

National Association of Rooflight Manufacturers



**Use of Rooflights to satisfy the
2002 Building Regulations
for the Conservation of Fuel and Power.**

**Approved Document L.1 and L.2 (England and Wales)
Regulation 22 Part J (Scotland)**

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Part I - General Information

Introduction

The Government is committed to the reduction of greenhouse gases and the Building Regulations for England, Wales and Scotland which cover "Conservation of fuel and power" have been updated as a result. The revised Regulations require buildings to have more efficient insulation to the building envelope and to elements such as water pipes and heating ducts. In addition buildings must have heating and ventilation systems that meet a minimum standard. The Regulations also require that levels of natural daylight into the building are adequate to offset energy consumption.

Regulations

Two documents will apply :-

1. The Building Regulations 2000 (England and Wales) Approved Document L.
 - (i) L1 : Conservation of Fuel and Power in Dwellings.
 - (ii) L2 : Conservation of Fuel and Power in Buildings other than Dwellings.
2. The Building Standards (Scotland) Regulations 2001. Regulation 22 Part J : Conservation of Fuel and Power.

In this document, the only reference to L.1 is in Part III where out of plane rooflights may be used on domestic dwellings.

The Regulation Part J for Scotland has similar requirements to Part L.2 and for the purpose of this information document all general comments and any specific reference to L.2 will equally apply to Part J unless indicated otherwise.

Timing

The Regulations came into force on April 1st, 2002 in England and Wales and 4th March in Scotland and are applicable to all buildings where construction has not commenced by that date.

Day Lighting

Daylight is essential for healthy living. In business, it is an established fact that ample daylight brings significant productivity and safety benefits through a general feeling of health and well being in the work force.

Workplace (Health Safety and Welfare) Regulations 1992 state that every workplace shall have suitable and sufficient lighting which shall, so far as is reasonably practicable, be by natural light.

These comments are restated in HSG.38 - Lighting at Work.

It is also an established fact that the suicide rate in northern Norway and Sweden is far higher in the winter months when the sun does not rise above the horizon during the day. If you design large buildings without rooflights, you are imposing similar conditions on the work force for 365 days a year.

The most effective method of providing even, consistent daylight, particularly in large buildings, is through roof-lighting - up to three times more efficient than windows. Diffusing materials should be used wherever possible to provide even light distribution and avoid glare. Wall glazing is less effective and can create internal shadows and dark corners.

The existing regulatory requirements are now reflected in the revisions to Part L.2. Para 1.14 states that "special care needs to be given to confirm that levels of daylight are adequate" and Para 1.55 states "Where it is practical, the aim of lighting control should be to encourage the maximum use of daylight and to avoid unnecessary lighting during the time when spaces are unoccupied"

Daylight Levels

It is clear that there is a regulatory requirement for natural daylight but Part L.2 does not include any definitive guidance on how to determine adequate daylight levels. It does define a minimum level ; Para. 1.45 says "that for any office, industrial and storage building, a day-lit space is defined as any space within 6m of a window wall, provided that the glazing area is at least 20% of the internal area of the window wall. Alternatively, it can be roof-lit with a glazing area at least 10% of the floor area. The normal light transmittance of the glazing should be at least 70% (when tested to EN.1013 Part 1,) or, if the light transmittance is reduced below 70%, the glazing area could be increased proportionately but subject to the maximum daylight area given later in this document.

The conclusion of this statement is that for any such building, where the work area is more than 6m from a window wall, consideration should be given to provide natural daylight by roof-lighting to a minimum of 10% of the floor area but greater areas may be required depending on building use and location. The following information may help in the absence of more definitive requirements.

Daylight Factors

The unit of measure used in daylight design is the Daylight Factor. This factor is the percentage of light which is available inside a building compared to that simultaneously available outside.

For factories the Daylight Factor should be between 5% and 7%

For storage buildings, it should be between 2% and 3%

For recreational buildings it should be around 10%

The rooflight area required to achieve these daylight factors will depend on a location factor as shown in Table A.

Table A : Location Correction Factor.

Type of Location	Angle of Glazing to Horizontal	
	0° - 9°	10° - 60°
Clean (rural suburban)	0.7	0.8
Industrial (urban)	0.5	0.6

Using the Daylight Factor, Location Factor and the light transmission of the rooflights, the suitable rooflight area can be determined as a percentage of the floor area. Table B shows the appropriate rooflight area for double skin rooflights (assuming light transmission of 75%) and triple skin rooflights (light transmission 65%).

Table B : Suitable Rooflight area as a percentage of the floor area.

Location Factor	Daylight Factor Required						
	2%	3%	4%	5%	6%	7%	10%
0.5 Double skin	4	7	10	12	15	17	25
Triple skin	5	8	11	14	17	20	29
0.6 Double skin	3	6	8	10	12	14	21
Triple skin	4	7	9	12	14	17	24
0.7 Double skin	3	5	7	9	10	12	18
Triple skin	3	5	8	10	12	14	21
0.8 Double skin	3	4	6	8	9	11	16
Triple skin	3	5	7	9	11	13	18
Rooflights as a percentage of Floor Area							

Thus, typically, an urban industrial factory with a roof pitch of less than 10° and thus a location factor of 0.5, will require rooflighting to an area of 12% to 17% when using double skin rooflights.

When designing for a storage building, architects should consider the possibility of a change of use in the future to a production unit and the daylight levels that will then be required. Retrofitting rooflights is much more costly than inclusion in the roof during construction. It is therefore recommended that the design daylight factor should normally be a minimum of 5% in Table B.

General Design.

In order to achieve energy efficiency in practice, the building and its services systems shall be appropriately designed and constructed. To show compliance, three methods are given to demonstrate that reasonable provisions have been made for the conservation of fuel and power.

1. Elemental Method.

This method considers the performance of each element of the building individually. To comply, a minimum level of performance should be achieved in each of the elements. Some flexibility is provided for trading off between different elements of the construction.

2. The Whole Building Method.

This considers the performance of the whole building. Under reference L2 Summary Guide Step 25 this method is not applicable to industrial and storage buildings but does apply to schools, hospitals and offices.

3. Carbon Emissions Calculated Method.

This method also considers the whole building performance including building services and can be applied to any building type. To comply the annual carbon emissions from the building should be no greater than the notional building that meets the compliance criteria of the Elemental Method.

Since the calculation method under (3) is complicated, it will be normal for most industrial buildings to be designed to the Elemental Method. In Scotland the calculations are done by the Heat Loss Method.

Elemental Method - Standard U-values.

To show compliance the building envelope has to provide certain minimum levels of insulation. To be specific it considers the total heat loss from a structure by stating Standard U-values for each constructional element as given in Table C below.

Table C : Standard U-values of Construction Elements

Exposed Element	U-value
Flat Roof, Pitched Roof below 10° All roofs with integral insulation (composite or site assembled).	0.25
Walls	0.35
Walls Part J Scotland	0.30
Floors	0.25
Rooflights *	2.2
Windows translucent wall areas	2.0

* For barrel lights and dome lights the standard applies only to the performance of the unit excluding any upstands. Reasonable provision would be to insulate any upstand or otherwise isolate it from the internal environment.

Maximum Glazed Areas.

Since the insulation value of the glazed areas will be less than that of the opaque insulated areas, provision must be made to limit the rate of heat loss through the glazed areas. One way of complying would be to limit the amount of glazing so that they do not exceed the values given in Table D (Ref L.2 Para 1.12 Table 2). Note that area of glazing can be exceeded if it can be shown that the heat loss has been compensated for in some other way by using products with greater insulation values.

Table D : Maximum areas of openings unless compensating measures are taken

Building Type	Windows & Doors as % of area of exposed wall	Rooflight as a % of area of roof
Places of assembly Offices and shops	40	20
Industrial & Storage	15	20

Thus rooflights that achieve a U-value of 2.2 and up to a rooflight area of 20% will fully meet the requirements of the new Regulations. Well designed triple skin rooflights will normally achieve this and are available from most rooflight manufacturers. They offer a significant reduction in heat loss through the rooflights compared with double skin lights and are the recommended method of achieving the aims of the new legislation.

Trade Off

L2 Para 1.14 states that in order to provide greater design flexibility, the U-value of construction elements and the areas of windows, doors and rooflights may vary from the values given in Table C and Table D provided that suitable compensating measures are taken. If the rooflight areas are reduced from those given in Table D, special care needs to be given to confirm that levels of daylight are adequate. Guidance on daylight levels are given above in "Daylight Factors".

Trade off compliance for rooflights will be met if the rate of heat loss from the proposed building does not exceed that from a notional building of the same size and shape that meets the criteria set out in Table C and Table D.

This therefore means that Trade off for rooflights at the maximum area of 20% can be increased or decreased with an appropriate improvement or reduction in the thermal transmittance (U-value) of the rooflight element.

Rooflight U-value Requirements

U-values are determined by complex calculations as detailed in BS.EN.ISO. 10211-1:1996 Thermal Bridging in Building Construction - Calculations of Heat Flows and Surface Temperatures - Part 1 General Methods as specified in L.2 Para 0.15.

To meet the new Regulations the rooflight assembly needs to meet the Standard U-value of 2.2 W/m²K.

Limited Trade Off within the roof and wall light areas is allowed provided that the total heat loss from the building does not exceed the notional value determined from the requirements laid down in Table C and Table D.

From this notional value, maximum allowable U-values for rooflights for a given area of the roof may be determined, as shown below in Table E.

Table E : Maximum Rooflight U-values per Roof Area.

Opaque Roof Area at U-Value 0.25W/m ² K	Rooflight Area	Rooflight Assembly U-Value W/m ² K
70%	30%	1.5
75%	25%	1.8
80%	20%	2.2
85%	15%	2.8
88%	12%	3.5
90%	10%	4.1

Constraints to Trade Off.

L.2 Para 1.14 says that care must be taken to confirm that the levels of daylight are adequate. If the rooflight area is reduced below 20%, the designer must ensure that the natural daylight levels are sufficient for the building purpose.

L.2. Para.1.16(c) states that no more than half of the allowable rooflight area can be converted into increased areas of the window (vertical) and doors. There is no provision for converting vertical openings into the roof.

Para. 1.16(b) states that if the area of rooflights is less than the values shown in Table D, the average value of the opaque areas of the roof, wall and floor cannot exceed the appropriate value given in Table C by more than 0.02 W/m²K.

Thus, no matter how much notional heat loss saving is made by reducing the rooflight area, the U-value of the insulated roof cannot be greater than 0.27 W/m²K.

Air Leakage.

Air Leakage requirements do not apply to Building Standards (Scotland) : Part J and for Part L.1 - Dwellings - only reasonable provision is required.

Buildings should be reasonably airtight to avoid unnecessary space heating and cooling demand.

The permeability of the cladding should be no worse than 10 m³/h/m² at an applied pressure difference of 50 Pascals. The square metre area is the total area of the perimeter walls, roofs and ground floor area.

There is a requirement under Part L.2 that all buildings that exceed 1000m² gross floor area are required to be air tested on building completion to show compliance. Gross floor area means the summation of all floors including multi-floor buildings. Buildings of less than 1000m² gross floor area will be compliant providing evidence that appropriate design detail and construction techniques have been used.

Provided that rooflights are fixed and adequately sealed as generally detailed in Part II and Part III of this document, rooflight assemblies will easily comply with the above requirements.

Association members strongly recommend that Contractors take care in the fixing and sealing of rooflights in accordance with recommendations, since subsequent air test failure will generally require extensive remedial work which could prove to be very expensive.

Thermal Bridging.

The building fabric should be constructed so that there are no significant thermal bridges.

All in-plane rooflight materials are such that of themselves they do not provide a cold bridge. Individual and continuous out of plane lights may have cold bridges via aluminium /steel frames.

Detail of assembly is shown in Part II and Part III and where insulated support brackets and thermal barriers are used, these should be noted to ensure that thermal bridging is avoided.

Solar Overheating.

Solar Overheating requirements do not apply to Building Standards (Scotland) : Part J.

Rooflighting is beneficial to the use of fuel and power in that it provides solar gain and the "feel good factor".

However, excessive levels of glazing can generate solar overheating making the work environment unpleasant.

Buildings should be constructed such that those occupied spaces that rely on natural ventilation should not overheat when subject to a moderate level of internal heat gain and that those spaces that do incorporate mechanical ventilation or cooling do not require excessive cooling plant capacity.

There are 6 ways specified to reduce the effect of solar overheating.

1. The appropriate specification of glazing.
2. Incorporation of passive measures such as shading.
3. Mechanical ventilation without excessive cooling plant capacity.

4. Use of exposed thermal capacity combined with night ventilation.
5. By calculation Ref L.2. Para. 1.23.

If none of the above are provided then :-

6. Compliance can be achieved by limiting the area of glazing facing only one orientation to the glazed open areas shown in Table F. (L.2 Para 1.22 Table 4)

Table F : Solar Overheating - Maximum allowable areas of Glazing.

Orientation of Opening	Maximum allowable area of opening
N	50%
NE/NW/S	40%
E/SE/W/SW	32%
Roofs (below 75°)	12%

N.B. L.2. Table 4 refers to Horizontal - 12%. The N.A.R.M have obtained an interpretation from the B.R.E that "Horizontal" will be applied to all roofs below 75° pitch.

Thus in England and Wales compliance is only demonstrated if one or a combination of the above 6 requirements is adopted to minimise solar overheating. If roof lighting is limited to 12% to satisfy solar overheating, the designer needs to ensure that the daylight levels are adequate for the purpose of the building. (Ref. L.2 Para 1.14).

Exempt Buildings

Buildings or parts of buildings with low levels of heating or unheated buildings do not require measures to limit heat transfer through the fabric of the building and are exempt from these Regulations. For such buildings, single skin roof-lights would be acceptable.

Low level heated buildings have a heating requirement no more than 25 W/m² and typically could be a warehouse used for storing goods to protect them from condensation or frost.

A cold store building is one where insulation would be required but will be determined by operational needs.

Roof Refurbishment.

The Regulations apply to both new buildings and to refurbishing old buildings. However, if single components are defective and need replacing, the component will be exempt from the Regulations.

Thus, if a roof is being stripped and replaced, the new roof would need to comply with the new Standard U-values of the Construction Elements with Trade Off allowed for the rooflights as described above.

Where only the rooflights are deemed to require replacement, a direct replacement will be allowable.

Where the old roof is insulated and rooflights are in place but only single skin and deemed to be defective, it would be advisable to replace the rooflights with rooflights that comply with new requirements if it is feasible to do so.

PART II - In-Plane Rooflights

In-Plane Rooflights are designed to match factory made sandwich metal panels and the top sheet and liners of site assembled insulated metal assemblies.

The material generally employed for such rooflights is glass reinforced polyester (G.R.P.), which has light diffusing qualities to reduce glare and shadows, incorporates U.V light absorbers at the weather surface to avoid yellowing and incorporates fire retardant resins to meet the fire performance requirements of the Building Regulations.

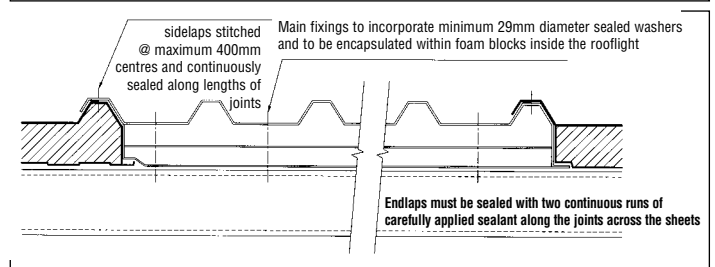
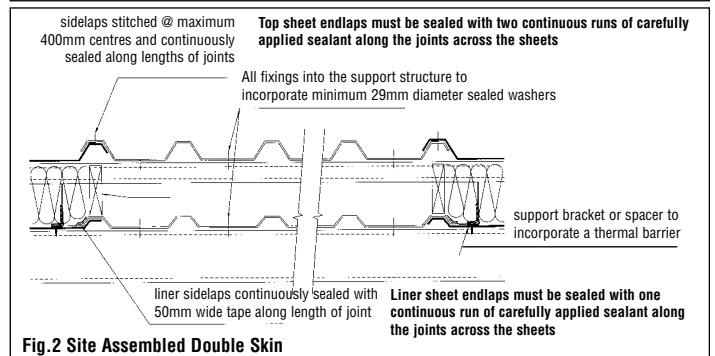
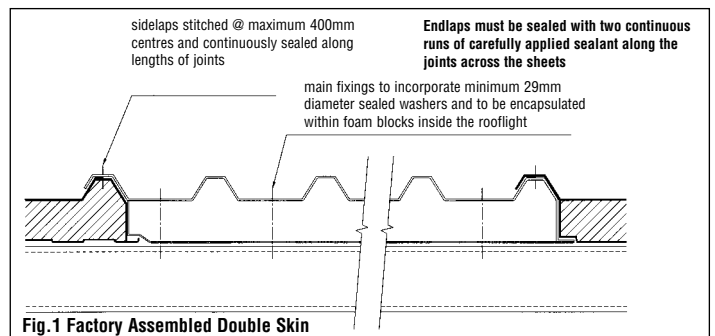
An alternative material is polycarbonate which is also available, profiled for in-plane applications and normally provided with a high level of U.V. absorber to avoid yellowing and available in clear, tinted and opal options to provide a choice on the type of light entering the building. Polycarbonate is inherently fire retardant and generally does not require additives to meet the fire performance requirements of the Building Regulations.

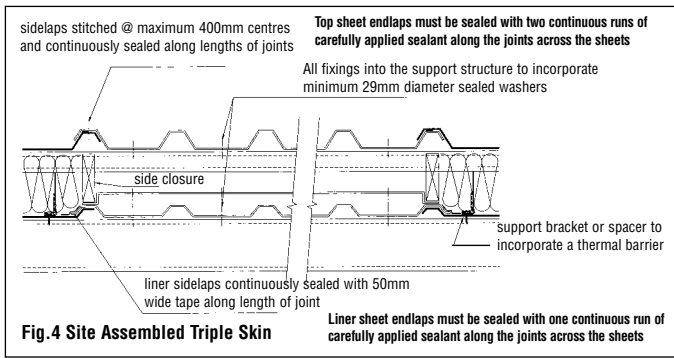
Both G.R.P and polycarbonate can be designed to meet the non-fragility requirements of the C.D.M Regulations.

In-Plane Rooflights - Typical Design and U-values.

To achieve the U-values determined in Table E in Part I of this document, the rooflight assemblies will require to be a Double Skin or Triple Skin construction or an appropriate insulated system.

Typical designs are given opposite :-





U-Values for these typical designs are shown in Table G.

Table G: U-Values for Multiskin Rooflights using G.R.P. or Polycarbonate.

Type	Cross Section	Construction			U-Value W/m ² K
		Outer	Core	Liner	
Factory Ass. Double Skin	Fig 1	32mm Profile	-	Flat ^①	2.98
Site Ass. Double Skin	Fig 2	32mm Profiled	-	20mm Profiled ^②	3.13
Factory Ass. Triple Skin	Fig 3	32mm Profiled	Flat ^①	Flat ^①	1.94
Site Ass. Triple Skin	Fig 4	32mm Profiled	Flat ^①	20mm Profiled ^②	2.00

Notes to Table G.

- ① Mini rib profiled sheet up to 10 mm deep will provide additional rigidity and have only marginal effect on the U-value.
- ② Site assembled liners are generally 20 mm deep. Using liners of the same depth as the outer sheet at 32 mm deep will make a difference to the U-value and may need checking by the manufacturer.

Liners of significant depth, say 80 mm, designed to support the outer skin, will give U-values of the order of 4.3 W/m²K.

It is clear from the above that profile and design can make a significant difference to the rooflight U-value. Designers should seek guidance from the manufacturer on the U-value calculation.

In Plane Rooflights - Conclusions.

1. Triple skin or an appropriate insulating double skin rooflight must be specified if rooflights are designed to a U-value of 2.2 W/m²K.
2. Triple skin rooflights are generally necessary where the rooflight area exceeds 14%.
3. Rooflight area in England and Wales will be restricted to 12% unless other compensating measures are adopted to reduce solar overheating.
4. Whilst 12% rooflight area may be deemed to be acceptable for industrial and general purpose buildings, consideration should be given to the additional benefits of natural daylighting and the Daylighting Levels specified in Table B.
5. At 12% rooflight area, double skin applications will generally comply when the practice of trading off is adopted.
6. Natural daylight is an important and regulatory requirement for all buildings. 10% rooflight area is defined as a minimum rooflight area, higher areas may be necessary, depending on building use and location.
7. Triple skin, site assembled or factory assembled in-plane rooflights are available from most manufacturers, they can be fitted easily and economically and are the only method of achieving a reduction in power consumption and hence meeting the intentions of the new Regulations. The National Association of Rooflight Manufacturers therefore recommends that designers should consider the use of triple skin rooflights for most applications.

Part III - Out of Plane Individual & Continuous Rooflights

This section discusses the requirements for rooflights, which are installed on upstands that are above the plane of the roof. They are used on all building types therefore both Document L.1 and L.2 are relevant.

These rooflights can be divided into two types, Individual and Continuous.

Both types are used to provide daylight in circulation spaces and working areas in all building types and are particularly useful where windows are ineffective. Not only providing a source of natural light they can also be specified to include both natural and mechanical ventilation. Other additional benefits available within a rooflight are means of access to surrounding roof areas and the provision of natural fire ventilation.

Individual rooflights are often used in single storey extensions to houses; their use is controlled by Document L.1, which contains some important differences from that of Document L.2.

Individual rooflights are most often produced from solid polycarbonate sheet moulded into a variety of shapes. The mouldings are assembled to produce double or triple glazed rooflights. The assemblies can be contained in a variety of metal or

PVCu frames which attach to upstands that are embedded in the roof insulation and weather proofing systems. In other instances the choice may be to purchase only the moulded element and fit it to a site manufactured upstand.

The importance of providing a well-lit environment is a requirement of both sections of the document. The comments contained in Part I and II of this guide apply equally to all rooflights in or above the plane of the roof.

As with the previous section of this guide the elemental method of demonstrating compliance is used.

Rooflight U-value requirements for Dwellings.

Document L.1 states that rooflights in PVCu frames, doors and windows all have the same U-value W/m²K. The standard area provision states that the requirement would be met if the average U-value of the three elements and their combined areas does not exceed 25% of the total floor area. The average U-value is an area weighted value for the whole dwelling.

Individual rooflights are used in the construction of dwellings, often on house extensions. For small extensions where the new heated space has an area not more than 6m², reasonable provision would be to use products which have an energy performance no worse than used in the existing building. For extensions of larger area full compliance to Document L.1 is necessary.

Whilst document L.1 notes that it is preferable to use manufacturers U-values obtained by calculation or test, it must also be recognised that there are no standards for calculation of moulded individual rooflights and that the range of designs available from manufacturers would preclude testing of every type and style. Therefore the indicative values given in Document L.1 for various glazing types are of importance. The values that are relevant are reproduced in Table H.

Table H : Indicative U-values for rooflights for dwellings

Frame glazing type	PVCu	Adjustment	Indicative value	Metal •	Adjustment for Thermal Break **	Indicative value
Double	2.7	+0.2	2.9	3.3	+0.3	3.6
Triple	2.0	+0.2	2.2	2.5	+0.3	2.8

- The adjustment is for a thermal break 4 mm.

Other values apply between 0 and 16 mm.

The use of rooflights is dependent upon calculations, which have to be made by the designer, to obtain an average U-value for windows, doors and rooflights. Various U-values and differing areas can be used to obtain an area-weighted average provided that heat loss when calculated by using the U-values given in Table H and the 25% of total floor area are not exceeded.

Generally rooflights do not represent a larger percentage of the total permitted area in dwellings and the continued use of double or triple glazed rooflights is unlikely to change.

Examples of how average U-values can be calculated are given in Document L.1 Appendix D.

Limiting Air Leakage - Dwellings

Document L.1 states that reasonable provision should be made to reduce unwanted air leakage. Unlike the requirement for other building types there is no level of air leakage set as a requirement.

Rooflight U-value - Building types other than Dwellings.

Rooflights are given a U-value of 2.2 W/m²K and the maximum permitted area of the roof area of 20%. The above limits are specific to the rooflight unit and exclude the upstand.

Indicative U-values are given for rooflights in both PVCu and metal frames with thermal breaks. Unlike the values given for dwellings there is no requirement to make an upward adjustment. There is still the requirement to adjust the value for metal frames with respect to the width of the thermal break.

Table J : Indicative U-values rooflights for building types other than dwellings (W/m²K)

Frame Glazing Type	PVCu	Metal Thermally broken*
Double	2.7	3.3
Triple	2.0	2.5

* The adjustment is for a thermal break of 4 mm.

Other values apply between 0 and 16 mm

In order to provide greater design flexibility the U-values of rooflights and the areas may vary provided those specified requirements are met. The guide lines for trade off are detailed in Part I.

Upstands for all building types.

Rooflight manufacturers provide a range of designs of upstands which are produced from material such as PVCu, GRP, Steel and Aluminium. As stand alone items each type will have varying thermal performance depending on the detailed design. Insulation can be factory fitted to upstands and recommendations made for the termination of the roofing material.

Upstands are intended to be incorporated in the total roofing system. As such it is common practice to site apply insulation, generally of the type being installed on the roof, to the exposed faces of the upstand.

Document L.1 does not contain a reference regarding the requirement to insulate rooflight upstands where as Document L.2 does. In the case of the latter it is clear that the indicative U-values given in Table J apply only to the glazed element. The document further states that reasonable provision would be to insulate the upstand or otherwise insulate it from the internal environment.

Continuous Rooflights - Barrel Vaults.

Continuous barrel vaults are predominately manufactured with aluminium frames, which are glazed with double or triple layers of solid polycarbonate or G.R.P. sheet. Alternatively multi-wall polycarbonate sheets are used. Like solid sheets these can be installed in a double layer arrangement.

There are numerous specifications of polycarbonate and G.R.P. which can be used singly or in combinations which when considered with the framing system provide a range of system U-values. Table E shows that systems that have U-values of 2.8 W/m²K can occupy 15% of the roof area. This value would satisfy a large proportion of the current out of plane rooflight usage.

Continuous Rooflights - Ridge Lights and Pyramids.

This category of rooflights is predominately glazed with glass. The chosen glazing can be of the low emissivity type using argon gas filling. Solar reflective properties can also be specified. The use of such specifications can provide a range of system U-values and in addition provide protection from solar over heating. Individual manufacturers should be consulted for guidance.

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