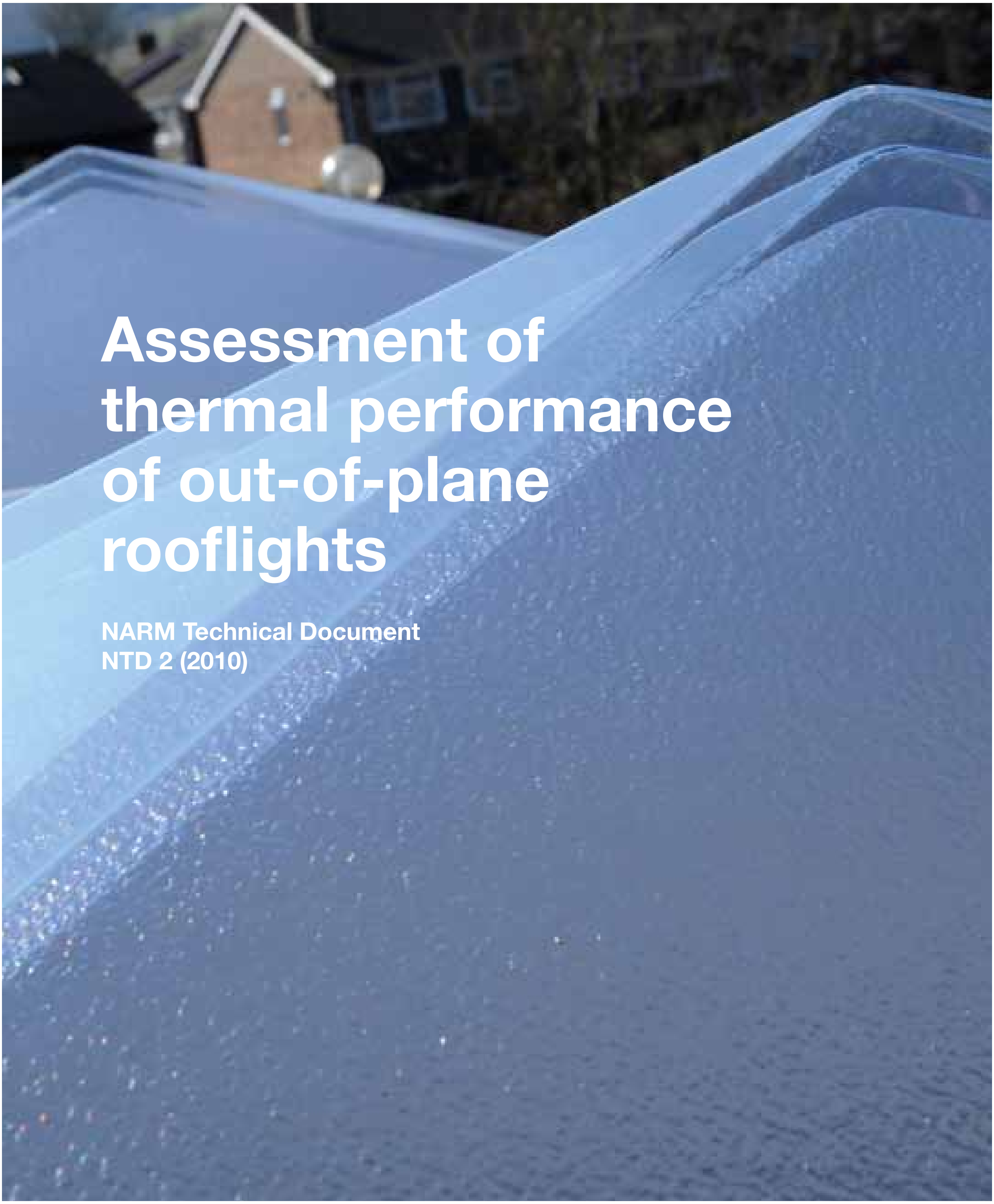

Assessment of thermal performance of out-of-plane rooflights

NARM Technical Document
NTD 2 (2010)

National Association of Rooflight Manufacturers

Contents

Introduction

For all non-domestic applications, the worst acceptable standards for the thermal performance of roof-lights in new build work are defined in Building Regulations Approved Document L2A Table 4, and for all other work in Building Regulations Approved Document L2B Table 3.

Table 4 Limiting fabric parameters

Roof	0.25 W/m².K
Wall	0.35 W/m².K
Floor	0.25 W/m².K
Windows, roof windows, rooflights[3], curtain walling and pedestrian doors[1,2]	2.2 W/m².K
Vehicle access and similar large doors	1.5 W/m².K
High-usage entrance doors	3.5 W/m².K
Roof ventilators (inc. smoke vents)	3.5 W/m².K
Air permeability	10.0 m³/h.m² at 50 Pa

Notes:

Table 3 Standards for controlled fittings

Fitting	Standard
Windows, roof windows and glazed rooflights[1]	1.8 W/m².K for the whole unit
Alternative option for windows in buildings that are essentially domestic in character[2]	A window energy rating[3] of Band C
Plastic rooflight[4]	1.8 W/m².K
Curtain walling	See paragraph 4.28
Pedestrian doors where the door has more than 50% of its internal face area glazed	1.8 W/m².K for the whole unit
High-usage entrance doors for people	3.5 W/m².K
Vehicle access and similar large doors	1.5 W/m².K
Other doors	1.8 W/m².K
Roof ventilators (including smoke extract ventilators)	3.5 W/m².K

These tables both include footnotes which relate to rooflights (footnote 3 to ADL2A Table 4 and footnote 4 to ADL2B Table 3) 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."

The true U-value 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.

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_d-value.

This document defines the U_d-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_d-values. It is important to harmonise the method of assessment of U_d-value to ensure different products can be compared directly, that Regulatory requirements are being complied with consistently, and that software to assess CO2 emissions (eg SBEM) can handle data in a valid manner.

A U_d-value can be calculated for a rooflight alone. For a rooflight-and-kerb assembly, a U_d-value can be calculated for both the rooflight alone, and also for the rooflight-and-kerb assembly.

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-kerb assembly. The U_d-value for the rooflight alone and rooflight-and-kerb assembly must both meet the limiting values of the Building Regulations. It is therefore important that for rooflight-and-kerb 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 rooflights) on a kerb simply because the U_d-value for the rooflight-and-kerb assembly is less than the limiting values in the Building Regulations, unless the U_d-value for the rooflight alone also meets the limiting values.

Scope

This document:
defines U_d-value, based on the developed area of the rooflight, which is the value which should be checked against Building Regulation limits provides detail on how U_d-value should be calculated for out-of-plane rooflights, and for rooflight-and-kerb assemblies clarifies the difference between U-value and U_d-value, and how data on U_d-value should be quoted explains why use of U_d-value rather than U-value is appropriate for use as the limiting value in Building Regulations.

This document defines how the surface area of out-of-plane rooflights should be measured to calculate surface:area ratio and/or U_d-value but does not define how to calculate or measure heat loss through a sample, or calculate true U-value, which are defined elsewhere.

Definition of rooflight U-values

The true 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

However, many rooflights are out-of-plane rooflights that sit proud of the plane of the roof (typically mounted on upstands or kerbs). The range includes modular rooflights (typically domes or pyramids), continuous barrel vaults, 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 kerb 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-kerb assembly, as shown in *Figure 2,* and it is essential to be clear which of these areas should be used when defining U-value and U_d-value.

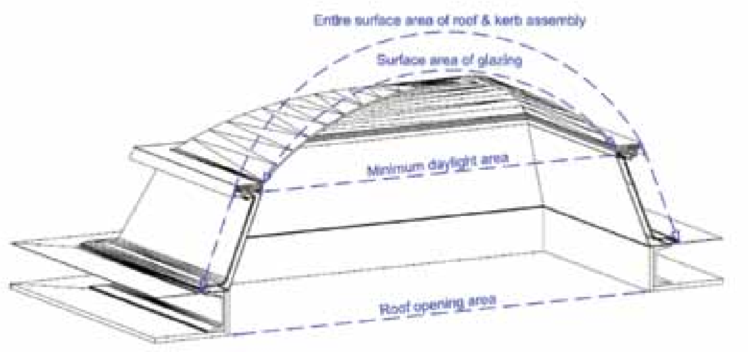

Figure 2

Definition of U-value for out-of-plane rooflights

The true U-value of an out-of-plane rooflight as defined in BR443 is the total heat loss through the product, divided by the area of the roof opening, as shown in *Equation 1:*

$$U = \frac{\Phi}{A_A \times \Delta T}$$

Where

U	U-value (as defined in the measurement standards)	($W/m^2.K$)
Φ	Heat flow rate through system	(Watts)
A_A	Area of aperture or roof opening	(m^2)
ΔT	Temperature difference across a system	(K)

Equation 1

This can be quoted for a rooflight only (where fitted to a separate upstand) or for a rooflight-and-kerb assembly. This principle is illustrated in *Figure 3.*

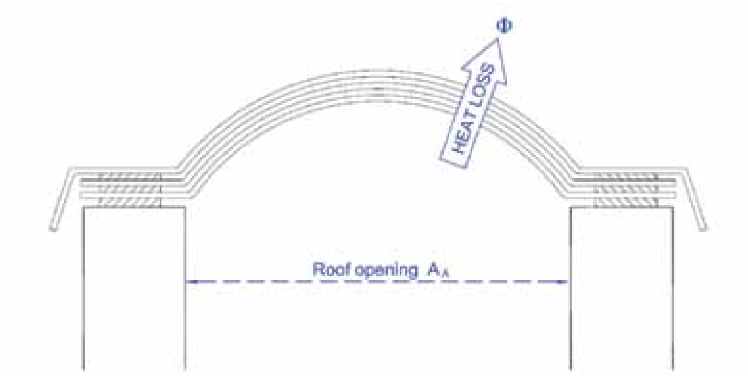

Figure 3

Unfortunately this can create an inconsistency. For example, an out of plane rooflight formed from two areas of pitched flat glazing, as shown in *Figure 4,* can be considered in two different ways:

- either be considered as two areas of flat glazing which could both be treated in the same way as glazing in the plane of a roof *(as shown in Figure 1)*, where the area would be taken to be the glazed area.
- as a single rooflight which could be treated as defined in BR443 *(as shown in Figure 3)* where the area would be taken to be the area of the roof opening.

Although the same product is being considered, and the product performance and total heat loss is the same, the difference in defined area will give completely different U-values.

Effectively, this means the true U-value (as defined in BR 443) can be dependant on application rather than being a property of a product: for example, the same glazing system used in the different ways illustrated by *Figures 1 and 4* will have completely different U-value.

In principle, Building Regulations aim to regulate the insulation value of building elements, but do not attempt to influence the geometry or architectural aspects of building design (so do not, for example, try to restrict surface area of the envelope for a given area of useable space). Similarly, Part L Regulations do not seek to influence architectural design or choice of rooflight geometry, and therefore apply a limit to the U_d-value, defined in this document as the total heat loss through the product, divided by the surface area (or developed area) of the rooflight – as detailed in the Introduction section of this document.

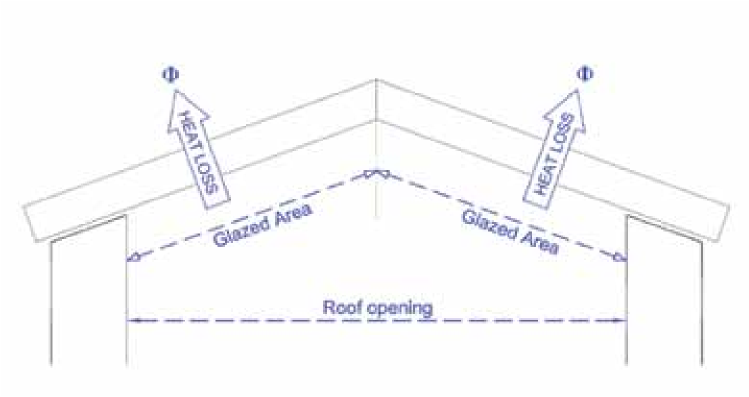

Figure 4

Definition of rooflight U_d-value

The U_d-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-kerb assembly, should be calculated as shown in *Equation 2:*

$$U_d = \frac{\Phi}{AD_R \times \Delta T}$$

where

U_d	U_d-value calculated using the developed area of the system	(W/m^2.K)
Φ	Heat flow rate through system	(Watts)
AD_R	Developed area of roof light or actual surface area	(m^2)
ΔT	Temperature difference across a system	(K)

Equation 2

This value must always meet or exceed the limiting values shown in Part L Building Regulations.

Where a rooflight-and-kerb assembly is being supplied, the rooflight supplier should be able to quote this value for the rooflight only to ensure Building Regulation compliance. The supplier may also quote the U_d-value for a rooflight- and-kerb assembly, as shown in *Equation 3:*

$$U_d = \frac{\Phi}{AD_{Tot} \times \Delta T}$$

where

U_d	U_d-value calculated using the developed area of the system	(W/m^2.K)
Φ	Heat flow rate through system	(Watts)
AD_{Tot}	Developed area of roof light plus upstand	(m^2)
ΔT	Temperature difference across a system	(K)

Equation 3

This principle is illustrated in *Figure 5*.

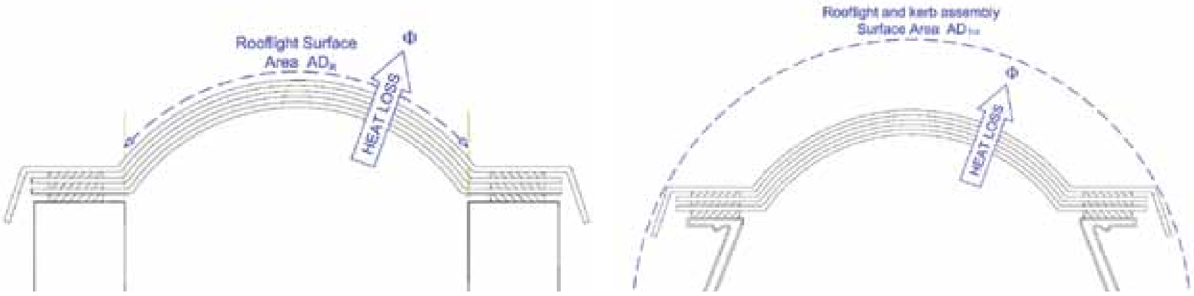

Figure 5

Where a rooflight-and-kerb assembly is supplied, the U_d-value for both the rooflight only and the rooflight-and-kerb assembly must always meet or exceed the limiting values shown in Part L Building Regulations.

It is not acceptable to use an assembly of a rooflight with poorer thermal performance (such as double skin rooflights) on a kerb simply because the U_d-value for the rooflight-and-kerb assembly as shown in *Equation 3* is less than the limiting values in the Building Regulations, unless the U_d-value for the rooflight alone as shown in *Equation 2* also meets the limiting values.

Note that the total heat loss through a product is always equal to both

U-value x roof opening ($\Phi = U\ A_A\ \Delta T$)
U_d-value x surface area ($\Phi = U_d\ AD_R\ \Delta T$)

so heat loss will be greater for a rooflight with high surface area, than it will for another product with the same U_d-value but lower surface area.

If the surface area is the same as the area of the opening in a roof, then

U-value = U_d-value

Presentation of U-value and U_d-value

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 as shown in *Figure 3*.

Rooflight manufacturers should also be able to quote a U_d-value for their products. This should be obtained from the total heat loss through the whole product, divided by the surface area of the product, as shown in Figure 5. This document defines exactly how the total surface area of an out-of-plane rooflight or rooflight-and-kerb assembly should be calculated.

By definition, the ratio of U_d-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.

$$U_d\text{-value} = \frac{\text{U-value}}{\text{surface:area ratio}}$$

U_d-value is only a secondary value which offers a useful method of governing product performance rather than the true U-value.

In order to avoid confusion, it is essential that whenever a U_d-value is quoted, it must always be explicit that it is a U_d-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_d-value should not be quoted alone. For example, alternative ways of quoting product performance may be:

U-value =	Note [1]
U_d-value =	Note [2]
Or: U-value =	Note [1]
Or: U_d-value =	Note [3]

Based on surface: area ratio of …………..

[1] based on roof opening area
[2] based on surface area of rooflight only, and total heat loss through rooflight only
[3] based on surface area of rooflight-and-kerb assembly and total heat loss through while assembly

It must also be explicit whether values being quoted apply to the rooflight only, or to a rooflight-and-kerb assembly.

The energy loss / CO2 emission calculations required by Part L Regulations (eg by SBEM or other approved software) should include the actual total heat loss through an actual product – which is derived from a combination of U_d-value and surface:area ratio.

Measurement of U_d-value of rooflight only

Rooflights can be multiple skin, and on some rooflights (particularly modular rooflights) areas of internal and external skins may be different. Modular rooflights can also often be complex three dimensional shapes (eg square based domes) where surface area can be difficult to calculate or measure accurately, and often incorporate features such as fixing flanges outside the glazed area.

U_d-value is defined as the total heat loss through the rooflight, divided by the surface area of the rooflight

$$U_d = \frac{\Phi}{AD_R \times \Delta T}$$

Equation 2

The heat loss Φ should always be measured or calculated as the total heat loss through the product (including all fixing flanges etc).

However, when calculating the surface area of a rooflight, only those areas through which there is significant heat conduction should be included, to prevent calculation of excessively large surface areas (and correspondingly low U_d-values). For example, external fixing flanges and details should be excluded from the area calculation, even though the small heat loss from them should be included in any heat loss calculations or physical measurement.

The surface area ADR should be calculated in accordance with the following guidelines:

1. for definition of surface:area ratio and/or calculation of U_d-value, the surface area of the glazed element should be defined as the outer surface of the glazing.
2. the area of any dome rooflight should be estimated using the method shown in Appendix A.
3. the area calculated for any rooflight should include all the area inside the dimensions of the roof opening, but exclude any area outside this (eg fixing flange over the top of an upstand, or any external drip detail) as shown in *Figure 6.*
4. if the outer skin of a rooflight is not in direct contact with the roof opening but oversails it, an imaginary line should be drawn from the edge of the roof opening to the outer glazing, perpendicular to the outer glazing. The surface area of the rooflight should be defined as the area of the outer glazing which is inside the imaginary line, as shown in *Figure 7*.
5. 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_d-value.

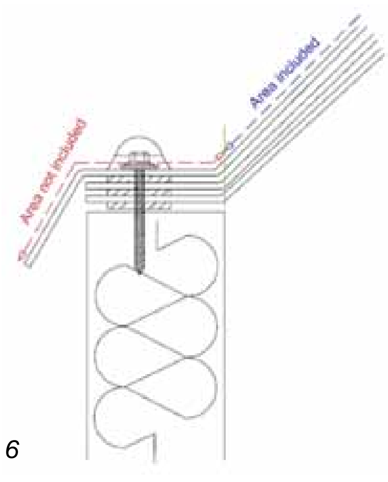

Figure 6

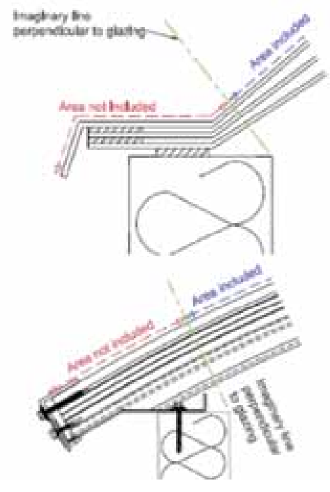

Figure 7

Measurement of U_d-value of rooflight-and-kerb assembly

Measurement of the areas of a kerb-and-rooflight assembly is at least as complex as measurement of the glazed area of a rooflight only.

Similar principles apply as when considering rooflights only, but in addition particular care is required when considering deeper kerbs (over 150mm deep), as these are often buried within insulation when installed, so the additional surface area of deeper kerbs should not be considered when calculating surface area.

U_d-value for a rooflight-and-kerb assembly is defined as the total heat loss through the rooflight-and-kerb assembly, divided by the surface area of the assembly.

$$U_d = \frac{\Phi}{AD_{Tot} \times \Delta T}$$

Equation 3

The heat loss Φ should always be measured or calculated as the total heat loss through the rooflight-and-kerb assembly (including all fixing flanges etc).

When calculating the surface area of the assembly, only those areas through which there is significant heat conduction should be included, to prevent calculation of excessively large surface areas (and correspondingly low U_d-values). As with rooflights only, external fixing flanges and details should be excluded from the area calculation, and in addition the base of any kerb which may be buried in insulation should be excluded form the area calculation, even though the heat loss should be included in any heat loss calculations or physical measurement.

The surface area ADTot should be calculated in accordance with the following guidelines:

1. for definition of surface:area ratio and/or calculation of U_d-value, the surface area of a kerb supplied with a rooflight should be defined as the inner surface of the kerb (since this usually aligns with the roof opening, so corresponds to the values for a rooflight only, is usually a ‘cleaner’ surface and does not have additional roof coverings applied to it in practice).

2. where kerb height exceed 150mm, the heat loss through the whole kerb assembly should be included, but only the surface area of the top 150mm (vertically) of the kerb should be included in measurement of the surface area, since the foot of most taller kerbs is often not exposed but may be buried within insulation, so including the lower protion within area calculations could result in artificially high surface:area ratios (and correspondingly low U_d-values) being derived for excessively tall kerbs which actually give higher heat loss in practice.

3. in some cases the outer skin of the rooflight may be in direct contact with the inner edge of the kerb opening, in which case the surface area of the assembly is simply the outer surface area of the glazing plus the inner surface area of the kerb as shown in *Figure 8.*

4. in other cases, the outer skin of a rooflight may not be in direct contact with the inner edge of the kerb but will oversail it. In these cases, an imaginary line should be drawn from the inner edge of the kerb to the outer glazing, perpendicular to the outer glazing. The surface area of the rooflight-and-kerb assembly should be defined as the inner surface area of the kerb, plus the area of the imaginary line, plus the outer surface area of the glazing which is inside the imaginary line, as shown in *Figure 9.*

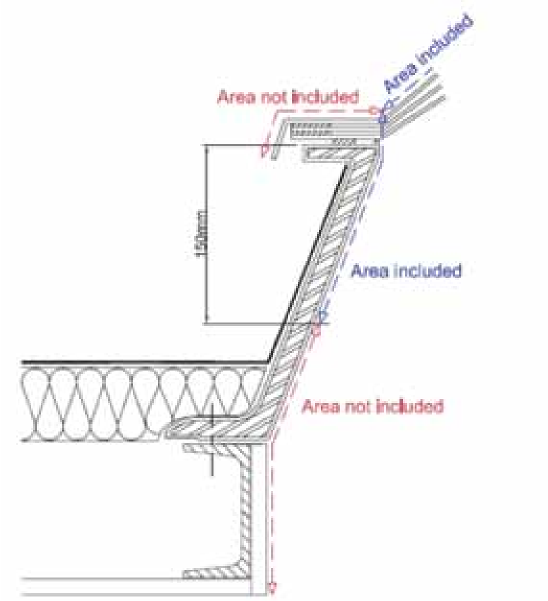

Figure 8

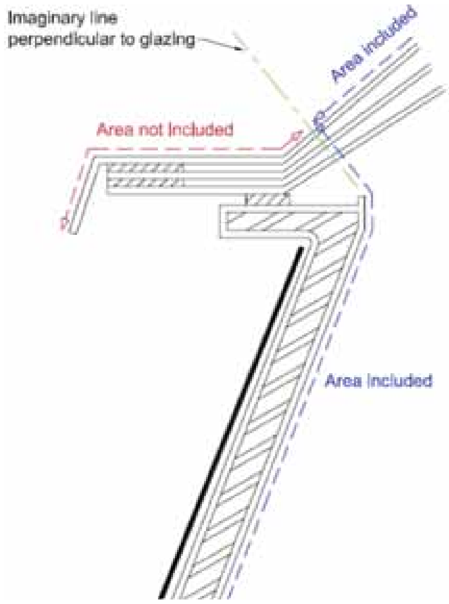

Figure 9

ANNEX A

Simplified method for calculation of rooflight dome developed area

To estimate the surface area of a square based dome shape, formed to a known height.

When thermoformed into a dome shape, thermoplastic will theoretically find the shortest distance between three known points; this equates to an arc through the clamped edges of the moulding and the crown of the dome.

Method

Divide the plan area of the dome into eight triangular sections *(see fig A1)*.

Take this triangular shape and flatten it out where the lengths of side of this triangle are given as:-

- half of the span of the blown area
- half of the developed length of the dome across the span
- half of the developed length of the dome across the diagonal

The area of the developed triangle can then be found.

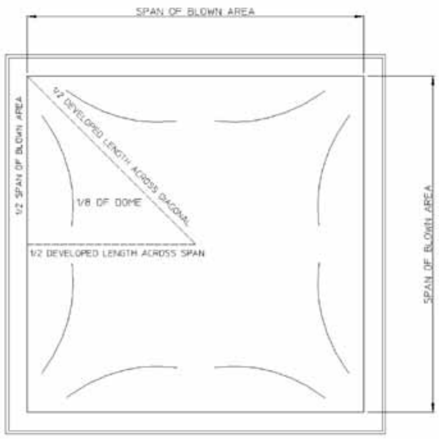

Figure A1

Find the developed length of arc

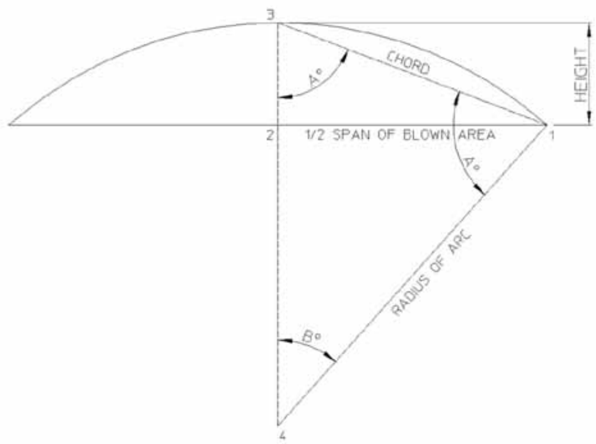

Figure A2

Firstly consider triangle 1,2,3 *(see fig A2)*:

- the chord is given as $\sqrt{}$ (span of blown area/2)^2 + height^2
- angle A is given as Tan^{-1} ((span of blown area/2) / height)

Now consider triangle 1,4,3:

- angle B is given as (180 – (angle A x 2))
- the radius of arc is given as (Sin A x chord) / Sin B

The developed length of arc between point 1 and 3 is given as:

- (radius of arc x π) / 180 x angle B

Find the area of the developed triangle

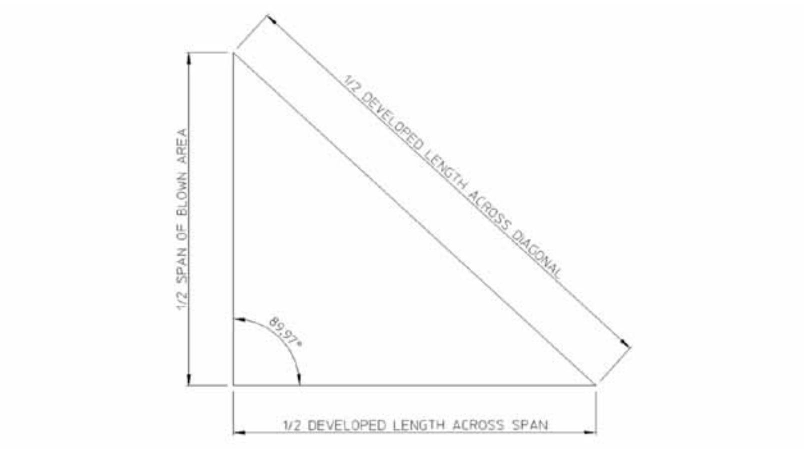

Fig A3

The area of this triangle is given as:

- ½ x (developed length across span/2) x (span of blown area/2)

The total surface area of thermoformed dome = area of developed triangle x 8

Rectangular Based Dome

This method of calculation is an estimate; when used for a rectangular based dome the same principle should be applied, but the calculation for the developed triangular areas 1 & 2 *(see Fig A4)* gives slightly different answers, and should therefore be calculated separately

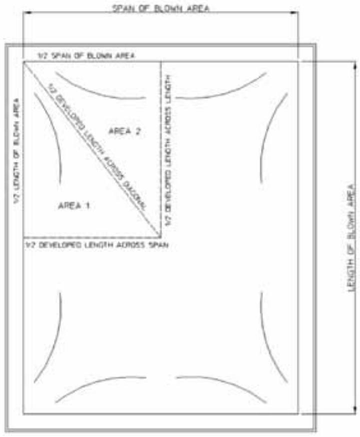

Figure A4

The Total Surface Area of the blown area of the dome is then given as

Total surface area of thermoformed dome = (Area of Developed Triangle 1 + Area of Developed Triangle 2) * 4

Published by:

NARM Secretariat
43 Clare Croft
Middleton
Milton Keynes
MK10 9HD
Tel: +44 (0)1908 692325
Fax: +44 (0)1908 674122
Email: admin@narm.org.uk
www.narm.org.uk

NARM/TAOOPR/030311.PDF