TECHNICAL DOCUMENT NTD02.1
2022

THE ROOFLIGHT ASSOCIATION

ASSESSMENT OF THERMAL PERFORMANCE OF OUT OF PLANE ROOFLIGHTS

CONTENTS

FOREWORD

The 2021 version of NTD02 is updated to reflect the changes of BR443 and the 2021 version of Approved Document L in England.

The main changes are:

- The layout of ADL has been rationalised into two volumes – volume 1 for dwellings and volume 2 for non-dwellings and the guidance in this document has been updated to reflect this.
- Rooflight u-values are now calculated in the horizontal orientation.
- In all instances the limiting u-value for rooflights is now 2.2W/(m^2•K) (in the horizontal plane).
- Rooflight upstands are treated differently depending upon whether it is built on site or supplied as part of the rooflight.
- The limiting u-value for upstands built on site is 0.35W/(m^2•K).
- When supplied as part of the rooflight, the limiting value of the upstand is combined as part of the overall rooflight u-value.
- The definition of the developed area has changed to fall in line with BS EN 1873:2014 with U_d changing to U_r or U_{rc}.

SCOPE

This document:

- Defines U_r and U_{rc} values, based on the developed area of the rooflight, which is the value which should be checked against Building Regulation fabric limits
- Explains why use of U_r and U_{rc}-values rather than $U_{roof\_opening}$-value is appropriate for use as the limiting value in Building Regulations.
- Provides detail on how U_r and U_{rc}-values should be calculated for out-of-plane rooflights, and for rooflight-and-upstand assemblies.
- Defines how the developed area of out-of-plane rooflights should be measured to calculate surface:area ratio and/or U_r-value but does not define how to calculate or measure heat loss through a sample, or calculate the true U-value, which are defined elsewhere.
- Clarifies the difference between $U_{roof\_opening}$-value and U_r or U_{rc}-values, and how data on U_r and U_{rc}-values should be quoted.

INTRODUCTION

Approved Document L – Volume 1: Dwellings

For all domestic applications, the worst acceptable standards for the thermal performance of rooflights in new build work are defined in Building Regulations Approved Document L Volume 1 Table 4.1 and for existing dwellings in Building Regulations Approved Document L Volume 1 Table 4.2.

Table 4.1 Limiting U-values for new fabric elements and air permeability in new dwellings

Element type	Maximum U-value[1] W/(m².K)
All roof types [2]	0.16
Wall [2]	0.26
Floor	0.18
Party wall	0.20
Swimming pool basin [3]	0.25
Window [4] [5]	1.6
Rooflight [6] [7]	2.2
Doors (including glazed doors)	1.6
Air permeability	8.0m³/h.m² @ 50Pa 1.57m³/h.m² @ 4Pa

Table 4.2 Limiting U-values for new fabric elements in existing dwellings

Element type	Maximum U-value[1] W/(m².K)
Roof [2]	0.15
Wall [2] [3]	0.18
Floor [4] [5]	0.18
Swimming pool basin [6]	0.25
Window [7] [8] [9]	1.4 or Window Energy Rating [10] Band B minimum
Rooflight [11] [12]	2.2
Doors with >60% of internal face glazed [13]	1.4 or Doorset Energy Rating [10] Band C minimum
Other doors [13] [14]	1.4 or Doorset Energy Rating [10] Band B minimum

Note: To aid clarity the footnotes appended to Tables 4.1 and 4.2 have been omitted above.
Please refer to the Approved Documents for original text / footnotes.

INTRODUCTION CONTINUED

Approved Document L – Volume 2: Non Dwellings

For all non-domestic applications, the worst acceptable standards for the thermal performance of rooflights in both new and existing buildings is defined in Building Regulations Approved Document L Volume 2 Table 4.1.

Table 4.1 Limiting U-values for new or replacement elements in new and existing buildings and air permeability in new buildings

Element type	Maximum U-value[1] W/(m².K) or air permeability
Roof (flat roof) [2]	0.18
Roof (pitched roof) [2	0.16
Wall [2] [3]	0.26
Floor [4] [5]	0.18
Swimming pool basin [6]	0.25
Windows in buildings similar to dwellings [7] [8]	1.6 or Window Energy Rating [9] Band B
All other windows [8] [10] [11] roof windows, curtain walling	1.6
Rooflights [12] [13])	2.2
Pedestrian doors (including glazed doors) [14]	1.6
Vehicle access and similar large doors	1.3
High usage entrance doors	3.0
Roof ventilators (including smoke vents)	3.0
Air permeability (for new buildings)	8.0m³/(h.m²) @ 50Pa
Other doors [13] [14]	1.4 or Doorset Energy Rating [10] Band B minimum

Note: To aid clarity the footnotes appended to Table 4.1 have been omitted above. Please refer to the Approved Document for original text / footnotes.

INTRODUCTION CONTINUED

These tables all include footnotes which relate to rooflights which clearly state that “the rooflight U-value for checking against these limits is that based on the developed area of the rooflight, not the area of the roof aperture”, i.e. the U_r or U_{rc} value.

There are further notes relating to the upstands and these make it clear that where the upstand is provided as part of the rooflight then the additional surface area of the upstand can be included in the calculation and the same limiting value applies. Where the upstand is constructed on site or sourced separately from the rooflight, the upstand cannot be included with the relevant limiting value being 0.35W/(m^2•K).

The U-value used for energy calculations (SAP, SBEM) as defined in BR443 is based on the area of the roof aperture and is therefore not the value to which Building Regulation limiting values should be applied.

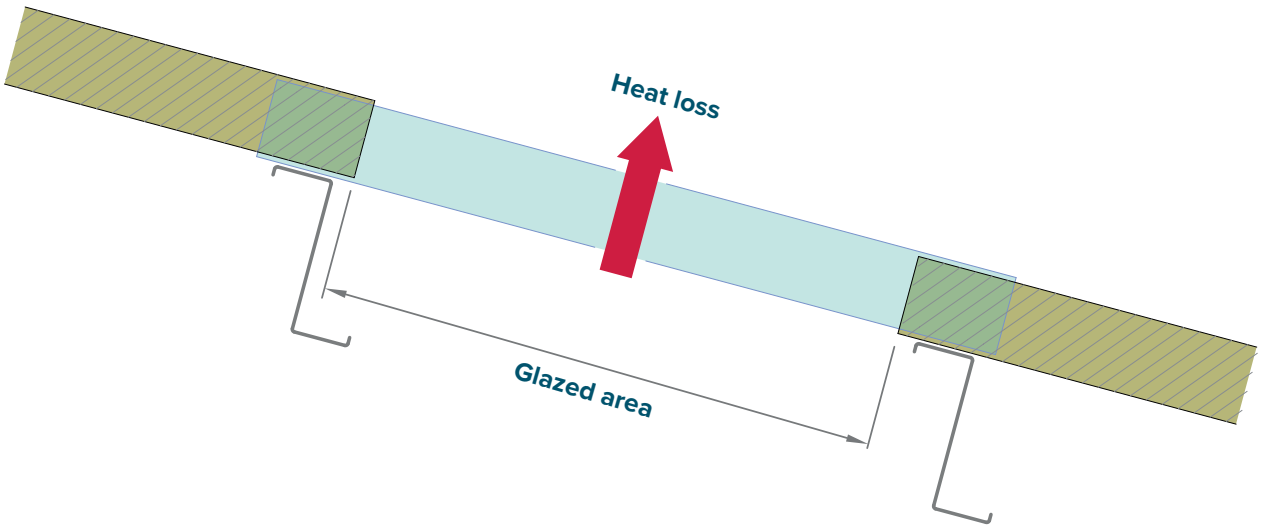
Definition of rooflight U-values:

The U-value of a building element or product is defined as the heat loss through the element, divided by the area of that element.

This is straightforward for plane, flat products (such as a roof or wall). Where products are installed at a pitch (such as a roof, or a rooflight in the plane of the roof) the area is generally defined as being perpendicular to the plane of the product.

For example, if a flat glazing system is installed in the plane of a pitched roof as shown in Figure 1, the U-value of both the opaque roof, and the glazing would be based on the area of the roof or the glazing respectively, rather than the area of floor they cover.

Figure 1

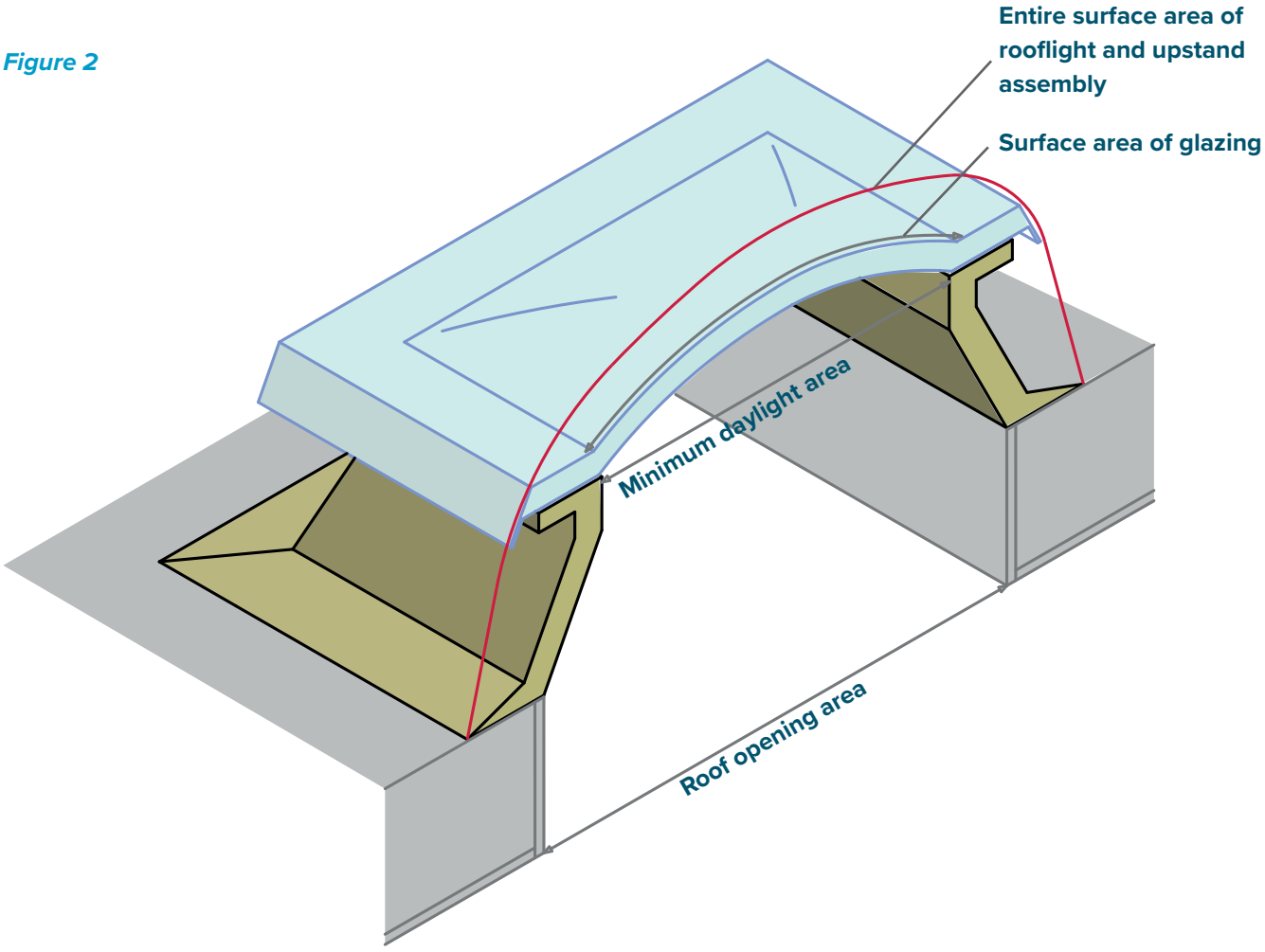


INTRODUCTION CONTINUED

However, many rooflights are out-of-plane rooflights that sit proud of the plane of the roof (typically mounted on upstands). The range includes modular rooflights (typically domes or pyramids), continuous barrel vaults, lanterns, boxes and glazing bar systems. Furthermore, rooflights may be mounted onto upstands designed and supplied by others, which can effectively be considered as part of the roof, or some rooflights (particularly individual dome and pyramid modular rooflights) can be supplied as an assembly with a pre-manufactured upstand matched to the rooflight itself.

There are significant differences between the area of the opening in the roof, the minimum daylight area, the surface area of the glazing, and the surface area of a rooflight-and-upstand assembly, as shown in Figure 2, and it is essential to be clear which of these areas should be used when defining the thermal performance values.

Figure 2



INTRODUCTION CONTINUED

Out of plane rooflight U-values:

A different value, based on the developed area of the rooflight, is therefore required as the value which should be checked against limiting values in Building Regulations – this is termed the U_r-value for the rooflight only or U_{Urc}–value where the rooflight is supplied with an upstand. This is based on the principles set out in Annex D of the rooflight product standard BS EN 1873:2014. Although this standard covers rooflights made of plastics the same principle can be applied to all out of plane rooflights.

This document defines the U_r and U_{rc}-value, and how the developed area of the rooflight should be assessed, as this can be difficult, and different interpretations on how to assess developed area can give wildly differing U_r and U_{rc}-values. It is important to harmonise the method of assessment of these values to ensure different products can be compared directly.

A U_r-value can be calculated for a rooflight alone. For a rooflight-and-upstand assembly, a U_{rc}-value should be calculated for the rooflight-and-upstand assembly: in both cases this will usually be a lower value than the true U-value as the developed area is greater than the area of the roof opening.

It is important to note that the limiting values in Building Regulations must be met by every rooflight (alone), even when supplied as part of a rooflight-and-upstand assembly. The U_r-value for the rooflight alone, when supplied as part of a rooflight-and-upstand assembly, must also meet the limiting values of ADL as well as the whole assembly. It is therefore important that for rooflight-and-upstand assemblies, manufacturers should be able to quote both values.

Note that it is not acceptable to use an assembly of a rooflight with poorer thermal performance (such as double skin plastic rooflights) on an upstand simply because the U_{rc}-value for the rooflight-and-upstand assembly is less than the limiting values in the Building Regulations, unless the U_r-value for the rooflight alone also meets the limiting values.

DEFINITIONS

Table A below details the references used by EN1873, BR443 and Approved Document L (ADL). These references do differ and this table can be used to determine the corresponding value in each publication.

Table A: Definitions and references

EN1873	BR443	ADL	DEFINITION
U-value	$U_{roof\_opening}$	U-value	True U-value, required for energy calculations (i.e. SAP, SBEM).
U_r-value	U_p-value	U_d-value	Developed area U-value, rooflight only; for comparison / ADL compliance check.
U_{rc}-value	U_p-value	U_d-value	Developed area U-value, rooflight-and-upstand assembly; for comparison / ADL compliance check.
A_r	A_p	-	Developed area, rooflight only.
A_{rc}	A_{rc}	-	Developed area, rooflight-and-upstand assembly.
A	$A_{roof\_opening}$	-	Internal roof opening area.
surface:area ratio	-	-	Ratio of the developed area (Ar) divided by the internal roof opening area (A).

For the purpose of this document the naming convention of EN1873:2014 is used. Where reference is made to 'upstands' the term 'kerb' is also commonly used, either term can be used to describe the same component.

It should be noted that Approved Document L, Volumes 1 & 2 2021 refer to U_d. This term was used in older versions of ADL Vol 1A, 1B, 2A and 2B as well as the 2010 version of this document, NTD02. In these cases the developed area was based on the internal surface area and the U-value being calculated in a vertical orientation, (i.e. horizontal heat flow). The 2021 version of ADL Volumes 1 and 2 now base rooflight U-values being calculated in a horizontal orientation, (i.e. vertical heat flow) and where the developed area is based on the external area of the rooflight as defined in BR443 2019.

In this instance the product U-value should be referred to as Ur for rooflights only or U_{rc} for rooflights with upstands to align with the product standard for rooflights EN1873. Therefore where ADL:2021 refers to U_d this document will refer to U_r or U_{rc}. Any older references to Ud should be ignored as the definition of U_d for calculation purposes is not the same as U_r or U_{rc}.

DEFINING THE U_r VALUE

The U_r-value:

The U_r-value for a rooflight only, whether a rooflight supplied for use on a separate builders upstand or as the rooflight element of a rooflight-and-upstand assembly, should be calculated as shown in Equation 1:

$$U_r = \frac{\Phi}{A_r \cdot \Delta T}$$

Where

U_r = U_r-value calculated using the developed area of the system ($W/(m^2 \cdot K)$)

Φ = Heat flow rate through system (Watts)

A_r = Developed area of rooflight as defined in Annex D of BS EN 1873:2014 (m^2)

ΔT = Temperature difference across a system (K)

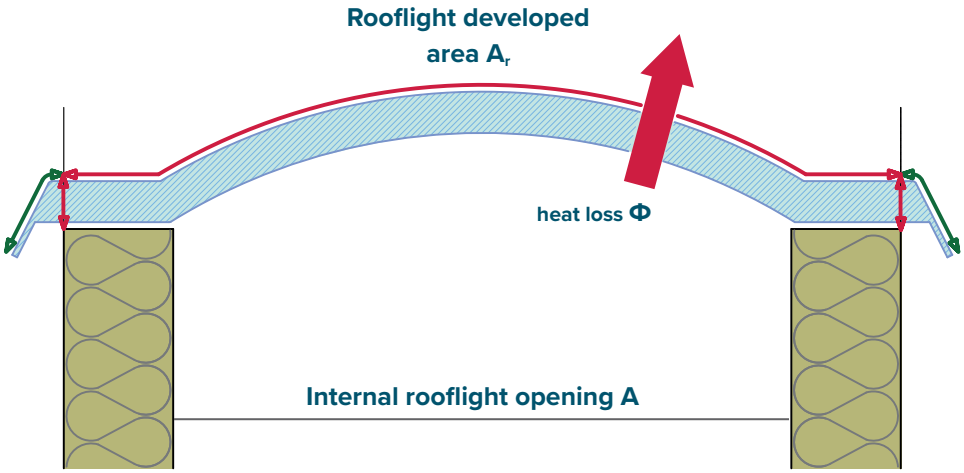


Figure 3

The heat loss Φ should always be measured or calculated as the total heat loss through the product, obtained either by measurement in a hot box according to BS EN ISO 12567-1, or by computer simulation according to BS EN ISO 10077-2 and BS EN 673 where appropriate, and dividing this by the rooflight developed area as shown in Figure 3 (red line).

However, when calculating the developed area of a rooflight, only those areas through which there is significant heat conduction should be included, to prevent calculation of excessively large developed areas (and correspondingly low U_r-values).

For example, external fixing flanges and details should be excluded from the area calculation, and the heat loss from them excluded in any heat loss calculations or physical measurement. See clause 6.3.1 of BS EN ISO 10077-2:2017.

The Ur value must always meet or exceed the limiting values shown in ADL.

DEFINING THE U_r VALUE CONTINUED...

The rooflight developed area A_r:

The developed area A_r should be calculated in accordance with EN1873:2014 annex D, and with the following guidelines:

i. the area calculated for any rooflight should include all the area inside the external face of the upstand dimensions, but exclude any area outside this as shown in Figure 3 & 4a (red line).

ii. if the outer skin of a rooflight is not in direct contact with the roof upstand but over sails it, an imaginary line should be drawn from the outside face of the upstand to the outer glazing, perpendicular to the outer glazing. The developed area of the rooflight should be defined as the area of the outer glazing which is inside the imaginary line, as shown in Figure 3 & 4a.

iii. for definition of surface:area ratio and/or calculation of the U_r-value, the ratio will be the developed area (A_r) divided by the internal roof opening area (A).

iv. the area of any dome rooflight should be estimated by taking the flat area and multiplying by the K factor for the shape in accordance with clause 3.5 in Annex D of BS EN 1873.

v. If a rooflight includes glazing bars or frame, then both heat loss through the glazing bars, and area of the glazing bars, should be included in calculation of U-value and U_r-value, see Figure 4b.

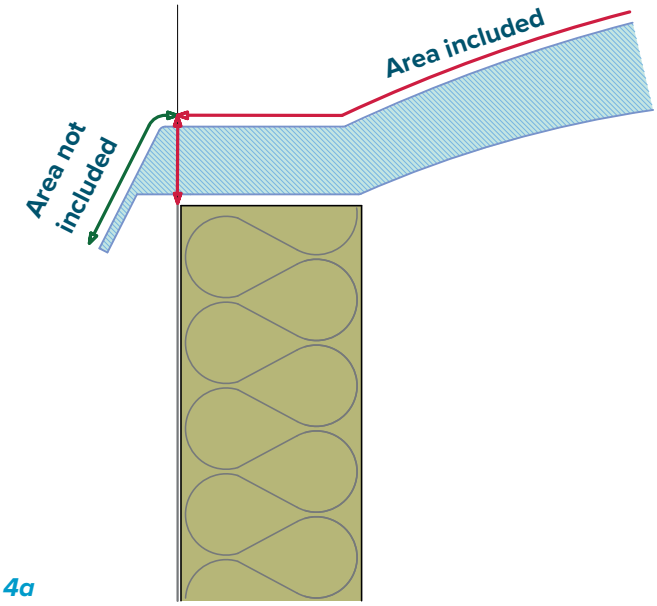


Figure 4a

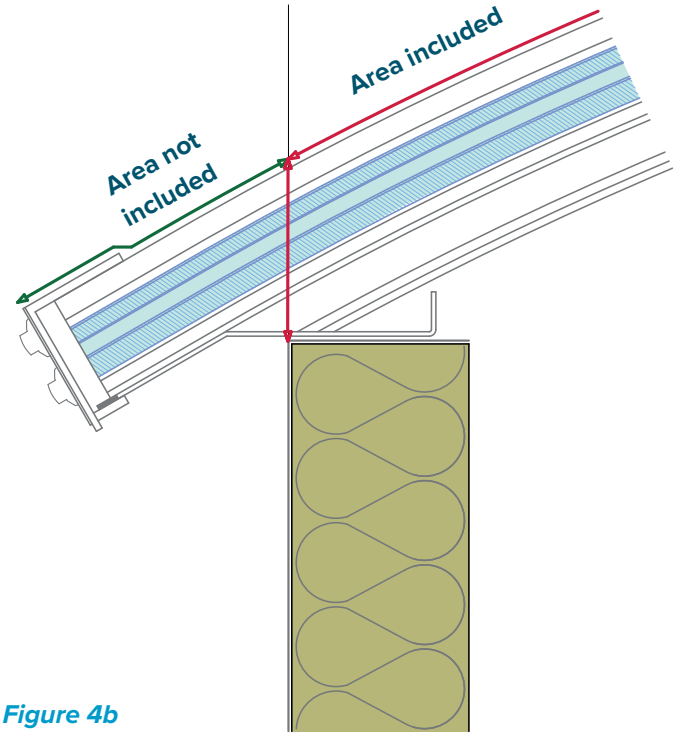


Figure 4b

DEFINING THE U_r VALUE CONTINUED...

Presentation of U_r and U-values:

Rooflight manufacturers should be able to quote both the U_r-value and the true U-value for their products.

The U_r value, being the total heat loss divided by the rooflight developed area, is required for comparison against other products and for checking against the worst case limiting U-value in ADL only.

The true U-value is required for the purpose of energy calculations (such as SAP, SBEM or other approved software).

Both values are therefore required and rooflight manufacturers must be explicit in communicating their performance values, either as a U_r and U-value per product or one of these values and the surface:area ratio. A U_r or U-value should not be quoted alone.

DEFINING THE U_{rc} VALUE

The U_{rc} value:

The U_{rc}-value for a rooflight-and-upstand assembly should be calculated as shown in Equation 2. Similar principles apply as when considering rooflights only, but in addition particular care is required when considering deeper upstands (over 150mm deep), as these are often buried within insulation when installed, so the additional surface area of deeper upstands should not be considered when calculating developed area.

$$U_{rc} = \frac{\Phi}{A_{rc} \cdot \Delta T}$$

Where

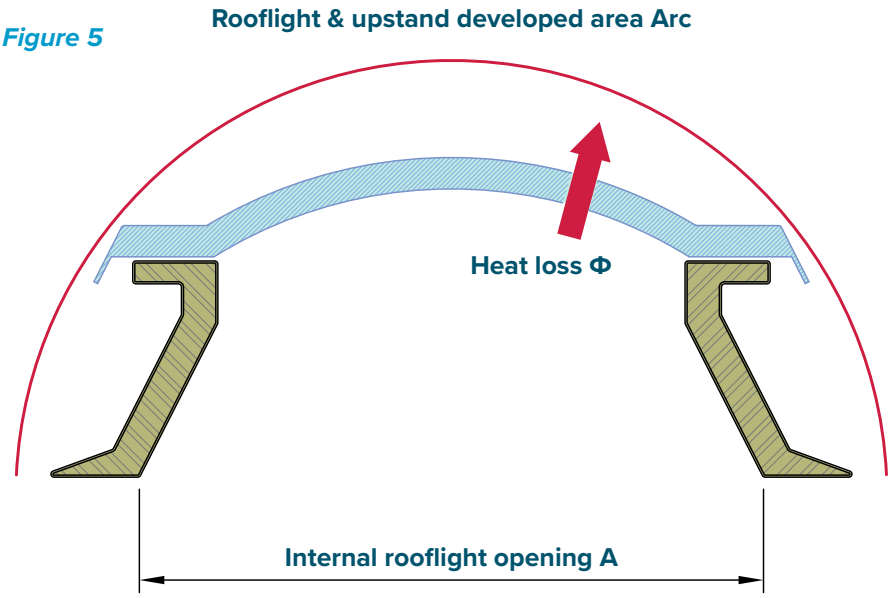
U_{rc} = U_{rc}-value calculated using the developed area of the system (W/(m^2•K))

Φ = Heat flow rate through system (Watts)

Arc = Developed area of rooflight-upstand assembly as defined in Annex D of BS EN1 873:2014 (m^2)

ΔT = Temperature difference across a system (K)

Figure 5



The heat loss Φ should always be measured or calculated as the total heat loss through the rooflight-and-upstand assembly, obtained either by measurement in a hot box according to BS EN ISO 12567-1, or by computer simulation according to BS EN ISO 10077-2 and BS EN 673 where appropriate, and dividing this by the rooflight developed area as shown in Figure 6a.

When calculating the developed area of the assembly, only those areas through which there is significant heat conduction should be included, to prevent calculation of excessively large developed areas (and correspondingly low U_{rc}-values).

As with rooflights only, external fixing flanges and details should be excluded from the area calculation, and in addition the base of any upstand which may be buried in insulation should be excluded from the area calculation, likewise the heat loss should be excluded in any heat loss calculations or physical measurement.

The U_{rc} value must always meet or exceed the limiting values shown in ADL.

DEFINING THE U_{rc} VALUE CONTINUED...

The rooflight developed area A_{rc}:

The developed area A_{rc} should be calculated in accordance with EN1873:2014 annex D, and with the following guidelines:

i. the area calculated for a rooflight-and-upstand assembly is split in three sections: the upstand, edge profile and glazed area, based on the external area of these sections, but excludes any area outside of this (e.g. fixing flange that extends beyond the external datum line).

ii. if the outer skin of a rooflight is not in direct contact with the roof upstand but over sails it, an imaginary datum line should be drawn from the outside face of the upstand to the outer glazing, perpendicular to the outer glazing. The developed area of the rooflight should be defined as the area of the outer glazing, edge and upstand, as shown in Figure 6a

iii. for definition of surface:area ratio and/or calculation of the Urc-value, the ratio will be the developed area (Arc) divided by the internal roof opening area (A)

iv. the area of any dome rooflight should be estimated by taking the flat area and multiplying by the K factor for the shape in accordance with clause 3.5 in Annex D of BS EN 1873

v. where the upstand height exceeds 150mm, the heat loss through the whole upstand assembly should be included, but only the surface area of the top 150mm (vertically) of the upstand should be included in measurement of the developed area, since the foot of most taller upstands is often not exposed but may be buried within insulation, so including the lower portion within area calculations could result in artificially high surface:area ratios (and correspondingly low Urc-values) being derived for excessively tall upstands which actually give higher heat loss in practice, see figure 6b.

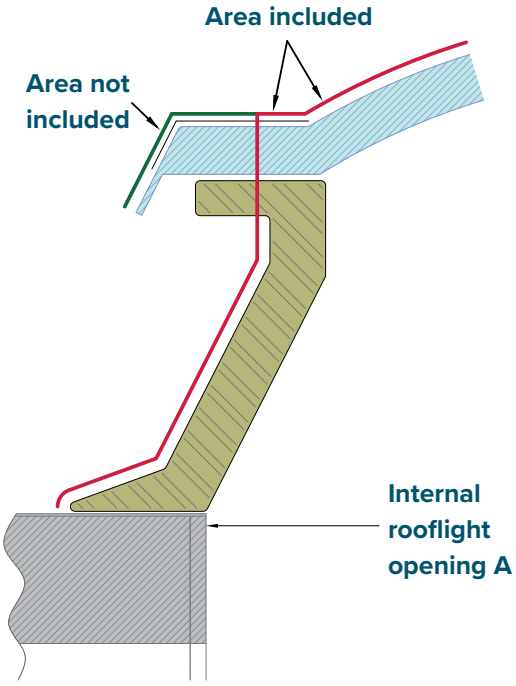


Figure 6a

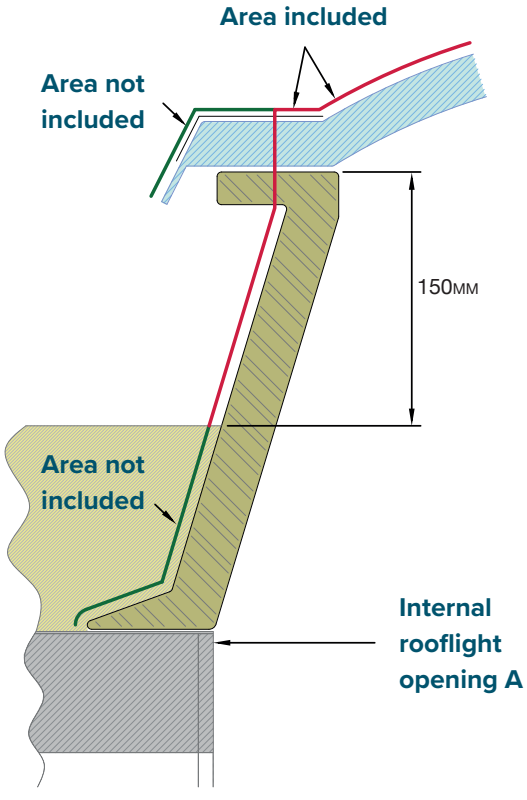


Figure 6b

DEFINING THE U_{rc} VALUE CONTINUED...

Presentation of U_{rc} and U-values:

Rooflight manufacturers should be able to quote both the U_r-value and the true U-value for their products.

The U_{rc} value, being the total heat loss divided by the rooflight developed area, is required for comparison against other products and for checking against the worst case limiting U-value in ADL only.

The true U-value is required for the purpose of energy calculations (such as SAP, SBEM or other approved software).

Both values are therefore required and rooflight manufacturers must be explicit in communicating their performance values, either as a U_r and U-value per product or one of these values and the surface:area ratio. A U_{rc} or U-value should not be quoted alone.

CONCLUSION

In conclusion, the U_r or U_{rc}-value is only a secondary value which offers a useful method of governing product performance rather than the true U-value.

By definition, the ratio of U_r or U_{rc}-value to true U-value is always the same as the ratio of the developed surface area of the system to the area of the roof aperture, which is referred to in this document as the surface:area ratio.

$$U_r \text{ or } U_{rc} = \frac{\text{U-value}}{\text{surface:area ratio}}$$

Rooflight manufacturers should be able to quote true U-values for their products. These should obtained by establishing the total heat loss through the product (either by measurement in a hot box according to BS EN ISO 12567-1, or by computer simulation according to BS EN ISO 10077-2 and BS EN 673 where appropriate), and dividing this by the area of the roof opening. This document uses the conventions detailed in EN1873:2014 however, for the purposes of calculating a true U-value the following formula is referenced from BR443:

$$U_{roof\_opening} = \frac{A_p \times U_p}{A_{roof\_opening}}$$

In order to avoid confusion, it is essential that whenever a U_r or U_{rc}-value is quoted, it must always be explicit that it is a U_r or U_{rc}-value rather than a true U-value, and it must always be quoted in conjunction with the true U-value, or in conjunction with the surface:area ratio (allowing the true U-value to be derived):

U_r or U_{rc}-values should not be quoted alone.

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