measured between bearing profiles(standard sheet),
A_{tr} area of translucent parts measured between gable end and next bearing profile (marginal sheet),
A_{ge} Area of the outer exposed surface of the gable end
$A_{t,ge}$ area of the translucent part of the gable end
b_a width of bearing profiles (junction part)
$b_{r,h}$ horizontal width of junction part at the gable end
$b_{r,v}$ vertical width of junction part at the gable end
l_c arc length of the translucent part (= arc length of bearing profiles)

Figure 17: Exemplary overview of the aera of junction part of gable end for continuous rooflights

The area of the junction parts for bearing profiles A_j is defined as:

$$A_j = A_{j,b} + A_{j,r} \quad [m^2] \qquad (18)$$

Where
$A_{j,b}$ total area of bearing profiles (junction parts)
$A_{j,r}$ area of junction parts at gable ends

The total area of bearing profiles is defined as:

$$A_{j.b} = n_{b.p} \cdot l_c \cdot b_a \quad [m^2] \qquad (19)$$

Where
$n_{b,p}$ number of bearing profiles

l_c arc length of bearing profiles, in m
b_a width of bearing profile, in m

The total area of junction part at the gable end is defined as:

$A_{j,r} = 2 \cdot l_c \cdot (b_{r.h} + b_{r.v})$ [m²] (20)

Where
$b_{r.h}$ horizontal width of junction part at the gable end, in m
$b_{r.v}$ vertical width of junction part at the gable end, in m
l_c arc length of bearing profiles, in m

7.2.5 Area of the translucent part

The area of the translucent part A_t is the outer exposed surface and for a symmetrical continuous rooflight defined as:

$A_t = A_{t.b} + A_{t.r} + 2 \cdot A_{t,ge}$ [m²] (21)

Where
$A_{t.b}$ area of translucent parts measured between bearing profiles, in m²
$A_{t.r}$ area of translucent parts measured between gable end and next bearing profiles, in m²
$A_{t,ge}$ area of translucent part of gable end, in m²

The area of translucent parts between bearing profiles is defined as:

$A_{t.b} = (n_{b.p} - 1) \cdot l_c \cdot a_p$ [m²] (22)

Where
a_p width measured between bearing profiles according to figure 17 (standard section), in m
l_c arc length of bearing profiles, in m
$n_{b,p}$ number of bearing profiles

The total area of translucent parts between gable end (junction part) and next bearing profile is defined as:

$A_{t.r} = 2 \cdot l_c \cdot a_r$ [m²] (23)
Where
a_r the width between gable end (junction part) and next bearing profile, in m
l_c arc length of bearing profiles. in m

The area of the translucent part of the gable end is defined as:

$A_{t,ge} = 2 \cdot (A_{ge} - b_{r,v} \cdot l_c - e_{es,v} \cdot w_o)$ (24)

Where
A_{ge} the total area of the gable end, in m²
$b_{r,v}$ vertical width of junction part at the gable end, in m
$e_{es,v}$ virtual height of the edge profile in transversal direction, in m
l_c arc length of bearing profile, in m
w_o width of the clear opening, in m

As an example the total area of the gable end A_{ge} for a continuous rooflight with a curved design (circular segment) is defined as:

$$A_{ge} = \pi \cdot r^2 \cdot \left(\frac{\beta}{360^\circ}\right) - \frac{r^2}{2}\sin\beta \ \text{[m²]} \qquad (25)$$

NOTE: Angle in degree.

Where

β central angle (= 2α), in degree

r bending radius of the system, in m

7.2.6 Area of panels

If panels replace some translucent parts or the gable ends of a continuous rooflight, the affected areas $A_{t.b}$, $A_{t.r}$ or $A_{t,ge}$ in equation 21 has to be adapted by equivalent areas $A_{p.b}$, $A_{p.r}$ or $A_{p,ge}$.

Where

$A_{p.b}$ area of panels measured between bearing profiles, in m²

$A_{p,ge}$ area of panels of gable end, in m²

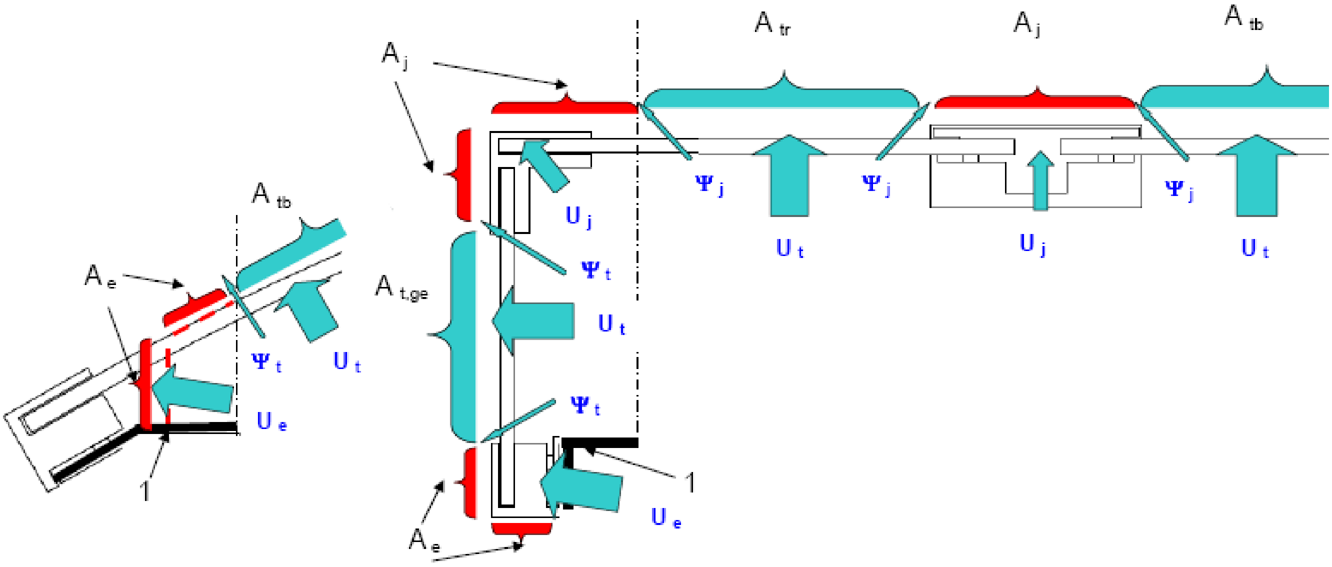
$A_{p.r}$ area of panels measured between gable end and next bearing profiles, in m²

7.3 Total thermal transmittance of continuous rooflights

The total-U-value of an continuous rooflight shall be evaluated taking into account characteristics of the translucent part, the edge profiles, junction parts, panels, if so and the upstand:

- Area of the upstand A_{up} as defined in 7.2.2
- Area of the edge profile part A_e as defined 7.2.3
- Area of the junction part A_j as defined 7.2.4
- Area of the translucent part A_t as defined in 7.2.5
- Area of the panels A_p as defined in 7.2.6
- Thermal transmittance of the upstand U_{up} and in combination with edge profile $U_{up,e}$ as defined in 7.1.2.1
- Thermal transmittance of the junction part U_j as defined in 7.1.2.3
- T hermal transmittance of translucent part U_t as defined in 7.1.2.4
- Thermal transmittance of untransparent panels U_p as defined in 7.1.2.5
- the linear heat transfer coefficient in the transition zone of the translucent part and junction part Ψ_j as Ψ_j defined in 7.1.2.6
- the linear heat transfer coefficient in the transition zone of the translucent part and edge profile Ψ_t as Ψ_t defined in 7.1.2.6

7.3.1 Total thermal transmittance U_r of continuous rooflights including the edge profile and bearing profiles



Key:

1	starting point of calculation
A_e	the outer exposed surface of the edge profile
A_j	the outer exposed surface of the junction part
A_{tb}	the outer exposed surface of the translucent part (standard section)
$A_{t,ge}$	area of the translucent part of the gable end
$A_{t.r}$	area of translucent parts measured between limit of the rooflight in longitudinal direction and next bearing profile (marginal sheet), , in m²
U_e	thermal transmittance of the edge profile, in W/(m² · K)
U_j	thermal transmittance of the junction part
U_t	the thermal transmittance of the translucent part
Ψ_j	linear heat transfer coefficient in the transition zone of translucent part and junction part
Ψ_t	the linear heat transfer coefficient in the transition zone of the translucent part and the edge profile

Figure 18: Explanation of the factors for calculation of the thermal transmittance for continuous rooflights

The U-value of the continuous rooflight U_r with the edge profile but without upstand is calculated as followed:

$$U_r = \frac{A_e \times U_e + A_j \times U_j + A_t \times U_t + l_j \times \Psi_j + l_t \times \Psi_t}{A_e + A_j + A_t} \qquad \text{[W/(m}^2\cdot\text{K)]} \qquad (26)$$

Where

A_e	outer exposed surface of the edge profile, in m²
A_j	outer exposed surface of the junction part, in m²
A_t	outer exposed surface of the translucent part, in m²
l_j	length of the transition between translucent part and junction part, in m
l_t	length of the transition zone between translucent part and edge profile, in m
U_e	thermal transmittance of the edge profile, in W/(m²·K)
U_j	thermal transmittance of the junction part, in W/(m²·K)
U_t	thermal transmittance of the translucent part, in W/(m²·K)
Ψ_j	linear heat transfer coefficient in the transition zone of translucent part and junction part, in W/(m·K)

Ψ_t linear heat transfer coefficient in the transition zone of the translucent part and edge profile, in W/(m·K)

The total length of the junction parts is defined as:

$l_j = (n_{b.p}+1) \cdot l_c$ [m] (27)

Where

l_c arc length of bearing profile, in m

$n_{b.p}$ number of bearing profiles

The total length of the transition zone between translucent parts and edge profiles is defined as:

$l_t = 2 \cdot [(n_{b.p}-1) \cdot a_p + 2 \cdot a_r + w_o]$ [m] (28)

Where

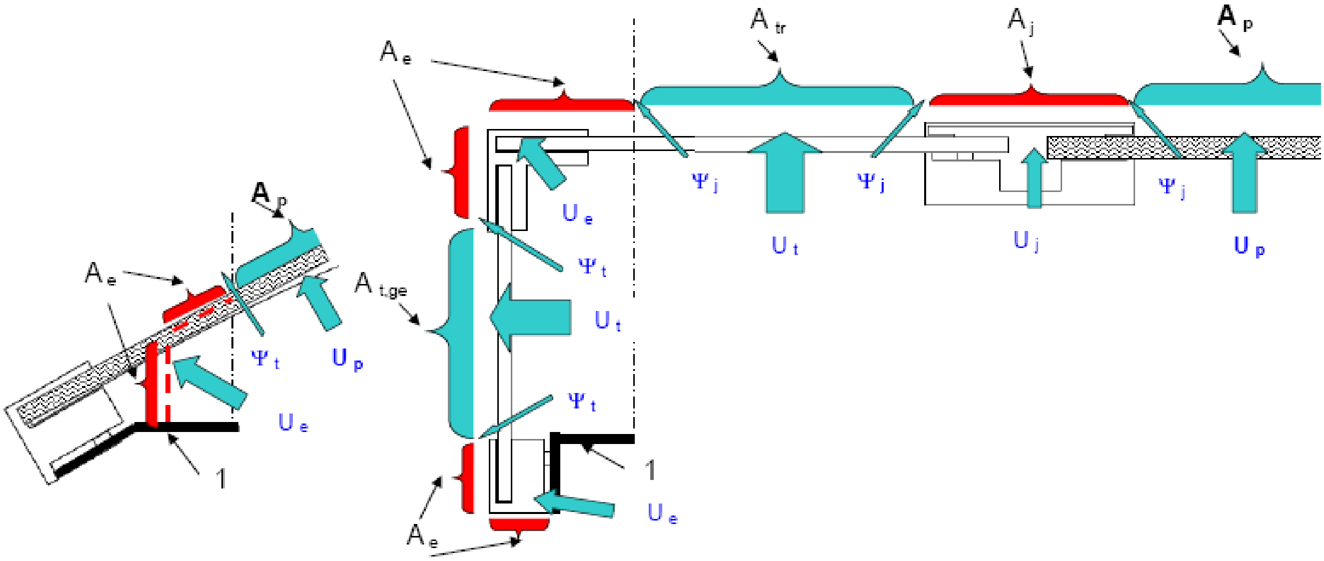
a_p width of translucent part, in m

a_r width of translucent part (end section) , in m

w_o width of the clear opening, in m

$n_{b.p}$ number of bearing profiles

7.3.2 Total thermal transmittance U_r of continuous rooflights including the edge profile, bearing profiles and panels



Key:

1 starting point of calculation

A_e Area of the outer exposed surface of the edge profile

A_j the outer exposed surface of the junction part

$A_{p.b}$ area of panels measured between bearing profiles (standard sheet)

$A_{t,ge}$ area of the translucent part of the gable end

$A_{t.b}$ area of translucent parts measured between bearing profiles(standard sheet)

$A_{t.r}$ area of translucent parts measured between limit of the rooflight in longitudinal direction and next bearing profile (marginal sheet)

U_j thermal transmittance of the junction part

U_p thermal transmittance of panels

U_t the thermal transmittance of the translucent part

Ψ_j linear heat transfer coefficient in the transition zone of translucent part or panel and junction part

Ψ_t the linear heat transfer coefficient in the transition zone of the translucent part or panel and the edge profile

Figure 19: Explanation of the factors for calculation of the thermal transmittance for continuous rooflights with panels

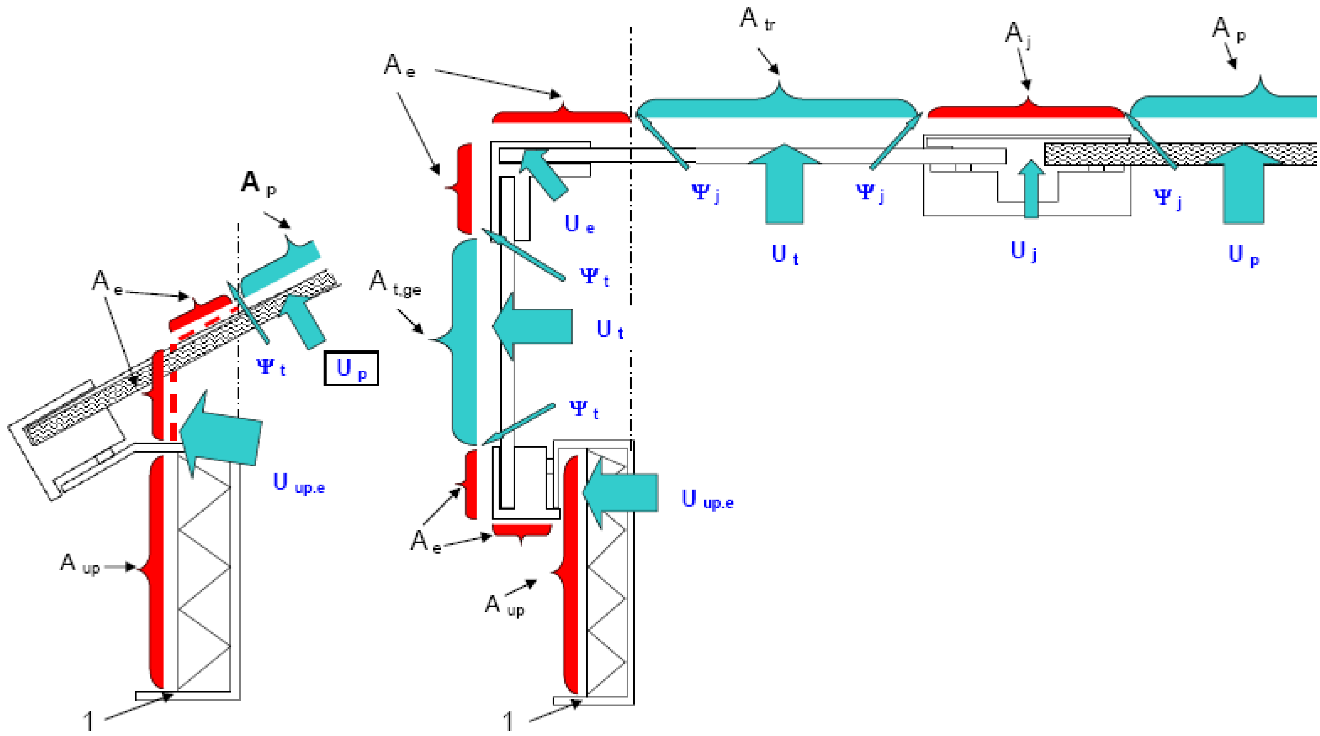
The U-value of the continuous rooflight U_r with the edge profile and panels but without upstand is calculated as followed:

$$U_r = \frac{A_e \times U_e + A_j \times U_j + A_p \times U_p + A_t \times U_t + l_j \times \Psi_j + l_t \times \Psi_t}{A_e + A_j + A_p + A_t} \quad [\text{W/(m}^2\cdot\text{K)}] \qquad (29)$$

Where

A_e outer exposed surface of the edge profile, in m²
A_j outer exposed surface of the junction part, in m²
A_p outer exposed surface of the panels, in m²
A_t outer exposed surface of the translucent part, in m²
l_j length of the transition between translucent part and junction part, in m
l_t length of the transition zone between translucent part and edge profile, in m
U_e thermal transmittance of the edge profile, in W/(m²·K)
U_j thermal transmittance of the junction part, in W/(m²·K)
U_p thermal transmittance of the panels, in W/(m²·K)
U_t thermal transmittance of the translucent part, in W/(m²·K)
Ψ_j linear heat transfer coefficient in the transition zone of translucent part or panels and junction part, in W/(m·K)
Ψ_t linear heat transfer coefficient in the transition zone of the translucent part or panels and edge profile, in W/(m·K)

7.3.3 Total thermal transmittance U_{rc} of continuous rooflights including edge profiles, bearing profiles, panels and upstand



Key:

1	starting point of calculation
A_j	the outer exposed surface of the junction part
A_p	the outer exposed surface of panels
A_t	the outer exposed surface of the translucent part
A_{up}	the outer exposed surface of the upstand
U_j	thermal transmittance of the junction part
U_p	thermal transmittance of panels
U_t	the thermal transmittance of the translucent part
$U_{up,e}$	the thermal transmittance of the upstand including edge profiles
Ψ_j	linear heat transfer coefficient in the transition zone of translucent part and junction part
Ψ_t	the linear heat transfer coefficient in the transition zone of the translucent part and the edge profile

Figure 20: Explanation of the factors for calculation of the thermal transmittance for continuous rooflights with upstand

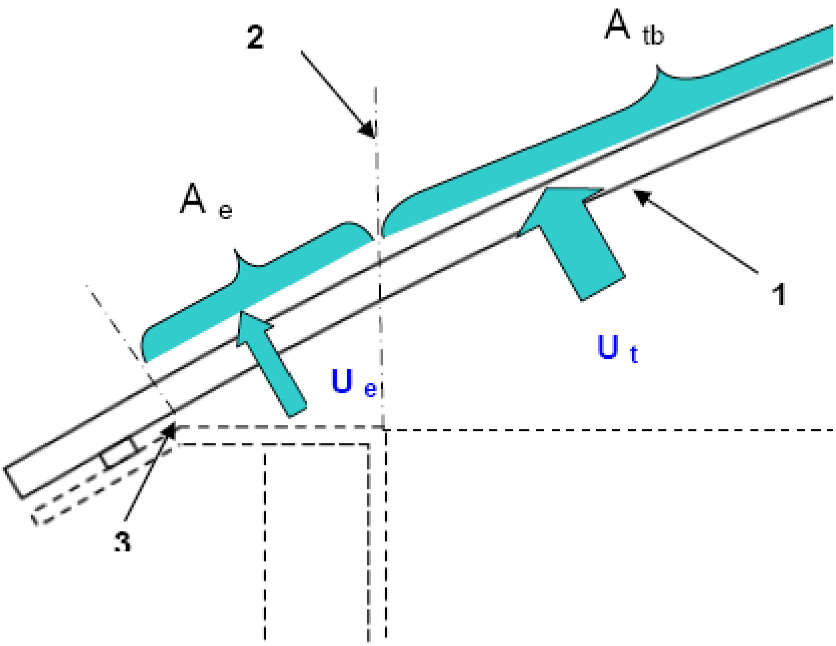
The U-value of the complete continuous rooflight U_{rc} consisting of transparent parts, edge profiles, panels and upstand is calculated as followed:

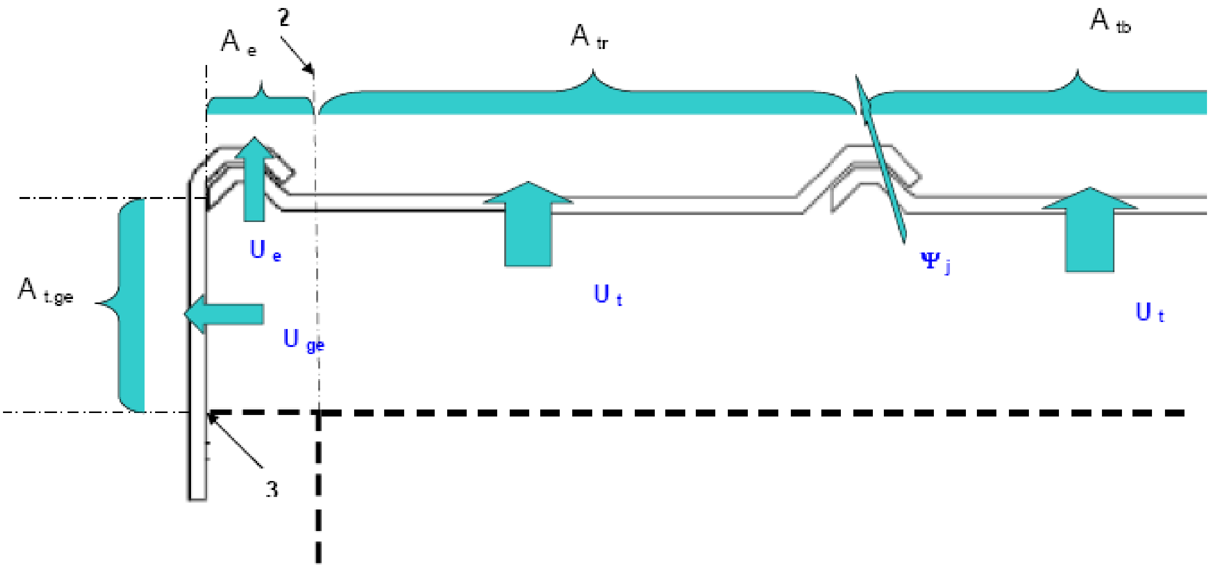
$$U_{rc} = \frac{(A_{up} + A_e) \times U_{up,e} + A_j \times U_j + A_p \times U_p + A_t \times U_t + l_j \times \Psi_j + l_t \times \Psi_t}{A_{up} + A_e + A_j + A_p + A_t}$$ [W/(m²·K)] (30)

Where

A_e	the outer exposed surface of the edge profile, in m²
A_j	the outer exposed surface of the junction part, in m²
A_p	outer exposed surface of the panels, in m²
A_t	the outer exposed surface of the translucent part, in m²
A_{up}	the outer exposed surface of the upstand, in m²
l_j	length of the transition zone between translucent part and junction part, in m (according equation 27)
l_t	length of the transition between translucent part and edge profile, in m (according equation 28)
U_e	the thermal transmittance of the edge profile, in W/(m²·K)
U_p	thermal transmittance of the panels, in W/(m²·K)
U_t	the thermal transmittance of the translucent part, in W/(m²·K)
$U_{up.e}$	the thermal transmittance of the upstand and edge profile, in W/(m²·K)
Ψ_j	the linear heat transfer coefficient in the transition zone of translucent part and junction part, in W/(m·K)
Ψ_t	the linear heat transfer coefficient in the transition zone of the translucent part and edge profile, in W/(m·K)

7.3.4 Total thermal transmittance U_r of selfsupporting continuous rooflights without upstand





Key:

1	translucent part
2	limit of clear opening
3	starting point of calculation
A_e	the outer exposed surface of the edge profile
$A_{t,ge}$	area of the translucent part of the gable end
$A_{t.b}$	area of translucent parts (standard sheet)
$A_{t.r}$	area of translucent parts (marginal sheet)
U_e	the thermal transmittance of the edge profile
U_{ge}	thermal transmittance of the gable end
U_p	thermal transmittance of panels
U_t	the thermal transmittance of the translucent part
Ψ_j	linear heat transfer coefficient in the transition zone of translucent part and junction part

Figure 21: Explanation of the factors for calculation of the thermal transmittance for selfsupporting continuous rooflights without upstand

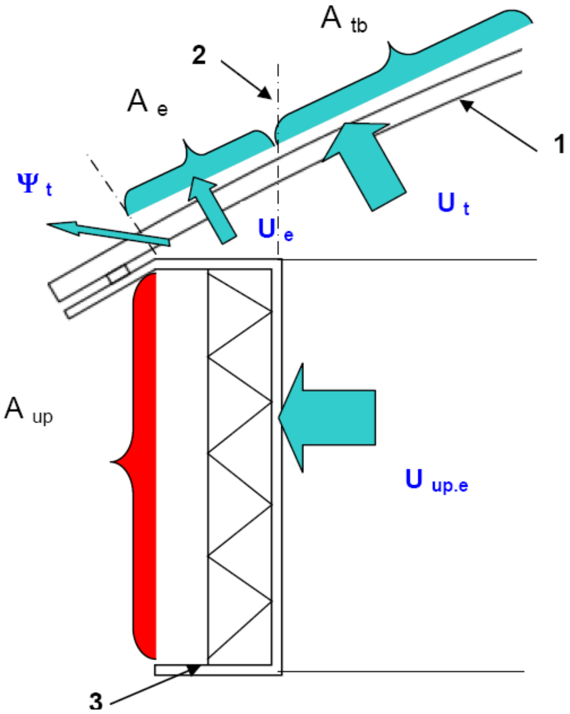
The U-value of the selfsupporting continuous rooflight U_r without upstand is calculated as followed:

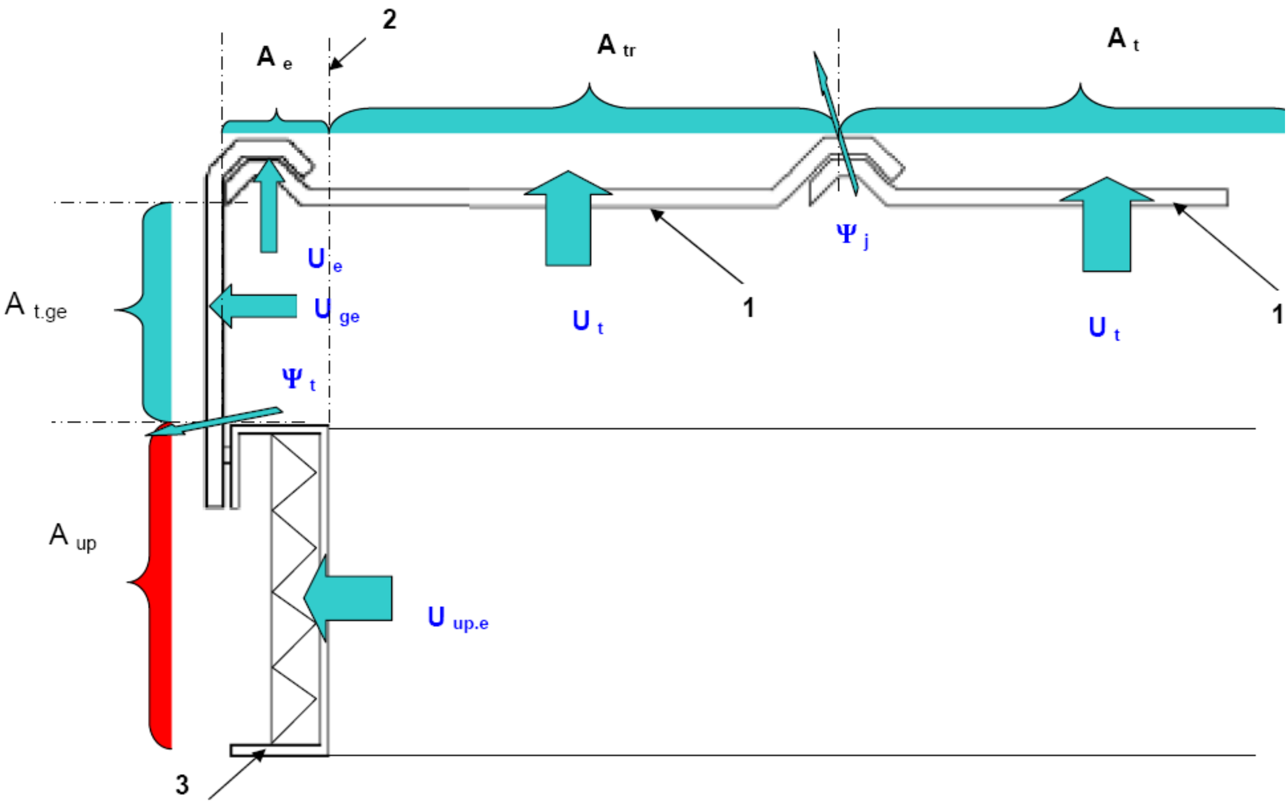
$$U_r = \frac{A_t \times U_t + A_e \times U_e + A_{t.ge} \times U_{ge} + l_j \times \Psi_j}{A_t + A_{t.ge} + A_e} \quad [W/(m^2 \cdot K)] \quad (31)$$

Where

A_e	the outer exposed surface of the edge profile, in m²
$A_{t,ge}$	area of the translucent part of the gable end, in m²
A_t	the outer exposed surface of the translucent part, in m²
l_j	length of the transition zone between adjacent translucent part, in m (according equation 27)
U_e	the thermal transmittance of the edge profile, in W/(m²·K)
U_t	thermal transmittance of the translucent part, in W/(m²·K)
U_{ge}	thermal transmittance of the gable end, in W/(m²·K)
Ψ_j	the linear heat transfer coefficient in the transition zone of adjacent translucent parts, in W/(m·K)

7.3.5 Total thermal transmittance U_{rc} of selfsupporting continuous rooflights with upstand





Key:

1	translucent part
2	limit of clear opening
3	starting point of calculation
A_e	the outer exposed surface of the edge profile
$A_{t,ge}$	area of the translucent part of the gable end
$A_{t.b}$	area of translucent parts (standard sheet)
$A_{t.r}$	area of translucent parts (marginal sheet)
A_{up}	the outer exposed surface of the upstand
l_j	length of the transition zone between adjacent translucent part
U_e	the thermal transmittance of the edge profile
U_t	thermal transmittance of the translucent part
U_{ge}	thermal transmittance of the gable end
$U_{up,e}$	thermal transmittance of the upstand including edge profiles
Ψ_j	the linear heat transfer coefficient in the transition zone of adjacent translucent parts
Ψ_t	the linear heat transfer coefficient in the transition zone of the translucent part and upstand

Figure 22: Explanation of the factors for calculation of the thermal transmittance for selfsupporting continuous rooflights with upstand

The U-value U_{rc} of the complete selfsupporting rooflight with upstand is calculated as followed:

$$U_{rc} = \frac{A_{up} \times U_{up,e} + A_e \times U_e + A_{t.ge} \times U_{ge} + A_t \times U_t + l_j \times \Psi_j + l_t \times \Psi_t}{A_{up} + A_e + A_{t.ge} + A_t} \quad [\mathrm{W/(m^2 \cdot K)}] \tag{32}$$

Where

$A_{t,ge}$ area of the translucent part of the gable end, in m²

A_{up} the outer exposed surface of the upstand, in m²
A_t the outer exposed surface of the translucent part, in m²
l_j length of the transition zone between adjacent translucent part, in m (according equation 27)
l_t length of the transition zone between translucent part and upstand, in m (according equation 28)
U_e the thermal transmittance of the edge profile, in W/(m²·K)
$U_{up.e}$ thermal transmittance of the upstand and junction with translucent part, in W/(m²·K)
U_t thermal transmittance of the translucent part, in W/(m²·K)
U_{ge} thermal transmittance of the end of the continuous rooflight, in W/(m²·K)
Ψ_j the linear heat transfer coefficient in the transition zone of adjacent translucent part, in W/(m·K)
Ψ_t the linear heat transfer coefficient in the transition zone of the translucent part and upstand, in W/(m·K)

7.3.6 Rounding to be used for thermal transmittance in calculation and classification

For the calculation of the thermal transmittance values of U_e, U_{up} and Ψ and values of the surfaces as input have to be indicated using 3 significant digits.
For the ouput (result for classification), values have to be indicated using 2 significant digits.

For example:
Calculation = 1.41 becomes 1.4 W/(m²·K)
Calculation = 1.45 becomes 1.5 W/(m²·K)
Calculation = 0.741 becomes 0.74 W/(m²·K)
Calculation = 0.745 becomes 0.75 W/(m²·K)

8 Evaluation of thermal transmittance for rooflights manufactured by EUROLUX members

8.1 General

For the purpose of comparing the product performances of all manufacturers EUROLUX recommends to evaluate, for each family, the thermal transmittance of reference models indicated in following clauses.

This reference value should be certified by a third party laboratory.

The reference model depends only on the nominal size of the roof opening and the height of the upstand. The supplied products may have different dimensions.

The calculation method described in this guideline allows to evaluate and declare the specific U-value of the supplied product.

8.2 Reference models

8.2.1 Individual rooflight without upstand

Table 2: Overview of the reference models for individual rooflights without upstand

Type A Individual rooflight with only one translucent part	**Type B** Individual rooflight with two or more translucent parts
Nominal size of the roof opening 1.20 m x 1.20 m	Nominal size of the roof opening 1.50 m x 1.50 m
$U_{r,ref}$, $A_{r,ref}$	$U_{r,ref}$, $A_{r,ref}$

To characterize the reference individual rooflight model the following statements in relation to the $U_{r,ref}$-value declaration has to be made:
Type: A or B
Translucent part: glazing material; number of shells; light transmission; size of the translucent parts

Edge profile: YES or NO; in case of YES the material has to be declared
fixed or openable; in case of openable the number of sealing has to be declared

8.2.2 Individual rooflight with upstand

Upstand height: 300 mm

Table 3: Overview of the reference models for individual rooflights with upstands

Type A Individual rooflight with upstand and with only one translucent part	**Type B** Individual rooflight with upstand and with two or more translucent parts
Nominal size of the roof opening 1.20 m x 1.20 m	Nominal size of the roof opening 1.50 m x 1.50 m
$U_{rc,ref300}$, $A_{r,ref300}$	$U_{rc,ref300}$, $A_{r,ref300}$

To characterize the reference individual rooflight model with upstand the following statements in relation to the $U_{rc,ref300}$-value declaration has to be made:

Type: A or B
Translucent part: glazing material; number of shells; light transmission; size of the translucent parts
Edge profile: YES or NO; in case of YES the material has to be declared
fixed or openable; in case of openable the number of sealing has to be declared
Upstand: bearing material; insulation material; thickness of insulation

8.2.3 Continuous rooflight without upstand

Table 4: Overview of the reference models for continuous rooflights without upstand

Type A Continuous rooflight with only one translucent part
Nominal size of the roof opening 2 m x 5 m
$U_{r,ref}$, $A_{r,ref}$

To characterize the reference continous rooflight model the following statements in relation to the $U_{r,ref}$-value declaration has to be made:

Type: A

Translucent part: glazing material; number of shells; light transmission; size of the translucent parts

Edge profile: YES or NO; in case of YES the material has to be declared

fixed or openable; in case of openable the number of sealing has to be declared

8.2.4 Continuous rooflight with upstand

Upstand height: 300 mm

Table 5: Overview of the reference models for continuous rooflights with upstand

Continuous rooflight with upstand and with translucent part
Nominal size 2 m x 5 m
$U_{rc,ref300}$, $A_{r,ref300}$

To characterize the reference individual rooflight model with upstand the following statements in relation to the $U_{rc,ref300}$ value declaration has to be made:

Type:	A
Translucent part:	glazing material; number of shells; light transmission; size of the translucent parts
Edge profile:	YES or NO; in case of YES the material has to be declared
	fixed or openable; in case of openable the number of sealing has to be declared
Upstand:	bearing material; insulation material; thickness of insulatio

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Annex 1:

Method of calculation of the heat flow trough a rooflight installed on a bulding, taking into account the integration of the upstand in the roofing complex

In a planning or designing phase of a building this annex can be used for calculation of the energy efficiency of the rooflight as installed.

Manufacturer should indicate the following characteristics for the rooflight supplied.

$U_{r,ref}$- $A_{r,ref}$	or	$U_{rc,ref300}$- $A_{rc,ref300}$ values	for the reference model,
U_r- A_r	or	U_{rc}- A_{rc} values, nominal size, k_t	for each supplied rooflight

Planer has to take into account the part of the upstand in the insulating part of the roof and the nominal sizes of the openings for the rooflights in the roof area.

The performance of the rooflight as installed is a function of:

- the U_{rc} value of the rooflight
- the depth of integration of the upstand in the roofing complex.

This annex defines how to calculate the design U-value, $U_{rc,inst}$, of an individual rooflight or a continuous rooflight from U_{rc} (value of CE marking) for each specific application of building envelope.
This annex gives informations to calculate equivalent thermal transmittance for the roof opening according to the sizes and design of the rooflight.

The thermal transmittance of the rooflight as installed in the roof, $U_{rc,inst}$, is calculated as followed:

$$U_{rc,inst} = U_{rc} - \left(h_{insulat} \times k_t\right) \quad \text{W/[m}^2\text{·K]} \qquad \text{(A1.1)}$$

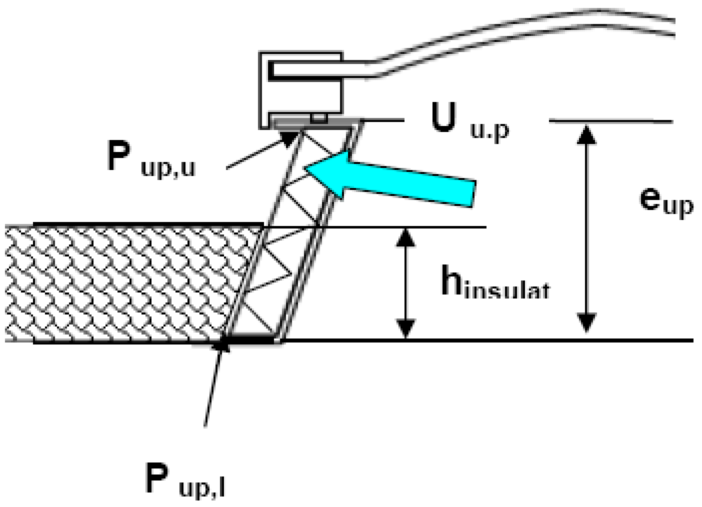
Where:

$h_{insulat}$	height of insulating part of the roof, in m
k_t	coefficient of covering the part of upstand by insulating part of the roof, in W/(m·K)
U_{rc}	total thermal transmittance of rooflight, in W/(m²·K)

$$k_t = \frac{U_{up} \times P_{up}}{A_{rc}} \quad \text{W/[m}^3\text{·K]} \qquad \text{(A1.2)}$$

Where:

A_{rc}	surface of the rooflight with upstand, in m²
P_{up}	the reference perimeter of the upstand (calculated as average of upper outer perimeter $P_{up,u}$ and lower outer perimeter $P_{up,l}$), in m
U_{up}	the thermal transmittance of the upstand, in W/(m²·K)



Key:

$h_{insulat}$ height of insulating part of the roof
$P_{up,u}$ upper outer perimeter of the upstand
$P_{up,l}$ lower outer perimeter of the upstand

U_{up} the thermal transmittance of the upstand

The design heat flow H_{rc} trough a rooflight installed is calculated as followed:

$$H_{rc} = A_{rc} \times U_{rc,inst} \text{ W/K} \quad \text{(A1.3)}$$

Where

A_{rc} outer exposed surface of the rooflight with upstand, in m²
$U_{rc,inst}$ thermal transmittance of the rooflight, installed on the roof, in W/[m²·K]

Annex 2:

Calculation of U-values for transparent parts of continuous rooflights made out of solid acrylic or polycarbonate sheets

A2.1 Basics

A2.1.1 General approach

According to EN 673 the calculation of the U-value is determined by

$$\frac{1}{U} = \frac{1}{h_e} + \frac{1}{h_t} + \frac{1}{h_i} \qquad \text{(A2.1)}$$

Where

h_e external heat transfer coefficient in W/(m²·K)
h_i internal heat transfer coefficient in W/(m²·K)
h_t overall coefficient of heat transfer for glazing in W/(m²·K)

$$R = \frac{1}{U} = \frac{1}{h_i} + \sum_{i=1}^{n} r_i + \frac{1}{h_e} \qquad \text{(A2.2)}$$

Where

h_e external heat transfer coefficient in W/(m²·K)
h_i internal heat transfer coefficient in W/(m²·K)
r_i individual thermal resistance in (m²·K)/W
R overall thermal resistance in (m²·K)/W
U thermal transmittance in W/(m²·K)

The value of the internal heat transfer coefficient h_i for a horizontal heat flow is equal to 8

W/(m²·K) and the 1/ h_i is round off to 0,13 (m²·K)/W.

According to EN ISO 10077-1 the value of the internal heat transfer coefficient h_i for a vertical heat flow is equal to 10 W/(m² · K) and the 1/ h_i is 0,10 (m²·K)/W.

The value of the external heat transfer coefficient h_e for a horizontal or vertical heat flow is equal to 23 W/(m²·K) and the 1/h_e is round off to 0,04 (m²·K)/W.

For solid, homogeneous materials the individual thermal resistance r_i is defined as:

$$r_i = \frac{d_i}{\lambda_i} \qquad \text{(A2.3)}$$

Where

d_i thickness of material i in m
λ_i coefficient of thermal conductivity of material i in W/(m·K)

For common applications the followings values acc. EN ISO 10456, Table 3, can be used:

λ_{PMMA} = 0,18 W/(m·K)

λ_{PC} = 0,20 W/(m·K)

A2.1.2 Static air layer

An air layer forms an especial high thermal resistance, which depends not linear from the thickness of the layer. In thin layers the resistance increases rapidly with the thickness, in thick layers the resistance changes only marginal due to air movement within the layer (see Figure 1).

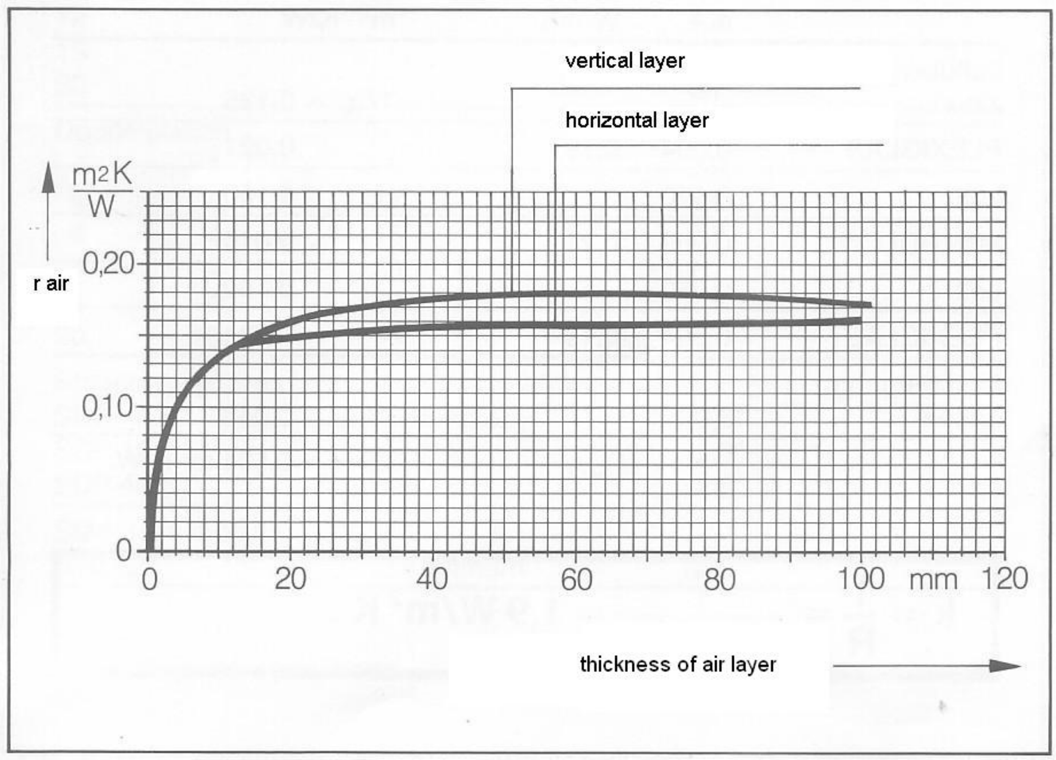


Figure 1: thermal resistance r for static air layers arranged horizontal or vertical (including the heat transfer coefficients in the air gap)

(Source: Röhm-Architektenordner, Abschnitt PU 3, HRSG. Baurat Amtor Schwabe)

A2.2 Calculation

A2.2.1 Single sheet

$$R = \frac{1}{U} = \frac{1}{h_i} + \frac{d}{\lambda} + \frac{1}{h_e} \qquad \text{(A2.4)}$$

Example 1:

What is the U_t-value for the transparent part of a continuous rooflight with a 4 mm thick acrylic sheet?

Data:

d = 0,004 m

$1/h_e$ = 0,04 (m²·K)/W

$1/h_i$ = 0,10 (m²·K)/W

λ_{PMMA} = 0,18 W/(m·K)

Result:

$$R = \frac{1}{U_t} = \frac{1}{10W/m^2K} + \frac{0{,}004m}{0{,}18W/mK} + \frac{1}{25W/m^2K} = 0{,}162m^2K/W \quad \text{(A2.5)}$$

U_t = 6,2 W/(m²·K) (A2.6)

A2.2.2 Double sheet with static air layer

$$R = \frac{1}{U_t} = \frac{1}{h_i} + \frac{1}{\Lambda} + \frac{1}{h_e} = \frac{1}{h_i} + \frac{d_1}{\lambda_1} + r_{air} + \frac{d_2}{\lambda_2} + \frac{1}{h_e} \quad \text{(A2.7)}$$

Example 2:

What is the U-value for the transparent part of a continuous rooflight with a combination of two 4 mm thick acrylic sheets and a static air layer of 40 mm thickness?

Data:

$d_{1,2}$ = 0,004 m

$1/h_e$ = 0,04 (m²·K)/W

$1/h_i$ = 0,10 (m²·K)/W

r_{air} = 0,15 (m²·K)/W

$\lambda_{1,2}$ = λ_{PMMA} = 0,18 W/(m·K)

Result:

$$R = \frac{1}{U_t} = 0{,}10m^2K/W + \frac{0{,}004m}{0{,}18W/mK} + 0{,}15m^2K/W + \frac{0{,}004m}{0{,}18W/m^2K} + 0{,}04m^2K/W = 0{,}334m^2K/W \quad \text{(A2.8)}$$

U_t = 3,0 W/(m²·K) (A2.9)

A2.2.3 Triple Sheet

$$R = \frac{1}{U_t} = \frac{1}{h_i} + \frac{1}{\Lambda} + \frac{1}{h_e} = \frac{1}{h_i} + \frac{d_1}{\lambda_1} + r_{1,air} + \frac{d_2}{\lambda_2} + r_{2,air} + \frac{d_3}{\lambda_3} + \frac{1}{h_e} \quad \text{(A2.10)}$$

Example 3:

What is the U-value for the transparent part of a continuous rooflight with a combination of two acrylic sheets (4 mm each) and a PC-sheet of 3 mm thickness and air layers of 50 mm and 20 mm thicknesses?

Data:

$d_{1,3}$ = 0,004 m

d_2 = 0,003 m

$1/h_e$ = 0,04 (m²·K)/W

$1/h_i$ = 0,10 (m²·K)/W

$r_{1,air}$ = 0,15 (m²·K)/W

$r_{2,air}$ = 0,16 (m²·K)/W

$\lambda_{1,3}$ = λ_{PMMA} = 0,18 W/(m·K)

λ_2 = λ_{PC} = 0,20 W/(m·K)

Result:

$$R = \frac{1}{U_t} = 0{,}10 m^2K/W + \frac{0{,}004m}{0{,}18W/mK} + 0{,}15 m^2K/W + \frac{0{,}003m}{0{,}20W/m^2K} + 0{,}16 m^2K + \frac{0{,}004m}{0{,}18W/mK} + 0{,}04 m^2K/W = 0{,}509 m^2K/W \quad \text{(A2.11)}$$

U_t = 1,96 W/(m²·K) (A2.12)

A2.2.4 Calculation of combinations of sheets using available U-values

Example 4:

What is the U-value for the transparent part of a continuous rooflight with a combination of a PC solid sheet (4 mm) and a PC multiwall sheet of 16 mm thickness (sextuple skin/S6P16) and an air layer of 50 mm thickness?

Data:

d_1 = 0,004 m

$1/h_e$ = 0,04 (m²·K)/W

$1/h_i$ = 0,10 (m²·K)/W

$r_{1,air}$ = 0,16 (m²·K)/W

U_{S6P16} = 1,85 W/(m²·K) (see EN 15193, Table C.3a)

$\lambda_2 = \lambda_{PC}$ = 0,20 W/(m·K)

Result:

Using equation (2) to determine r_{S6P16}:

$$r_{S6P16} = \frac{1}{1{,}85W/(m^2K)} - 0{,}1 m^2K/W - 0{,}04 m^2K/W = 0{,}401 m^2K/W \quad \text{(A2.13)}$$

$$R = \frac{1}{U_t} = 0{,}10 m^2K/W + \frac{0{,}004m}{0{,}20W/mK} + 0{,}16 m^2K/W + 0{,}401 m^2K/W + 0{,}04 m^2K/W = 0{,}72 m^2K/W \quad \text{(A2.14)}$$

U_t = 1,39 W/(m²·K) (A2.15)

GUIDELINE 01

Détermination of thermal transmittance of rooflights

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